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Long-run Money Demand in Latin American Countries: A Nonstationary Panel Data Approach

César Carrera

Systemic Risk, Aggregate Demand, and Commodity Prices: An Application to Colombia

Javier Guillermo Gómez-Pineda
Juan Manuel Julio-Román

Abstract

We embed a small open economy model for Colombia into the systemic risk model of Gómez, Guillaume, and Tanyeri (2015). The small open economy model is estimated by Bayesian methods and used for analysis and projections. Parameters estimates are constrained to yield an appropriate behavior to impulse responses, the evolution of latent variables, equation fit, error decompositions, and model forecast performance. The model enables us to give a consistent treatment of shocks to systemic risk, country risk, oil and commodity prices because rest-of-the-world variables are endogenous among themselves instead of exogenous rest-of-the-world variables for Colombia so that its economy responds to the reaction of these variables to the shocks of interest. Among other results we found that the identified episodes of retrenchment and buoyancy in

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systemic risk were transmitted to Colombia's country risk premium and that systemic risk shocks are important drivers of Colombia's output and unemployment gaps. Finally, aggregate demand-related shocks are unimportant drivers of noncore inflation in Colombia. This result contrasts with findings for other countries.

Keywords: global risk, financial linkages, commodity prices.

JEL classification: F32, F37, F41, F31, F47, E58.

1. INTRODUCTION

This paper studies the effect of systemic risk on Colombia, a small open developing economy. The systemic risk shock is dealt with consistently, meaning that the Colombian economy reacts directly to the systemic risk shock and indirectly via the reaction of world output, interest rates, inflation, and exchange rates to the shock under study. This contrasts sharply with the approach that appends an exogenous *rest-of-the-world* to a small open economy (SOE) model where *rest-of-the-world* variables are exogenous. The paper also deals with shocks to oil and commodity food prices in a consistent way.

In order to reap these benefits, the systemic risk global model in Gómez, Guillaume and Tanyeri (2015), hereafter GGT, is adapted to explain systemic risk transmission in a particular SOE (Colombia), instead of the average country in its region. As a matter of fact, GGT proposed a global model that explains the systemic risk transmission mechanisms across different regions of the world thus missing the idiosyncrasies of individually small countries within its region as is the case of Colombia. As a result, in this paper Colombia is treated as a new region that follows the same equations as any other region but with different parameter values. The soundness of this approach arises from the fact that the effect of the USA subprime crisis in Latin America seems to have been heterogeneous among its major economies. See Dufrénot et al. (2011) for instance.

In very general terms, GGT's model considers a world consisting of a series of regions: United States (US), European Union (EU), Japan (JA), East Asia (EA), and Latin America (LA); whose local behavior is similar except for its parameter values and variable's realized values. For each region, the model describes the behavior of macro variables measured as gaps over stochastic trends that is very similar to models used for inflation targeting. GGT propose to

1) Measure systemic risk as a common unobserved global factor encompassed by the global model;

2) Introduce an explicit channel, through which systemic risk transmits to country risk premiums;

3) Provide a transmission mechanism from systemic risk to global output and regional output gaps;

4) Include commodity prices and its effect on local inflation as well as real effects of commodity prices such as oil to global output; and,

5) "A treatment of the trade balance and a simple approximation to the current account" (Gómez et al., 2015, p. 5).

Colombia is an important case not only because it serves as an example on the implementation of the GGT model for specific needs, but also because of the unique effects the 2007-2009 global financial crisis and its medium-term aftermath had in this country. As a matter of fact, Dufrénot et al. (2011) found that "the financial stress in the USA markets is transmitted to these [Brazil, Chile, Colombia, Mexico, and Peru] countries' stock market volatility, but not in the same scale. Our findings support the idea of heterogeneity among the LAC markets, in the sense that the 2007/2008 subprime crisis did not equally affect all the countries, despite the fact that high volatility of the equity prices was observed everywhere". These results suggest that Latin American financial markets decoupled heterogeneously from USA as pointed out by Dooley and Hutchison (2009).

In the same vein, Julio et al. (2013) report a structural break in the relation between the appetite for risk of international investors and the Colombian component of the Emerging Markets Bond Index (EMBI)-Colombia, in the second half of the 2000s decade that lowered the financial cost of government debt. This sovereign risk break, according to these authors, is "apparently associated to [the aftermath of] the global financial crisis". However, these authors do not deeply explore the channels through which sovereign risk, which we explore further through the use of GGT's model.

As a result, the estimation of Colombian parameters is emphasized. In fact, provided that regions of GGT are identical except for their corresponding parameter values and their variables realizations, the key to model these responses lies on parameter estimates.

Furthermore, to our knowledge this is not the first time that a model of a SOE is embedded into a global model, but we are unaware of published papers on the topic as of now.

The paper has the following four sections in addition to this short introduction. The second briefly describes the model. The third deals with all the data aspects, namely, its sources as well as the model calibration and estimates. The fourth contains the impulse responses under the main shocks, the smoothing and error decomposition results, and the forecasting performance of the model. The fifth concludes and deals mainly with the role of systemic risk shocks in explaining local output gap, unemployment, and country energy and food prices.

2. THE MODEL

The model consists of a SOE model calibrated for Colombia embedded into the systemic risk model of Gómez et al. (2015). As in GGT, the model is built to incorporate three channels of transmission. First, systemic risk and its transmission to the country risk premium. Second, the transmission from country risk premiums to demand-related variables such as the output gap, the trade balance and unemployment. And third, the transmission from commodity prices to country inflation. With these features, the model can be operated to analyze financial booms and busts (low and high risk premium), and the effect of booms and boosts on output, unemployment, and the trade balance, as well as commodity-price shocks and their effect on inflation.

The model used in this paper draws extensively on GGT as the Colombian economy is modeled as one GGT block. Therefore, just as in GGT, the Colombian block is in the spirit a simple gap model of the type central banks use for their inflation targeting procedures.

That is, the model is based on two transmission channels: an aggregate demand channel and an exchange rate channel. The former describes the effect of interest rates on aggregate demand, inflation, and back again to the interest feedback rule, while the later establishes the effect of interest rates on the exchange rate, aggregate demand, inflation, and then to the interest rate feedback rule. These standard transmission channels, whose origin is the interest rate, may be extended to country risk premiums as follows. The *domestic aggregate demand channel* is the effect of a shock to the country risk premium on the country's output gap, inflation, and finally on the interest rate feedback rule. The *domestic exchange rate channel* comprises the effect of the country risk premium on output and trade balance gaps through the exchange rate; the interest rate feedback rule then takes the economy back to equilibrium.

The Colombian model also makes use of the three transmission channels incorporated in GGT, namely, the *systemic risk channel, the foreign aggregate demand channel, and the foreign exchange rate channel.* Further details on this matter may be found in Gómez et al. (2015, pp. 7-12).

The model consists of 22 core equations. These equations are, on one hand, behavioral equations for the following variables: risk premium, output gap, trade balance gap, capital flows, core inflation, energy prices, food prices, interest rates, unemployment, export prices, import prices, and real exchange rate. And on the other, identities for the variables foreign risk premiums, foreign real interest rates, real multilateral exchange rate, terms of trade, absorption, CPI inflation, nominal exchange rate, real interest rate, and a breakdown of the uncovered interest parity residual.[1]

The reader is referred to Gómez et al. (2015) for the model's details. Instead of transcribing the whole model in this paper, we describe the parameters of interest and refer the reader to the appropriate equations in GGT's paper.

Our interest lies on the estimation of 13 parameters that determine the responses to key shocks through the transmission channels described in GGT's model. The rest of parameters were either calibrated or estimated in GGT and taken here as given. A sample of those may be found in Tables A.1 and A.2. In turn, Table A.4 contains a list of the parameters we are interested in. The first parameter, $\alpha_{2,CO}$ determines the contemporary transmission of systemic risk shocks to the Colombian risk premium $\hat{\rho}_t$ in Gómez et al. (2015, Eq. 2, pp. 7). The second and the third, $\delta_{2,CO}$ and $\delta_{3,CO}$, determine the effect of the expected inflation gap $\pi_{t+5|t} - \bar{\pi}_{t+5|t}$, and the current output gap $\hat{y}_t$ on the current nominal interest rate i_t in the policy rule at Gómez et al. (2015, Eq. 56, pp. 15), respectively. The effect of the output gap $\hat{y}_t$ and the real exchange rate (RER) gap q_t^{RER} on the inflationary core π_t^C in the Phillips curve is determined by ν_2 and ν_3, respectively (Gómez et al., 2015, Eq. 39, pp. 13). The transmission from global food (commodity) prices $\hat{q}_t^{Food}$ to Colombian food prices $\hat{q}_t^f$ in Gómez et al. (2015, Eq. 34, pp. 12) depends on ν_4, and the effect of local prices $\hat{q}_t$ on local food prices depends on ν_5. In the same vein, the transmission from oil prices $\hat{q}_t^{Oil}$ and local prices $\hat{q}_t$ to domestic energy prices $\hat{q}_t^e$ are determined by ν_8 and ν_{12}, respectively, in Gómez et al. (2015, Eq. 33, pp. 12). The response of the NAIRU gap $(\hat{u}_t)$ to the output gap is $-\theta_2$ in $\hat{u}_t = \theta_1 \hat{u}_{t-1} - \theta_2 \hat{y}_t + \varepsilon_t^{\hat{u}}$. The last two parameters, $\sigma_{\rho,CO}$ and $\sigma_{rr,CO}$ correspond to the expanded version of the output gap equation which may be found

[1] The number of equations in the SOE model rises to 117 owing to the type of variables involved (in deviation and latent form), the several definitions used for growth and inflation, a set of equations for autocorrelated residuals, and another equation for exogenous interventions on the output gap.

in Gómez et al. (2015, Eq. 19-20, pp. 51), and represent the multiplicative inverse of the effect of the country risk and the real rate gap on the output gap, respectively.

As a result the most important parameters in the transmission of the shocks of interest are estimated based on sample information rather than calibrated.

3. MODEL ESTIMATION

In order to check the validity of preliminary prior parameters means (that is, the calibration) we compare the peak response of the output gap to country risk premium shocks in the model and in a global VAR model in Figure B.1.[2] The shock to the country risk premium is a unit and autocorrelated. Figure B.1 shows that the peak response of the output gap to the country risk premium shock is similar in the model and in the VAR. In like fashion, the peak response of the output gap to interest rate shocks is also similar in the model and in the VAR.

The hyperparameters of the a priori parameters distributions were obtained from the calibration of the model. The calibration covered 121 parameters, 41 of which are standard deviations; while the estimation covered 13 parameters. The calibration was obtained by analyzing impulse response functions, the evolution of latent variables, equation fit, error decompositions, and model forecast performance. As a result, calibration provides the mean, variance and limits for all 13 a priori parameter distributions.

The samples of calibrated parameters in Table A.1 and the estimated parameters in Table A.2 come directly from Gómez et al. (2015).[3]

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[2] To calibrate the effect of the country risk premium and real interest rate to the output gap GGT estimates a global VAR model that includes, for each region, the country risk premium gap, the local real interest rate gap, the local output gap and the output gap of the rest of the world. See Gómez et al. (2015, Eq. 63, pp. 17).

[3] The sources of the data are specified in Gómez et al. (2015). In the particular case of Colombia, the country risk premium was measured with Colombia's EMBI spread.

Once the a priori distributions are set, parameter estimation can be carried out by Bayesian methods. Under a zero-one loss function the 13 Bayesian parameter estimators correspond to the mode of the posterior distributions, while under mean squared error loss they correspond to posterior means. We chose Bayesian estimation as it helps tackle key estimation issues that arise when working with big and complicated models such as the one used in this paper, see Del-Negro and Schorfheide (2011).

However, because of the model's size and complexity the posterior distributions do not have closed form from which the modes and means could be derived. As a result, we have to rely on simulation. Simulation of the samples from the parameters posterior distributions was carried out by the adaptive version of the random walk Metropolis algorithm; see Haario et al. (1999). By design, this simulation technique guaranties an adequate degree of sample mixing when coupled with a *good* choice for the parameters of the proposal distribution, in particular its variance-covariance matrix. See Gelman et al. (2013).

In order to obtain an appropriate estimate of covariance matrix for the proposal distribution, the posterior distribution was maximized as follows. First, a good approximation to the posterior distribution mode [that is, the regularized likelihood maximum in Ljung (1999)] is found through the particle swarm algorithm.[4] And second, a Newton-Raphson

4 The particle swarm algorithm is a time inexpensive maximization technique, see Johnston (2013). In this algorithm, a population (swarm) of particles climbs the log posterior at a number of arbitrary points. In every iteration, each particle knows its own altitude, its maximum historical altitude and the maximum altitude historically attained in the population. When coupled with a behavioral rule and some degree of persistence, this algorithm is a time inexpensive alternative to find a global maximum. Furthermore, since this algorithm computes the function only once for each particle in every iteration, it is able to solve the maximization problem very fast using parallel computing, which further enhances the time savings.

maximization algorithm is started at the result of the particle swarm in order to reach the posterior's maximum if it has not been attained already. Therefore, the use of the time expensive Newton-Raphson procedure is reduced and an estimate of the covariance matrix at the posterior mode is obtained.

The last generation of parameters in the particle swarm algorithm was fed to the Newton-Raphson procedure, which converged in just one step. This last procedure provided estimates of both the posterior mode as well as the covariance matrix at the maximum for the random walk Metropolis algorithm. After a burn sample of size 30,000, 100,000 samples were simulated in order to estimate the posterior distributions.

In order to check convergence to a maximum, Figure B.2 depicts the profiles of the negative log regularized likelihood along with the corresponding (maximum) achieved by the Newton-Raphson algorithm. These plots confirm that a mode was reached and thus we can confidently use the Hessian at the maximum to provide an estimate of the covariance matrix for the proposal distribution. Furthermore, a comparison of the posterior mode with the prior mean in Table A.4 shows important similarities among the values of all parameters, except v_3. Thus, at least from a 0-1 loss perspective the data seems to provide information about the value of some parameters.

Once this covariance matrix is fed into the random walk Metropolis algorithm, samples from the posterior distributions of the 13 parameters can be obtained. These simulations are used to estimate the 13 posterior densities and their corresponding moments. Table A.3 summarizes the simulation setup for the 13 parameters posterior distribution. The upper panel contains the setup for the maximization of the posterior, while the lower panel summarizes the setup of the random walk Metropolis simulator. Parameters a priori distributions were assumed to be independent normal, so that the regularized likelihood corresponds to the posterior mode. The particle swarm algorithm population ran in four parallel workers (processors) and contained a swarm of 80 members who were programed to climb the regularized log likelihood for up to

200 generations. Convergence, within a one in a millionth difference, was achieved after just 172 generations.

To check for convergence to the steady state distributions of the parameters posteriors, it is common to analyze the acceptance ratio of the proposed simulations, which in our case was 22.87%, a value close to the expected rate of acceptance in Gelman et al. (2013). The second criteria checks for changes in the variance at different intervals of the simulations. In our case the variance ratio of the first and second half of the marginal simulated samples is 1.09, which being close to one validates our simulations. Furthermore, Figure B.3 shows a small portion of the sample simulated path of four parameters. The upper left and right panels show that the marginal simulation of some parameters converge to a steady state distribution quite fast regardless of the starting point. In contrast, the lower panels show that the unconditional simulation of some parameters takes longer to explore different sets of their corresponding parameter spaces to achieve the required degree of mixing, regardless of the starting point also. In order to test for an adequate degree of mixing, a variance ratio among the two halves of the simulation was calculated, 1.09; which is close enough to one. This suggests that the simulations are adequate to infer the posterior densities and their moments.

Table A.4 summarizes the results of the Bayesian estimation. A priori distributions were assumed independent truncated normal with means and standard deviations displayed in the second and fifth columns, and truncation limits in columns three and four, respectively. The parameters of the a priori distributions arise from a very careful calibration of the impulse responses and historical decompositions of the model, and the standard deviation and truncation limits are set as wide as possible to reduce the amount information input to the estimation process. The final results of the estimation process, under square loss, are located at the right hand side panel of the table. Column seven contains the posterior means and columns eight and nine show the corresponding highest probability density confidence limits at 95%, respectively.

The estimated marginal posteriors and priors may be found in Figure B.4. From this figure it can be observed that the sample information does contain information about the parameters of interest as priors and posteriors tend to differ in their location (mean or mode) and their variance, or both, except for particular cases. These results, along with Table A.4 depict slight mean shifts from the prior to the posterior for δ_2 , ν_{12} , ν_2 , ν_1 , and σ_r; and in an important shift in the mean of ν_3 . Furthermore, the introduction of prior information reduced parameter uncertainty quite significantly for δ_3 , ν_{12} , ν_2 , ν_3 , ν_4 , ν_8 , θ_2 , and σ_r . Therefore, the sample data contains information about ν_3 (i.e., reduced uncertainty and shifted its mean), and contains some information about coefficients δ_3 , ν_{12} , ν_2 , ν_3 , ν_4 , ν_8 , θ_2 , and σ_r (i.e., sharply reduced uncertainty).

Once the parameters are estimated, these values are introduced in the model to further study the transmission channels of interest.

4. RESULTS

The results deal with the three main topics developed in the paper,

1) The transmission from systemic risk to the country risk premium;

2) The transmission from the country risk premium to aggregated demand–related variables such as the output gap, the trade balance gap, and unemployment; and

3) The transmission from commodity prices to country energy and food country prices.

In addition, impulse response analysis includes a shock to the policy interest rate, given that this shock is an explanation of the transmission mechanisms of monetary policy.

A Shock to Systemic Risk

Figure B.5, panel A, shows the behavior of the country variables in response to a shock to systemic risk. Global risk is shown to affect Colombia's country risk premium, output gap, and trade balance gap. The country risk premium and the output gap respond according to the strength of the systemic risk and aggregate demand channels.

The trade balance gap deteriorates owing primarily to the strength of the systemic risk channel. As loading factor α_2 is small, the country risk premium rises less than abroad, the country risk premium differential drops, and the trade balance deteriorates.

A Shock to the Country Risk Premium

Figure B.5, panel B, shows the response of the output gap to shocks to the country risk premiums. In response to an upward shock to the domestic risk premium, the output gap drops. Two channels are at work, the domestic aggregate demand and domestic exchange rate channels.

In response to an upward shock to a foreign risk premium, the output gap also drops. Both the foreign aggregate demand and foreign exchange rate channels help explain this response.

The output gap reacts to shocks to the domestic risk premium far more than to shocks to foreign risk premiums. In a relatively open economy, the output gap may react strongly to foreign risk premium shocks because the aggregate demand channel tends to be weak, while the foreign aggregate demand channel tends to be strong. But this is not the case of the country under study, Colombia.

Concerning the response of the trade balance gap to country risk premium shocks, Figure B.5, panel C, the trade balance gap improves with shocks to the domestic risk premium and drops with shocks to foreign risk premiums. The strength of the response of the trade balance gap to shocks to foreign risk premiums depends, mostly, on the export share of the country where the shock takes place.

Shock to Commodity Prices

The response of country variables to a shock to the price of oil appears in Figure B.5, panel D. The response involves higher inflation and interest rates. The monetary policy rules at home and abroad prescribe larger interest rate increases in Colombia; hence, Colombia's currency appreciates causing output gap to drop further.

Altogether, a shock to the price of oil has effects on inflation and the output gap that may be important, but quantitatively not as important as the effect of a one standard deviation shock to systemic risk.

A shock to the commodity price of food appears in Figure B.5, panel E. The response of the output gap and inflation is similar in kind and extent to that of a shock to the price of oil. Some differences do arise as to the extent of the response of the nominal interest rate and in the persistence of CPI inflation. These differences are explained by the higher persistence of the country food and energy prices under shocks to commodity food prices and to the price of oil, respectively.

An Interest Rate Shock

The focus here is on the effect of interest rate shocks on the country output and trade balance gaps. As expected, the relevant shocks are those to the own interest rates, while shocks to foreign interest rates are largely unimportant.

Consider first the response of the output gap to a shock to the domestic interest rate in Figure B.5, panel F. The response is standard with the domestic aggregate demand and exchange rate channels being involved.

Next, consider the effect of foreign interest rate shocks on the output gap, also in Figure B.5, panel F. The response of the output gap to a foreign interest rate shock is the result of transmission channels that work in opposite directions. In response to an increase in a foreign interest rate, the foreign aggregate demand channel causes a drop in the output gap; the foreign exchange rate channel causes a rise in it. Both effects offset each other to the extent that the response of the output gap to a foreign interest rate shock is trivial.

Next, consider the effect of an interest rate shock on the trade balance gap in Figure B.5, panel G. The response to an upward shock in the domestic interest rate is a drop in the trade balance gap. By the aggregate demand channel, a rise in the domestic interest rate decreases aggregate demand and hence imports. Consequently, the trade balance improves. Through the exchange rate channel, a rise in the domestic interest rate appreciates the exchange rate; thus, the trade balance deteriorates. The later effect predominates.

Finally, consider the effect of a foreign interest rate shock on the trade balance gap also in Figure B.5, panel G. As explained in GGT, the sign of the response of the trade balance gap to a foreign interest rate shock is opposite to that of a shock to the domestic interest rate. Thus, in response to an upward shock to a foreign interest rate the trade balance gap rises.

Smoothing Results

Reported smoothing results also deal with the three topics dealt with in the paper.

The first of the topics is presented in Figure B.6, panel A. The estimated, unobserved systemic risk marks periods of higher volatility during the end of the century crisis, the stock market downturn of 2002, the global financial crisis, and the eurozone crisis.

Figure B.6, panel B also shows the country risk premium. In deviation form, the country risk premium moves with global and idiosyncratic events. In latent form, the country risk premiums drops during the transition to lower inflation that started in the early 2000s.

The second of the topics appears in Figure B.6, panels C and D. Two of the three peaks in systemic risk and the country risk premium (the end of the century crisis and the global financial crisis) correspond with busts in output and increases in unemployment. During these episodes, the trade balance improved. Because the trade balance improved at the time the output gap dropped, absorption dropped more than output; in this light the trade balance is understood to be procyclical.

The third of the topics appears in Figure B.6, panels I and J. Country energy prices have low correlation with the price of oil, probably owing to the rule used to set gasoline prices in Colombia. Country food prices depict some correlation with commodity food prices.

Historical Decomposition Results

The historical decomposition of systemic risk, estimated with the model in Gómez et al. (2015), appears in Figure B.7, panel A. Global risk points at four episodes of retrenchment: The end-of-the-century crisis, the stock market downturn of 2002, the global financial crisis, and the eurozone crisis.

The historical decomposition of the Colombia's country risk premium gap appears in Figure B.7, panel B. Global risk shocks have a massive influence on the country risk premium. Peaks in the country risk premium are explained by systemic risk shocks in all episodes of global retrenchment. Note that the country risk premium is not explained by systemic risk during the burst of the dot-com bubble which is a USA event.

As to the historical decomposition of Colombia's output gap in Figure B.7, panel C, systemic risk shocks are important while own and foreign risk premium shocks are trivial. Other demand-related shocks, such as output and real interest rate shocks are also less important. Also, shocks to foreign variables are also trivial in explaining the output gap.

The decomposition of the unemployment gap also makes clear that systemic risk shocks are relevant and country risk premium shocks are trivial (Figure B.7, panel D). Global risk shocks help explain the rise in unemployment during the global financial crisis while interest rate shocks help explain the rise during the end of the century crisis. Again, foreign shocks are trivial.

The historical decomposition of the trade balance gap appears in Figure B.7, panel E. Recall that systemic risk shocks affect country risk premiums to different extents and that trade balance gaps depend on the country risk premium differential. In Colombia, an upward shock to systemic risk tends to cause a drop in the trade balance gap.

Country energy and food price gaps are broken down into the contributions from shocks in panels F and G. Demand related shocks play a role in explaining country energy prices and to a minor extent country food prices. The role of demand related variables in explaining the relative price of noncore inflation was emphasized in GGT. The same argument applies here to the relative price of energy.

However, the case is different regarding the aggregate of energy and food prices. Figure B.7, panel H, presents the decomposition of the aggregate of Colombia's energy and food prices. As noted in GGT, this aggregate is a measure of the deviation of CPI inflation from core inflation. The effect of demand related shocks is trivial on the aggregate. The reason is that while the effect of demand-related shocks on the country price of energy is large, the share of country energy prices in the CPI is small. In the aggregate, demand-related shocks are unimportant. Moreover, commodity food price shocks predominate.

Forecasting Properties

Table A.5 compares the model forecasts with the forecasts of analysts.[5] Model growth forecasts are better at one and four quarters ahead horizons[6] (Table A.5). As to inflation forecasts,

[5] The survey of analysts' forecasts is taken from Consensus Economics.

[6] Except for the four quarters ahead growth forecast for the United States.

model forecasts are better at one quarter horizon but worse at four and eight quarter horizons.

The relatively good performance of the model may in part be explained by the fact that analysts did not know the model, the shock, and the coefficients that we know after we set up, calibrate, and estimate the model throughout the sample. This is particularly relevant during the global financial crisis. The parameters do incorporate the effect of higher systemic risk on growth and inflation during the global financial crisis while it is fairly known that analysts performed quite poorly.

Figure B.8 shows the forecast variance of a handful of variables. The figure shows that systemic risk shocks are important in explaining the forecast variance of the country risk premium, output growth, trade balance, unemployment and energy and food price inflation.

5. CONCLUSIONS

The paper dealt with three main topics; first, the transmission of systemic risk to the Colombia's country risk premium; second, the effect of Colombia's country risk premium on aggregated demand-related variables such as the output gap, the trade balance gap, and unemployment; and third, the transmission from commodity prices to country energy and food prices.

On the first topic, systemic risk shocks were transmitted to Colombia's country risk premium in all events of global retrenchment. Although country risk premium shocks also mark some periods of idiosyncratic risk, the bulk of the country risk premium was explained by systemic risk shocks.

On the second topic, systemic risk was relevant at explaining Colombia's output gap, particularly during the global financial crisis. The historical decomposition of the country output and unemployment gaps showed the relevance of systemic risk shocks and the more trivial role of country risk premium shocks.

It was in the trade balance gap where country, domestic risk premium shocks played a more relevant role. The reason is that the trade balance gap is explained by the country risk premium differential. During retrenchment, systemic risk permeated with different intensity to country risk premiums. In Colombia, where the systemic risk channel is weaker, the risk differential dropped and the trade balance deteriorated.

On the third topic, the paper showed that in Colombia supply shocks were more relevant that demand-related shocks, given the higher weight of food in the CPI.

The model performed relatively well in forecasting, as compared to a survey of analysts' forecasts. Global risk shocks helped explain the variance of the forecasts for a handful of Colombian macroeconomic variables.

ANNEXES

Annex A

Table A.1

SOME CALIBRATED PARAMETERS

Parameter	*Value*	*Parameter*	*Value*	*Parameter*	*Value*	*Parameter*	*Value*
$1/\sigma_{\rho,CO}$	0.333	$1/\sigma_{r,CO}$	0.143	$\sigma_{1,CO}$	0.040	$\sigma_{2,CO}$	0.780
$\alpha_{1,CO}$	0.630	$\delta_{1,CO}$	0.200	$\nu_{1,CO}$	0.850	$\vartheta_{1,CO}$	0.780
$\nu_{7,CO}$	0.550	$\sigma_{6,CO}$	0.600	$\sigma_{11,CO}$	0.600	β_1	0.500
λ_{CO}	0.005	$\bar{x}_{CO}$	0.171	$\bar{m}_{CO}$	0.194	β_4	0.700

Source: Authors' calculations.

Table A.2

SOME ESTIMATED PARAMETERS

Parameter	*Prior mode*	*Posterior mode*	*Parameter*	*Prior mode*	*Posterior mode*
$\alpha_{2,US}$	0.495	0.267	$\delta_{2,US}$	0.082	0.084
$\delta_{3,US}$	0.275	0.304	$\vartheta_{2,US}$	0.266	0.215
$\nu_{2,US}$	0.082	0.084	$\nu_{3,US}$	0.020	0.028
$\nu_{5,US}$	0.624	0.119	$\nu_{8,US}$	0.486	0.643
$\nu_{4,EU}$	0.040	0.038	$\nu_{12,EU}$	0.040	0.042
ν_{US}	0.200	0.000	β_2	6.959	7.373

Source: Authors' calculations.

Table A.3

PARAMETERS FOR POSTERIORS SIMULATIONS

Process	*Feature*	*Value*
Maximizing the posterior	Parameters	13
	Population size	80
	Generations	200
	Generations to convergence	172
	Parallel workers	4
	Newton-Raphson iterations	1
Adaptive Metropolis	Iterations	100,000
	Burn in sample	30%
	Acceptance ratio	22.87%
	Average variance ratio	1.0941

Note: Iris Toolbox 20120121, Benes and Johnston (2014); particle swarm algorithm, Johnston (2013).
Source: Authors' calculations.

Table A.4

PARAMETERS PRIOR AND POSTERIOR DISTRIBUTIONS FEATURES

	Prior				Posterior			
Parameter	*Mean*	*Min*	*Max*	*Std*	*Mode*	*Mean*	*HPDI_05*	*HPDI_95*
$\sigma_{2,CO}$	0.8000	0.0000	1.6000	0.0800	0.8000	0.7939	0.6635	0.9302
$\delta_{2,CO}$	1.0000	0.0000	2.0000	0.1000	1.0836	1.0835	0.9199	1.2286
$\delta_{3,CO}$	0.5000	0.0000	1.0000	0.0500	0.5137	0.5170	0.5157	0.5192
$v_{12,CO}$	0.0400	0.0000	0.0800	0.0040	0.0400	0.0409	0.0385	0.0429
$v_{2,CO}$	0.1000	0.0000	0.2000	0.0100	0.1013	0.0922	0.0860	0.0995
$v_{3,CO}$	0.0400	0.0000	0.0800	0.0040	0.0503	0.0502	0.0476	0.0520
$v_{4,CO}$	0.0400	0.0000	0.0800	0.0040	0.0400	0.0394	0.0384	0.0409

$\nu_{5,CO}$	0.0800	0.0000	0.1600	0.0080	0.0800	0.0798	0.0668	0.0930
$\nu_{8,CO}$	0.0500	0.0000	0.1000	0.0050	0.0500	0.0548	0.0530	0.0569
ν_{CO}	0.2000	0.0000	0.4000	0.0200	0.2039	0.2038	0.1718	0.2371
$\sigma_{\rho,CO}$	4.8000	0.0000	9.6000	0.4800	4.8246	4.8089	4.0555	5.5593
$\sigma_{rr,CO}$	15.0000	0.0000	30.0000	1.5000	14.6967	14.7293	14.6764	14.7802
$\theta_{2,CO}$	0.2000	0.0000	0.4000	0.0200	0.1999	0.1964	0.1895	0.2023

Note: Adaptive version of the random walk Metropolis algorithm.
Source: Authors' calculations.

Table A.5

GOODNESS OF FIT

Root mean squared errors in percentage points

	One quarter ahead		*Four quarters ahead*		*Eight quarters ahead*	
	Consensus Forecast	*Global risk model*	*Consensus Forecast*	*Global risk model*	*Consensus Forecast*	*Global risk model*
Colombia's growth	1.019	0.28	2.273	1.887	1.902	2.72
Colombia's inflation	0.943	0.875	2.292	3.615	1.596	3.987

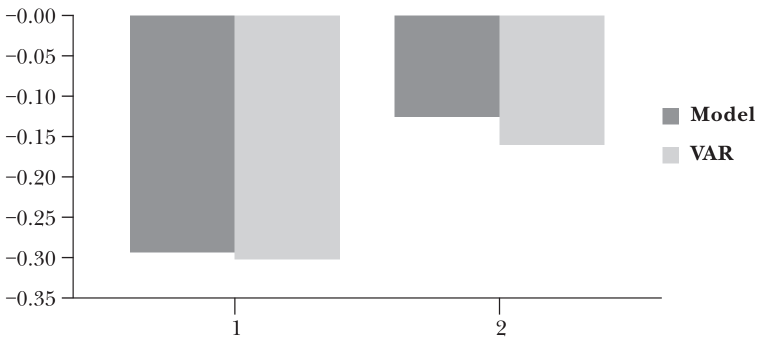
Note: To make Consensus Forecast (CF) and global risk model forecasts (GR) broadly comparable we approximated the CF and GR forecasts as follows. The one quarter ahead forecast is the October forecast for the end of the year; the four quarters ahead forecast is the October forecast for the end of the following year; and the eight quarters ahead forecasts is the October forecast two years ahead. The sample is 1996-2013.
Source: Authors' calculations.

Annex B

Figure B.1

MODEL CALIBRATION

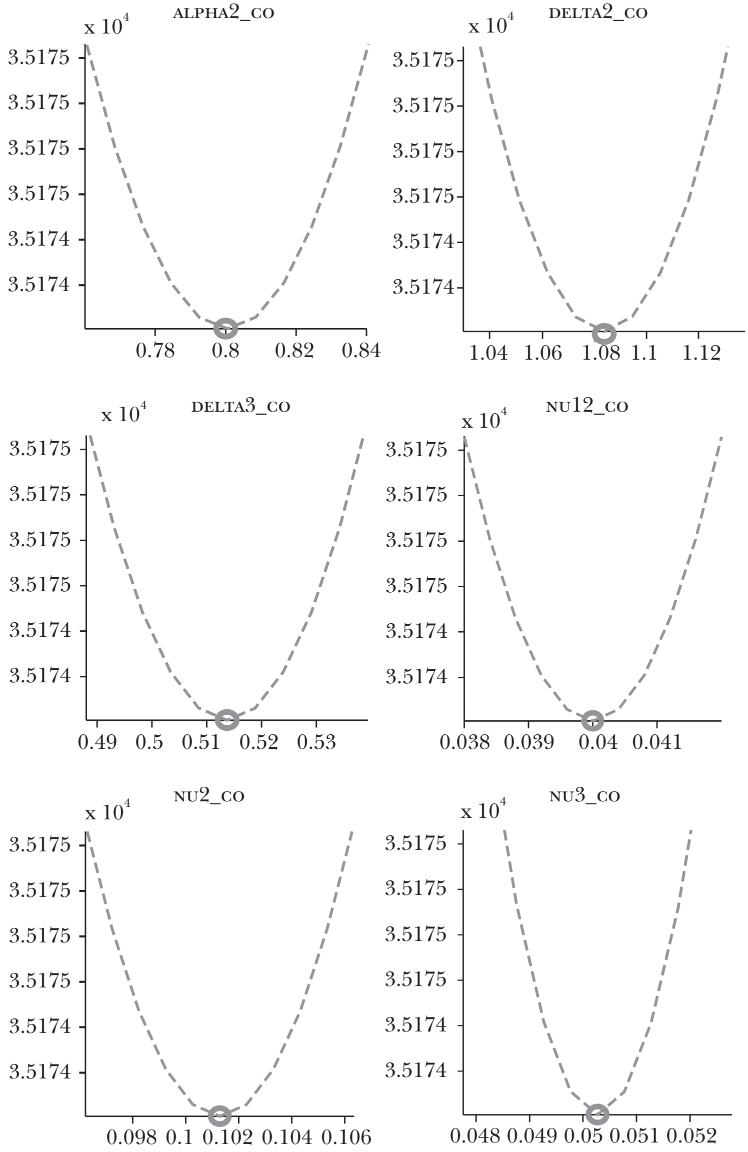
Peak response to a unit shock to the country risk premium (1) and the interest rate (2)



Source: Authors' calculations.

Figure B.2

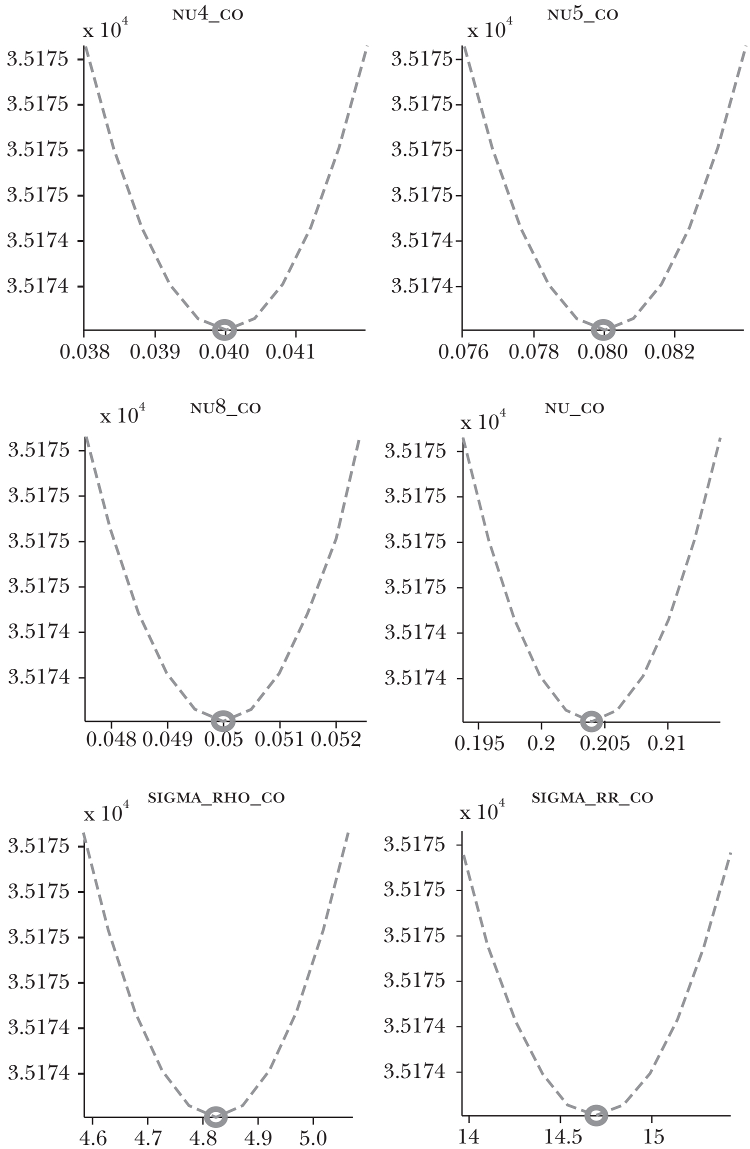
CHECKING CONVERGENCE TO THE MAXIMUM OF THE REGULARIZED LIKELIHOOD FUNCTION



Source: Authors' calculation.

Figure B.2 (cont.)

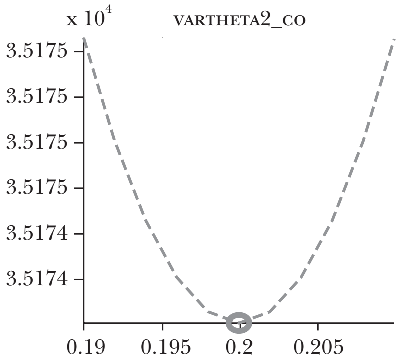
CHECKING CONVERGENCE TO THE MAXIMUM OF THE REGULARIZED LIKELIHOOD FUNCTION



Source: Authors' calculation.

Figure B.2 (cont.)

CHECKING CONVERGENCE TO THE MAXIMUM OF THE REGULARIZED LIKELIHOOD FUNCTION

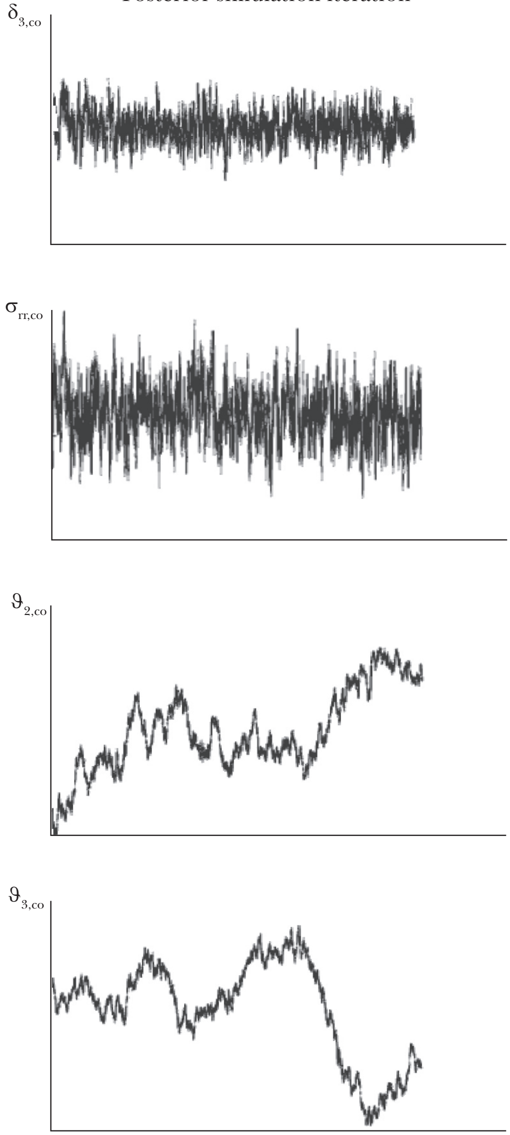


Source: Authors' calculation.

Figure B.3

SIMULATION PATHS OF FOUR SELECTED PARAMETERS

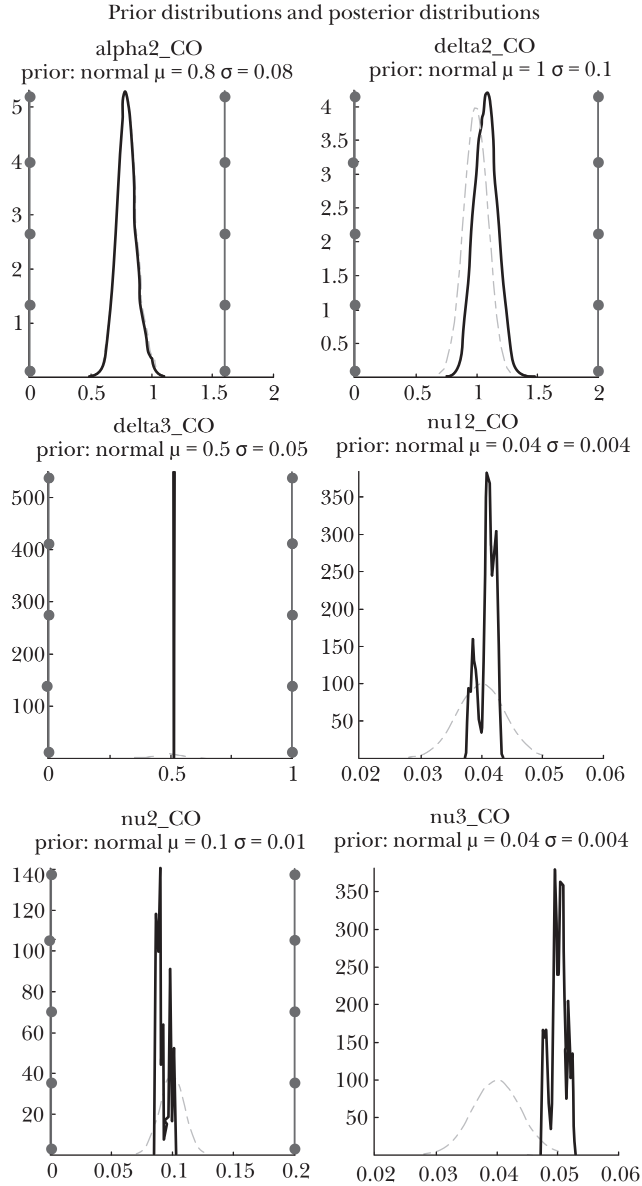
Posterior simulation iteration



Source: Authors' calculation.

Figure B.4

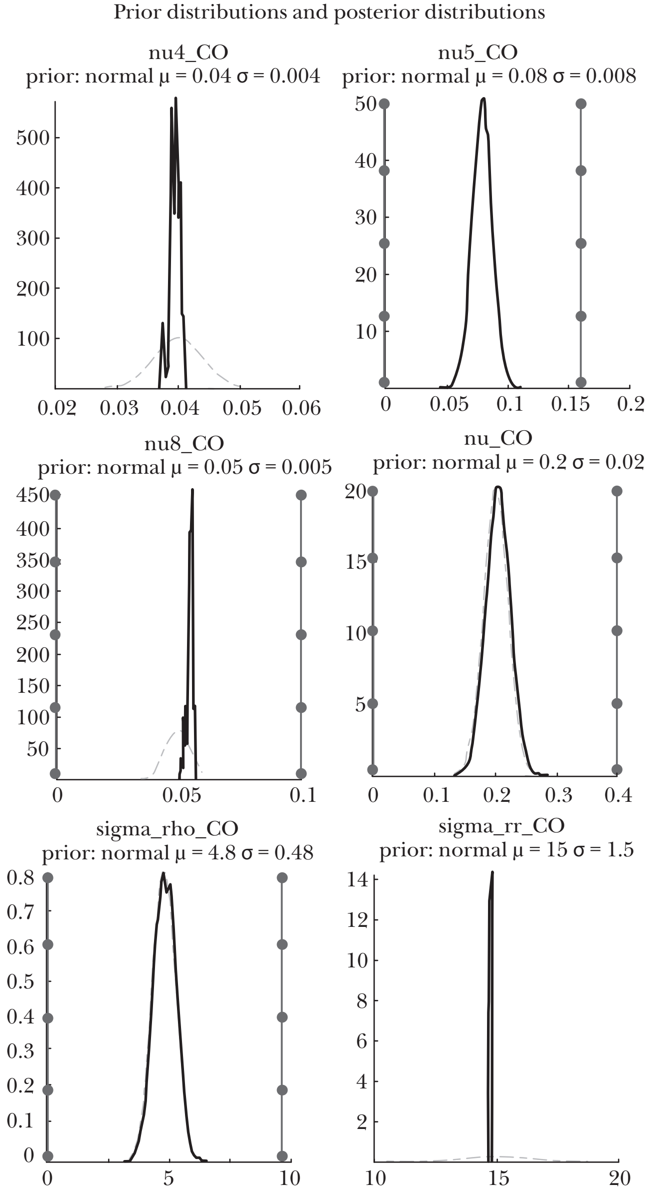
PARAMETERS MARGINAL A-PRIORI AND A-POSTERIORI DENSITIES



Source: Authors' calculations.

Figure B.4 (cont.)

PARAMETERS MARGINAL A-PRIORI AND A-POSTERIORI DENSITIES

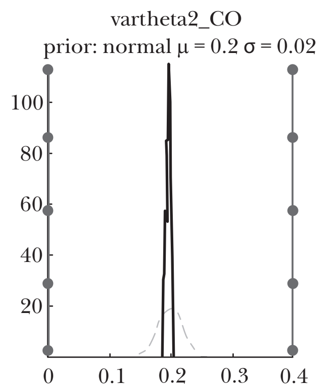


Source: Authors' calculations.

Figure B.4 (cont.)

PARAMETERS MARGINAL A-PRIOR AND A-POSTERIORI DENSITIES

Prior distributions and posterior distributions



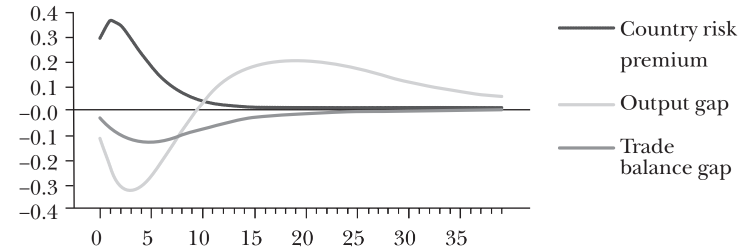
Source: Authors' calculations.

Figure B.5

IMPULSE RESPONSES

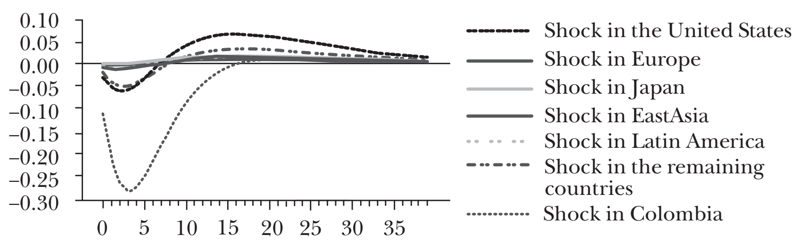
PANEL A

RESPONSE TO A ONE STANDARD DEVIATION SHOCK TO GLOBAL RISK



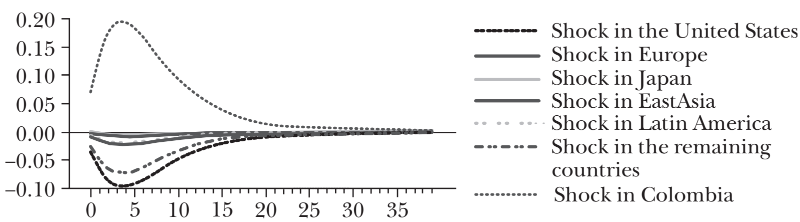
PANEL B: OUTPUT GAP

RESPONSE TO A ONE STANDARD DEVIATION SHOCK TO THE COUNTRY RISK PREMIUM



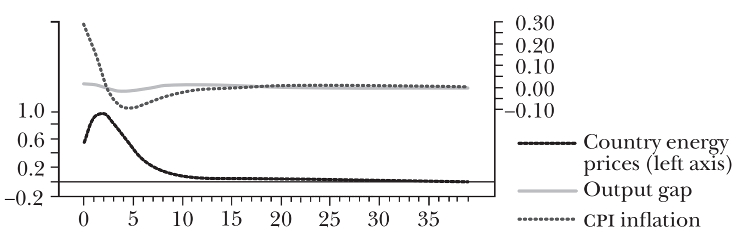
PANEL C: TRADE BALANCE GAP

RESPONSE TO A ONE STANDARD DEVIATION SHOCK TO THE COUNTRY RISK PREMIUM



PANEL D

RESPONSE TO A ONE STANDARD DEVIATION SHOCK TO THE PRICE OF OIL

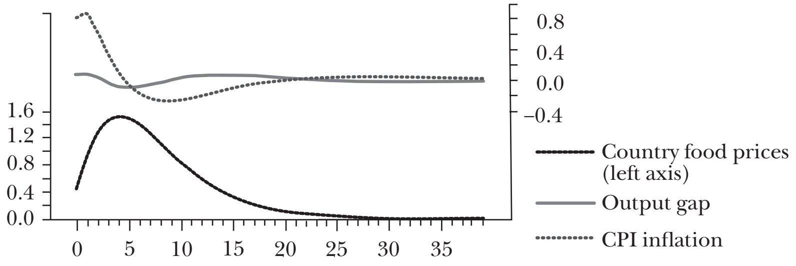


Source: Authors' calculations.

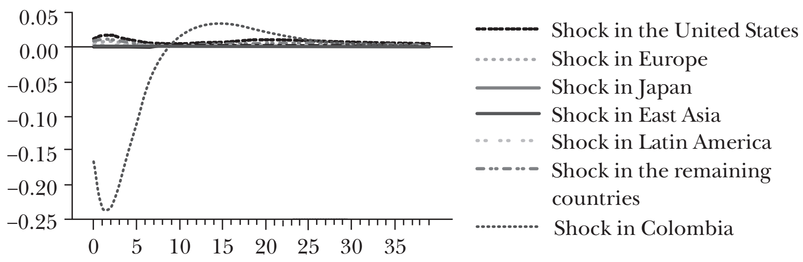
Figure B.5

IMPULSE RESPONSES

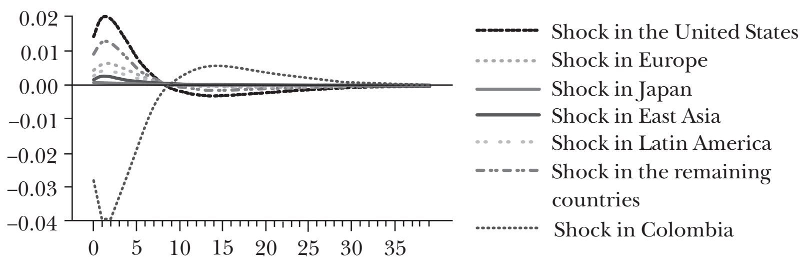
PANEL E
RESPONSE TO A ONE STANDARD DEVIATION SHOCK TO COMMODITY FOOD PRICES



PANEL F: OUTPUT GAP
RESPONSE TO A UNIT SHOCK TO THE INTEREST RATE



PANEL G: TRADE BALANCE GAP
RESPONSE TO A UNIT SHOCK TO THE INTEREST RATE

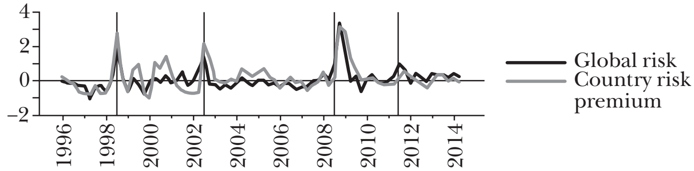


Source: Authors' calculations.

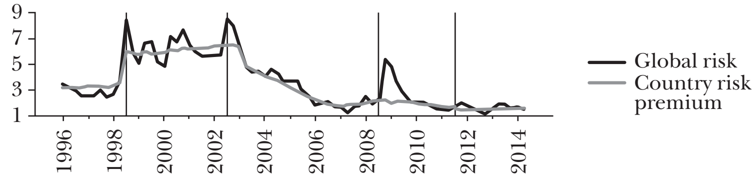
Figure B.6

SMOOTHING RESULTS

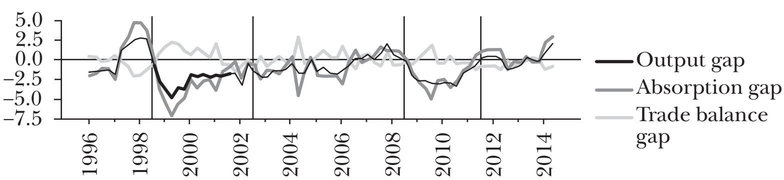
PANEL A
GLOBAL RISK AND COUNTRY RISK PREMIUM
IN PERCENT



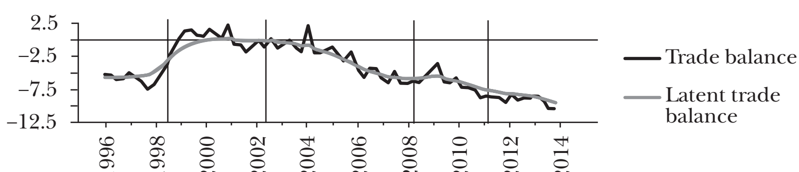
PANEL B
COUNTRY RISK PREMIUM AND LATENT COUNTRY RISK PREMIUM
IN DEVIATION FROM LATENT VALUES



PANEL C
OUTPUT, ABSORPTION, AND TRADE BALANCE GAPS
LOG PERCENT DEVIATION FROM LATENT VALUES



PANEL D
THE TRADE BALANCE
LOG PERCENT OF GDP

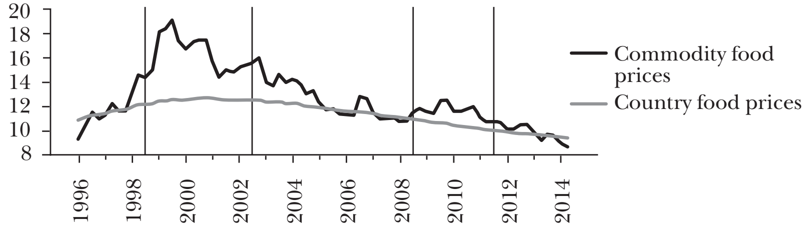


Note: The grid indicates the end of the century crisis, the stock market downturn of 2002, the global financial crisis, and the financial crisis, and the eurozone crisis.
Source: Authors' calculations.

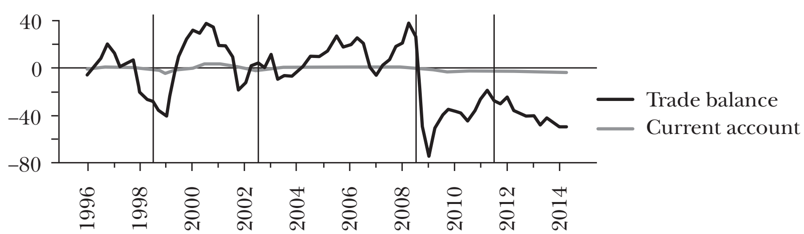
Figure B.6 (cont.)

SMOOTHING RESULTS

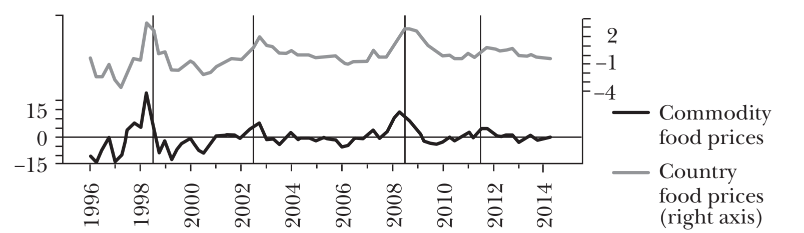
PANEL E
UNEMPLOYMENT AND LATENT UNEMPLOYMENT
PERCENT DEVIATION FROM LATENT VALUES



PANEL F
THE PRICE OF OIL AND COUNTRY ENERGY PRICES
IN PERCENT OF GDP



PANEL G
COMMODITY FOOD PRICES AND COUNTRY FOOD PRICES
PERCENT DEVIATION FROM LATENT VALUES

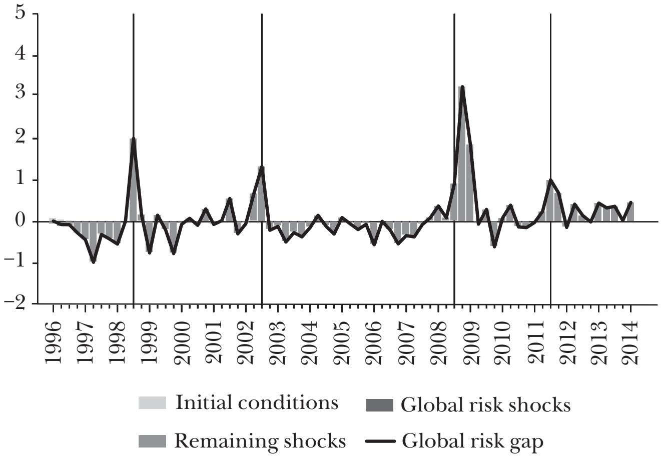


Note: The grid indicates the end of the century crisis, the stock market downturn of 2002, the global financial crisis, and the financial crisis, and the eurozone crisis.
Source: Authors' calculations.

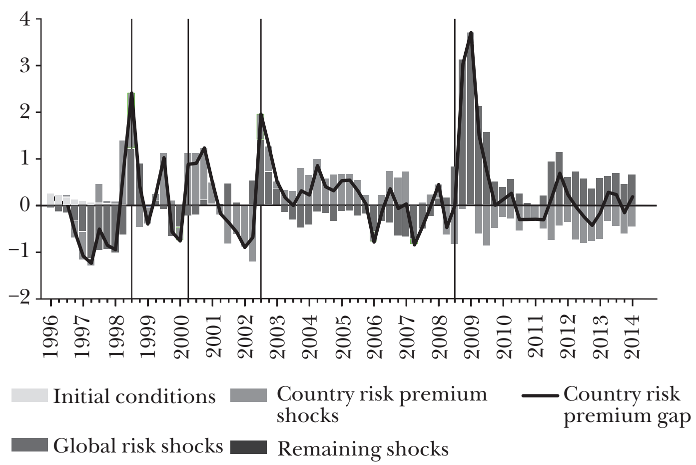
Figure B.7

HISTORICAL DECOMPOSITIONS

PANEL A. WORLD: GLOBAL RISK GAP
HISTORICAL DECOMPOSITION INTO PERCENT CONTRIBUTIONS FROM SHOCKS



PANEL B. COLOMBIA: COUNTRY RISK PREMIUM GAP
HISTORICAL DECOMPOSITION INTO PERCENT CONTRIBUTIONS FROM SHOCKS

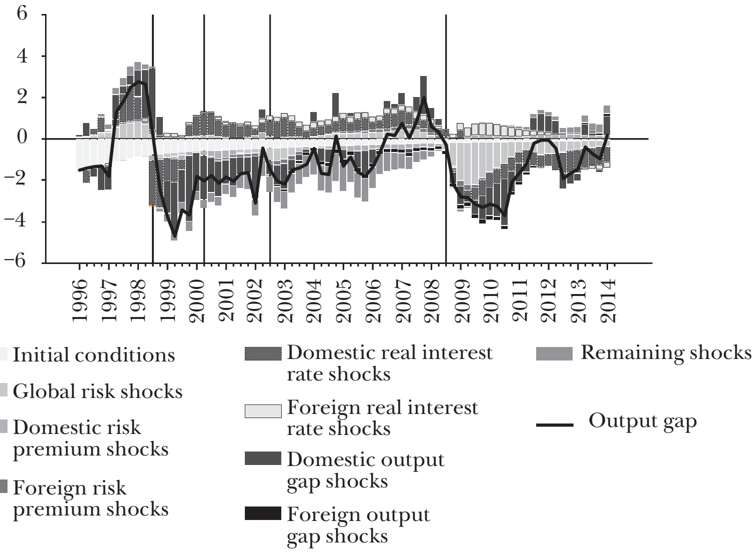


The grid indicates the end of the century crisis, the stock market downturn of 2002, the global financial crisis, and the financial crisis, and the eurozone crisis.
Source: Authors' calculation.

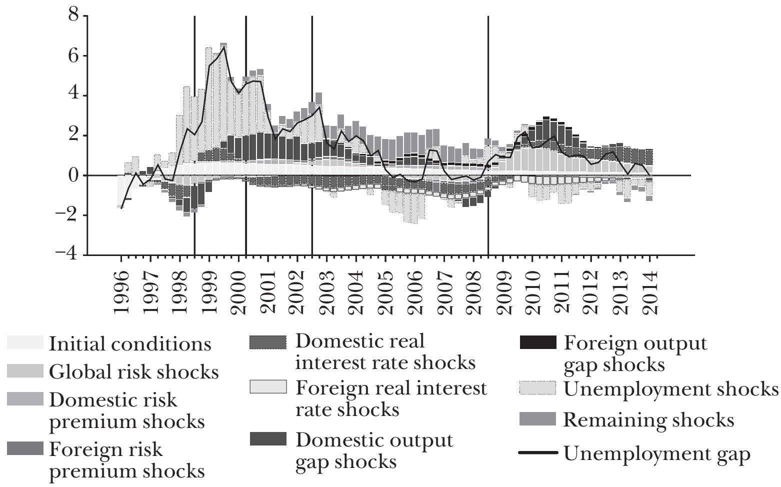
Figure B.7 (cont.)

HISTORICAL DECOMPOSITIONS

PANEL C. OUTPUT GAP
HISTORICAL DECOMPOSITION INTO PERCENT CONTRIBUTIONS FROM SHOCKS



PANEL D. UNEMPLOYMENT GAP
HISTORICAL DECOMPOSITION INTO PERCENT CONTRIBUTIONS FROM SHOCKS

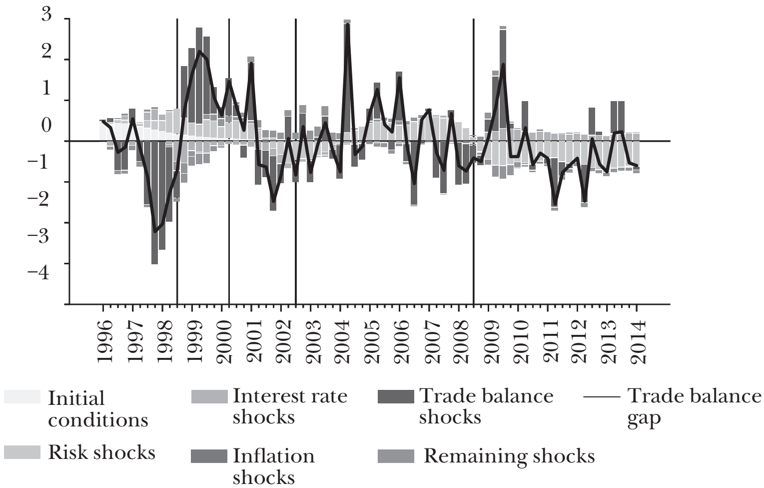


The grid indicates the end of the century crisis, the stock market downturn of 2002, the global financial crisis, and the financial crisis, and the eurozone crisis.
Source: Authors' calculation.

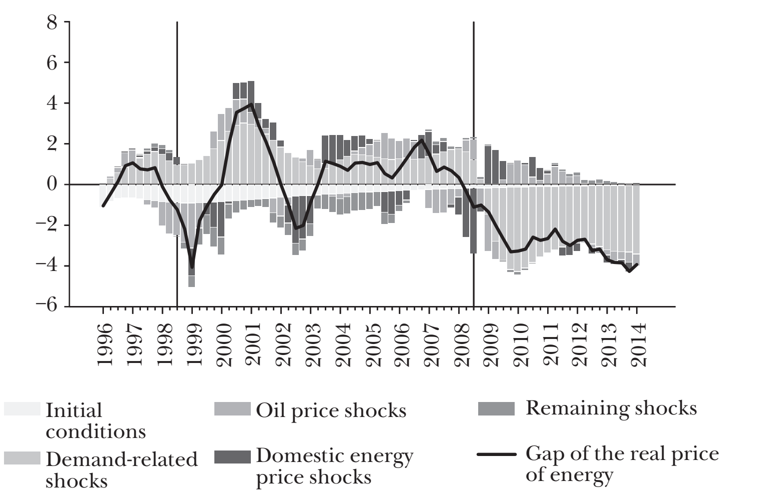
Figure B.7 (cont.)

HISTORICAL DECOMPOSITIONS

PANEL E. TRADE BALANCE GAP
HISTORICAL DECOMPOSITION INTO PERCENT CONTRIBUTIONS FROM SHOCKS



PANEL F. GAP OF COUNTRY ENERGY PRICES
HISTORICAL DECOMPOSITION INTO PERCENT CONTRIBUTIONS FROM SHOCKS

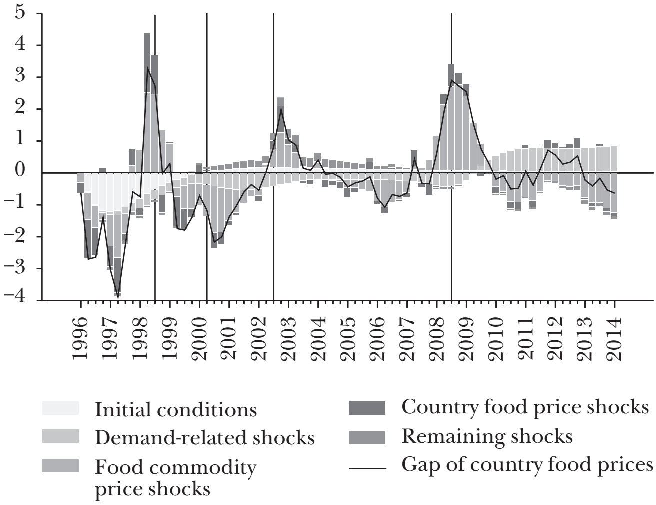


The grid indicates the end of the century crisis, the stock market downturn of 2002, the global financial crisis, and the financial crisis, and the eurozone crisis.
Source: Authors' calculation.

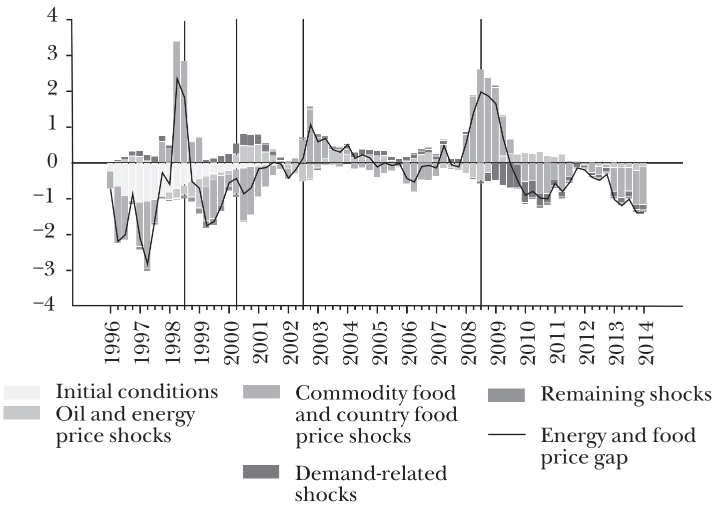
Figure B.7 (Cont.)

HISTORICAL DECOMPOSITIONS

PANEL G. GAP OF COUNTRY FOOD PRICES
HISTORICAL DECOMPOSITION INTO PERCENT CONTRIBUTIONS FROM SHOCKS



PANEL H. ENERGY AND FOOD PRICE GAP
HISTORICAL DECOMPOSITION INTO PERCENT CONTRIBUTIONS FROM SHOCKS

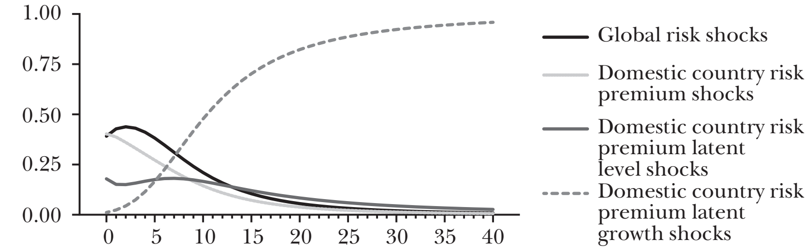


Note: the grid indicates the end of the century crisis, the stock market downturn of 2002, the global financial crisis, and the financial crisis, and the eurozone crisis.
Source: Authors' calculation.

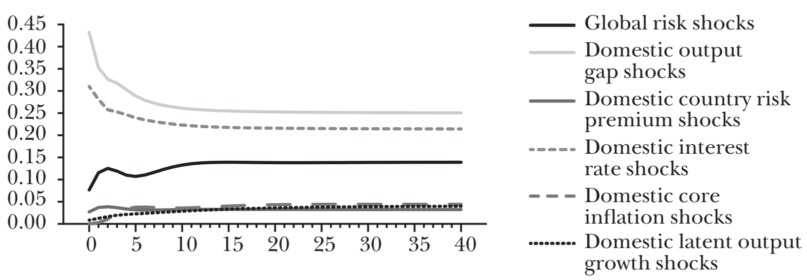
Figure B.8

FORECAST ERROR VARIANCE DECOMPOSITION

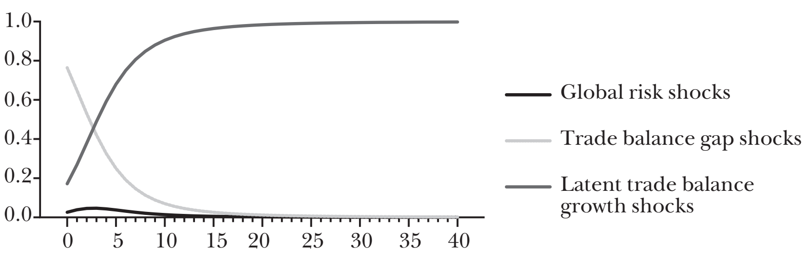
PANEL A. COUNTRY RISK PREMIUM
FORECAST ERROR VARIANCE DECOMPOSITION



PANEL B. OUTPUT GROWTH
FORECAST ERROR VARIANCE DECOMPOSITION



PANEL C. TRADE BALANCE
FORECAST ERROR VARIANCE DECOMPOSITION

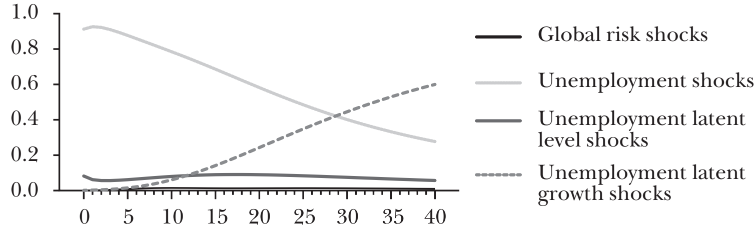


Source: Authors' calculation.

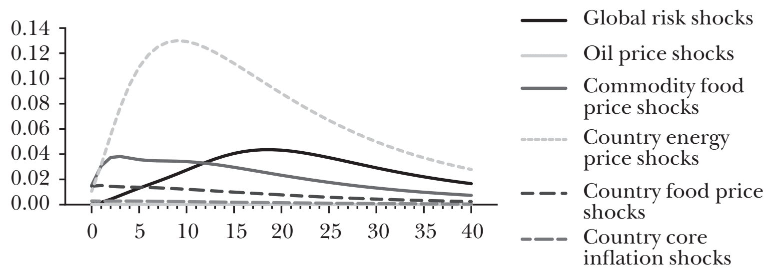
Figure B.8 (cont.)

FORECAST ERROR VARIANCE DECOMPOSITION

PANEL D. UNEMPLOYMENT
FORECAST ERROR VARIANCE DECOMPOSITION



PANEL E. ENERGY AND FOOD PRICE INFLATION
FORECAST ERROR VARIANCE DECOMPOSITION



Source: Authors' calculation.

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Dutch Disease Exchange Rate Incidence over Profits of Traded and Nontraded Goods

Eduardo Sarmiento G.
Martha López

Abstract

Oil prices hikes since 2004 caused a natural resource windfall in the Colombian economy like in many other developed and developing countries. This paper finds strong empirical support of a positive and negative relation between the real exchange rate and the profits of the traded and nontraded sectors, respectively. Moreover, the effect on the manufacturing sector shows a deindustrialization in the Colombian economy due to the shock in oil prices. Compared by size, smaller firms are more vulnerable to exchange rate appreciation. We discuss the role of fiscal policy in addressing the Dutch disease.

Keywords: Dutch disease; traded and nontraded goods profits; real exchange rate; booming sector.

JEL classification: C1, F20, F41, F43, O1, O4, O5, Q0, O2.

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1. INTRODUCTION

The increase in global oil prices since 2004 led to a booming oil sector in the Colombian economy, which in turn resulted in the appreciation of the exchange rate until 2012, and a Dutch disease over the profits of traded and nontraded goods. This process led to increased specialization in the resource and nontraded sectors leaving the economy more vulnerable to resource-specific shocks. The main goal of our article is to present empirical evidence of Dutch disease in the Colombian economy based on a theoretical framework that takes into account the transmission mechanism through profits. We use microdata of 3,385 Colombian firms with a methodology that is innovative in the empirical literature.

In the theoretical framework developed in this article, we consider traded and nontraded goods, the prices of traded goods that equal the exchange rate, and the prices of nontraded goods that depend on the exchange rate, wages, and monetary policy. This corresponds to an economy with nominal wages that are exogenous, varying in real terms depending on price adjustment. The model considers the dynamics of profits in traded goods (agriculture and manufacturing) and nontraded goods (construction and services) as a result of the expansion of the booming mining sector, that corresponds to traded goods.

When the exchange rate depreciates, the prices of traded goods increase more than the prices of nontraded goods, wages remain fixed; and the profits of traded goods rise, simultaneously the profits of nontraded goods go down. Conversely, when the exchange rate appreciates, the prices of traded goods decrease more than the prices of nontraded goods, wages remain fixed; and the profits of traded goods fall in tandem with an increase in the profits of nontraded goods. The decline in traded goods profits and improvement in nontraded goods profits has, respectively, negative and positive incidence over the sectors' growth.

In the theoretical literature, Corden and Neary (1982) considered a neoclassical framework in which the Dutch disease results from a booming sector that causes a resource movement effect and a spending effect. The resource movement effect results from the booming sector that draws factors from other sectors, causing a reduction in the production of nontraded and nonbooming traded goods. The spending effect results from an increase in income of the booming mining sector that appreciates the exchange rate, raising the production of nontraded goods and reducing the production of nonbooming traded goods. If the nontraded goods are labor intensive with respect to the nonbooming traded goods, the resource movement effect and the spending effect cause an increase in wages and a reduction in the rental of capital.

If traded goods prices remained fixed in the model of the theoretical framework developed in our article, as in Corden and Neary, the booming sector that causes the Dutch disease, and the exogenous increase in nominal wages due to inertia,[1] would result also in an increase in the prices of nontraded goods, but lower than the one in wages. This is equivalent, in terms of relative prices, to a fall in traded goods prices greater than the decrease in nontraded goods prices, and fixed wages. Besides, the implications of our results in terms of the Dutch disease are similar to those of Corden and Neary.

Regarding the empirical literature that supports the evidence on macroeconomic impact of Dutch disease, this has been mainly related to the *natural resource curse.* The influential studies by Sachs and Warner (1995, 2001) are representative of a stream of literature that finds that natural resource abundance has a strong negative impact on growth. With a cross-country growth equation based on Barro (1991), Sachs

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[1] In an inflationary economy the booming sector, holding traded goods prices fixed, results in an increase in wages greater than nontraded goods prices. In this case, the appreciation of the exchange rate reduces inflation, with an increase in prices that results only from the adjustment of wages and monetary policy.

and Warner (1995) show regression evidence that the resource intensive economies did indeed have slower growth in manufacturing exports, after holding constant the initial share of manufacturing in total exports. In addition, their results show that resource-intensive economies had a higher ratio in output of services to output of manufactures. Moreover, these authors provide evidence that a crowding-out logic explains the curse.

In Sachs and Warner (2001) the positive wealth shocks from the natural resource sector cause excess demand for nontraded goods, increasing their prices, and also nontraded input costs and wages. This squeezes profits in traded activities such as manufacturing that use nontraded products as inputs and sell their products on international markets at fixed foreign prices. The decline in manufacturing then reduces growth. Their empirical evidence shows first that the natural resource intensive economies indeed tend to have higher price level, and second that this lower competitiveness impeded export growth and that, therefore, resource-abundant countries never successfully pursued export-led growth.

Sala-i-Martin and Subramanian (2003) also address the question if natural resources such as oil and minerals may or not be a curse on balance. They examine the case of oil discoveries in Nigeria between 1965 and 2000 and relate those to economic growth during this period. Their main finding is that the oil revenues did not add to the standard of living. The main explanation given to stunted institutional development (corruption, rent seeking and weak governance among others). In addition, they do not find strong evidence of Dutch disease.

Much stronger evidence of Dutch disease is presented by Ismail (2010) whose study for oil-exporting countries during the period 1977 to 2004 shows that permanent increases in oil price negatively impact output in manufacturing and that oil windfall shocks have a stronger impact in countries with more open capital markets to foreign investment (like Colombia). Ismail develops a static model that focuses on two structural aspects, relative factor intensities of the sectors and the mobility of factors across countries (capital mobility), and estimates the model using cross-sectional reduced form estimation of the effect of permanent oil price shocks on the industries across countries.

Finally, with respect to the relation between exchange rate overvaluation and growth, there is empirical evidence that suggests that substantial exchange rate overvaluation has a strong negative impact on growth (Brahmbhatt, Canuto and Vostroknutova, 2010). This evidence is relevant to the extent that the real exchange rate overshoots, for example, if agents overestimate mistakenly the permanence of a terms-of-trade improvement.

However, it must be considered that not always natural resources are a curse (Van der Ploeg, 2011). This can sometimes result in a blessing. The volatility in some countries determines the result. For example as documented by Sala-i-Martin and Subramanian (2003) the case of Nigeria is the most representative of the curse, as mentioned before. Other countries like Iran, Venezuela, Libya, and Iraq also present deindustrialization and a declining GDP per capita. Meanwhile, the case of Botswana and Norway is a successful story. Botswana has the second highest public expenditure in education as a share of GDP and enjoys the world's highest growth rate since 1965. Norway has shown remarkable growth of manufacturing and the rest of the economy compared with its neighbors. Van der Ploeg provides evidence that the result depends on the severity of volatility of countries in terms of the quality of institutions and lack of rule of law, corruption, presidential democracies, and underdeveloped financial systems. For example, the author points out that:

> The political economy of massive resources rents combined with badly defined property rights, imperfect markets, and poorly functioning legal systems provide ideal opportunities for rent seeking behavior of producers, thus diverting resources away from more productive activities (pp. 388).

The evidence described before is related mainly to economic growth. However, the evidence of Dutch disease is scant. In this paper, we present empirical evidence of Dutch disease for Colombia, a country that like other small open economies was affected by the hikes in oil prices since 2004. Based on an accounting framework the article considers the exchange rate incidence over profits of traded and nontraded goods. As mentioned before, we use information on a panel of 3,385 Colombian firms during the period 2002-2014. To our knowledge, this is the first time that such empirical study, based on profit-by-profit information of a panel of firms relating real exchange rate and actual behavior of profits is being carried out.

Griffin (2015) used a similar approach, but studied only the manufacturing sector. Because we distinguish further between traded and nontraded sectors, we get more results that provide sharper tests of the theory.

In the document, firms' profits for traded and nontraded goods are determined by the exchange rate, domestic output growth, and leverage. In the case of traded goods, we also consider the incidence of trade partners' output growth. In our results, as expected, the exchange rate appreciation incidence over profits is to reduce the ones of traded goods and increase the ones of nontraded goods. Meanwhile, profits relate positively with the output growth and negatively with the leverage.

In addition, the incidence of the import component over profits is considered for the manufacturing sector. Finally, the regressions consider interactions that take into account the size of the firms, and the result is that the effect of the exchange rate over profits is higher the smaller the firms are.

The rest of the paper is organized as follows. The second Section corresponds to the theoretical framework. The third Section presents a brief discussion about Dutch disease and fiscal policy in Colombia. The fourth Section describes the incidence of the exchange rate over profits by means of a regression analysis with ordinary least squares (OLS) and Arellano-Bond panel methods. Finally, the last Section corresponds to the conclusions.

2. THEORETICAL FRAMEWORK

In this Section, a simple model is developed to shed light on the key relation between profits and real exchange rate at the firm level.

The article considers the exchange rate incidence over firms' profits, assuming traded goods prices equal the exchange rate; nontraded goods prices are determined by the exchange rate, wages and money supply; and quantities remain fixed. In the incidence over profits the nominal exchange rate varies, meanwhile wages and money supply are constant.

Firms' profits equal revenue minus costs. Revenue depends on sales, meanwhile costs result from wages, and traded and nontraded inputs. Real profits are shown in Equations 1 and 2, and are assumed positive before the exchange rate shock.

1 $$\pi_T = \frac{(P_T q_T - wL_T - P_T i_{TT} q_T - P_N\left(P_T, w, M\right) i_{TN} q_T)}{\propto_N\ P_N\left(P_T, w, M\right) + \propto_T\ P_T},$$

2 $$\pi_N = \frac{(P_N\left(P_T, w, M\right) q_N - wL_N - P_T i_{NT} q_N - P_N\left(P_T, w, M\right) i_{NN} q_N)}{\propto_N\ P_N\left(P_T, w, M\right) + \propto_T\ P_T},$$

3 $$P_N\left(P_T, w, M\right) = \rho_1 P_T + \rho_2 w + \rho_3 M,$$

$$\propto_N + \propto_T = 1, \quad 0 \le \rho_1 \le 1,$$

where π_T is traded goods profits; π_N, nontraded goods profits; P_T, traded goods price; P_N, nontraded goods price; w, wages; M, money supply; q_T, quantity of traded goods; q_N, quantity of nontraded goods; L_T, employment of traded goods firm; L_N, employment of nontraded goods firm; $\propto_N$, and $\propto_T$ are the proportion in general prices of nontraded and traded goods, respectively; and i_{TT}, i_{NT}, i_{TN}, and i_{NN} are the proportion in output of traded and nontraded inputs.

For both traded and nontraded goods, we consider the incidence of the exchange rate over profits. The parameter ρ_1 is the main incidence determinant. With a smaller value of ρ_1, the increase in traded goods profits and as well the fall in nontraded goods profits is stronger when the exchange rate depreciates (Equations 4 and 5).[2]

At the same time, the higher the increase in the value of sales, the stronger the positive effect of the exchange rate on traded goods profits, and the higher the increase in the costs of domestic inputs and of the general prices the lower the impact of the exchange rate over profits.

By the same token, the higher the increase in the price of inputs and of the general prices, the stronger the negative incidence of the exchange rate over nontraded goods profits; however, this can be compensated partially or totally by the increase in the value of sales when nontraded prices become higher.

$$\textbf{4} \quad \frac{\partial \pi_T}{\partial P_T} = \frac{\left(1-i_{TT}\right)q_T - \rho_1 i_{TN} q_T}{\propto_N \ P_N\left(P_T, w, M\right) + \propto_T \ P_T} - \frac{\pi_T\left(\propto_N \ \rho_1 + \propto_T\right)}{\propto_N \ P_N\left(P_T, w, M\right) + \propto_T \ P_T},$$

$$\textbf{5} \quad \frac{\partial \pi_N}{\partial P_T} = \frac{\rho_1\left(1-i_{NN}\right)q_N - i_{NT} q_N}{\propto_N \ P_N\left(P_T, w, M\right) + \propto_T \ P_T} - \frac{\pi_N\left(\propto_N \ \rho_1 + \propto_T\right)}{\propto_N \ P_N\left(P_T, w, M\right) + \propto_T \ P_T},$$

$\dfrac{\partial \pi_T}{\partial P_T} > 0$ when:

$$\frac{\left(\left(1-i_{TT}\right) - \rho_1 i_{TN}\right)q_T}{\propto_N \ \rho_1 + \propto_T} > \pi_T,$$

$\dfrac{\partial \pi_N}{\partial P_T} < 0$ when:

[2] The incidence of ρ_1 over nontraded goods applies since:

$$\left(1-i_{NN}q_N\right) > \frac{\left(1-i_{NN}q_N\right) - \dfrac{wL_N}{P_N\left(P_T, w, M\right)} - \dfrac{P_T i_{NT} q_N}{P_N\left(P_T, w, M\right)}}{1 + \dfrac{\left(\alpha_T/\alpha_N\right)P_T}{P_N\left(P_T, w, M\right)}}.$$

$$\frac{(\rho_1(1-i_{NN})-i_{NT})q_N}{\propto_N \ \rho_1+\propto_T}<\pi_N \ .$$

In one extreme, when $\rho_1=1$, and $\rho_2=\rho_3=0$, the prices of nontraded goods equal P_T and a depreciation increases both the profits of traded and nontraded goods in the amount that real wages decrease (Equation 6).

6
$$\frac{\partial \pi_T}{\partial P_T}=\left(\frac{w}{P_T^{\ 2}}\right)L_T; \quad \frac{\partial \pi_N}{\partial P_T}=\left(\frac{w}{P_T^{\ 2}}\right)L_N.$$

In the other extreme, when $\rho_1=0$ the nontraded prices do not depend on the exchange rate, the depreciation incidence over traded goods profits is the highest possible and over nontraded goods is the lowest possible. The traded goods profits increase because of higher sales prices, which are only partially compensated by traded input costs and the increase in the general price level, with sign unambiguously positive (Equation 7). In nontraded goods, profits decrease because of the increase in traded inputs price and in the general prices, and the sign is unambiguously negative (Equation 8).

7
$$\frac{\partial \pi_T}{\partial P_T}=\frac{(1-i_{TT})q_T}{\propto_N \ P_N(w,M)+\propto_T \ P_T}-\frac{\pi_T \propto_T}{\propto_N \ P_N(w,M)+\propto_T \ P_T}=$$

$$=\frac{\propto_N \ P_N(w,M)\left((1-i_{TT})q_T\right)+\propto_T \ wL_T+\propto_T \ P_N(w,M)i_{TN}q_T}{\left(\propto_N \ P_N(w,M)+\propto_T \ P_T\right)^2},$$

$$\frac{\partial \pi_T}{\partial P_T}>0.$$

8
$$\frac{\partial \pi_N}{\partial P_T}=\frac{-i_{NT}q_N}{\propto_N P_N(w,M)+\propto_T P_T}-\frac{\pi_N \propto_T}{\propto_N P_N(w,M)+\propto_T P_T}=$$

$$=\frac{-\propto_N P_N(w,M)i_{NT}q_N-\propto_T P_N(w,M)q_N+\propto_T wL_N+\propto_T P_N(w,M)i_{NN}q_N}{\left(\propto_N P_N(w,M)+\propto_T P_T\right)^2},$$

$$\frac{\partial \pi_N}{\partial P_T} < 0.$$

Although the above equations do not show changes in quantities, the maximizing behavior of firms adjusts production, inputs, exports, and imports to obtain the highest possible profits. This reduces the profits fluctuations caused by the exchange rate. Although this behavior reduces fluctuations, the incidence of an appreciation on profits is expected to be negative over traded goods and positive over nontraded goods.

3. DUTCH DISEASE AND FISCAL POLICY IN COLOMBIA

3.1 Stylized Facts

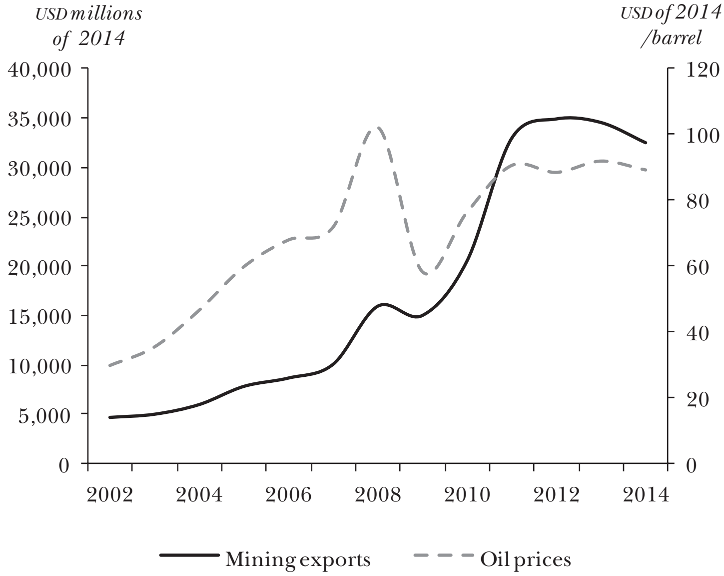
As mentioned before, the global increase in oil prices since 2004 caused considerable fluctuations in the behavior of traded sectors (agriculture, manufacturing and mining) and nontraded sectors (construction and services) in Colombia. The mining sector expansion caused by the foreign exogenous shock resulted in a Dutch disease that was characterized by an increase in profits of the nontraded sectors and a fall in profits in the nonbooming traded sectors.

In traded and nontraded goods models the exchange rate depreciation or appreciation has incidence over relative prices and production (Obstfeld and Rogoff, 1996). The traded and nontraded goods framework is usually considered to analyze the Dutch disease, as is the case in this article. This framework is used to analyze the Colombian case during 2002-2014.

The oil price reached a value of 89 USD per barrel in 2014; meanwhile, the growth of mining exports in Colombia was considerable: 2004 (19.8%), 2005 (31.1%), 2006 (10.9%), 2007 (16.2%), 2008 (58.9%), 2010 (37.0%) and 2011 (60.7%) (Figure 1). The increase in global oil prices since 2004 caused the mining boom in the economy and appreciated the exchange rate until 2012. Although the appreciation stopped in 2013 and

Figure 1

MINING EXPORTS AND OIL PRICES



Source: DANE and Illinois Crude.

2014, during both years the exchange rate level remained appreciated with respect to 2002 and 2003 (Figure 2).[3]

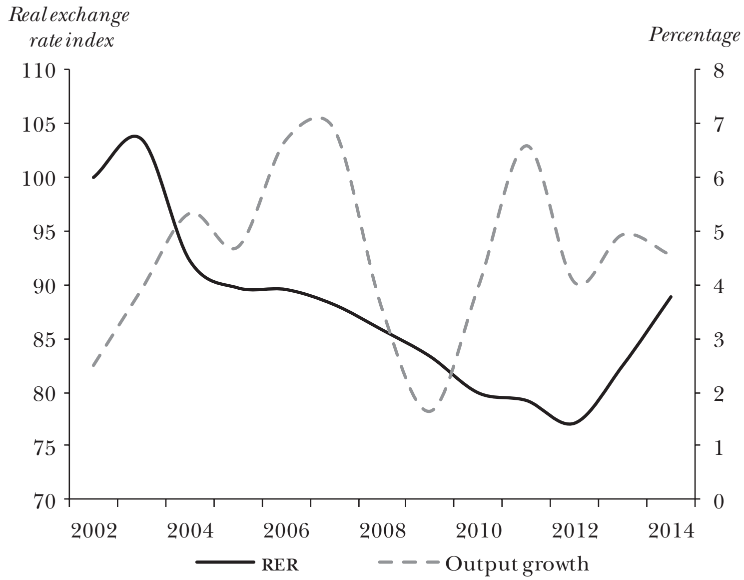
Although the Colombian economy grew well since 2004, this economic growth was unbalanced towards a higher increase in mining and nontraded goods. In consequence, the sectors with smaller growth were agriculture and manufacturing. The growth of the economy reached high rates since 2004 until 2014, with a decline only in 2008 and 2009 due to the international financial crisis (Figure 2).

Since 2004, there was an appreciation of the exchange rate, which implied an increase in relative prices of nontraded goods

[3] The exchange rate is considered in terms of producer prices. The appreciation considered varies in terms of producer prices from 100 in 2002 to 88.9 in 2014, and in terms of consumer prices, respectively, from 100 to 73.7.

Figure 2

REAL EXCHANGE RATE AND OUTPUT GROWTH



Source: Banco de la República and DANE.

with respect to nonbooming traded goods. Meanwhile, the increase in minimum wages, which are set in Colombia by the agreement between the government and the workers, was close to the increase in productivity. During 2004-2014, the minimum wage mean growth was 1.5% and the per capita income mean growth was 3 percent.

During 2002-2014 there was a reduction of unemployment from 15.6% to 9.1%. The adjustment of wages during the period, although lower than per capita income, was higher than nominal devaluation, which in addition to the currency expansion and low interest rates caused an inflation that appreciated the real exchange.

The nominal and real exchange rate appreciation of the Colombian peso has been mainly explained by the direct effect of the increase in terms of trade. However, the permanent character of the capital inflows in Colombia, which had an important long-term component, played an important role in the appreciation of the currency.

The Colombian economy experienced a growing current account deficit and, at the same time, a surge in capital inflows since 2004. The financing of the current account deficit during 2002-2014 relied upon foreign direct investment (FDI) net inflows, even though foreign indebtedness was still an important source. The importance of FDI as a source of funding of the growing current account deficit of the Colombian economy is noticeable also when it is compared with other countries in the region as pointed out by Vargas and Varela (2008):

> At the beginning of the decade FDI represented 2.9% of GDP, one of the lowest among the largest Latin American economies. Between 2004 and 2006, FDI in Colombia surged and reached ratios of GDP among the highest in the region (around 6% of GDP) (p. 3).

Foreign direct investment in the oil and mining sectors as a share of total FDI went from 19.6% in the 1990s to 41.0% in 2008. This was related mainly to the increase of the international prices of these commodities, and the more favorable contractual conditions for foreign firms.

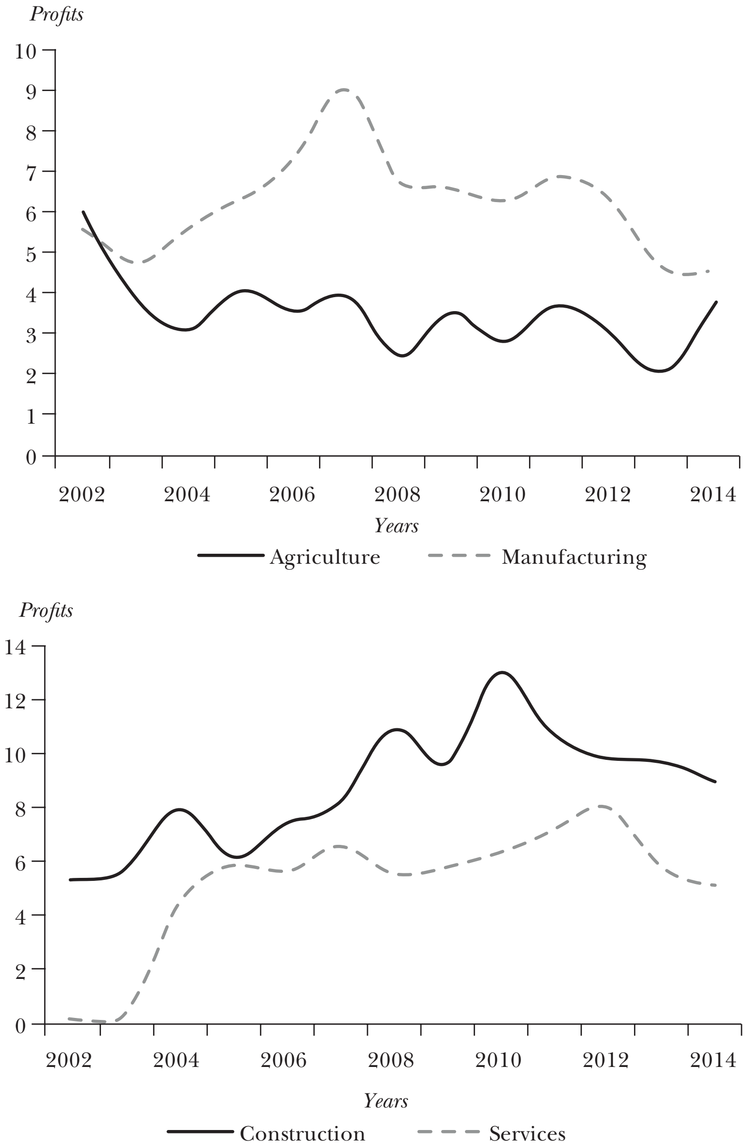
On the side of the public debt inflows, these increased since 2000-2004, but they were reduced after 2004 within a strategy of decreasing the foreign exchange exposure of the public sector and in coordination with the Central Bank to avoid the continuous appreciation of the exchange rate caused by the capital inflows.

Another factor that contributed to the appreciation of the exchange rate was the declining trend of the country risk premia (EMBI). This was an important factor given that between 2004 and 2008 the US short-term interest rates were increasing relative to domestic rates.

Finally, during 2004-2014, consumption –in terms of aggregate demand households– grew at similar rates as product;

Figure 3

SECTOR PROFITS



Source: Superintendencia de Sociedades.

public consumption grew at higher rates; and total investment increased at very high rates. The increasing households and public demand contributed to the appreciation of the exchange rate.

The appreciation of the currency since 2004 caused a Dutch disease during 2004-2014, with an increase in the profits of nontraded goods and a fall in profits of nonbooming traded goods. The Dutch disease originated a squeeze in profits of agriculture (measured as return on equity, ROE) during 2003-2014 and in profits of manufacturing from 2008 to 2014.[4] Simultaneously, the profits of construction and services had a strong positive trend for the same period (Figure 3).

3.2 Fiscal Policy

One of the policy responses addressed in the literature to curve the Dutch disease is related to the role of fiscal policy. As pointed out by Brahmbhatt, Canuto, and Vostroknutova (2010), fiscal policy is the main instrument for dealing with the negative impact of Dutch disease because it is a tool that can make the increase in wealth permanent. It can constrain the spending effect and can smooth expenditures to reduce volatility, particularly in a country with a large share of non-Ricardian agents like Colombia.[5] The smoothing is achieved through the introduction of fiscal rules and the detachment of spending from the resource revenues.

There is empirical evidence that government spending is correlated with the increase in resource revenues. In the case of Colombia, government's oil revenues from Ecopetrol (the largest oil company in the country) increased from 0.4% of GDP in 2002 to 1.9% of GDP in 2013. At the same time, government total spending increased from 16.4% of GDP in 2002 to 19.1% of GDP in 2013.

[4] ROE = profits/equity.

[5] In Colombia near 70% of the population is credit constrained.

In Colombia, in July 2011, a fiscal rule was introduced according to which the structural surplus target for the year 2014 was −2.3%, which aimed to reduce the long-run debt to GDP ratio to 12%, compared to the actual 30% of GDP level. The structural rule had also the implication that it would help to stabilize the business cycle and volatility of fiscal instruments. The so-called structural surplus rule tied the government spending to structural/permanent government revenues. Countries like Chile (Céspedes, Fornero and Galí, 2012), and Norway (Pieschacón, 2012) have used this kind of rule. In the case of Colombia, González et al. (2014) calibrated a DSGE model for its economy, and showed how in addition to the spending smoothing effect of a structural surplus rule it allows the Central Bank to be less aggressive in fighting inflation when an oil price shock hits the economy, and welfare is improved.

In addition to the fiscal rule, the Colombian government implemented the General System of Prerogatives (Sistema General de Regalías) of Law 1530 of 2012, which regulates the use by the regions of the government revenue participation over mining activities. As the fiscal rule, this regulates spending and savings, depending on the amount of resources. The budget, determined by the Secretary of Finance (Ministerio de Hacienda), establishes savings with the objective of stabilizing regional investment.

The budget is biannual, independent from the one of the National Central Government, used only for investment and assigned between expenditure and savings. The expenditures correspond to the Regional Compensation Fund, Regional Development Fund, Science, Technology and Innovation Fund and Direct Regional Assignments. Meanwhile, savings correspond to the Savings and Stabilization Fund and the Territorial Pension Fund.

4. INCIDENCE OF DUTCH DISEASE OVER PROFITS

In this Section we present empirical evidence about the relation between the real exchange rate and the profitability of the firms. In our econometric study, we do not subscribe ourselves to the type of aggregate analysis used in the existing works of the empirical literature about Dutch disease, but instead, using information about 3,385 Colombian firms, we estimate a model using profit-by-profit level information to assess the effect of the exchange rate over the profitability of firms.

The model presented in Section 2 briefly highlights the expected relation between profits and the real exchange rate. In addition, for our econometric specification we complement the model with macroeconomic and microeconomic variables using the same approach that Griffin (2015) applied for the case of the industrial sector.

Our basic regression equation is the following:

9
$$\pi_{ft} = \alpha_0 + \alpha_1 RER_t + \alpha_2 GDPG_t + \alpha_3 Leverage_{ft} + \\ + \alpha_4 PartnersGDPG_t + \mu_f + \varepsilon_{ft},$$

where π_{ft} represents the profits of firm *f*; RER_t is the real exchange rate of the economy; $GDPG_t$ is the annual output growth; $Leverage_{ft}$ is the ratio of total debt to total assets of the firm *f*; $PartnersGDP_t$ corresponds to the real GDP growth of the three main commercial partners of Colombia; μ_f is a firm fixed effect to control for idiosyncratic characteristics of the firm; and ε_{ft} is a random error.

The theoretical framework of Section 2 presented the expected sign for the RER_t depending on the sector to which the firm belongs. For the traded sector we expect a positive relation between profits and RER_t, and for the nontraded sector a negative sign. Two other factors are included to explain the behavior of profits; the demand for goods of the firm whose proxy in our model is $GDPG_t$, and the level of $Leverage_{ft}$. We decided to use leverage because the Colombian firms increased their level of domestic borrowing during the analysis period due to the strong capital inflows in the economy (see González et al., 2014). The expected sign is negative because the higher the level of leverage the riskier the firm and according to Bernanke, Gertler and Gilchrist (1999) the higher will be the external

Table 1

SUMMARY STATISTICS

Variable	*Definition*	*Mean*	*Std. dev.*	*Min*	*Max*
ROE_{ft}	Firm net profits/equity (%)	6.7	1.6	3.0	8.3
Real exchange $rate_t$	Is considered in terms of producer prices 2002=100 and a basket of goods with the main countries with which Colombia trades	87.7	7.7	77.2	103.6
Output $growth_t$	Real gross domestic product growth (%)	4.6	1.6	1.7	6.9
Partners $GDPG_t$	Trade partners real gross domestic product trade (%)	3.8	1.9	–0.5	6.4
$Leverage_{ft}$	Firm total liabilities/total assets (%)	32.7	2.1	30.6	36.8
Firm $size_{ft}$	ln(firm total assets)	26.1	0.4	25.5	26.7
$Exports_{ft}$	Real exports considered in terms of consumer price index 2002=100 (billions of COP)	7,329	1,089	5,370	9,256

Source: Author's calculations.

finance premium charged by the financial intermediaries to the firm to finance investment and the lower the profits will be. In the case of the traded sector, we also included *Partners* GDP_t and expect a positive effect on profits.

For our analysis, we use a panel that consists of 3,385 firms including large ones that are publicly listed. The data is annual from 2002 to 2014. The number of firms is in agriculture 289, in manufacture 897, in services 1,932, and in construction 267. The firms in the panel are the same for the whole period. The source of the data are the Colombia's Superintendence of Corporations (Superintendencia de Sociedades), that collects a large amount of data on financial and income statements from private corporations that are not listed in the stock exchange, and the Financial Superintendence (Superintendencia Financiera) that reports information for large firms that are listed in the stock exchange.

Table 1 presents the descriptive statistics of the aggregated variables. The average level during the period was 87.7 for RER_t; 4.6%, $GDPG_t$; 6.7%, ROE_{ft}; 32.7%, $Leverage_{ft}$; 7,329 billion of 2002 Colombian pesos (COP), $Exports_{ft}$; 3.8%, $PartnersGDP_t$; and 26.1, $Firm\ size_{ft}$ [measured as the ln(total assets)].

The subsectors' descriptive statistics are presented in Table 2. In manufacturing, the ROE's mean during 2002-2014 was lowest in the subsectors of manufacture of textiles (0.2%); manufacture of rubber and plastics products (1.5%); and manufacture of basic metals (2.5%). In the main manufacturing subsectors, leverage mean was between 18.4% and 52.5%. The subsectors with higher exports were manufacture of chemicals and chemical products; and manufacture of food products and beverages.

In agriculture, the ROE was lower in growing of bananas (0.8%), farming of cattle (1.8%), growing of flowers (2.1%), growing of sugar cane (2.8%), and growing of cereals and oil crops (2.9%). The exports mean was 279 billion of 2002 COP for growing of flowers, which was the highest in agriculture.

During the period, in construction, the results were for ROE 8.9% and leverage 51.8%. In the services subsectors with more number of firms, the ROE was between 3.1% and 11.5%, and leverage was between 10.4% and 57.8 percent.

Table 2

SUBSECTORS' SUMMARY STATISTICS (MEAN)

ISIC rev. 3	*Subsector*	*ROE*	*Leverage*	*Number of firms*	*Exports (2002 million COP)*
112	Growing of flowers	2.1	45.0	48	278,724
113	Growing of bananas	0.8	29.9	17	4
114	Growing of sugar cane	2.8	14.1	49	314
115	Growing of cereals and oil crops	2.9	27.0	37	1,741
117	Growing of fruit, nuts, beverage, and spice crops	6.4	42.9	8	1,658
121	Farming of cattle	1.8	17.3	30	0
15	Manufacture of food products and beverages	6.5	28.5	176	1,116,543
17	Manufacture of textiles	0.2	42.1	46	457,327
18	Manufacture of wearing apparel; dressing and dyeing of fur	4.5	50.7	54	326,507
21	Manufacture of paper and paper products	4.8	26.1	20	507,168
24	Manufacture of chemicals and chemical products	8.7	43.2	116	1,722,759
25	Manufacture of rubber and plastics products	1.5	46.9	88	461,965
26	Manufacture of other non-metallic mineral products	3.6	18.4	42	263,687
27	Manufacture of basic metals	2.5	45.4	19	178,922

28	Manufacture of fabricated metal products, except machinery and equipment	4.3	49.3	64	547,560
29	Manufacture of machinery and equipment n.e.c.	5.5	50.8	29	218,946
31	Manufacture of electrical machinery and apparatus n.e.c.	7.2	52.5	19	201,821
34	Manufacture of motor vehicles, trailers and semitrailers	7.4	49.0	37	133,897
45	Construction	8.9	51.8	267	-
50	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	11.5	57.8	177	-
51	Wholesale trade and commission trade, except of motor vehicles and motorcycles	8.9	53.8	529	-
52	Retail trade, except motor vehicles and motorcycles; repair of personal household goods	4.1	44.4	187	-
55	Hotels and restaurants	3.1	42.4	74	-
65	Financial intermediation, except insurance and pension funding	4.3	10.4	214	-
70	Real estate activities	3.3	22.6	268	-

Source: Authors' calculations.

Table 3

DESCRIPTION OF MANUFACTURING SUBSECTORS

ISIC rev. 3	*Description*
	High Tech
24	Manufacture of chemicals and chemical products
29	Manufacture of machinery and equipment n.e.c.
30	Manufacture of office, accounting, and computing machinery
31	Manufacture of electrical machinery and apparatus n.e.c.
32	Manufacture of radio, television and communication equipment and apparatus
33	Manufacture of medical, precision and optical instruments, watches and clocks
34	Manufacture of motor vehicles, trailers and semitrailers
35	Manufacture of other transport equipment
	Low Tech
15	Manufacture of food products and beverages
16	Manufacture of tobacco products
17	Manufacture of textiles
18	Manufacture of wearing apparel; dressing and dyeing of fur
19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear
20	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
21	Manufacture of paper and paper products
22	Publishing, printing and reproduction of recorded media
23	Manufacture of coke, refined petroleum products and nuclear fuel
25	Manufacture of rubber and plastics products
26	Manufacture of other non-metallic mineral products
27	Manufacture of basic metals
28	Manufacture of fabricated metal products, except machinery and equipment
36	Manufacture of furniture; manufacturing n.e.c.

Source: Organisation for Economic Co-operation and Development, Eurostat, and United Nations.

4.1 The Impact of the Real Exchange Rate over Profits

As explained above, the real exchange rate has a direct effect on profits of traded and nontraded goods. Here we study this effect using the specification presented in equation 9.

In a preliminary step, using data for the period 2002-2014 we estimated the impact of real exchange rate on profits of traded goods[6] and nontraded goods and over the individual sectors (agriculture, manufacturing, construction and services), using OLS (Table 4).[7] The results are very suggestive, in all the cases the incidence of the exchange rate is significant and with the expected sign, except for agriculture and construction in which it is not significant. According to the regressions, the exchange rate appreciation had a negative impact on the profitability of traded goods and manufacturing; and a positive effect on the profitability of nontraded goods and services.

In Table 4 the relation of profits to output growth results positive and with leverage results negative. The output growth has the expected sign in all cases except agriculture, but it is not significant; while, leverage results significant and with the expected sign for traded goods, agriculture, and manufacturing. The GDP growth of the trade partners resulted with a positive sign as expected but not significant.

However, in order to take into account the lagged dependent variable and given that some of the explanatory variables might be determined at the same time as the left-hand-side variable, we use a generalized method of moments estimator. This is a better approach because linear dynamic panel-data models include p lags of the dependent variable as covariates and contain unobserved panel-level effects, fixed or random. By construction, the unobserved panel-level effects are correlated with the lagged dependent variables, making standard

6 Traded goods in regressions include manufacturing and agriculture, and do not include mining.

7 This period corresponds to the years of appreciation of the real exchange rate in Colombia due to the continuous increase in oil prices.

Table 4

	PANEL: OLS					
Variable	*Traded* *(1)*	*Nontraded* *(2)*	*Agriculture* *(3)*	*Manufacturing* *(4)*	*Construction* *(5)*	*Services* *(6)*
Dependent variable: Profits/Equity$_{ft}$ (ROE)						
Constant	−13.47	115.99[c]	−3.32	−16.45[c]	42.89	126.15
	(7.80)	(64.28)	(13.16)	(8.17)	(28.88)	(75.41)
Real exchange rate$_t$	0.24[a]	−1.38[c]	0.17	0.27[a]	−0.42	−1.51[c]
	(0.06)	(0.73)	(0.11)	(0.07)	(0.30)	(0.86)
Output growth$_t$	0.15	1.83	−0.93	0.50	0.54	2.01
	(0.80)	(1.34)	(1.04)	(0.81)	(0.87)	(1.57)
Leverage$_{ft}$	−14.61[b]	−9.40	−30.81[c]	−12.55[c]	−9.46	−9.59
	(6.47)	(12.08)	(14.79)	(7.16)	(11.26)	(12.81)
Partners GDPG$_t$	0.48		0.88	0.36		
	(0.38)		(0.64)	(0.38)		
Number of observations	15,418	28,587	3,757	11,661	3,471	25,116
Number of groups	1,186	2,199	289	897	267	1,932
Tests						
F (variables −1, 12)	5.37	1.68	3.19	4.48	0.77	1.42
p-value	0.01	0.22	0.05	0.02	0.53	0.28

Notes: Clustered by time, standard errors reported in parenthesis. The symbols [a], [b] and [c] indicate significance at levels 1%, 5% and 10%, respectively.
Source: Authors' calculations.

estimators inconsistent. Arellano and Bond (1991) derived a consistent generalized method of moments estimator for the parameters of these models.

Table 5 presents the results. The incidence of the exchange rate is significant and with the expected sign, except for construction. The exchange rate appreciation decreased the profitability of traded goods, agriculture and manufacturing; and increased the profitability of nontraded goods and services. An increase of one unit in the RER_t index increases the profitability of the traded goods firms in 0.49% and decreases the profitability of nontraded goods firms in 3.40%. The highest impact is on the services sector.[8]

Regarding the manufacturing subsectors, the more affected by the appreciation of the exchange rate were: manufacture of textiles (17); manufacture of wearing apparel, dressing and dyeing of fur (18); manufacture of rubber and plastics products (25); manufacture of non-metallic mineral products (26); manufacture of basic metals (27); manufacture of fabricated metal products, except machinery and equipment (28); and manufacture of motor vehicles, trailers and semitrailers (34).[9] In the Colombian economy, these subsectors are characterized by their higher value of exports and production with respect to the rest of manufacturing.

Colombia has been characterized with respect to other Latin American countries by the more diversified and highest proportion of manufacturing in total output, with comparative advantage in the production of low technology subsectors as textiles and wearing apparel. Besides, the Colombian economy has an important production in manufacture of chemicals and chemical products that has been more successful with respect to the production of other high technology products. This subsector was not affected by the appreciation of the real exchange rate during the period. Meanwhile, in the manufacture of motor vehicles, trailers and semitrailers, the profits during the

8 The real exchange rate index is 100 in 2002.

9 ISIC classification (rev. 3).

Table 5

PANEL: ARELLANO-BOND

Variable	*Traded (1)*	*Nontraded (2)*	*Agriculture (3)*	*Manufacturing (4)*	*Construction (5)*	*Services (6)*
Dependent variable: Profits/Equity$_{ft}$ (ROE)						
Profits/equity$_{ft-1}$	0.00	−0.01[c]	−1.50[a]	0.03[b]	−0.19[a]	−0.01
	(0.01)	(0.01)	(0.08)	(0.01)	(0.01)	(0.01)
Constant	−29.53[c]	283.31[a]	−61.69[b]	−34.10[c]	31.17[c]	326.02[a]
	(16.49)	(67.99)	(25.38)	(20.14)	(18.99)	(77.33)
Real exchange rate$_t$	0.49[a]	−3.40[a]	0.85[a]	0.52[b]	0.10	−3.93[a]
	(0.18)	(0.75)	(0.28)	(0.21)	(0.20)	(0.86)
Output growth$_t$	−0.12	2.98	−2.85[b]	0.37	−0.39	3.46
	(0.90)	(2.63)	(1.42)	(1.10)	(0.75)	(2.99)
Leverage$_{ft}$	−28.97[b]	−6.25	−15.05	−22.70	−62.24[a]	−5.38
	(12.28)	(10.48)	(19.09)	(14.91)	(10.56)	(11.23)
Partners GDPG$_t$	1.06[c]		3.05[a]	0.76		
	(0.65)		(1.02)	(0.79)		
Number of observations	13,042	24,136	3,179	9,863	2,928	21,208

Number of groups	1,186	2,199	289	897	267	1,932
Sargan-test [$\chi^2(11)$] / p-value	17.5630 0.0923	11.1268 0.4327	5.7927 0.8868	20.4605 0.0394	13.3876 0.2688	11.3187 0.4170
First-order autocorrelation [z-stat / p-value]	−1.6363 0.1018	−1.6579 0.0973	−1.4040 0.1603	−1.5417 0.1231	−1.6415 0.1007	−1.6544 0.0981
Second-Order Autocorrelation [z-stat / p-value]	1.2119 0.2255	0.0048 0.9961	0.8297 0.4067	1.0189 0.3082	0.0636 0.9493	0.0242 0.9807

Note: Standard errors reported in parenthesis. The symbols [a], [b] and [c] indicate significance levels at 1%, 5% and 10%, respectively.
Source: Authors' calculations.

period decreased with the appreciation of the exchange rate because of the expansion in the demand of durable goods, which competed with domestic production.

In agriculture, the subsectors that declined more in profitability were growing of flowers (112), growing of sugar cane (114), growing of cereals and oil crops (115), and growing of fruit, nuts, beverage and spice crops (117).

The appreciation of the exchange rate and positive capital movements caused an increase in real estate prices and a boom in consumption of durable goods along with high rates of GDP growth. The expansion of profits of the construction sector was significant. Among the subsectors with highest profits growth in services were trade, and hotels and restaurants.

Finally, in our Arellano-Bond regressions in Table 5, output growth is not significant. With respect to leverage the relation has the expected negative sign for all of the sectors and is significant for traded goods and construction. The GDP growth of the trade partners has the expected sign in all cases and it is significant for traded goods and agriculture.

The results of the Sargan test shows that in all cases the overidentified restrictions are valid and the *AR(i)* test shows no autocorrelation for the Arellano Bond estimations.

4.2 Controlling for the Imported Component

One important aspect to take into account when examining the impact of the exchange rate over profits is the imported component of goods. However, there are not data available at the firm level. Our approach to take into account the imported component was the following: for the manufacturing sector, we divide the 2-digits subsectors into high tech and low tech according with the Organisation for Economic Co-operation and Development and Eurostat (Table 3). The high tech subsectors such as chemicals have an important imported component. So we use a dummy variable equal to one for high tech and equal to zero for the low tech subsectors and we call it $Technology_{ft}$.

We run the regression:

10 $$\pi_{ft} = \alpha_0 + \alpha_1 RER_t + \alpha_2 GDPG_t + \alpha_3 Leverage_{ft} + \alpha_4 PartnersGDPG_t + \\ + \alpha_5 Technology_{ft} + \mu_f + \varepsilon_{ft}.$$

The results are presented in Table 6. As we can see, the real exchange rate presents the expected sign and it is significant when controlling for this variable. The $Technology_{ft}$ variable has the expected sign but it is not significant. The other variables also have the expected sign but are not significant.

Table 6

PANEL: OLS (IMPORTED COMPONENT)

Variable	*Manufacturing*
Dependent variable: Profits/Equity$_{ft}$ (ROE)	
Constant	−16.84[c] (8.27)
Real exchange rate$_t$	0.27[a] (0.07)
Output growth$_t$	0.49 (0.81)
Leverage$_{ft}$	−12.58 (7.17)
Partners GDPG$_t$	0.35 (0.37)
Technology$_{ft}$	1.69 (1.71)
Number of observations	11,661
Number of groups	897
Tests	
$F(5, 12)$	3.76
p-value	0.03

Notes: Clustered by time, standard errors reported in parenthesis. The symbols [a], [b] and [c] indicate significance levels at 1%, 5% and 10%, respectively.
Source: Authors' calculations.

4.3 Which Firms Are Affected the Most?

A last question that we ask in our article is: does the real exchange rate affect more to some firms? Until now, we presented evidence that in average an appreciation of the real exchange rate results in a reduction in profits of traded goods and improvement in non-traded goods. In Table 7 we consider if the profits reaction is stronger for some type of firms, more precisely, smaller or larger firms. For doing so, we introduce interaction effects between the real exchange rate and the size of the firm (as measured by the natural logarithm of total assets) with Arellano-Bond regressions. The specification used is:

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$$\pi_{ft} = \alpha_0 + \alpha_1 RER_t + \alpha_2 GDPG_t + \alpha_3 Leverage_{ft} + \alpha_4 RER_t * Firm_{size_{ft}} + \\ + \alpha_5 PartnersGDPG_t + \mu_f + \varepsilon_{ft}.$$

The results show that the interactions have a negative sign for traded goods and a positive sign for nontraded goods. This implies that when the exchange rate appreciates and the profits of traded goods decrease, the result is stronger for smaller firms. Similarly, for nontraded goods the firms more affected are the smaller ones. This is that smaller firms are more vulnerable to the movements in the real exchange rate.

Additionally, the exchange rate was significant and its sign was the expected for traded goods, manufacturing, agriculture and construction. The incidence of output was of the expected sign for nontraded goods and services. The leverage was of the expected sign and significant in all cases, with the exception of nontraded goods and services.

Finally, the interactions in all of the sectors indicate that fluctuations become more pronounced for smaller firms with respect to a mining boom. This is that all the regressions indicate that the sectors are sensitive to the exchange rate in the expected sign, and that it causes greater fluctuations in smaller firms.

Table 7

PANEL: ARELLANO-BOND (INTERACTIONS)

Variable	*Traded (1)*	*Nontraded (2)*	*Agriculture (3)*	*Manufacturing (4)*	*Construction (5)*	*Services (6)*
Dependent variable: Profits/equity$_{ft}$ (ROE)						
Profits/equity$_{ft-1}$	−0.02[b] (0.01)	−0.01 (0.01)	−1.05[a] (0.06)	−0.01[c] (0.01)	−0.19[a] (0.01)	−0.01 (0.01)
Constant	−12.62 (19.07)	256.40[a] (79.97)	23.89 (27.59)	−22.92 (23.24)	−33.58 (22.06)	300.34[a] (91.00)
Real exchange rate$_t$	1.89[a] (0.73)	−3.90 (2.44)	5.01[a] (0.92)	2.12[b] (0.93)	−3.42[a] (0.55)	−3.91 (2.86)
Output growth$_t$	−0.24 (0.92)	3.01 (2.62)	−1.14 (1.44)	0.00 (1.11)	−0.16 (0.74)	3.52 (2.99)
Leverage$_{ft}$	−44.12[a] (11.92)	−6.30 (10.48)	−36.81[b] (18.73)	−41.48[a] (14.35)	−89.29[a] (10.98)	−5.50 (11.24)
Real exchange rate$_t$*Firm size$_{ft}$	−0.09[b] (0.05)	0.05 (0.15)	−0.32[a] (0.06)	−0.10[c] (0.06)	0.27[a] (0.03)	0.02 (0.18)
Partners GDPG$_t$	1.40[b] (0.68)		1.03 (1.03)	1.49[c] (0.82)		

Variable	*Traded (1)*	*Nontraded (2)*	*Agriculture (3)*	*Manufacturing (4)*	*Construction (5)*	*Services (6)*
Number of observations	13,046	24,189	3,179	9,867	2,937	21,252
Number of groups	1,186	2,199	289	897	267	1,932
Sargan-test [$\chi^2(11)$] / p-value	14.1432 0.2252	10.4604 0.4011	5.6771 0.8940	14.0156 0.2321	22.3032 0.0136	10.5990 0.3896
First-order autocorrelation [z-stat / p-value]	−1.6316 0.1028	−1.6658 0.0957	−1.4116 0.1581	−1.5308 0.1258	−1.6320 0.1027	−1.6625 0.0964
Second-order autocorrelation [z-stat / p-value]	1.2150 0.224	0.0309 0.9754	0.8406 0.4005	0.9975 0.3185	0.1448 0.8849	0.0006 0.9995

Note: Standard errors reported in parenthesis. The symbols [a], [b] and [c] indicate significance levels at 1%, 5% and 10%, respectively.
Source: Authors' calculations.

5. CONCLUSIONS

The increase in oil prices since 2004 caused a Dutch disease in the Colombian economy that was characterized by the increase in mining exports, the appreciation of the exchange rate, and the decrease in profits of nonbooming traded goods and the increase in profits of nontraded goods. The exchange rate stopped appreciating during 2013-2014, but the level remained below 2002-2003.

The government macroeconomic policy could enable high rates of growth during the period, but the Dutch disease resulted in an unbalanced growth with smaller rates in the manufacturing and agriculture sectors. On the other side, the amount of spending of the economy increased in both the private and public sectors, behavior that caused the appreciation of the exchange rate during the period.

In the article, the theoretical framework considers traded and nontraded goods, and nontraded goods prices depending on the exchange rate, wages and money supply. It is shown that the depreciation (appreciation) of the exchange rate has a positive (negative) impact on traded goods profits and a negative (positive) impact on nontraded goods profits. The overall result depends critically on the parameter of the relation between the nontraded goods prices with the exchange rate. When the parameter is lower, the depreciation (appreciation) causes higher (lower) traded goods profits and lower (higher) nontraded goods profits.

The regression analysis shows strong evidence that the appreciation of the exchange rate during 2002-2014 reduced the profits of traded goods, manufacturing and agriculture; and increased the profits of nontraded goods, construction, and services. In all goods, more leverage caused a reduction of profits, and nontraded goods and services were more related with output growth than other sectors. The real exchange rate has a positive and significant impact on manufacturing when controlling by the imported component in this sector. Finally, smaller firms in both traded and nontraded goods are more affected by the movements in the exchange rate.

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Ecuadorian Financial System Exposures: A Network Theory Approach

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Abstract

The purpose of this research is to analyze interrelations in the Ecuadorian financial system by means of a network theory approach. The network structure was defined using interbank exposure in absolute and relative terms. A static-comparative graphic analysis of the networks was carried out providing for the deposit and investment exposure of financial institutions in the financial system from December 2012 through December 2015, and the monthly metrics for each financial entity during this period were calculated. Using relative exposures, which consider the capital of each financial institution as collateral against entrusted deposits and investments, a transmission index was developed and a ranking of systemic importance was determined. The calculated metrics show that the stability of the structure of the Ecuadorian financial system as a network and that of its financial institutions has remained unchanged; in this regard, the status of systemically important financial institutions also remains unchanged.

Keywords: network, expositions, systemic risk, regulation.
JEL classification: D85, G21, E58, G28.

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1. INTRODUCTION

One of the ways to define systemic risk is to refer to risk created due to system or market interdependencies. Authors such as Billio, Getmansky, and Lo and Pelizzon (2010) have determined that systemic risk is "any set of circumstances that threaten stability or confidence in the financial system." Accordingly, the failure of an entity or group of entities would cause a cascade effect and a possible collapse of the system or market as a whole as a result of market interrelations.

The construction of a model of the Ecuadorian financial system's interconnections using a network theory approach is an exercise in innovative methodology that permits, among other things, the determination of measures related to financial networks for the purpose of identifying the structure of the interrelations that exist between the entities that make up the financial system. It also allows those entities categorized as systemically important to the system to be monitored, and, in the future, to carry out resistance testing and contagion analysis as a dynamic and timely exercise such as the distribution of losses in certain circumstances, such as shocks. All the aforementioned analyses constitute inputs that, in the field of macroprudential policy, become technical foundations for the analysis of the stability of the financial system as a whole; and therefore for proposing of lines of action that strengthen the capacity to mitigate possible disturbances.

In this context, a comparative analysis of interbank exposures from December 2012 to December 2015[1] was undertaken for the purpose of identifying if the networks' structure,

[1] Due to the availability of the information disseminated by the entities of the Ecuadorian financial system regarding the structure corresponding to minimum liquidity reserves and the internal liquidity ratio, the analyzed period begins in December 2012, since prior to that month the structures about which the information was provided were different and therefore not comparable (Regulation 032-2012 of the Directorio, Banco Central del Ecuador).

configured by the deposits and investments of the Ecuadorian financial system, had changed. Additionally, the financial institution measures were calculated on a monthly basis during the period studied.

Based on the relative exposures, taking into consideration each financial institution's capital used to guarantee deposits and investments, a transmission risk index was built and a rating of systemic importance was determined.

With respect to total interbank exposures, a higher density was seen in the sector of interrelations in the largest private banks, corresponding to amounts of more than 5 million USD. On the other hand, the participation of both private and cooperative banks in the debt market, and the limited interconnectedness between mutuals and financial companies –with the exception of the largest financial entities– with most of the financial system, are notable. There is a noticeable concentration in deposits, especially in private banks: 66% of the total exposure of these assets was concentrated in the banks up to December 2015. Taking into consideration the investment market's interconnections, a large participation by banks and cooperatives as both lenders and borrowers was seen. The banks and cooperatives have more interconnections in the debt market which made up between 56% and 42% of total investments as of December 2015. The structure of the Ecuadorian financial system remained stable during the period under analysis in accordance with the calculated measures, both in network and individual financial entity terms. In this regard, the financial institutions of most systemic importance remained unchanged during the period analyzed.

2. THEORETICAL ASPECTS OF NETWORK ANALYSIS

The theoretical aspects related to network analysis are based on a document published by The Depositary Trust & Clearing Corporation-DTCC (2015).

In terms of the relations between entities in a structure or system, *interconnection* is defined as the relations between economic agents created by financial transactions or payment arrangements, and this interconnection refers specifically to the links between the following institutions and by means of them: financial entities, financial infrastructure services providers, sellers, and third parties tied to the aforementioned entities. For this reason, interconnection is one of the key factors that must be taken into account when evaluating systemic financial sector risk.

Along the same lines, a *financial interconnection* is the network of credit exposures, exchange channels and other relations and dependencies between financial agents. An interconnection has contrarian aspects, as it can act as a conduit for contagion. The effect of a highly connected entity's failure can spread rapidly and extensively throughout the financial system to the point where it can cause global financial instability. Financial interconnectivity can be direct or indirect.

A *direct financial interconnection* refers to direct ties between entities via financial transactions, debentures, contracts and other agreements or relations that can be documented either explicitly or through indirect observation.

Credit exposures between banks are among the most basic types of direct interconnection. Bank A lends funds to Bank B; the two banks are directly connected and the interbank loan will appear as an asset on Bank A's balance sheet and a liability on Bank B's. Bank A is exposed to Bank B and could suffer losses if Bank B were to become insolvent. Credit exposure can also result from the acquisition of securities issued by other institutions, securities funding transactions, derivatives trading, and other activities beyond the interbank lending market. Finally, credit exposures may also appear in holding companies and other structures where legal entities are connected by property ties.

An *indirect financial interconnection* refers to channels where the expectation is that one entity can affect another entity, including where there is no link between the two. The expectation of an effect between entities where there is no apparent relation between the two can be propagated in many ways, as for example when there is exposure to common assets. Financial institutions that maintain common assets are indirectly interconnected. Concentrations of common asset holdings have exposed financial institutions to large price fluctuations and elevated risk, above all during periods of market volatility or turmoil. Supply and demand distortions, such as the effect of prices on assets, represent additional vulnerabilities for financial institutions and can move quickly through the financial system in response to an initial market shock, the actions of market participants, and subsequent reactions.

It is relevant to consider that both indirect and direct financial interconnectivity are closely related to financial contagion and its side effects.

On the other hand, *financial contagion* is the process by which an adverse shock in one financial institution can have negative consequences for the rest. Shocks that propagate through indirect interconnectivity can affect a wide range of institutions more or less simultaneously. As a result, market conditions may deteriorate further and affect a growing number of businesses, leading to negative feedback that increases the initial shock and deepens stress throughout the entire system. This can trigger a cascade effect.

2.1 Representing the Interbank System's Network Structure

The relations between the entities that make up a financial system can be represented as a direct network with weights (Cont, Moussa and Santos, 2012), or a defined network such as $I=\left(N,A,c\right)$, where:

- N is the set of nodes that correspond to each financial entity,
- A is the adjacency matrix showing the bilateral exposures between the financial entities, for which A_{ij} denotes the exposure of node i to node j as the accounted for the value of entity i's distinct assets in entity j in the case of interconnection, but zero in the case where the entities maintain

no interrelation. In other words, the exposure can be interpreted as node i's loss as a result of node j's problems.

- $c = c(i), i \in N$, where $c(i)$ is institution i's capital representing the ability of each financial entity to absorb losses; supposing that, facing any problem in debtors' payment capacities, the capital shall be the tool used to mitigate the loss.

Said network is shown as a graph in which its nodes represent a financial entity and its connections are interpreted as the exposures between them.

Additionally, the in-degree $\left(k_{in}(i)\right)$ of a node i $(i \in N)$ is defined as its number of creditors and the out-degree $\left(k_{out}(i)\right)$ as its number of debtors, so that the total degree[2] of entity i, is defined as $k(i) = k_{in}(i) + k_{out}(i)$ and shows the level of connectivity of entity i at any given moment.

On the other hand, financial entity i's assets S can be expressed as the following:

$$S(i) = \sum_{j \in N} A_{ij} .$$

While the liabilities P of entity i can be denoted as:

$$P(i) = \sum_{j \in N} A_{ji} .$$

2.2 Relative Bilateral Exposures

To construct the Ecuadorian financial system's interbank networks, the basis for making the relative exposure calculations is based on the criteria that assumes that the assets of the depository entities are liabilities for the entities that receive them.

Relative bilateral exposures can be expressed as the coefficient of the exposure of entity i to entity j for i's capital.

[2] The degree of a node is a measure of connectivity that shows the number of borders that a node has as one of its ends. This translates into the number of a bank's counterparts.

$$\frac{A_{ij}}{c(i)}.$$

This type of exposure allows the level of *i's* exposure in the face of a possible bankruptcy of entity *j* to be verified using its capital as an instrument for responding to the loss. In other words, it indicates at what level the capital of *i* could protect its exposure to entity *j*.

Moreover, the cumulative relative exposure level was calculated in a horizontal fashion, which refers to the ratio of total assets to capital for each entity. For entity *i* it can be defined as:

$$\sum_{j=1}^{N-1}\frac{A_{ij}}{c(i)} = S(i)/c(i), \text{ where } S(i) = \sum_{j\in N} A_{ij}.$$

This type of exposure identifies the most vulnerable financial institutions taking into consideration their incapacity to use their capital to confront the losses.

On the other hand, the relative vertical accumulated exposure defines the role the financial entities perform as transmitters in the financial system since their failure would have great consequences for their counterparts. In the case of entity *i* this type of exposure can be defined as:

$$\sum_{j=1}^{N-1}\frac{A_{ji}}{c(j)}.$$

In this way, financial institutions were grouped into four categories:

1) Vulnerable and transmitting entities. This group covers entities whose relative cumulative vertical and horizontal exposure exceeds 100%, which implies that in the face of their counterparts' problems, they run the risk of being weakened and in turn could spread the problem to other entities.

$$\sum_{j=1}^{N-1}\frac{A_{ij}}{c(i)} > 100\%,\ \sum_{j=1}^{N-1}\frac{A_{ji}}{c(j)} > 100\%.$$

2) Vulnerable entities. This group covers entities whose relative cumulative horizontal exposure exceeds 100%, implying that in the face of their counterparts' problems they could be affected, as their capital would not allow them to cope with their losses.

3) Immune entities. This group corresponds to entities that could not be affected by their counterparts' problems and also do not meet the role of transmitters, so they are indifferent to failures in the system; that is, their relative cumulative vertical and horizontal exposure is less than 100 percent.

$$\sum_{j=1}^{N-1} \frac{A_{ij}}{c(i)} < 100\%, \sum_{j=1}^{N-1} \frac{A_{ji}}{c(j)} < 100\%.$$

4) Transmitter entities. This category covers entities whose cumulative relative vertical exposure exceeds 100%, which means that in the face of problems they might have, their counterparts would be affected.

$$\sum_{j=1}^{N-1} \frac{A_{ij}}{c(i)} > 100\%.$$

2.3 Transmission Risk Index

Depending on the bilateral relative exposure, an index was obtained for each entity in order to be able to identify which are systemically important. In order to establish this index, three aspects were taken into account that show, on the one hand, the number of entities tied to each institution, and on the other, their ability to transmit a shock to other entities, and finally, their position in the network.

- Selection of entities that comply with an exposure relatively greater than 20%,

$$\frac{A_{ij}}{c(i)} \geq 20\% \cup \frac{A_{ji}}{c(j)} \geq 20\% \, \forall \, i.$$

From the selection, and adjacency matrix is obtained with the number of entities that fulfill the previous condition. Thus, we calculate the total degree of each entity *i* and proceed with the transformation between 0 and 1[3] of the total degree of each institution.

In this case, the number of creditor and debtor entities can be observed,[4] with values in the range of 0 to 1, where 0 corresponds to the entity with the lowest total degree and 1 to the entity whose degree adds up to the highest value.

- Core-periphery algorithm[5] that allows the position of the node in the network to be observed and delivers a value of 0 to the entities categorized as being peripheral and a value of one to those categorized as being core.
- The transformation between 0 and 1 of the internodal measurement[6] of each entity *i*, where 0 corresponds to the entity with the lowest internodal measure and 1 to the entity through which pass the highest number of connections, a condition that allows the identification of the capacity of transmitting a shock to a part of an entity.

The final result is to add the obtained valued according to the criteria detailed above in order to have a measure or index with a range from zero to three that permits the establishment of a grade of systematic importance for each entity in the financial system.

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3 The transformation between 0 and 1 of the X_i is obtained by:

$$\left(\frac{X_i - Min\left(X_i\right)}{Max\left(X_i\right) - Min\left(X_i\right)}\right).$$

4 In-degree and out-degree.

5 Measure proposed by Craig and Von Peter (2014) that consists of the division of the network into two subdivisions.

6 Centrality measure that refers to the number of times a node acts as a tie between two other actors.

3. STRUCTURE AND ANALYSIS OF THE ECUADORIAN FINANCIAL SYSTEM EXPOSURES

The Ecuadorian financial system analyzed in this research was made up of 75 operating financial entities at the close of 2015.[7] Private banks make up the largest participation in the system in accordance with their assets which are: 22 banks comprising 79.4% of all assets; 39 cooperatives,[8] comprising 14.2%; 10 financial societies making up 4.9%, and 4 mutuals at 1.8 percent.

As of December 2015, four large financial institutions accounted for 52.3% of total assets. They were followed by five medium-sized financial entities with a concentration of 23.3%. The largest bank in the Ecuadorian financial sector held 23.4% of all assets, and the second largest bank had 11 percent.

As for the evolution of all regular and term deposits, between December 2012 and December 2015, on average, regular deposits made up 64% of the capital raised by the financial entities under analysis. The data series shows positive annual variation rates up to March 2015 and a consecutive fall with respect to the previous year, ending in December 2015 with the lowest rate (–16%) during the period under analysis. On the other hand, time deposits corresponded to 36% of the financial entities' raised assets and showed positive rates up to August 2015. During the following months, negative variation rates were seen, reaching the lowest point for the period under analysis at –4% in December 2015.

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7 For the comparative analysis of this research, 80 financial institutions were considered, of which 75 are in operation and five closed (four private banks and one financial company) by December 2015.

8 The Board of Monetary and Financial Policy via resolution number 038-2015-F issued as "Standard for the Segmentation of Widespread and Supportive Financial Sector Entities" in accordance with the type and amount of its assets. For this reason, the cooperative referred to in the analysis correspond to segment 1 of the mentioned regulation (taking into consideration the largest entities in terms of the size of the assets)

Table 1

STRUCTURE OF THE ECUADORIAN FINANCIAL SYSTEM AS OF DECEMBER 2015

Type of entity	*Number of entities*	*Assets (millions of dollars)*	*Share of assets (%)*
Private banks	22	30,864	79.4
Cooperatives	39	5,529	14.2
Segment 1	22	4,934	12.7
Segment 2	11	517	1.3
Segment 3	6	78	0.2
Mutuals	4	687	1.8
Financial societies	10	1,804	4.6
Total	75	38,885	100.0

Source: Created by the authors.

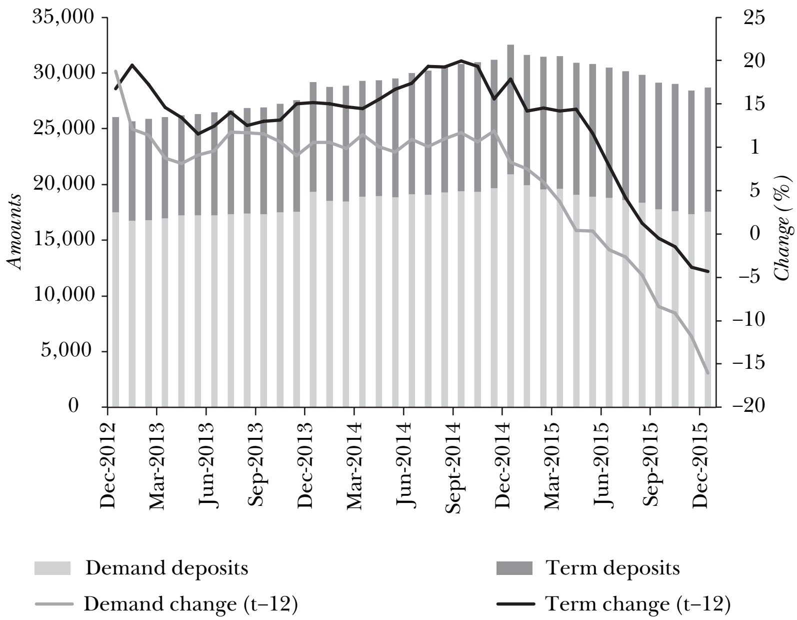
The evolution of the 80 entities' total loan portfolios, analyzed between December 2012 and December 2015, showed positive but decreasing rates of variation until October 2015. In the last months of the fourth quarter of 2015, negative rates of variation were seen until reaching the lowest point in December 2015 at –4%. Additionally, in Figure 2, the bars correspond to the amount of credit authorized in each segment,[9] and it can be seen that the largest proportion is distributed between consumer and commercial credit with microlending accounting for 12%, housing credit approximately 8% and education lending less than 2% on average during the year under analysis.

In terms of loan portfolio management, the evolution of the non performing loans ratio per credit segment shows that from December 2012 the total index increases, reaching it highest value in November 2015 at 4.9%. The highest non performing loans ratios correspond to the microcredit and consumer segments at 6.7% and 6.3% respectively, as of December 2015, while the lowest rates correspond to housing and commercial loans at 2.3% and 1.2% respectively.

[9] The credit segments have been grouped for comparative purposes, since new segments began operating in April 2015.

Figure 1

ECUADOR'S FINANCIAL SYSTEM: EVOLUTION AND RATE OF CHANGE OF DEMAND DEPOSITS AND TERM DEPOSITS, DECEMBER 2012 TO DECEMBER 2015
(millions of dollars and percentages)



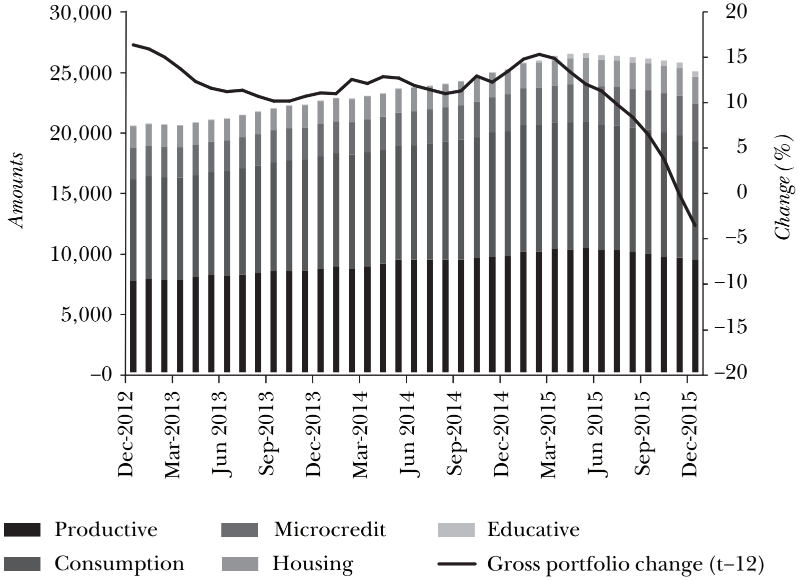
Source: Banco Central del Ecuador.

According to Camacho et al. (2015), given the decline in oil prices since the second half of 2014 and the appreciation of the dollar, the Banco Central del Ecuador undertook a series of counter-cyclical policies to prevent the economic slowdown from sharpening. As a result of resolutions[10] issued by the Board

[10] The Board of Monetary and Financial Policy via resolution number 043-2015-F issued "Norms that Regulate the Segmentation of Credit Portfolios Pertaining to Entities with the National Financial System," and via resolution number 044-2015-F set the "Norms Regulating the Setting of Effective Maximum Active Interest Rates."

Figure 2

ECUADOR'S FINANCIAL SYSTEM: EVOLUTION AND RATE OF CHANGE OF TOTAL LOAN PORTFOLIO BY SEGMENTS, DECEMBER 2012 TO DECEMBER 2015
(millions of dollars and percentages)



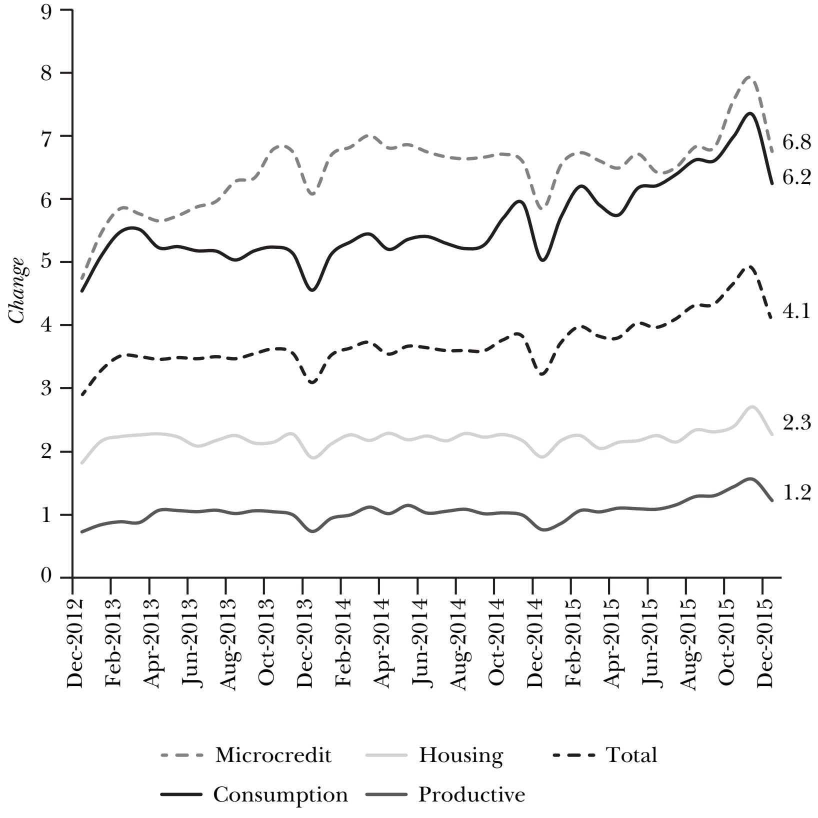
Source: Banco Central del Ecuador.

of Monetary and Financial Policy new credit segments were established accompanied by board rules for setting maximum active interest rates. Credit segments went from 9 to 15 and were in force as of April 2015.

Various analyses were undertaken from the perspective of network theory given the described structure of the Ecuadorian financial system. This innovative methodology permitted, among other things, the determination of financial network measurements, the analysis of bilateral exposure relative to each entity's capital, and the rating of entities of systemic importance to the financial system overall. These analyses provide a technical foundation for the analysis of the financial system's

Figure 3

ECUADOR'S FINANCIAL SYSTEM: EVOLUTION OF NON PERFORMING LOANS RATIO BY CREDIT SEGMENT, FEBRUARY 2012 TO DECEMBER 2015
(percentages)



Source: Banco Central del Ecuador.

Table 2

ECUADOR FINANCIAL SYSTEM: CREDIT SEGMENT CLASSIFICATION BEGINNING APRIL 1, 2015

Credit segment	*Credit subsegment*	*Maximum interest rates in effect since April 2015 (%)*
Business credit	Corporate	9.33
	Business	10.21
	SME	11.83
Ordinary business credit		11.83
Priority business credit	Priority corporate business	9.33
	Priority commercial business	10.21
	Priority commercial SME	11.83
Ordinary consumer credit		16.30
Priority consumer credit		16.30
Education credit		9.00
Public interest housing credit		4.99
Real estate credit		11.33
Microcredit	Retail	30.50
	Simple buildup (no more than 10,000 USD)	27.50
	Extended buildop (more than 10,000 USD)	27.50

Source: Board of Monetary and Financial Policy.

stability overall, and subsequently for proposing courses of action for strengthening the capacity to deal with possible disturbances and creating important inputs for the macroprudential policy environment.

The configuration of interbank exposure networks was determined as the aggregate network of deposits and investments that each financial entity has with others in the financial

Table 3

ECUADOR FINANCIAL SYSTEM: DETAIL OF ACCOUNT BALANCES BY TYPE OF FINANCIAL ENTITY FOR THE ANALYSIS OF THE NETWORKS AS OF DECEMBER 2015
(billions of dollars)

Asset account	***Financial entities***				***Banking network***
Billions of dollars	*PB*	*CO*	*FS*	*MU*	
11 *Available funds*	6,049.5	471.3	198.4	37.1	
1101 Cash	1,153.8	77.5	0.4	6.6	
1102 Deposit reserves	1,679.6	–	34.7	16.4	
1103 Banks and other FEs	2,564.2	390.5	163.3	12.8	
110305 Banco Central del Ecuador	0.1	126.7	–	0.0	
110310 Banks and domestic FEs	828.5	205.5	133.6	12.1	X
110315 Banks and foreign FEs	1,735.7	1.3	29.6	0.7	
1104 Immediate clearing payments	282.6	3.3	0.1	1.3	
1105 Intransit remittances	369.3	0.0	–	0.1	
12 *Interbanking operations*	39.7	2.1	–	–	X
13 *Investments*	4,438.0	519.7	113.9	59.8	
1301 Fair value –private sector	57.9	12.7	0.4	–	X
1303 Available for sale –private sector	1,455.6	404.4	14.4	21.2	X
1305 Held until expiration –private sector	27.3	102.7	8.1	–	X
1302 Fair value–public sector	250.9	–	–	–	
1304 Available for sale –public sector	980.6	0.4	43.3	1.8	
1306 Held until sale –public sector	1,487.7	–	50.3	36.3	
1307 Restricted availability	245.2	0.9	–	0.7	X
1399 Provisions for investment	–67.33	–1.31	–2.60	–0.18	

Source: Created by the authors.

system. Within this framework, a static comparative analysis of the representation of the networks between December 2012 and December 2015 will be undertaken, and monthly measurements for each financial entity will be calculated for the entire period. In addition, relative bilateral exposures in the financial system will be determined in terms of each entity's capital used to guarantee deposits and entrusted investments. A transmission risk index will be created as an instrument for determining a systemic importance rating.

The accounting values that will be used to establish the interrelations are detailed in Table 3.

3.1 Interbank Exposure

For the analysis of interbank exposure, accounts on the books have been classified into two types: interbank deposits and investments (interbank debt market). Table 2 details the six assets that will be considered for creating the interbank network. These assets can be divided into *1)* available local financial institution funds such as assets facing other national institutions, and *2)* repurchase agreements that include the four assets classes that make up marketable securities and debt up to its maturity. These two subnetworks are distributed proportionally by the balance amounts with a slightly larger share of average debt holdings participation throughout the sample. Interbank deposits and repurchase agreements stand out as the main asset classes, so the analysis of the networks will focus on the aforementioned assets.

The information base included 80 deposit institutions both active and liquidated. The size of the network was fixed to control the relevance of changes in network structure resulting from the disappearance of institutions in the sample which are included in the network as disconnected nodes.[11] The re-

[11] Only depositary financial institutions that provide information about minimum liquid reserves and internal liquidity ratio were considered in the sample.

sults comparison was done between December 2012 and December 2015.[12]

Figure 4 shows the interbank network of the Ecuadorian financial system as of December 2015 within which the interconnections of financial entities occurs.[13] The size of the nodes is a function of the degree, while the thickness of the edges depends upon the book value of the assets being considered in the analysis. In this first representation of the interconnectivity, four sets of financial entities and their interconnectivity can be distinguished. In the first group, the majority of the cooperatives have ties with two mutuals and four banks (two of these being very small, one small and the other medium-sized). In the other three groups can be found the four largest banks in the country, and the financial companies evenly distributed; while there are two cooperatives for each grouping of entities. Finally, the two remaining mutuals are present in two of the three groups. It should be mentioned that the interrelations of these sets of entities in practice correspond to the country's financial groups.

The structure of the interconnections is then broken down into a network of deposits and a network of investments in order to observe the interrelations of the financial system in each case. At the same time, the size of the nodes found in both networks is a function of the number of connections, while the thickness of the edges depends on the book value of the deposits and investments (taken separately).

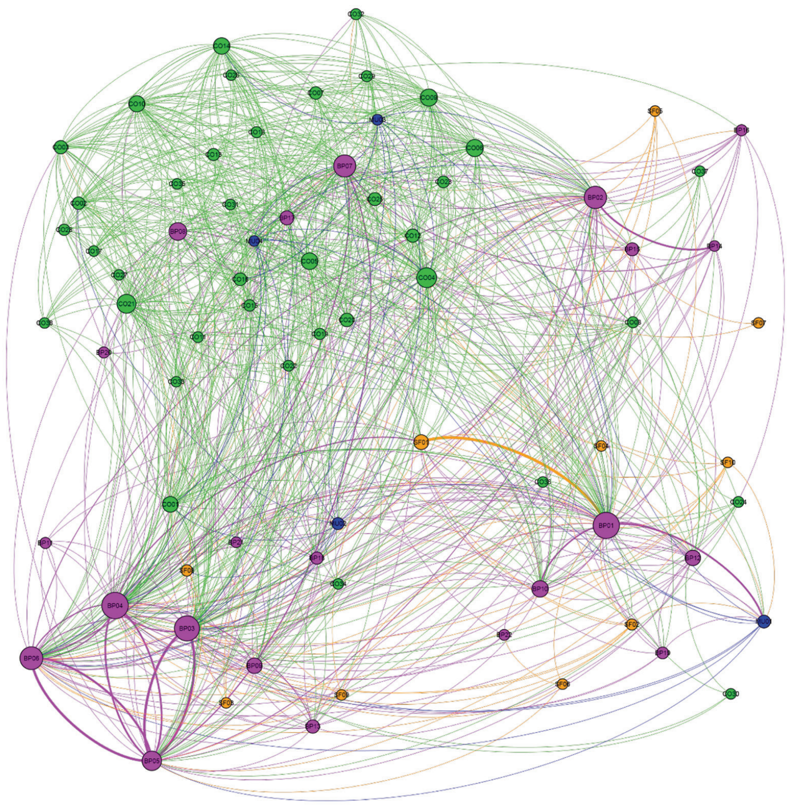
---

[12] The analysis period, from December 2012 to December 2015, was selected in terms of the comparison that can be made with respect to information structures in which financial institutions must report their minimum liquidity reserves (MLR) and domestic liquidity ratio (DLR) to the Banco Central del Ecuador pursuant to Regulation No. 032-2012 of the Directory of Banco Central del Ecuador.

[13] The network model selected for the analysis refers to the direct interconnection weighted by the book value of the selected assets.

Figure 4

ECUADOR'S FINANCIAL SYSTEM: INTERBANK NETWORK, DECEMBER 2015



Private banks

Cooperatives

Mutual societies

Financial societies

Source: Authors' elaboration.

Figure 5 shows the network of interbank deposits as of December 2015. In this case, the position of the nodes is stable and a strong link between the largest banks located in the lower left of the graph can be observed. Equally, a strong interconnection between the cooperatives can be seen. The importance of PB01 can be seen in the number of deposits coming from all types of entities, among which the relation with SF01 stands out. While for its part, this bank only maintains deposits with two entities belonging to the same financial grouping (PB10 and PB12).

On the other hand, Figure 6 shows the relations resulting from interbank investments in the financial system as of December 2015. This network shows an even stronger link between private banks, especially the interconnectivity between the large banks. The case of investments by MU01 in PB01 are notable. Similarly, the cooperatives maintain strong ties among themselves, while the mutuals, as in the case of financial companies, diversify their investments between various types of financial entities.

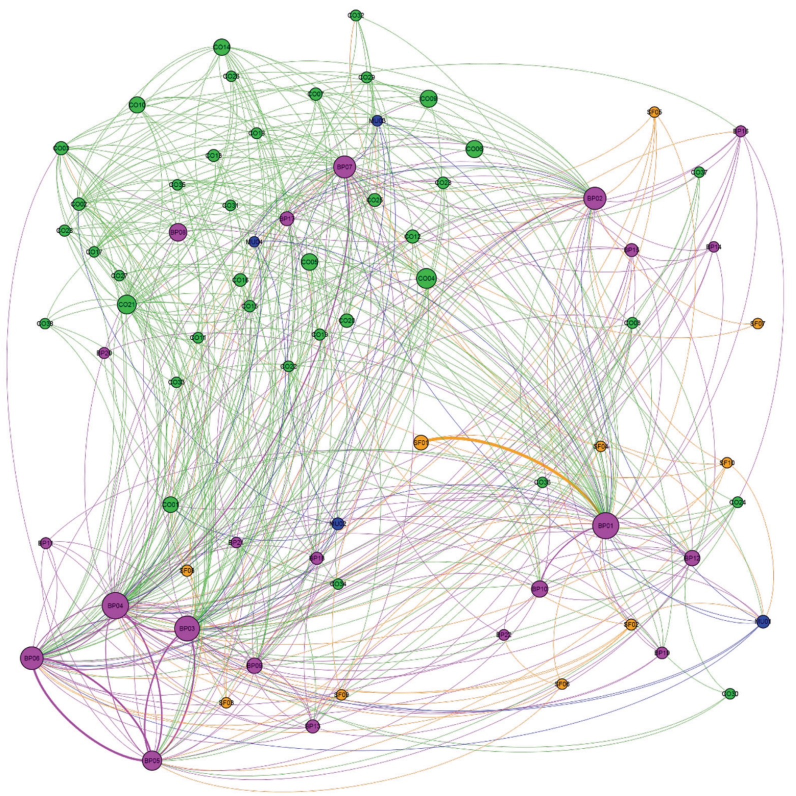
The graphical representation of the interbank network as of December 2015 is a first general view of the structure of the interconnections of the entities of the Ecuadorian financial system. It is, therefore, necessary to identify exposures by asset type, as well as to calculate the network measures for the purpose of describing the network structure, determining the systemic importance of certain entities in the Ecuadorian financial system, and making a comparison to determine if significant changes occurred between December 2012 and December 2015.

Figure 7 shows the interrelations of financial institutions[14] classified by type of entity and ordered according to each financial institution's amount of assets. As a result, the largest financial institutions occupy the first spaces in each type. Bilateral exposure is represented by the intersection of the coordinates

[14] In terms of total amounts deposited and invested in the counterparts of the financial system.

Figure 5

ECUADOR'S FINANCIAL SYSTEM: INTERBANK DEPOSITS NETWORK, DECEMBER 2015



Private banks

Cooperatives

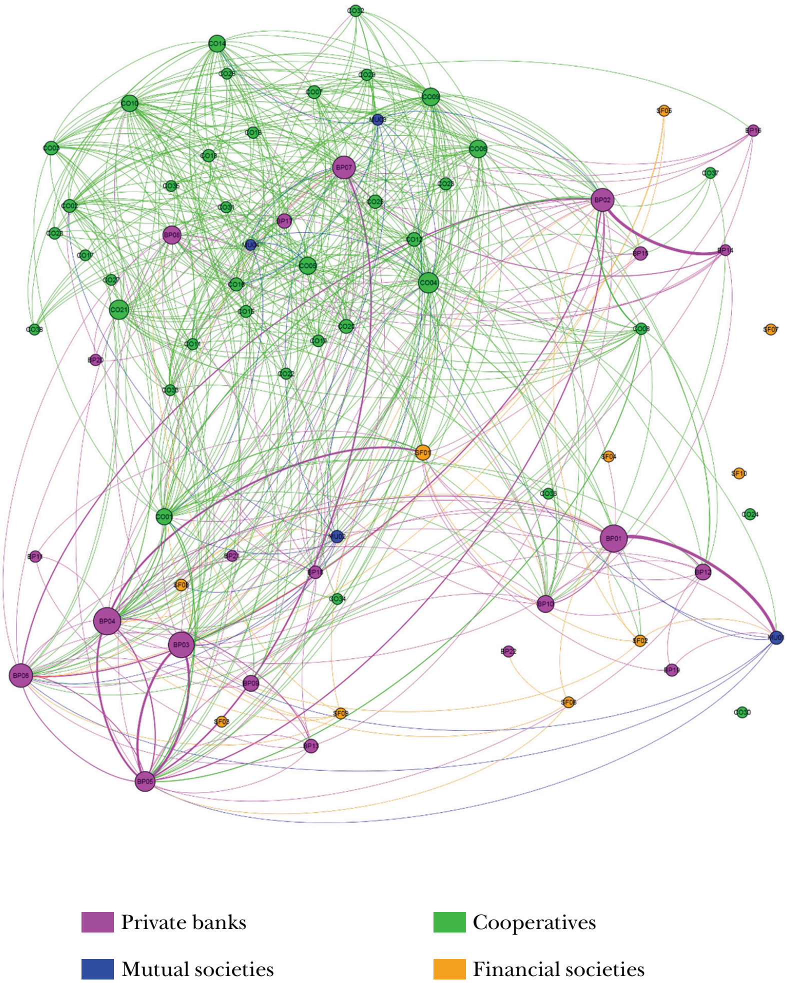
Mutual societies

Financial societies

Source: Authors' elaboration.

Figure 6

ECUADOR'S FINANCIAL SYSTEM: INTERBANK INVESTMENTS NETWORK, DECEMBER 2015



Source: Authors' elaboration.

Table 4

EXPOSURE AMOUNT RANGES
(dollars)

- More than 5M dollars
- Between 1M and 5M dollars
- Between 500,000 and 1M dollars
- Between 100,000 and 500,000 dollars
- Less than 100,000 dollars

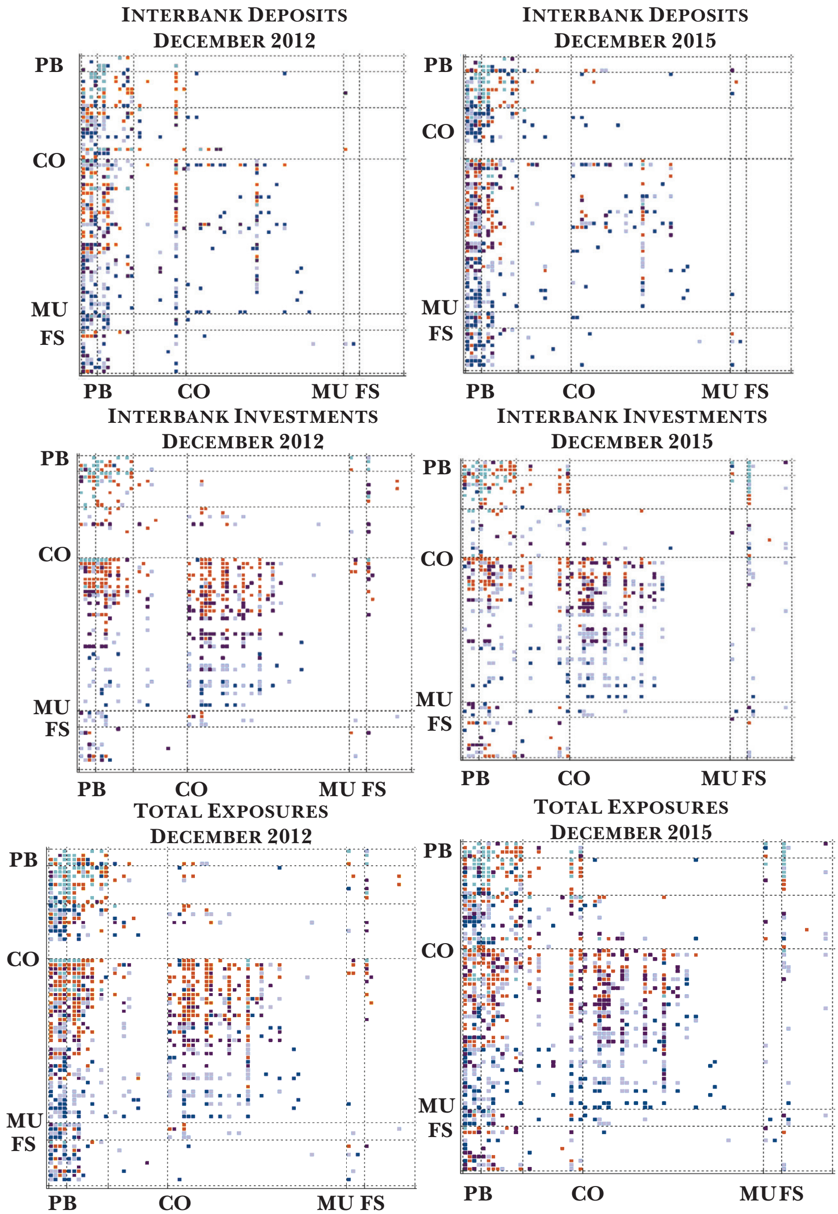
of the financial entities along the axes with a colored square. The amounts of the exposures differed according to the ranges shown in Table 4.

The first row of the figure shows local banks' available funds as well as the interbank operations of the financial institutions. In this case, it can be seen that for both periods the financial entities' deposits are concentrated, especially at private banks: as of December 2012, 70% of total exposure; while as of December 2015, participation decreased to 66%. The largest cooperatives are also receiving amounts of between 100,000 USD an 5 million USD, and only one received an amount greater (December 2015), although to a lesser proportion than the private banks. The mutuals and financial companies have almost no ties to the group and they act as net lenders to the rest of the system. In particular, mutuals and financial companies give their funds to private banks, although certain mutuals do so to some cooperatives. Their interconnectivity is very slight and limited to interactions with the large entities in the financial system.

The second row corresponds to the assets financial entities keep as investments. The financial system's interconnectivity regarding this type of asset demonstrates the large participation of banks and cooperatives as lenders and borrowers in the

Figure 7

ECUADOR'S FINANCIAL SYSTEM:
INTERBANK NETWORKS BY ASSET CLASS
(US dollars)



Note: PB: private banks, CO: cooperatives, SF: financial societies, MU: mutual societies.
Source: Authors' elaboration.

debt market. In contrast to the section regarding interbank deposits, the banks and cooperatives have more connections in the investment market, whose total represents 73% and 23% respectively as of December 2012, and between 56% and 42% as of December 2015. This situation creates important channels for the transmission of possible disturbances in this group of institutions. Although the largest exposures are concentrated in the larger cooperatives, even the smallest show a certain degree of interconnection. On the lending side, the largest institutions in each group obtain substantial financing from the private banks, especially through debt securities,[15] which creates an indirect channel for shocks between mutuals and financial societies and via the private banks for the rest of the system.

In the third row two types of assets (interbank deposits and investments) in each year are added, with the general result of a denser network in the sector where the large private banks are located, which also correspond to amounts of more than 5 million USD. On the other hand, the participation of both private and cooperative banks in the debt market, and the lack of interconnectedness between mutuals and financial companies with most of the financial system–with the exception of the largest financial entities–are notable. Between December 2012 and December 2015, there is a change in the financial companies where the interrelations with the financial system in general, and even more with private banks, loses its strength, and the amounts decrease from one period to another which could be explained by regulatory provisions covering these types of financial entities.

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[15] Documents representing a payment obligation for capital and interest on the part of the issuing company on a certain due date (Caxia, 2016). Debt securities are negotiable securities that incorporate a credit right in the strict sense, which allows the issuer to finance investments through its placement in the capital market (Comisión Nacional de Valores, 2007).

3.2 Measurements of Ecuadorian Financial System Exposures

While the representations of the structure of the networks during the two periods of time show some changes in the interconnections of the Ecuadorian financial system, it is necessary to analyze the behavior of the principal metrics over time to determine if there have been visible changes in their composition. The evolution of some important metrics of the interbank system of the financial system is represented in Figure 8.

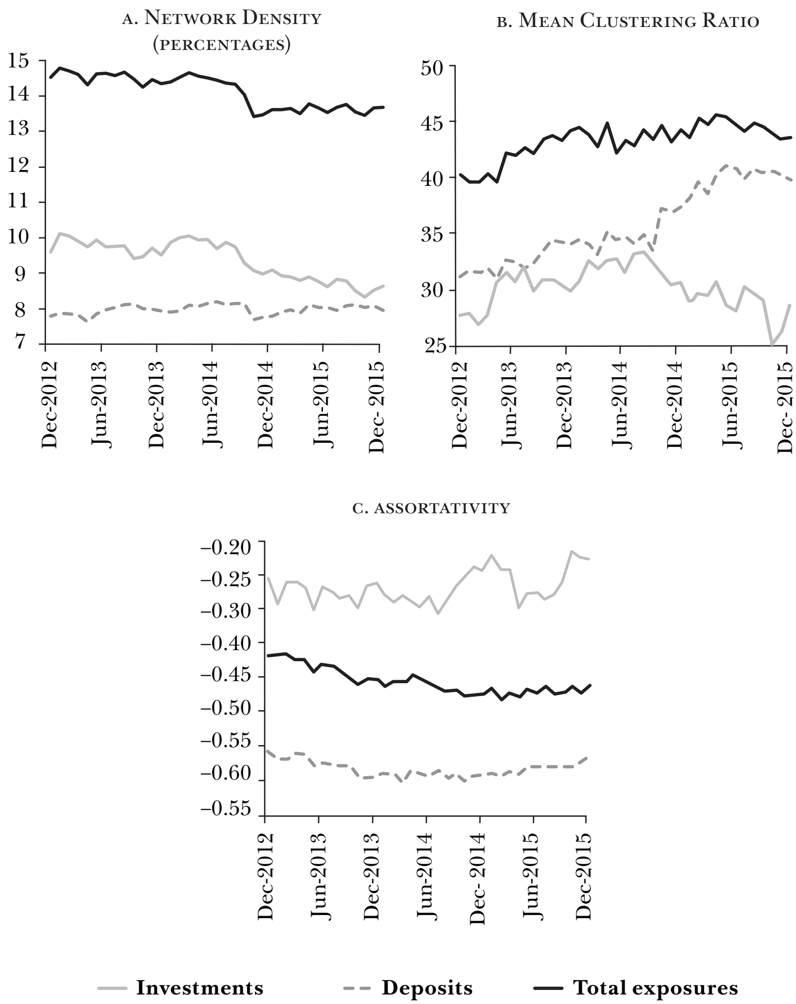
The density of the network is the proportion of links present in a network relative to the total number of possible links. The path of this indicator for the network of total exposures during the period shows a slight decline which probably can be explained by the decrease in the interconnection of the investment market subnetwork. In Figure 8:

- The evolution of the ties present in a network in relation to the total number of possible links is identified. The deposit subnetwork remains at around 8%, while the investment subnetwork decreases from 10% to 8.6% in December 2015, although this subnetwork has a higher density than those of the deposit interrelations.
- The path of the clustering coefficient is shown;[16] this indicator describes the interconnection of the nearest neighbors to some vertex. A high and upward-trending coefficient indicates that most financial institutions, if not directly connected, have common connections with other entities. In the case of the Ecuadorian financial system, interconnections between financial entities display the previously explained characteristic: They are not directly interrelated, but the distance separating their common vertices, to arrive from one to another, is short in the case of any eventual shocks.
- The path of the assortability coefficient refers to the tendency of the central nodes to be linked to others that meet this

[16] Metric of non-local character that calibrates the density of the connections around some vertex.

Figure 8

ECUADOR'S FINANCIAL SYSTEM: INTERBANK NETWORKS METRICS, DECEMBER 2012 TO DECEMBER 2015



Source: Authors' elaboration.

same characteristic, avoiding interlacing with lower grade nodes. The Ecuadorian financial system network presents negative coefficients over time, resulting in the manifestation of weakly connected entities that tend to have ties to entities that are strongly connected.[17]

3.3 Measurements of the Entities that Make Up the Ecuadorian Financial System

Table 5 shows the principal each financial entity's metrics by degree (entry and exit) as of December 2012 and December 2015. In section *a*, the entities with the highest degrees of exit are shown. The cooperatives diversify their relations in greater measure since only a bank appears on the list for each year, PB42 and PB04 respectively.[18] The principal entities based on entry grade are shown in section *b*. In this case, private banks show greater participation, which indicates, in first place, the concentration of assets on the part of the rest of the entities in those that have higher values; and, in second place, imply a large amount of uncertainty in the case of adverse shocks, due to the concentration they have.

Table 6 shows the financial institutions with the highest degree of average proximity. For this measure, the financial entities are the ones that possess a higher indicator and, as a consequence, have neighbors that have high levels of interconnection. For this reason, this would aid in the faster spread of an eventual shock throughout the financial system: Five of the 10 entities that appear on the list as of December 2012 also appear as of December 2015.

Table 7 shows the measures related to *betweenness*. During the period under analysis, there is a marked change among the

---

[17] If the assortability is negative, it implies that weakly connected nodes join with strongly connected nodes; if assortability is positive, it signifies that strongly connected nodes join with other strongly connected nodes.

[18] Considering that both entities were merged at the end of 2014.

Table 5

PRINCIPAL FINANCIAL ENTITIES BY DEGREE
(number of connections)

a) Exit Degree			*b) Entry Degree*		
Financial entities	*December 2012*	*Decembrer 2015*	*Financial entities*	*December 2012*	*Decembrer 2015*
CO02	29	29	PB04	40	65
CO10	18	26	PB01	68	62
CO14	21	24	PB03	59	58
CO05	21	23	PB06	51	49
CO09	17	23	PB07	43	47
CO03	18	22	PB02	38	47
CO08	26	21	CO04	35	38
CO01	18	20	PB05	38	36
CO11	13	20	CO21	32	33
CO33	19	19	PB08	19	29
CO19	14	19	PB24	48	0
PB04	11	19	PB26	34	0
CO06	20	18			
PB24	22	0			

Source: Authors' elaboration.

financial entities that present many possible contagion routes (centrally located for betweenness). In December 2012, of the ten principal financial entities, six were cooperatives, three banks, and one a mutual. In contrast, as of December 2015, six were banks and four were cooperatives. Finally, three entities maintained their statuses in both periods.

3.4 *Core* or *Peripheral* Entities

Also, when applying the core-periphery algorithm, the presence of financial entities cataloged as core or nuclear, was

Table 6

ENTITIES WITH THE LARGEST AVERAGE DEGREE OF PROXIMITY
(number of connections)

Financial entities	*December 2012*	*December 2015*
FS05	76.0	62.9
FS09	62.0	61.2
FS07	51.3	58.5
FS03	0.0	57.0
MU04	53.1	56.6
CO26	50.4	56.0
PB22	18.4	56.0
CO24	44.4	55.4
CO27	51.3	55.3
CO37	60.3	53.6
CO31	52.0	53.0
PB16	53.9	45.7
CO34	53.0	45.1
FS08	57.0	39.8
PB18	55.3	30.1

Source: Authors' elaboration.

verified. This structure affirms that the core entities serve as nodes between the periphery entities that do not directly interact among themselves but do so with core entities. In addition, the entities of the core interact intensely with each other and are systemically important in the network. This application uses the definition seen in Craig and Von Peter (2014). In the case of the Ecuadorian financial system, the number of entities that are cores or nodes is stable over time (an average of 18 entities for the total exposures network, 10 in the deposits network and 15 in the investments network), and they act as intermediary links between the peripheral entities that do not interrelate directly among themselves.

Table 7

ENTITIES WITH THE HIGHEST BETWEENNESS
Number of short routes

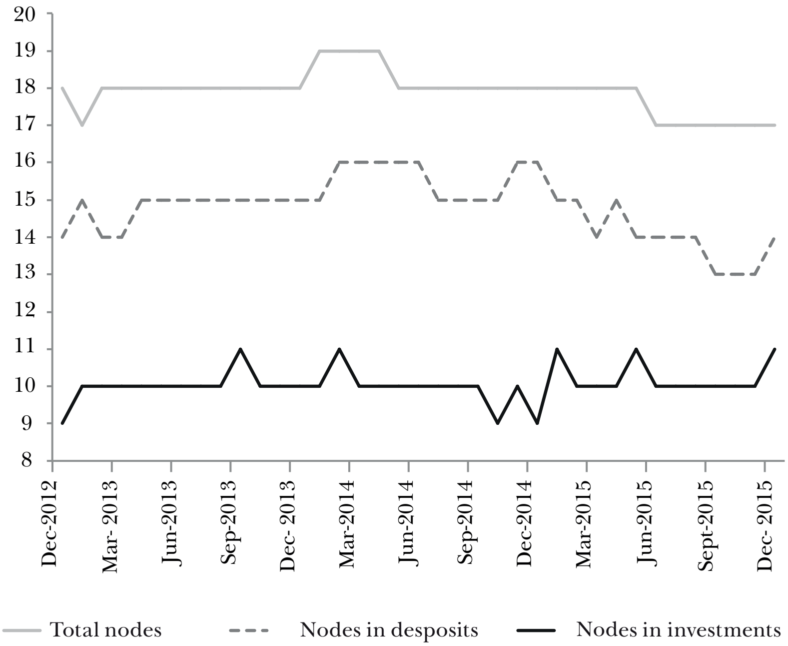
Financial entities	*December 2012*	*December 2015*
PB15	26	1,315
PB18	0	1,270
CO25	1,543	1,158
PB05	1,067	1,137
CO21	181	1,058
PB04	197	882
PB08	173	775
PB17	154	745
CO16	310	711
CO12	0	558
CO10	333	306
PB02	768	286
CO23	297	61
MU01	665	6
CO09	279	3
PB24	694	0
CO17	231	0

Source: Authors' elaboration.

The construction of the networks also made it possible to identify certain entities whose metrics show the importance they play in the financial system. In general, during the period under analysis, there is no change in the structure of these entities and they are stable in terms of their participation in the financial market (Table 8). Large private banks tend to be located at the top of the list, while many other institutions deserve attention from the point of view of systemic risk due to their role in all of the entity groups.

Figure 9

ECUADOR'S FINANCIAL SYSTEM: EVOLUTION OF THE NUMBER OF FINANCIAL INSTITUTIONS CONSIDERED AS NODES



Source: Authors' elaboration.

Table 8

ECUADOR FINANCIAL SYSTEM: FINANCIAL ENTITIES CATALOGED AS CORE

Order 2015	*Financial entity*	*December 2012*	*December 2013*	*December 2014*	*December 2015*
1	PB01	✓	✓	✓	✓
2	PB02	✓	✓	✓	✓
3	PB03	✓	✓	✓	✓
4	PB04	✓	✓	✓	✓
5	PB05	✓	✓	✓	✓
6	PB06	✓	✓	✓	✓
7	PB07	✓	✓	✓	✓
8	CO01			✓	✓
9	PB08		✓		✓
	PB09	✓			
	PB10		✓	✓	
10	CO02			✓	✓
	PB12	✓			
	CO03	✓	✓	✓	
11	CO04	✓	✓	✓	✓
12	CO05	✓	✓	✓	✓
13	CO06	✓	✓	✓	✓
14	CO09	✓	✓	✓	✓
15	CO10		✓	✓	✓
16	CO14	✓	✓	✓	✓
17	CO21	✓	✓	✓	✓
	PB24	✓	✓		
	PB26	✓			

Source: Authors' elaboration.

In this context, the largest private banks are of fundamental importance according to the measures calculated for the network; so, as a result, there is congruence between network centrality and the size of the assets. The magnitude of the private banks' participation plays an important role and this is transmitted by their market share in the system. Between December 2012 and December 2015, these entities have maintained their importance to both the total exposures environment as well as in each subnetwork (deposits and investments). In the investments submarket, some small private banks and medium-size cooperatives are of fundamental importance due to their active participation in the debt and deposit markets respectively.

The large private banks are also seen as core, and the small banks are the most important in terms of deposits exposures. Only the new cooperatives serve as nuclei and therefore are important in the financial system, while the mutuals and the financial companies do not play relevant roles as cores which implies their role as disrupters of shocks to the system.

3.5 Relative Exposures and Risk of Transmission

With respect to relative exposures, based on the adjacency matrix obtained as a function of the exposures in terms of capital that each financial entity can guarantee to its counterparts–as well as the calculation of the transmission risk index–, illustrations representing the transmission risk index for the years 2012 and 2015 have been created. The transmission risk index values were divided into four ranges that will later serve to establish the rating of systemic importance for each entity. The size of the bubbles representing the financial entities is a function of each entity's assets, while the entities' locations in the quadrants represent the accumulated vertical (abscissa axis) and horizontal (ordinate axis) exposures where each quadrant constitutes one of the four categories of relative exposure.

Table 9

CLASSIFICATION OF ENTITIES ACCORDING TO RELATIVE EXPOSURE CATEGORIES

Quadrant	*Entities*
1	Vulnerable and transmitters
2	Vulnerable
3	Indifferent
4	Transmitters

When comparing the two years of analysis, 2012 and 2015 (Figures 10 and 11), the entities that are high on the transmission risk index are principally located in quadrant 4 (next to entities that have intermediate values). These entities also have a high amount of assets and could be considered as the principal transmitters of any eventual shocks. They are entities categorized as cores, and their location in the network is strategic as well as the number of entities that are linked to them. In addition, the group of transmitter entities (quadrant 4) includes institutions with intermediate values on the transmission risk index and in accordance with the size of their assets, have a representative weighting in the financial system.

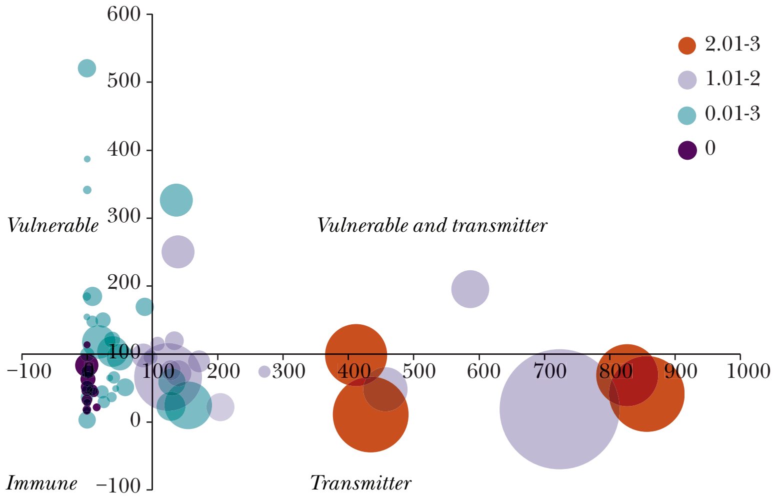
On the other hand, quadrant 3 principally contains entities that score zero on the index. These institutions have fewer assets and also do not represent a threat to the financial system in the case of shocks, so they were categorized as being immune.

Finally, in quadrant 2 which corresponds to vulnerable entities, we find institutions with relatively low values on the transmission risk index as well as having low participation in terms of their shares of assets in the financial system.

The main change between the two periods of analysis is the increase in entities that are located in quadrant 1 (vulnerable and transmitters) and that as of December 2015 are located in quadrant 4 (transmitters), as well as the increase in entities located in quadrant 3 (immunes) for 2015. Likewise, there is

Figure 10

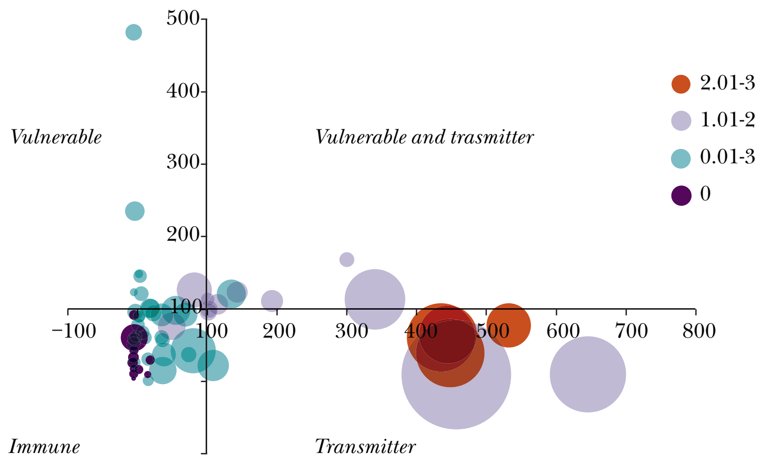
ECUADOR'S FINANCIAL SYSTEM: TOTAL EXPOSURES AND RANGES OF TRANSMISSION RISK INDEX, 2012



Source: Autors' elaboration.

Figure 11

ECUADOR'S FINANCIAL SYSTEM: TOTAL EXPOSURES AND RANGES OF TRANSMISSION RISK INDEX, 2015



Source: Authors' elaboration.

a decrease in the level of accumulated relative exposure both horizontally and vertically between 2012 and 2015.

Figure 12 compares the value of the transmission risk index for each entity between 2012 and 2015. It identifies a greater number of entities that have increased their values on the index in the period under analysis which implies an increase in the number of entities that have become systemically important. In this group of entities, savings and credit cooperatives, as well as financial companies are the most notable. On the other hand, the mutuals are the type of entities that show a decrease in their index value. Consequently, their importance in the financial system is diminished in contrast to the large private banks which have maintained a stable position as risk transmitters in the Ecuadorian private financial system.

The systemic importance of large banks is evident in their high values on the index both in December 2012 and December 2015, while the rest of the entities, in spite of their sizes, do not display an equal relevance.

Whenever relative exposures were identified, financial entities were classified in accordance with the proposed categories and the transmission risk index values were calculated for each of them. It is pertinent to simplify the network of relative exposure taking into consideration the entities whose index values for transmission risk are above 20%.[19] The networks in Figures 13 and 14 constitute a simplified financial system structure for the years 2012 and 2015 respectively. In this case, the size of the nodes is a function of the transmission risk index, and the thickness of the borders corresponds to the relative exposure of the entities that make up the financial system. There is a greater number of interrelations among the entities in 2012 compared to 2015[20] because in the first year there was

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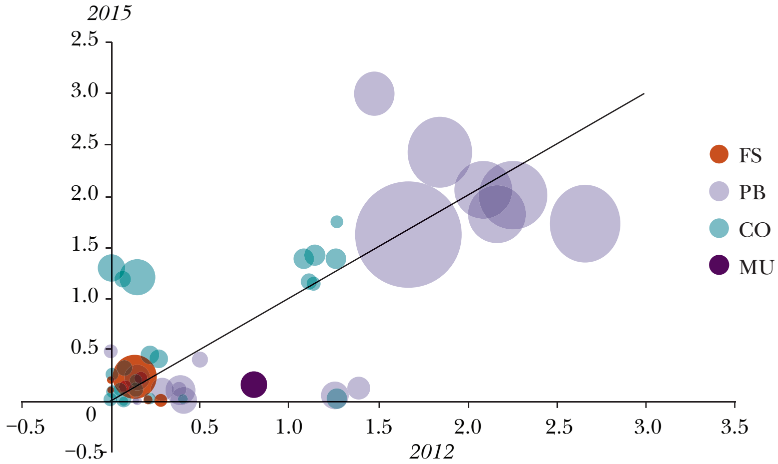
[19] It corresponds to the 90th percentile of the indexes calculated for 2015 and is a condition applied to the indexes for 2012.

[20] There is a total of 75 connections between 46 financial institutions for the year 2012 and 44 connections between 31 financial institutions for the year 2015.

Figure 12

ECUADOR'S FINANCIAL SYSTEM : VARIATION OF THE TRANSMISSION RISK INDEX, 2012-2015



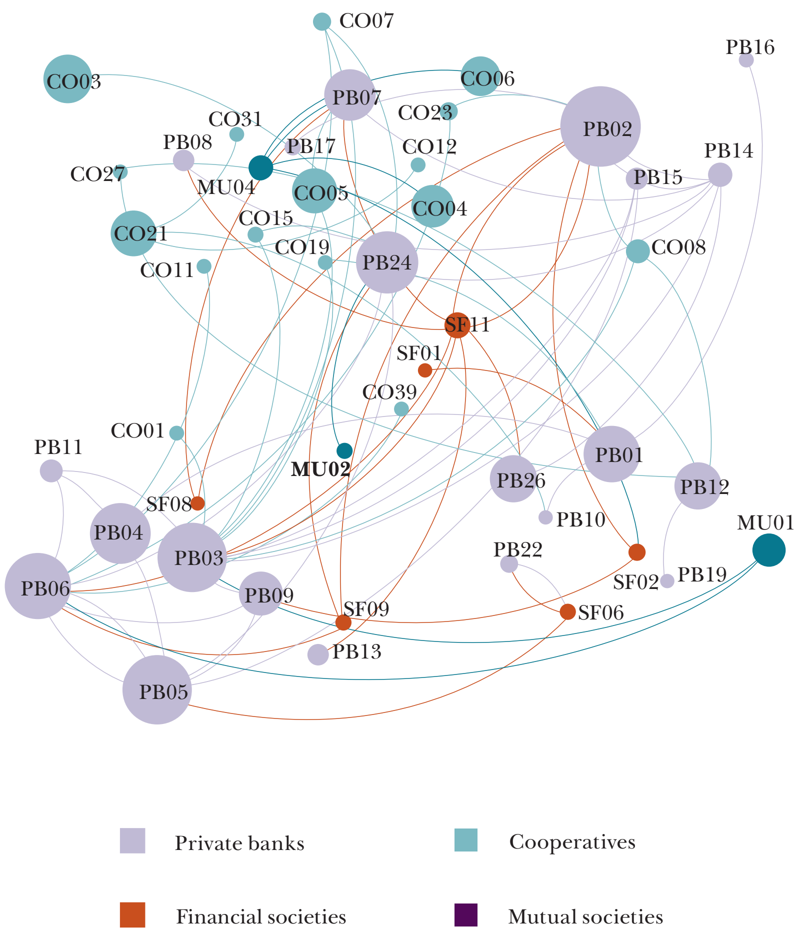
Note: PB: private banks, CO: cooperatives, FS: financial societies, MU: mutual societies
Source: Authors' elaboration.

a denser, more simplified network. Some entities have gained importance in the financial system in terms of their values on the transmission risk index, while others disappeared from the network due to their decreased values on the transmission risk index to less than 20% as was the case with eight private banks, four cooperatives, two mutuals and one financial company. However, the role played by private banks in the financial system, especially large and medium-sized ones, remains stable precisely because of their importance as links between their counterparts.

Regarding the classification of the entities of systemic importance, Table 6 shows the transmission risk index as a rating and verifies that five entities that have the most systemic importance between December 2012 and December 2015 are banks. In 2015, PB07 is notable. It doubled its value on the transmission risk index, showing the most accumulated relative exposure, the highest betweenness (strategic location in

Figure 13

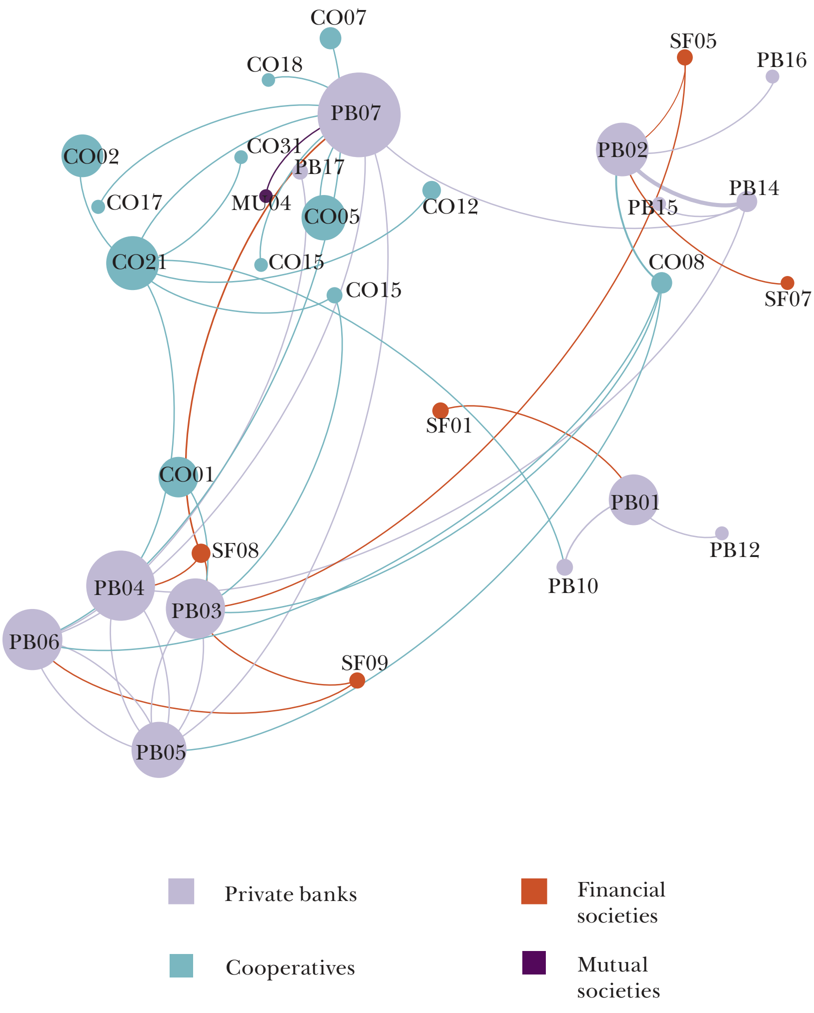
ECUADOR'S FINANCIAL SYSTEM: SIMPLIFIED NET OF RELATED EXPOSURES. INSTITUTIONS WITH RELEVANT EXPOSURE GREATER THAN 20%, DECEMBER 2012



Source: Authors' elaboration.

Figure 14

ECUADOR'S FINANCIAL SYSTEM: SIMPLIFIED NET OF RELATIVE EXPOSURES. INSTITUTIONS WITH RELATIVE EXPOSURE GREATER THAN 20%, DECEMBER 2015



Source: Authors' elaboration.

the network) and it is an entity that is considered core in the network. This financial institution is part of a group of transmitter entities which implies a high probability of triggering a strong shock or detrimental impact in the event that the referred to the institution has a failure.

The most significant variations are in the banks PB24 and PB26 which would respond to mergers between them and others in the financial system, while the cooperative CO03 has lost importance both in terms of its level of accumulated exposures and in the measure of betweenness. On the other hand, three cooperatives have gained systemic importance, which corresponds to their greater volumes of assets as of December 2015.

4. CONCLUSIONS

- With respect to interbank exposures referring exclusively to deposits with financial entities, the entities especially concentrate their deposits in private banks: 70% of the total exposures of these assets is concentrated in the banks as of December 2012, which declined to 66% as of December 2015.
- When considering the interconnections in the investments market, the financial system interconnections show a large participation on the part of the banks and cooperatives as lenders and borrowers in the debt market. In contrast, in the section of interbank deposits, the banks and the cooperatives have more interconnection in the debt market at 73% and 23% respectively as of December 2012, and at 56% and 42% respectively as of December 2015.
- With respect to total interbank exposures, a higher density network was seen in the sector where the largest private banks are located, corresponding to amounts of more than USD 5 million. On the other hand, the participation of both private banks and cooperatives in the debt market, and the lack of interconnectedness between mutuals and financial companies with most of the financial system–with the exception of the largest financial entities–are notable.

Table 10

QUALIFICATION OF FINANCIAL ENTITIES WITH SYSTEMIC IMPORTANCE ACCORDING TO THE TRANSMISSION RISK INDEX

Financial entities	*December 2012*	*December 2015*
PB07	1.47	3.00
PB04	1.86	2.41
PB06	2.10	2.05
PB03	2.23	2.01
PB05	2.17	1.82
CO21	1.26	1.74
PB02	2.64	1.73
PB01	1.66	1.62
CO04	1.15	1.42
CO05	1.26	1.39
CO06	1.08	1.38
CO02	0.00	1.29
CO01	0.15	1.19
CO10	0.06	1.18
CO09	1.11	1.15
CO14	1.13	1.14
PB12	1.38	0.10
PB09	1.26	0.05
CO03	1.27	0.00
PB24	1.87	0.00
PB26	1.32	0.00

Source: Authors' elaboration.

- Regarding networks metrics calculated from December 2012 to December 2015, the series are stable over time which points to a stable network structure over the period under analysis, results that are verified even when demand deposits and term deposits, the loan portfolio and the portfolio management indicators showed deterioration. In this context, the largest private banks are of fundamental importance according to the metrics calculated for the network; so network centrality is consistent with the amount of assets. The magnitude of the private banks' participation plays an important role in the path of estimated metrics, and such participation is transmitted by their market share in the system. This is shown in the 2015 measurement of systemically important entities, considering the risk transmission index based on relative exposures, the betweenness measure, and the core-periphery analysis.
- Between 2012 and 2015 many entities increased their values on the transmission risk index, implying an increase in the number of entities that have become systemically important. Large private banks maintained their position.
- The simplified relative bilateral exposure network for each year shows a denser network in 2012 compared to 2015, where fewer entities have more than 20% relative exposure in terms of the capital guarantees they have for their counterparts.

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Long-run Money Demand in Latin American Countries: A Nonstationary Panel Data Approach

César Carrera

Abstract

Central banks have long been interested in obtaining precise estimations of money demand given the fact that its evolution plays a key role over several monetary variables and the stability of the financial system. I use Pedroni's (2002) fully modified ordinary least squares (FMOLS) to estimate the coefficients of the long-run money demand for 15 Latin American countries. The FMOLS technique pools information regarding common long-run relations while allowing the associated short-run dynamics and fixed effects to be heterogeneous across different economies of the panel. For this group of countries, I find evidence of a cointegrating money demand, an income elasticity of 0.94, and an interest rate semielasticity of −0.01.

Keywords: money demand, panel cointegration, FMOLS, Latin America.

JEL classification: C22, C23, E41.

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1. INTRODUCTION

Central banks and economists have long been interested in obtaining precise estimates of money demand for at least two reasons. First, knowing the income elasticity of long-run money demand helps to determine the rate of monetary expansion that is consistent with long-run price level stability. Second, knowing the interest rate semielasticity of money demand aids in calculating the welfare costs of long-run inflation. In addition, a well-identified money demand function is key for understanding how to react to the observed financial progress (see Darrata and Al-Sowaidib, 2009).

Until the early 1970s, the discussion between the IS-LM model of John Maynard Keynes and John Hicks and the real business cycles paradigm of Robert Lucas, Finn Kydland, and Edward Prescott seemed to be irreconcilable. Real business cycle models assume full market clearing, whereas a central feature of IS-LM models is either wage or price rigidities. At some point, however, wage and price rigidities are introduced into those dynamic and stochastic models (now known as DSGE models), which narrowed the gap between these views. Some authors constructed DSGE models displaying some features of the IS-LM model such as Bénassy (2007) and Casares and McCallum (2006). In this regard, while the IS survived most of the critiques, the LM seems to be a less important feature (the quantity of money supplied in the economy is endogenously determined for central bank's decision over an interest rate target).

However, some authors argue that ignoring the LM curve could be troublesome. The preferences for money (money demand) motivated a series of studies such as its effects on the business cycles, correct identification of monetary policy shocks, or currency substitution. For example, Ireland (2004) argues that a structural model of the monetary business cycle implies that real money balances enter into a correctly-specified forward-looking IS curve if and only if it enter into a correctly-specified forward-looking Phillips curve. Ireland points out that empirical measures of real balances must be adjusted for shifts in money demand to accurately isolate and quantify the dynamic effects of money on output and inflation.

In this paper I follow the Ball (2001) and Mark and Sul (2003) approach of long-run money demand as a cointegrating relation. The reduced-form specification is based on the LM setup in which the elasticity of money with respect to income is positive and the semielasticity with respect to the interest rate is negative. While the original setup is heavily criticized on grounds of lack of microfundations, most of the results can be rescued with money-in-the-utility function or cash-in-advance models. In this regard, Walsh (2010) argues that the empirical literature on money demand is vast. Walsh presents money in the utility function model and discusses the parameter values of the money demand function for several cases. My results are supported by those of the previous literature, and the contribution is given for the technique used in the estimation of parameters that better characterizes the money demand function in Latin American.

I use fully modified OLS (FMOLS) proposed by Pedroni (1999). This panel cointegration technique allows researchers to selectively pool information regarding common long-run relations from across members of the panel while allowing the associated short-run dynamics and fixed effects to be heterogeneous across different members of the panel. According to Pedroni, it is reasonable to think in members of a panel as a sample drawing from a population that is either I(1) or I(0) and each member represents a sampling from its own separate population. For Pedroni, there is no theory that indicates if a member of a group that is selected would give a response (with respect to GDP, inflation, or other variable) that is informative enough for all remaining members of the group. Moreover, this author argues that FMOLS do a better job at estimating heterogeneous long-run relations than a dynamic OLS (DOLS).

Combining observations from 15 countries I build an unbalanced panel and employ FMOLS to estimate the coefficients of the long-run money demand function in these countries. I also test if the signs of the coefficients are consistent with the LM curve of the IS-LM model. These countries have a cointegrating money demand with an average income elasticity of 0.94, and an average interest-rate semielasticity of −0.01.

This paper is part of the literature that estimates money demand as an exogenous variable. For Latin American countries, most studies focus on individual country cases and to the best of my knowledge there are no panel studies for this region. This is an initial effort to reveal the parameters that govern this key relation in economics under a panel view.

The rest of the paper is organized as follows. Sections 2 and 3 introduce and discuss a theory on money demand, with special emphasis in the IS-LM model. In Section 4, I introduce nonstationary panels, test for cointegration, and use FMOLS to estimate the money demand for Latin American countries. Section 5 concludes.

2. MONEY DEMAND THEORY

First developed by John Hicks in 1937 the IS-LM model is an attempt to portray the central ideas of Keynes' general theory. As Bordo and Schwartz (2003) point out, monetarists dislike the IS-LM framework because it limits monetary influence too narrowly, essentially to the interest elasticity of money demand. The "IS-LM has survived all of its criticisms over the years [...] it is simple, elegant, and easy to manipulate [...] It is [...] the workhorse of open macroeconomics and of the IMF in its evaluation of member countries' economic balance [...] Finally it has now been endowed with the legitimacy of microfoundations based on optimizing behavior by households and firms" (Bordo and Schwartz, 2003, p. 22).

In this section I discuss the main money demand frameworks, specially the case of the LM. Referring to this, Mark and Sul (2003) point out that "in the era of dynamic general equilibrium models, Lucas (1988) shows that such a neoclassical model with cash in advance constraint generates a standard money demand function."[1]

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[1] Mark and Sul (2003), pp. 674-675. The authors cited Robert Lucas, *Money Demand in the United States: A Quantitative Review*, Carnegie-Rochester Conference Series on Public Policy, No. 29, 1998, pp.

2.1 Money Market Equilibrium in an Open Economy

This is a classic model setup. In order to study money demand, I consider a standard money market equilibrium model. First, I begin by assuming that the supply of money (M^s) is an exogenous policy variable decided by the monetary authority, such that:[2]

$$M^s = \bar{M}^s . \tag{1}$$

In a closed economy, the return on held money is negative and is given by the inflation rate $\hat{P}$. The opportunity cost of holding money is what it could have earned elsewhere, i.e. invested in other assets, which is r. The total opportunity cost of money therefore is given by this nominal interest rate:

$$r - (-\hat{P}) = r + \hat{P} = i, \tag{2}$$

where r is the real interest rate and i is the nominal interest rate.

Thus, the demand for money depends negatively on i. It also includes Y (income), an exogenous variable that determines the long-term demand for money.

In an open economy, assets are of two types: domestic and foreign. If the uncovered interest parity condition holds, then this return is the same as at home:

$$i_{t,k} = i^*_{t,k} + \hat{S}^e_{t,k}, \tag{3}$$

where $i_{t,k}$ and $i^*_{t,k}$ is the nominal interest rate in domestic and foreign, and $\hat{S}^e_{t,k}$ is the expected devaluation of the exchange rate.

137-168. For a Baumol-Tobin money demand approach, see Álvarez et al. (2003).

2 For models in which money is an endogenous policy variable in the context of the 2007 financial crisis, see the discussion between Lucas and Nicolini (2015) and Ireland (2015).

If uncovered interest parity does not hold, then $i_{t,k} \neq i^*_{t,k} + \hat{S}^e_{t,k}$ so I need to consider both i and $i^* + \hat{S}^e$ as potential opportunity costs. M^d then would depend on both i and $i^* + \hat{S}^e$,

$$M^d = M^d(\overset{-}{i}, \overset{-}{i^*}, \overset{-}{\tilde{S}^e}, \overset{+}{S}) \tag{4}$$

and in equilibrium, the interest rate clears the money market, i.e. , an equilibrium condition that equalizes money supply and money demand.

$$M^d = M^s. \tag{5}$$

2.2 International Business Cycles and the Mundell Fleming Model: A Keynesian Perspective of the Money Demand

In the short run, if prices adjust slowly (sticky prices), monetary policy can affect output. That is the essence of a Keynesian perspective. For a business cycles model, the combination of real resources or loanable funds market with the money market can be represented as:

$$S - I = NX \tag{6}$$

$$M^d = M^s, \tag{7}$$

where S is saving, I is investment, and NX is net exports.

Equations that show equilibrium on the demand side of the economy (IS) are

$$Y = C + I + XN$$
$$Y = C + S$$
$$S - I = XN$$

where C is consumption in the typical IS-LM setup.

To begin, it is assumed that the uncovered interest rate parity holds. Then, M^d depends on the opportunity cost of holding money, which is i. But, to relate this with the market for real resources, I express it in terms of the demand for real money balances,

8 $$\frac{M^d}{P} = \frac{M^d}{P}(\overset{-}{r}),$$

which reflects the opportunity cost of holding money as an asset.

Since I am interested in relating the market for real loanable funds, it is important to consider the effect of changes in Y over M^d/P, that is demand for money because of transaction needs:[3]

9 $$\frac{M^d}{P} = \frac{M^d}{P}(\overset{-}{r}, \overset{+}{Y}),$$

which means that real money balances depend negatively on interest rates and positively on the amount produced in an economy. Let me use L to denote the demand function for real money, so:

10 $$\frac{M^d}{P} = L(\overset{+}{Y}, \overset{-}{r}).$$

In an open economy, I consider that the central bank determines the money supply according to the assets that it holds both domestically and abroad. So that:

$$M^s = D + F,$$

where D is the domestic component of assets (such as domestic

[3] From Friedman's point of view, the Keynesian distinction between *active balances and idle balances* is irrelevant. "Each unit of money renders a variety of services that the household or firm equates at the margin" (Bordo and Schwartz, 2003, p. 7).

credit, bonds, etc.) and F is the foreign component of assets (such as gold, foreign reserves, etc.).

In real terms: $\frac{M^s}{P} = \frac{D+F}{P}$, and in equilibrium,

11 $$\left(\frac{M^s}{P}\right) = L(Y, r).$$

Combining the money market with the demand side (or loanable funds), I get an open economy IS-LM model (also known as the Mundell Fleming model), where:

- The IS curve depicts the different combinations of r and Y that are consistent with $S - I = NX$, that is, equilibrium in the loanable funds market.
- The LM curve depicts the different combinations of r and Y that are consistent with $\left(\frac{M^s}{P}\right) = L(Y, r)$.

3. REMARKS ON THE IS-LM MODEL

3.1 Recent Developments on the IS-LM Model

With respect to recent developments, Bordo and Schwartz (2003) mention that although the IS-LM is used to evaluate and conduct monetary policy, it does not actually have money in it. The model has three equations: An IS equation where the output gap depends on the real interest rate (the nominal rate minus the rationally expected inflation); a Phillips curve, which relates the inflation rate to the output gap and to both past inflation and rationally expected future inflation; and a policy rule (commonly known as the Taylor rule) that relates the short-term interest rate (central bank's policy instrument) to output.[4]

[4] "Although the model does not have an LM curve in it, one can add it on to identify the amount of money that the central bank will need to supply when it follows the policy rule, given the shocks that hit the economy. However, this fourth equation is not essential for the model" (Bordo and Schwartz, 2003, p. 23).

Friedman (2003) points out the work of Clarida et al. (1999) as the first and the standard new view of monetary policy, in line with the models described by Bordo and Schwartz (2003). He argues that the IS curve has survived, but the LM is gone due to changes in policymaking practice: "no central banker feels the need to be apologetic about believing the monetary policy does affect real outcomes" (Friedman, 2003, p. 8) given that monetary policy could not affect real outcomes because changes in expectations would undo the behavior that such models imply.

On the other hand, Leeper and Roush (2003) argue in favor of the role of money in monetary policy analysis. They find evidence of an essential role for money in the transmission of monetary policy. Both the money stock and the interest rate are needed to identify monetary policy effects. For a given exogenous change in the nominal interest rate, the estimated impact of monetary policy in economic activity increases monotonically with the response of the money supply; and the path of the real interest rate is not sufficient for determining policy impacts.[5]

3.2 Caveats and Other Remarks

In order to be consistent with the IS-LM model, knowing the effects of income over money demand facilitates the determination of the rate of monetary expansion that is consistent with the long-run price level stability. Moreover, due to the effects of interest rates on future consumption, knowing the interest rate effects over money demand eases the calculation of the welfare costs of long-run inflation.

[5] The authors basically estimate two models: with and without money, and analyze the outcome under a VAR approach, and find evidence that "money stock and the short term nominal interest rate jointly transmit monetary policy in the United States" (Leeper and Roush, 2003, p. 20).

Since the aim of this study is the money demand (LM curve), my main interest is to show the effects of an expansion of money supply through the money demand characterization. At least in the short run I would have an idea of how strong the effect is on output in response to an expansion of money supply. However, in order to be accurate I should also identify the IS curve.

Another relevant point about the IS-LM model is that in its evolution there are a number of Friedman's critics incorporated in the model, for example: "inflation is always and anywhere a monetary phenomenon and can be controlled by monetary policy; that monetary policy in the short run has important real effects because of the presence of nominal rigidities or lags in the adjustment of expected to actual inflation [...] and that policy rules are important anchors to stable monetary policy" (Bordo and Schwartz, 2003, pp. 23-24).

4. EMPIRICAL ANALYSIS

I follow Ball (2001) and Mark and Sul (2003) who approach the long-run money demand as a cointegrating relation.[6] However, it is important to mention that Ball (2001) uses time series analysis for the money demand in USA; meanwhile, Mark and Sul (2003) apply a panel DOLS (or pooled within-dimensions) to estimate the money demand of 19 OECD countries. My case is a group mean FMOLS (or group mean between-dimensions) to estimate the money demand in 15 Latin American countries.[7]

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6 Mark and Sul (2003) also mention the following authors whose research is in the same line: Stock and Watson (1993), "A Simple Estimator of Cointegrating Vectors in Higher Order Integrated Systems," *Econometrica,* Vol. 61, pp. 783-820; and, Hoffman (1995), "The Stability of Long-run Money Demand in Five Industrial Countries," *Journal of Monetary Economics*, Vol. 35, pp. 317-339. About studies of money demand for developing countries, see Kumar (2011).

7 See Walsh (2010, Chapter 2, pp. 49-52) for a review of the empirical literature on money demand.

The data I use in this paper comes from the International Financial Statistics (IFS) and covers the sample period 1948-2003. Money refers to M1 definition and interest rate is a short-term interest rate.

In this section, I *1)* introduce nonstationary panels, *2)* test for panel unit roots, *3)* test for cointegration, *4)* discuss FMOLS, and *5)* present results. I also present an exercise where the parameters of money demand can be compared between countries.

4.1 Nonstationary Panels

A nonstationary panel is a time series panel with unit root components which is typical of aggregate macro panels. Some of the characteristics of nonstationary panels are:

- substantial time series dimension (with serial correlation),
- substantial cross sectional dimension (with heterogeneity across members),
- single or multiple variables, and
- unit root present in at least some variables.

Nonstationary panel techniques are more useful when time series dimension is relatively large (too short for reliable inference for any member alone, but long enough to treat dynamics flexibly); cross sectional dimension, or number of members, is moderate (too large to be treated as a pure system); and at least some commonalities exist among the members (among parameters or hypothesis investigated).

If the time dimension is too short, it is difficult to model the underlying dynamics of the series. Typically, serial correlation properties differ across members of the panel, so sufficient time series length for each member is required to account for member specific dynamics.

Pedroni (2002) highlight the fact that panel methods minimally require at least some commonality across members (gain combining data from different members) so that improves upon reporting results for each member separately. The minimal types of commonalities required are either:

- Properties of the data (parameters or moments). The data do not have any shared values across members, but often must bound differences in a probabilistic sense (for example require that the probability that they are too far apart is bounded).

- Properties of the hypothesis. The hypothesis does not constrain all members to give the same answer to a hypothesis test, but different members of a panel should answer the same question, for example the answer for one member must have some bearing on a likely answer for another. Otherwise, the combination of data would not lead to better answering the research question.

In my case, I work an unbalanced nonstationary panel for the period 1948-2003, for 15 countries. With respect to commonalities, I restrain my analysis to the characteristics and parameters of the long-run money demand under a Keynesian approach for a group of countries. This group of countries is from Latin America, a particular region. In this paper, I assume that the financial systems and transactions technologies across Latin American countries are essentially similar.

4.2 Testing for Panel Unit Roots with Heterogeneous Dynamics

Panel approach involves some simplifications in order to achieve a reduction in the number of parameters to estimate. This is why exploiting commonalities must lie at the foundation of any panel time series approach.

From panel unit roots, if it is reasonable to imagine members of a panel as a sample drawing of a population that is either

I(1) or I(0) then it may substantially increase its power by using the panel dimension which substitutes observations over i=1, 2, 3, ..., N dimension to make up for short T dimension when members are independent over i.

In my case, I test if Keynesian monetary approach to money demand applies equally to all members of a panel. If it is not correct, it should fail regardless of which member is considered. This panel theory indicates property of data generating process for the population, while individual members of the panel are treated as different realizations from this population. Inability to see this on an individual basis for all members is due to low power in finite samples of the test, so as increase number of members, hence sample realizations of $\ln\left(M_{it}/P_{it}\right)$ improve the ability to conduct inference. Under this overview, panel test represents a direct increase in power over individual tests.

The reduce-form equation that I estimate is

$$\ln\left(\frac{M_{it}}{P_{it}}\right) = \alpha_i + \beta_y \ln Y_{it} + \beta_r R_{it} + u_{it}, \tag{12}$$

where M_{it} is a money measure, P_{it} is a price level, Y_{it} is the real GDP, R_{it} is a short term interest rate, α_i refers to specific effects in a country, β_y is the income elasticity, and β_r is the interest rate semielasticity; for i= 1, 2, ..., N; t= 1, 2, ...,T; where N= 15 and T= 56.

First, I test whether $\Delta\ln\left(M_{it}/P_{it}\right)$ is either I(0) or I(1). Then, I evaluate if $\Delta\ln\left(M_{it}/P_{it}\right)$ has a short-run serial correlation and has a long-run cointegration relations for all countries.

By applying unit root tests to the panel, I estimate the following relation:

$$\Delta\ln\left(\frac{M}{P}\right)_t^* = c + \prod\ln\left(\frac{M}{P}\right)_{t-1}^* + \sum_{k=1}^{k}\Phi_k\Delta\left(\frac{M}{P}\right)_{t-k}^* + \varepsilon_t^*. \tag{13}$$

In this case, I have stacked the panel into a time-series vector $\ln\left(M/P\right)_t^*$.

Panel unit root tests that allow heterogeneous dynamics can be classified in:[8]

- Pooled within dimension tests developed by Levin et al. (2002). They study three different test:

  1) Pooled Phillips-Perron p-statistic.

  2) Pooled Phillips-Perron t-statistic.

  3) Pooled ADF t-statistic.

  These tests are distributed standard normal by sequential limit.

- Group mean test developed by Im et al. (2003). This test has a normal standard distribution due to the central limit theorem.

Levin et al. (2002) point out that their proposed panel base unit root test does have the following limitation: There are some cases in which contemporaneous correlation cannot be removed by simply subtracting the cross sectional averages (results depend crucially upon the independence assumption across individuals, and hence not applicable if cross sectional correlation is present). Also, the assumption that all individuals are identical with respect to the presence or absence of a unit root is somewhat restrictive. On the other hand, Im et al. (2003) worked a panel unit root test without the assumption of identical first order correlation but under a different alternative hypothesis.[9]

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[8] For more details, see Harris and Sollis, *Panel Data Models and Cointegration*, chapter 7, 2003.

[9] "Maddala and Wu (1999) have done various simulations to compare the performance of competing tests, including IPS (Im, Pesaran, and Shin) test, LL (Levin, and Lin) test [...] Care must be taken to interpret their results. Strictly speaking, comparisons between the IPS test and LL test are not valid. Though both tests have the same null hypothesis, but the alternatives are quite different. The alternative hypothesis in this article is that all individual series are stationary with identical first order autoregressive coefficient, while the individual first order autoregressive in IPS test are al-

Table 1

TESTS FOR UNIT ROOTS

	$\ln\frac{M}{P}$	$\ln Y$	R
In levels			
LL ρ-statistic	0.89	1.58	−1.93
LL t-statistic	2.00	1.91	−0.24
LL ADF-statistic	2.54	0.92	−0.17
IPS ADF-statistic[1]	2.90	2.40	0.03
First differences			
LL ρ-statistic	−41.25	−42.83	−40.81
LL t-statistic	−27.21	−27.85	−18.27
LL ADF-statistic	−26.33	−49.26	−11.80
IPS ADF-statistic[1]	−48.24	−45.83	−10.73

Notes: Unbalanced panel data, sample of 15 countries. LL denotes Levin and Lin, and IPS denotes Im, Pesaran, and Shin.
[1]Using large sample adjustment.

Table 1 reports the unit root test under the H_0: *unit root.* In all cases I fail to reject H_0.[10] The results from unit root tests show that the three variables are first difference stationary.

4.3 Testing for Cointegration and Heterogeneity Restrictions

I first test for cointegration in order to estimate Equation 12. Then, I use the cointegrating relation to obtain the residuals.

lowed to vary under the alternative. If the stationary alternative with identical AR coefficients across individuals is appropriate, pooling would be more advantageous than Im et al. (2003) average t-statistics without pooling. Also note that the power simulations reported in Maddala and Wu (1999) are not size-corrected" (Levin et al., 2002, pp. 15-17).

[10] If the statistic is less than the critical value, −1.28, I can reject H_0 at 10% of confidence.

Later on, I test those residuals for unit roots. In other words, I evaluate if there are any cointegrating relations which are or might be consistent with 12.

The panel cointegrating tests that allow heterogeneity restrictions can be classified in

- Pooled within dimension tests developed by Pedroni (1999).[11] He researched four different tests running individual cointegrating regression for each member, collecting estimated residuals and computing pooled panel root test:[12]

  1) Pooled semiparametric variance test,

  2) Pooled semiparametric p-statistic test,

  3) Pooled semiparametric t-statistic test,

  4) Pooled fully parametric ADF t-statistic test.

- Group mean test developed by Pedroni (2002). He researched three different tests running individual cointegrating relations for each member, collecting estimated residuals, and computing group mean unit root test:

  1) Group mean semiparametric p-statistic test,

  2) Group mean semiparametric t-statistic test,

  3) Group mean fully parametric ADF t-statistic test.

[11] "Tests for the null of no cointegration in heterogeneous panels based on Pedroni (1995, 1997) have been limited to simple bivariate examples, in large part due to the lack of critical values available for more complex multivariate regressions. The purpose of this paper is to fill this gap by describing a method to implement tests for the null of no cointegration for the case with multiple regressors and to provide appropriate critical values for these cases." Pedroni (1999, p. 653). The author cited: Pedroni (1995), *Panel Cointegration: Asymptotic and Finite Sample Properties of Pooled Time Series Tests, with an Application to the PPP Hypothesis*, Indiana University Working Papers in Economics, June; and, Pedroni (1997), *Panel Cointegration; Asymptotic and Finite Sample Properties of Pooled Time Series Tests, with and Application to the PPP Hypothesis: New Results*," Indiana University Working Papers in Economics, April.

[12] These tests allow heterogeneous dynamics, heterogeneous cointegrating vectors, endogeneity, and normal distributed standard errors.

Table 2

TEST FOR COINTEGRATION OF $\ln\frac{M}{P}$, $\ln Y$, R

(panel cointegration statistics)

Pooled within dimension tests		*Group mean based tests*	
v-statistic	0.7713	ρ-statistic	−0.3088
ρ-statistic	−1.2108	t-statistic (nonparametric)	−3.4881
t-statistic (nonparametric)	−1.7032	t-statistic (parametric)	2.4981
t-statistic (parametric)	0.3501		

Note: Unbalanced panel data, sample of 15 countries.

In each case, the H_0: *No cointegration* can be rejected if the statistic is less than the critical value.[13] If it is less than −1.28, I can reject H_0 at 10% of confidence.

It is important to mention that the key difference between both pooled and group tests is that the residuals test is grouped rather than pooled. Group mean tests are preferred over the pooled tests since they allow greater flexibility under alternative hypotheses.[14]

Table 2 reports the test for cointegration. I reject the H_0 of no cointegration among these series in most cases. These results suggest that there is at least a cointegrating relation.

[13] "One can think of such panel cointegration test as being one in which the null hypothesis is taken to be that for each member of the panel variables of interest are not cointegrated and the alternative hypothesis is taken to be that for each member of the panel there exists a single cointegration vector, although this cointegration vector need not be the same for each member. Indeed, an important feature of these tests is that they allow the cointegration vector to differ across members under the alternative hypothesis" (Pedroni, 1999, p. 655).

[14] For details about how to estimate the statistics for each test, see the technical annex. See Section 4.4.1 for a discussion on the setup of alternative hypothesis

4.4 Estimating a Group Mean FMOLS

If the IS-LM model is consistent with the data, and the equilibrium in the money market holds, i.e., money demand equals money supply, I can expect Equation 10 to hold in the long run; while in equilibrium, Equation 11 should hold.

The result should hold true regardless of any details of dollar substitution, technological change, demand side preferences, or any other characteristic, under a pure Keynesian framework. If an alternative model is correct, the expected sign of this relation does not hold in the long run.

In my case study, the data from any particular country is too short to reliably choose null or alternative. However, data from many combined countries are sufficient to decide whether the prediction of the theory is accurate or not.

Also suggested in Pedroni (2002) it is reasonable to picture members of a panel as a sample drawn from a population that is either I(1) or I(0) and each member represents a sampling from its own separate population (time series realizations from any member would represent the population). In this case, the theory does not indicate that members must all give the same answer (panel test maybe *mixed* regarding whether null or alternative is correct). Specifically, for 12 the hypothesis to test is:

$$H_0\text{: } \beta_y = 0 \text{ and } \beta_r = 0 \text{ for all } i,$$

$$H_1\text{: } \beta_y > 0 \text{ and } \beta_r < 0 \text{ for enough } i,$$

where *enough* in the literature is often not precisely defined.

The advantage of the panel approach is that it has broadened the class of data to which the test has been applied by exploiting commonalities. The use of the panel is not to ask if a theory is correct or not, rather, it is asking how *pervasive* this particular characterization is for the particular group of members.

4.4.1 Advantages of Between-dimension Group Mean Panel (FMOLS) over Within Dimension Panel (DOLS)

Pedroni (2001) discusses three important advantages of the between-dimension estimators over within-dimension estimators.

1) The form in which the data is pooled in the FMOLS estimators allow for greater flexibility in the presence of heterogeneity of the cointegrating vectors. Test statistics constructed from the DOLS estimators are designed to test H_0: $\beta_i = \beta_0$ for all i against H_A: $\beta_i = \beta_A \neq \beta_0$ where the value β_A is the same for all i. Test statistics constructed from the FMOLS estimators are designed to test H_0: $\beta_i = \beta_0$ for all i against H_A: $\beta_i \neq \beta_0$ so that the values for β_i are not constrained to be the same under the alternative hypothesis. Pedroni highlights that this is an important advantage for applications, because there is no reason to believe that, if the cointegrating slopes are not equal, they necessarily take on some other arbitrary common value.

2) The point estimates of the FMOLS estimators have a more useful interpretation in the event that the true cointegrating vectors are heterogeneous. Specifically, point estimates for the FMOLS estimator can be interpreted as the mean value for the cointegrating vectors. This is not true for the DOLSestimators.

3) The test statistics constructed from the FMOLS estimators appear to have another advantage when the cointegrating vector is homogeneous even under the DOLS null hypothesis. Specifically, Pedroni (2002) shows that FMOLS estimators suffer from much lower small-sample size distortions than the DOLS estimators.

4.4.2 FMOLS Estimates

The equation that I evaluate for a money demand given by 12 is estimated by group-mean FMOLS because it has much better small sample size properties than pure time series case, and has clear advantages over panel DOLS. Even in cases where those estimations are difficult for pure time series case, it does fairly well in panels with heterogeneous dynamics due to the fact that biases tend to average out over N dimension, and in addition it has usual advantage of group-mean test, where the alternative hypothesis is more flexible.[15]

In my case the working hypothesis using Pedroni (2002) in group mean tests (estimate average long-run cointegrating relation) are[16]

$$H_0\colon\ \beta_y = 0 \text{ versus } H_A\colon\ \beta_y \neq 0\,,$$

$$H_0\colon\ \beta_r = 0 \text{ versus } H_A\colon\ \beta_r \neq 0\,.$$

The flexibility in this case is important because I do not need any prior value over the alternative hypothesis.[17] It also has the usual advantage of the FMOLS tests, in that estimates have more useful economic interpretation when cointegrating vectors are heterogeneous.

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[15] About the specification, Ball (2001) discuss if this is the correct money-demand function and the implicit assumption that the function does not include a time trend. He argues: "For given output and interest rates, money demand can change over time if there are changes in the economy's transaction technology" (Ball, 2001, p. 42). However, since money measure and output have trends, it can be argued that they cancel each other. This strategy can be found in the estimations of Mark and Sul (2003) where they find small differences estimating DOLS with and without trends. Ball also mentions "a trend is highly collinear with income, so one cannot disentangle their effects" (Ball, 2001, p. 42). Another approach, like cash in advance models, is developed in Álvarez et al. (2003) in which the framework is the Baumol-Tobin model. Finally, I review the work of Calza et al. (2001) which includes in the relation the long term interest rate in their estimation of the long-run money demand of the euro area, obtaining the wrong sign for this variable, and deleting it.

[16] Mark and Sul (2003) estimate pooled within tests that evaluate H_0: $\beta_Y = 0$ versus H_A: $\beta_Y = 1.0 \neq 0$, and H_0: $\beta_r = 0$ versus H_A: $\beta_r = -0.05 \neq 0$.

[17] However, Mark and Sul (2003) point out that "1.0 is a typical value of the income elasticity estimated in the literature while a common estimate of the interest rate semielasticity is −0.05" (Mark and Sul, 2003, p. 15). Ball (2001) estimate that the income elasticity money demand is 0.5 and the interest rate semielasticity is −0.05 for USA.

The test can be interpreted as the average of individual fully modified estimators. Each individual FMOLS estimator corrects for endogeneity, and for serial correlation by estimating long-run covariance directly, and the average over individual fully modified to obtain a group mean.

Thus, the group mean FMOLS estimators take the form

$$\hat{\beta}^*_{Y,GFM} = N^{-1}\sum_{i=1}^{N}\left(\sum_{t=1}^{T}\left(\ln Y_{it} - \overline{\ln Y_i}\right)^2\right)^{-1}\left(\sum_{t=1}^{T}\left(\ln Y_{it} - \overline{\ln Y_i}\right)\left(y^*_{Y,it} - T\hat{\gamma}_i\right)\right)$$
$$\hat{\beta}^*_{r,GFM} = N^{-1}\sum_{i=1}^{N}\left(\sum_{t=1}^{T}\left(r_{it} - \overline{r}_i\right)^2\right)^{-1}\left(\sum_{t=1}^{T}\left(r_{it} - \overline{r}_i\right)\left(y^*_{r,it} - T\hat{\gamma}_i\right)\right),$$

where $\left[y^*_{Y,it}\right] = \left[\ln\left(M/P\right)_{it} - \overline{\ln\left(M/P\right)_i}\right] - \left(\hat{\Omega}_{21i}/\hat{\Omega}_{22i}\right)\left[\Delta \ln Y_{it}\right]$ is the endogeneity correction and uses $\ln Y_{it}$ as an *internal instrument*.Also $\hat{\gamma}_i \equiv \hat{\Gamma}_{21i} + \hat{\Omega}^0_{21i} - \left(\hat{\Omega}_{21i}/\hat{\Omega}_{22i}\right)\left(\hat{\Gamma}_{22i} + \hat{\Omega}^0_{22i}\right)$ is the serial correlation correction, and Ω_i is the long-run covariance.[18]

Equivalently, the estimator can be expressed as $\hat{\beta}^*_{Y_G FM} = N^{-1}\sum_{i=1}^{N}\hat{\beta}^*_{Y_{FM},i}$, and for the t-statistic $t_{\hat{\beta}^*_{GFM}} = N^{-\frac{1}{2}}\sum_{i=1}^{N} t_{\hat{\beta}^*_{FM,i}}$, so that, individuals FMOLS tests are distributed N(0,1) as $T \to \infty$. Likewise, group FMOLS tests are distributed N(0,1) as $T \to \infty$ and $N \to \infty$ sequentially.[19]

4.5 Results

In Table 3, I present the FMOLS estimations. Single equation FMOLS estimates are seen to display a cross-sectional variability. In FMOLS regressions, the income elasticities are positive, with the exception of Argentina and Uruguay,[20] ranging from 0.44 (Paraguay) to a whopping 3.27 (Brazil), but the interest semielasticity has the

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[18] For details about the estimation of Ω and Γ see the technical annex.

[19] Similar analysis holds for the case of $y^*_{r,it}$.

[20] In both cases, they are not statistically significant.

Table 3

LONG-RUN MONEY DEMAND
(Single-equation and panel fully modified OLS estimates)

Country	β_y	*t-statistic*	β_r	*t-statistic*
Argentina	−1.00	−1.32	−0.002	−0.44
Bolivia	0.90	12.49	−0.001	−5.11
Brazil	3.27	11.58	0.002	1.47
Chile	1.07	16.84	−0.001	−0.39
Colombia	0.87	16.48	−0.004	−1.46
Costa Rica	1.09	12.18	−0.015	−2.50
Dominican Republic	0.75	12.86	−0.018	−4.27
Ecuador	1.06	48.26	−0.011	−4.41
Guatemala	1.66	17.49	−0.022	−5.59
Honduras	1.34	8.41	−0.008	−1.57
Mexico	0.76	4.93	−0.009	−5.71
Paraguay	0.44	1.50	−0.009	−1.74
Peru	1.05	7.94	−0.001	−0.71
Uruguay	−0.54	−1.68	−0.002	−1.65
Venezuela	1.33	26.46	−0.019	−10.19
Panel group FMOLS	0.94	50.20	−0.008	−11.43

wrong sign for Brazil,[21] and for the other countries it ranges from −0.022 (Guatemala) to −0.001 (Peru, Bolivia, and Chile).

This result is consistent with an underlying belief that the evolution of the financial systems and the transactions technologies' progress across Latin American countries are essentially similar.[22] The cross-sectional variability in these estimates must

[21] This statistic is also not statistically significant.

[22] In other words, money demand between Chile and Colombia is more alike than between Chile and Germany.

reflect the inherent difficulty of obtaining accurate estimates or even high quality data rather than evidence of disparate economic behavior.

Panel FMOLS estimate for income elasticity is 0.94 (with t-statistic equal to 50.2) and for the interest semielasticity is −0.008 (with t-statistic equal to −11.4).[23] There is evidence of a cointegrating money demand among Latin American countries. This result is important since it provides some support for a single currency in this region. However, this is only a small piece of information that is required if a monetary union is intended (as in the case of the Economic and Monetary European Union).[24]

As a group, the income elasticity is below one, which implies the existence of economies of scale in money management. Across countries, Mexico, Colombia, Paraguay, Bolivia, and Dominican Republic have income elasticity below one. This result is consistent with countries in which the process of dollarization is decreasing and the main function of the local currency (transactions) is being recovered slowly. In addition, there is a tendency to keep dollars mainly for precautionary matters (see Figure 1).

The semielasticity of the money demand with respect to the interest rate is low and has a low variability across countries. The reaction in the money demand to changes in the interest rate may be relatively similar within countries. Under the idea

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[23] Mark and Sul (2003) use a panel DOLS with trend among 19 developed economies (similar income levels and financial market development). "In our analysis, single equations DOLS with trend gives such disparate income elasticity estimates as −1.23 for New Zealand and 2.42 for Canada. The corresponding interest rate semielasticity estimates range from 0.02 for Ireland (which has the wrong sign) to −0.09 for the UK" (Mark and Sul, 2003, p. 658). "The estimates in which we have the most confidence are an income elasticity near one and an interest rate semielasticity of −0.02" (Mark and Sul, 2003, p. 679).

[24] The European Central Bank has a monetary aggregate operating target, which departs from other inflation targeting central banks. Part of the argument is based on a stable money demand, as shown in Funke (2001). See Poole (1970) for more details.

Figure 1

INCOME ELASTICITY OF THE MONEY DEMAND

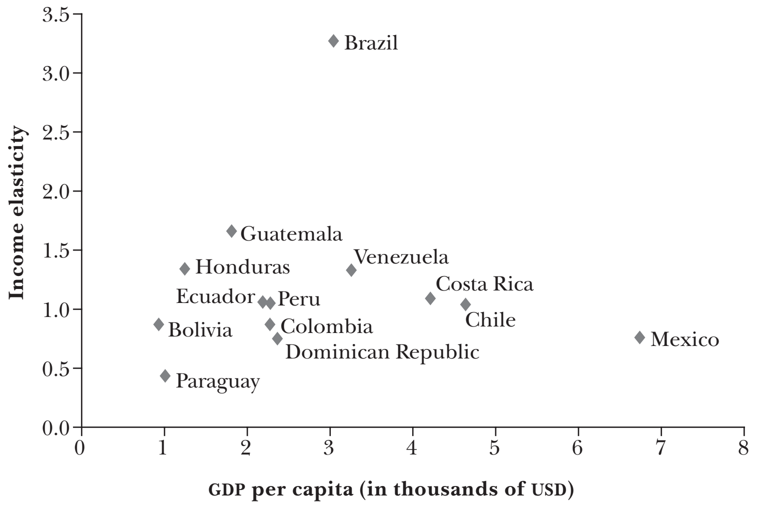
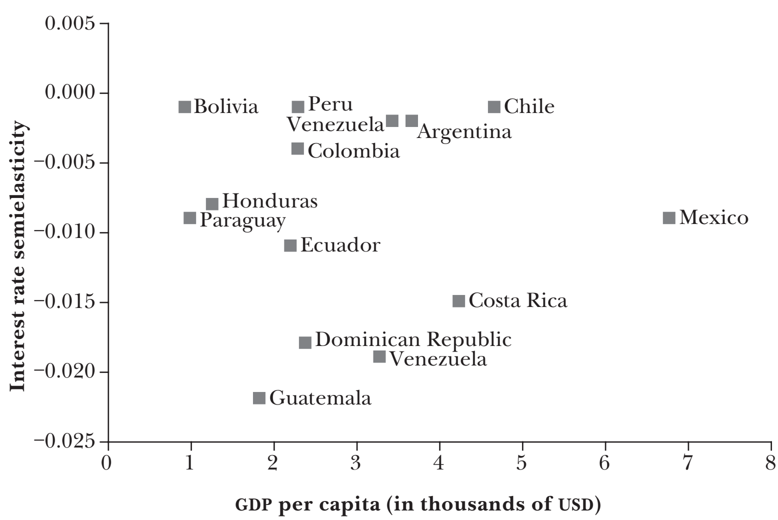


Figure 2

INTEREST RATE SEMIELASTICITY OF THE MONEY DEMAND



of a monetary union for Latin American countries, targeting the interest rate would work best as it is the case in many developed countries (see Figure 2).

As a matter of fact, Walsh (2010) discusses previous values found in the literature for this parameter.[25] My results are in line with those previously found.

4.6 An Increase in the Money Supply

As an exercise, I estimate the effect of the expansion of the money supply over output, based on Equation 12. In the short run (when the monetary policy has effects over output) prices are sticky, so taking differentials,

$$\Delta M = L_Y \Delta Y + L_r \Delta r, \tag{14}$$

where L_Y can be approached for the elasticity of money with respect to output and L_r is the semielasticity of money with respect to the interest rate. Re-arranging Equation 14, I find the following expression,

$$\frac{\Delta Y}{\Delta M} = \frac{1}{L_Y} - \frac{L_r}{L_Y}\frac{\Delta r}{\Delta M}. \tag{15}$$

Since I do not know the total effect over r (IS curve is missing from the analysis), I can only infer about the direct/fix effect of an increase of 1% in the money supply over output (see Figure 3) and the indirect/partial effect derived from movements in the interest rate, given the increase in money supply over output (see Figure 4).

I find that Paraguay, a country with low GDP per capita, has better opportunities to increase output with a monetary expansion. Colombia and Bolivia are also interesting cases, since a

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[25] See Walsh (2010), p. 50-51.

Figure 3

FIX EFFECT OF A 1% INCREASE IN MONEY SUPPLY OVER OUTPUT: DIRECT EFFECT OF MONEY

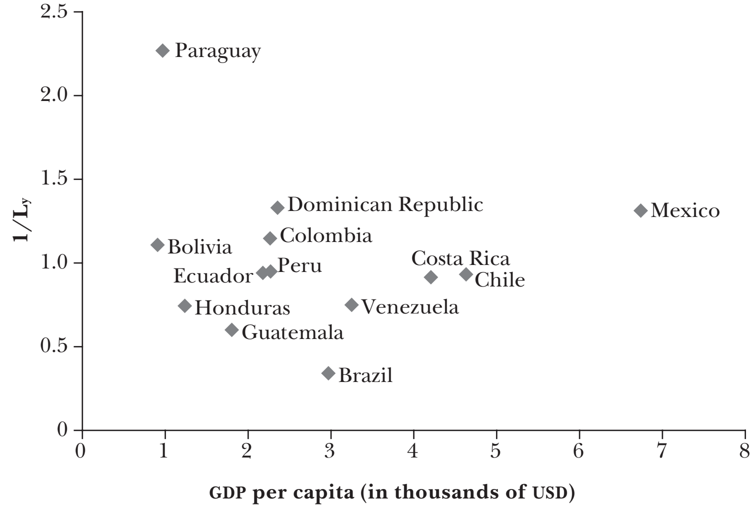
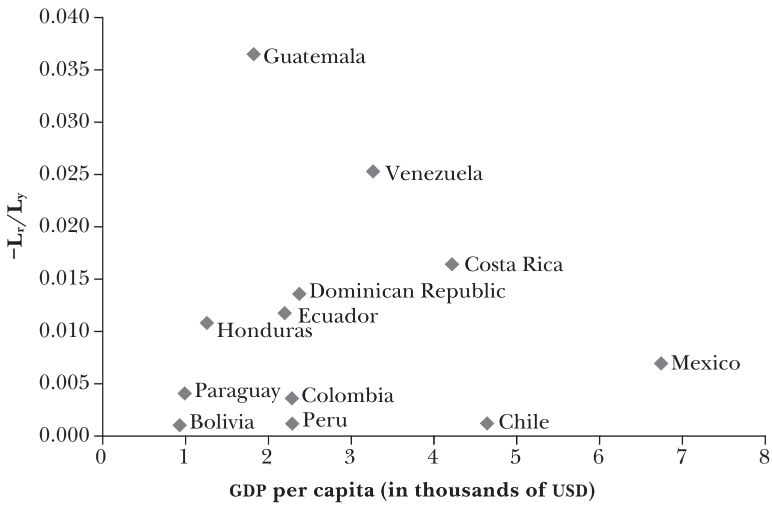


Figure 4

PARTIAL EFFECT OF A 1% INCREASE IN MONEY SUPPLY OVER OUTPUT: INDIRECT EFFECT OF INTEREST RATE



1% increases in money supply increase output by more than one percent.

This analysis is not complete yet. In order to estimate the total change in output I also need to estimate the IS curve. On the other hand, I have the ratio that measures the effects of the decrease in the interest rate, given the 1% expansion in the money supply, implied by the LM curve. Even though it is the interaction between the IS and LM that would provide the final interest rate level, this is a reasonable approximation of a money growth increase effect over output. If the IS-curve is too steep, countries like Guatemala and Venezuela would have less expansionary effects.

5. CONCLUSIONS

Combining observations across countries helps obtain relatively sharp and stable estimates of money demand elasticities. In that regard, the panel cointegration approach seems a well-suited technique. I applied the panel FMOLS method to estimate the long-run money demand for 15 Latin American countries. The estimates for this group of countries are an income elasticity of 0.94 and an interest rate semielasticity of −0.01.

These results are consistent with the LM approach, which expects positive values for the income elasticity money demand (for transactions) and negative values for the interest rate semielasticity money demand (for speculation/precaution). Even though some countries have the wrong sign in their estimators, those cases seem to be statistically not significant.

Regarding my estimates, the value slightly under 1 implies the existence of economies of scale in money management. This result is consistent with the slow process of *dedollarization* after the successful experiences of many central banks in Latin America by controlling the high inflation processes that were a problem in the late 1980s.

Another interesting result is the low variability in the money demand to changes in the interest rate across countries. Moreover, the low level of the parameter is consistent with the low opportunity cost of holding money.

Finally, I make a partial equilibrium exercise in which I measure the effects of a money supply increase in 1% over output. In most of the cases, the direct effect is less than a 1% increase in output.

Some points remain on agenda. Results from the exercise are not conclusive. To have accurate conclusions, I should first estimate the IS curve. As suggested by Kumar (2011), I may take into consideration structural breaks that capture the exogenous events that affect the money demand in order to fine tune these results.

A. TECHNICAL ANNEX

A. 1 Seven Panel Cointegration Statistics

1) Panel v-statistic (nonparametric)

16 $$T^2 N^{3/2} Z_{\hat{v}_{N,T}} \equiv T^2 N^{3/2} \left(\sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^{2} \right)^{-1}.$$

2) Panel ρ-statistic

17 $$T\sqrt{N} Z_{\hat{\rho}_{N,T^{-1}}} \equiv T\sqrt{N} \left(\sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^{2} \right)^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \left(\hat{e}_{i,t-1} \Delta \hat{e}_{i,t} - \hat{\lambda}_i \right).$$

3) Panel t-statistic (nonparametric)

18 $$Z_{t_{N,T}} \equiv \left(\tilde{\sigma}_{N,T}^{2} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^{2} \right)^{-1/2} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \left(\hat{e}_{i,t-1} \Delta \hat{e}_{i,t} - \hat{\lambda}_i \right).$$

4) Panel t-statistic (parametric)

19 $$Z_{t_{N,T}}^{*} \equiv \left(\tilde{s}_{N,T}^{*2} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^{2} \right)^{-1/2} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \left(\hat{e}_{i,t-1}^{*} \Delta \hat{e}_{i,t}^{*} \right).$$

5) Group ρ-statistic

20 $$T N^{1/2} \tilde{Z}_{\hat{\rho}_{N,T^{-1}}} \equiv T N^{1/2} \sum_{i=1}^{N} \left(\sum_{t=1}^{T} \hat{e}_{i,t-1}^{2} \right)^{-1} \sum_{t=1}^{T} \left(\hat{e}_{i,t-1} \Delta \hat{e}_{i,t} - \hat{\lambda}_i \right).$$

6) Group t-statistic (nonparametric)

21 $$N^{1/2}\tilde{Z}_{t_{N,T}} \equiv N^{1/2}\sum_{i=1}^{N}\left(\tilde{\sigma}_i^2\sum_{t=1}^{T}\hat{e}_{i,t-1}^2\right)^{-1/2}\sum_{t=1}^{T}\left(\hat{e}_{i,t-1}\Delta\hat{e}_{i,t}-\hat{\lambda}_i\right).$$

7) Group t-statistic (parametric)

22 $$N^{-1/2}Z_{t_{N,T}}^* \equiv N^{-1/2}\sum_{i=1}^{N}\left(\sum_{t=1}^{T}\hat{s}_i^{*2}\,\hat{e}_{i,t-1}^{*2}\right)^{-1/2}\sum_{t=1}^{T}\hat{e}_{i,t-1}^{*}\Delta\hat{e}_{i,t}^{*}$$

where,

$$\hat{\lambda}_i = \frac{1}{T}\sum_{s=1}^{k_i}\left(1-\frac{s}{k_i+1}\right)\sum_{t=s+1}^{T}\hat{\mu}_{i,t}\hat{\mu}_{i,t-s}, \hat{s}_i^2 \equiv \frac{1}{T}\sum_{t=1}^{T}\hat{\mu}_{i,t}^2, \hat{\sigma}_i^2 = \hat{s}_i^2 + 2\hat{\lambda}_i,$$

$$\hat{\sigma}_{N,T}^2 \equiv \frac{1}{N}\sum_{i=1}^{N}\hat{L}_{11i}^{-2}\hat{\sigma}_i^2$$

$$\hat{s}_i^{*2} \equiv \frac{1}{t}\sum_{t=1}^{T}\hat{\mu}_{i,t}^{*2}, \tilde{s}_{N,T}^{*2} \equiv \frac{1}{N}\sum_{t=1}^{N}\hat{s}_i^{*2}, \hat{L}_{11i}^2 = \frac{1}{T}\sum_{t=1}^{T}\hat{\eta}_{i,t}^2 + \frac{2}{T}\sum_{s=1}^{k_i}\left(1-\frac{s}{k_i+1}\right)\sum_{t=s+1}^{T}\hat{\eta}_{i,t}\hat{\eta}_{i,t-s},$$

and where the residuals $\hat{\mu}_{i,t}$, $\hat{\mu}_{i,t}^*$ and $\hat{\eta}_{i,t}$ are obtained from the following regressions:

$$\hat{e}_{i,t} = \hat{\gamma}_i\hat{e}_{i,t-1} + \hat{\mu}_{i,t},$$

$$\hat{e}_{i,t} = \hat{\gamma}_i\hat{e}_{i,t-1} + \sum_{k=1}^{K_i}\hat{\gamma}_{i,k}\Delta\hat{e}_{i,t-k} + \hat{\mu}_{i,t}^*,$$

$$\Delta y_{i,t} = \sum_{m=1}^{M}\hat{b}_{mi}\Delta x_{mi,t} + \hat{\eta}_{it}.$$

See Pedroni (1999, pp. 660-661) for more details.

A.2 Long-run Covariance[26]

Let $\varepsilon_{it} = \left(\hat{u}_{it}, \Delta\ln Y_{it}\right)'$ be a stationary vector consisting of the estimating residuals from the cointegrating regression and the differences in ln$Y$.

[26] This part is based on Pedroni (2001, p. 728).

Let $\Omega_i \equiv \lim_{T\to\infty} E\left[T^{-1}\left(\sum_{t=1}^{T}\varepsilon_{it}\right)\left(\sum_{t=1}^{T}\varepsilon'_{it}\right)\right]$ to be the long-run covariance for this vector process. It can be decomposed as $\Omega_i = \Omega_i^0 + \Gamma_i + \Gamma'_i$ where Ω_i^0 is the contemporaneous covariance and Γ_i is the weighted sum of autocovariances.

This procedure is the same for the case of *r*.

For more details, see Pedroni (2002).

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