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Beyond Bubbles: The Role of Asset Prices in *Early-Warning* Indicators

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Para além das bolhas: o papel dos preços dos activos na construção de indicadores de alerta precoce

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Os preços dos ativos tem se convertido em tema comum dentro do atual debate econômico. Não obstante, muito tempo se tem dedicado a determinar a existência ou não de bolhas especulativas nos mesmos, e não a estudar a profundidade a possível informação que estes preços contêm com respeito ao comportamento futuro dos mercados. Este trabalho é um esforço nessa direção, ao buscar desenvolver indicadores de *alerta precoce* para A Colômbia, utilizando variáveis reais e financeiras. Os resultados corroboram a hipótese de que efetivamente existe informação contida dentro destas séries, já que todos os indicadores (exceto o do preço da moradia nova), apresentam importantes desviações frente a sua tendência para o(os) ano(s) antecedente(s) à crise financeira de 1998-1999. Adicionalmente, encontra-se que o desempenho dos indicadores melhora quando se incluem conjuntamente o crédito e o investimento. Quando os indicadores estão ACESOS, o papel das autoridades relevantes deve ser *mais* atraente no mercado; não necessariamente em termos de movimentos nas taxas de juros, senão em comunicar-se com os agentes do mercado e promover a diversificação dos porta-fólios assim como do uso das técnicas de administração de risco disponíveis.

Palavras chave*:* bolhas em preços de ativos, indicadores de alerta precoce, crises financeiras, regulação prudencial.

Classificação JEL: E58, E44, G12, G18.

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Más allá de las burbujas: el rol de los precios de los activos en la construcción de indicadores de alerta temprana

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Los precios de los activos se han convertido en tema común dentro del actual debate económico. No obstante, mucho tiempo se ha dedicado a determinar la existencia o no de burbujas especulativas en los mismos, y no a estudiar a profundidad la posible información que estos precios contienen con respecto al comportamiento futuro de los mercados. Este trabajo es un esfuerzo en esa dirección, al buscar desarrollar indicadores de *alerta temprana* para Colombia, utilizando variables reales y financieras. Los resultados corroboran la hipótesis de que efectivamente existe información contenida dentro de estas series, ya que todos los indicadores (excepto el del precio de la vivienda nueva), presentan importantes desviaciones frente a su tendencia para el(los) año(s) antecedente(s) a la crisis financiera de 1998-1999. Adicionalmente, se encuentra que el desempeño de los indicadores mejora cuando se incluyen conjuntamente el crédito y la inversión. Cuando los indicadores están *encendidos*, el papel de las autoridades relevantes debe ser *más* activo en el mercado; no necesariamente en términos de movimientos en las tasas de interés, sino en comunicarse con los agentes del mercado y promover la diversificación de los portafolios así como del uso de las técnicas de administración de riesgo disponibles.

Palabras clave: burbujas en precios de activos, indicadores de alerta temprana, crisis financieras, regulación prudencial.

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Beyond Bubbles: The Role of Asset Prices in *Early-Warning* Indicators

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Asset prices have recently become a common topic in economic debate. Nevertheless, much time has been spent in determining if they effectively exhibit a bubble component, and not in examining whether asset prices contain relevant information concerning future market developments. This paper is an effort in this direction, aimed towards the construction of early-warning indicators for Colombia using financial and real variables. Results show evidence to support that there is relevant information embedded in these series, as all indicators (except the new housing price indicator) show a significant deviation for the year(s) prior to the 98-99 crisis. Additionally, the exercises here conducted show that the performance of asset price indicators is enhanced by including credit and investment. When the early-warning indicators are on, the role of the policy maker should be more active in the market; not necessarily in terms of altering interest rates, but in communicating with market agents, promoting portfolio diversification and urging financial agents to make the best use of the risk-management tools that are available to them.

Key Words: Asset Price Bubbles, Early-Warning Indicators, Financial Crisis, Prudential Regulation.

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I. INTRODUCTION

Asset price bubbles are amongst the most talked-about yet misunderstood topics in economics. Theoretical researchers debate between rational, nonrational or even non-existent bubbles, while empiricists tackle the issue with state-of-the-art econometric tools yielding mixed results.

A bubble is usually defined as the component of asset prices that cannot be accounted for by fundamentals.[1] A rational bubble arises when agents are willing to pay a higher price than the "fundamental price" because they believe that they can sell the asset at an even higher price in the future (Gurkanak, 2005). A nonrational bubble is defined as a rapid upward price movement, based on exaggerated beliefs about future outcomes (e.g. company earnings or the impact of a new technology), followed by a collapse (Meltzer, 2003).

Some theorists have also developed behavioral models with rational expectations which allow for explaining price behavior without bubble components. In a nut-shell, these models assume expectations are based on *imperfect* knowledge of future fundamentals, so that investors may overestimate potential income flows (i.e. earnings) and hence asset prices. As agents acquire new information, they correct their initial forecasts, altering their investment/consumption decisions and changing asset prices (Meltzer, 2003).

1 Fundamentals are the discounted value of expected future income flows.

On the empirical side, tests are usually constructed for rational bubbles, given the relative knowledge of researchers on testing the present value model of asset prices. Nonetheless, results vary and there does not appear to be a general consensus regarding a specific empirical test of bubbles. In fact, there is not even a common agreement on the interpretation of a rejection of the no-bubbles hypothesis; while some argue this is proof of the existence of bubbles others attribute this to a failure of the model in another dimension (e.g. misspecified fundamentals). In the end, the choice between bubble solutions and a misspecified model of price behavior remains a matter of belief.

The bottom-line is that even if there is no scientific *proof* of the existence of bubbles, the current volatility in asset prices worldwide has sprang a newfound interest in the subject.

The typical questions found in the literature usually read something like: How should bubbles be measured? Can they be measured? Are they rational or non-rational bubbles? Do bubbles *exist*? These are not the most relevant questions for decision-makers. Financial instability usually arises from a combination of economic imbalances and not a single event. That is, large increases in asset prices by themselves do not necessarily lead to widespread instability in the financial system. Rather, an increase in asset prices, rapid credit expansions and high levels of investment, occurring *simultaneously*, could lead to potential problems (Borio and Lowe, 2002, 2003). Thus, the relevant question for policymakers is not whether bubbles *exist*, but rather if the observed behavior in asset prices, along with other financial and real variables, is indicative of possible future imbalances.

It is important to note that the empirical relationship studied by Borio and Lowe (2002) between the development of the aforementioned variables and periods of financial distress stems from the theoretical literature focused on the so-called "financial accelerator". This literature states that, given asymmetric information in credit markets, external funding is costlier than internally-generated funds, and that collateral (i.e. assets) arises as an imperfect solution to the moral hazard problem. Given that collateral is determined by the market value of the assets in the agent's portfolio, when a shock adversely affects the price of these (e.g. a rise in interest rates), the agent's creditworthiness falls and so does his ability to obtain fully collateralized loans. Thus, investment decisions are affected and tend to contract further than expected from the typical cost-of-capital effect. In general, this literature suggests that economic shocks which deteriorate balance sheet conditions

on all agents "accelerate" the effects of such adverse shocks via a contraction of both demand (higher cost of capital) and supply (lower collateral value) of credit, further depressing investment, asset prices and overall economic activity (Bernanke et al. 1998).

From the above, it is clear that the choice of the variables follows from this literature and is not *ad hoc* and thus devoid of any theoretical justification. It is also clear that after the shock, the observed equilibrium would be a decrease in asset prices, followed by both lower credit disbursements and overall investment decisions. However, during the periods preceding this situation, one would have effectively witnessed high levels in ALL these variables, which is the basic premise behind the *early-warning* indicators as developed by Borio and Lowe, (2002, 2003).

In the same spirit, the aim of this document is to use the available information to identify possible future imbalances in financial markets. To achieve this, we use *ex ante* Colombian data on asset prices, credit and investment to construct *early-warning* indicators of financial distress. The idea behind the use of *ex ante* information is that of utilizing the same data that would be available to the policymaker when taking decisions.

The data covers the period between December of 1994 and December of 2006 and has a quarterly frequency. The indicators are constructed as the deviation of each observed series with respect to its long-term trend[2] to determine whether imbalances occur after such deviations overcome a specific threshold. These thresholds are chosen based on a *parsimony-criteria*, which in practical terms translates to a "fine-tuning" of the threshold levels in order to try and find the value that best identifies actual imbalance periods whilst minimizing the number of *false alarms* (i.e. the number of wrongly predicted crises). The hypothesis that lies behind this exercise is that such indicators contain relevant information for predicting an economic crisis.

Results strongly support this hypothesis. In particular, most of the indicators (all except the new housing price indicator) show evidence that supports the idea that there is relevant information embedded in these series. Additionally, *joint* indicators (constructed from different combinations of the series) prove to be more ro-

2 Calculated using a Hodrick-Prescott filter.

bust, in that they eliminate the *false alarms* of financial distress present in some individual indicators. The latter may be due to the fact that *joint* indicators consider information from multiple markets.

Although analyzing the deviation of a variable to its trend is by no means revolutionary (the loans to GDP ratio being one of the most common), analyzing real and financial variables *jointly* as *early-warning* indicators of financial distress has only become popular more recently. This is mainly due to the fact that although asset prices have made several appearances on historical accounts of financial instability, their empirical relationship with credit and aggregate demand has been less studied.

However, there have been various attempts in identifying the link between asset prices, financial stability and monetary policy. Some authors argue that a responsible monetary policy leads to low inflation, induces stable asset prices and efficient levels of liquidity, and reduces investors' uncertainty (by promoting a sounder macro environment), thus allowing for optimum consumption and investment decisions. On the other hand, some economists have began to realize that financial instability (and large asset price swings) CAN develop in periods of low inflation. A credible monetary policy results in low inflation expectations, meaning it takes longer for higher demand to translate into prices. As agents' expenditure increases, there is a higher demand for loans and banks increase their lending. Debt-financed spending may lead to a faster rise in asset prices, which does not immediately translate to higher inflation. The inverse is also true. There could be high inflation under a stable financial environment. Under this scenario, a rise in interest rates, consistent with the inflation goal, could lead to financial instability by increasing the burden of outstanding floating-rate debt and most importantly creating significant wealth effects through portfolio-valuation losses caused by the fall in the price of tradable assets (this is especially relevant in markets where balance sheets are *marked-to-market*), thus altering investment/consumption decisions. In other words, there is room for important *trade-offs* between monetary and financial stability.

The above does not mean that policymakers are thus left with their hands tied. In the first place, it would be foolish to overlook that asset prices contain a large amountof information from which policymakers can reap incredible benefits.[3] On second

3 Developments in asset prices and credit may have an impact on inflation and are therefore important for central banks when they set interest rates. Additionally, asset prices may be indicative of

place, even if there is no consensus on the exact link between financial and monetary stability there does seem to be a convergence with respect to the actions that should be undertaken by policymakers to reduce large asset-price swings. In short, these are aimed towards reducing information asymmetries in the market, promoting the long-term structure of certain specific institutional investors' portfolio (e.g. pension funds) as well as the diversification and sophistication of risk management tools. Additionally, they should promote deeper and wider capital markets to increase the universe of financial assets available to investors and encourage a closer monitoring of financial markets.

Both the retrieval of information embedded in asset prices as well as possible policy actions to help move financial markets into a stronger form of market efficiency (i.e. more shock-resistant) are crucial to policymakers worldwide. This is even more so in a country like Colombia, because emerging markets which are moving towards a model of financial integration are more vulnerable to the adverse effects that speculative capital flows have on the financial cycle. When there are waves of optimism in the real sector, credit grows spectacularly, there is a tendency to overinvest in physical capital, asset prices hike and consumption soars as well. All this factors lead to higher economic growth and a valorization of domestic assets, increasing foreign investors appetite for the latter. This leads to higher capital inflows, which in Colombia are highly (and positively) correlated with credit (see Villar et al. 2005), thus exacerbating the business cycle. When expectations change (e.g. due to new information on future fundamentals) and agents correct their initial forecasts, the wave of optimism crumbles, imbalances are corrected abruptly and there are perverse effects both on financial markets and the real economy (Collyns and Senhadji, 2003).

This paper is organized as follows. Section I presented a quick introduction to the subject at hand and its relevance to policymakers. Section II provides an overview of the empirical literature for Colombia aimed at utilizing the information embedded in asset prices, while section III presents and overview of the implications of the latter on monetary policy. Empirical exercises with Colombian data on asset prices, credit and investment as *early-warning* indicators are carried out in section IV. Section V concludes.

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future developments in output and demand. For the case of Colombia, the link between output and stock prices was carefully studied by Tenjo et al. 2007.

II. BUBBLES IN THE COLOMBIA[4]

Econometric tests for identifying bubbles have proven to be fairly ineffective. In principle, such tests are aimed towards rejecting the present value model (or market fundamental model), which is defined as:

$$P_t = \sum_{i=1}^{\infty} \left(\frac{1}{1+r} \right)^i E_t \left(d_{t+i} \right) \tag{1}$$

where P_t denotes the asset price at time t, r is a one period risk-free market rate and $E_t(d_{t+i})$ is the expected value of future income flows generated by the asset (the market fundamental component).[5]

A rejection of the model in equation (1) implies there is an unexplained component of price behavior which could be accounted for by bubbles. Nonetheless, this component can also be attributed to a misspecification of the fundamentals in the model. Hence, the conclusions which can be derived from such tests end up reflecting the personal preferences of the researcher between bubbles and fundamentals-based explanations of price movements. Essentially, all models fail because expectations are not observable, so assumptions must be made concerning how they are measured. Ultimately, this means that the so-called fundamental value is based on beliefs rather than on data.

In Colombia, there is little work on the empirical tests for assessing the existence of bubbles. In fact, literature has focused more on models to analyze the information embedded in assets prices (especially in the housing market) and less in identifying whether bubbles exist or not. In line with this argument, the most known frameworks in the country are the ones developed by Lopez, 2005 and Tenjo et al. 2007.

Lopez (2005) proposes a structural dynamic general equilibrium approach in modeling the relationship between variables that give rise to the "financial accelerator". The purpose of the author is to identify the possible responses that policy mak-

4 The review concerning econometric tests on asset price bubbles is based on a thorough overview of the literature done by Gurkanak, 2005. All the tests covered are related with *rational* bubbles.

5 In the case where *P* is the price of stock, *d* would denote future dividends; in the case where *P* denotes housing prices *d* would denote rental flows; whilst in the case where *P* denotes the price of a bond, *d* would stand for coupon payments.

ers can take against deviations of asset prices from their fundamental values. The model includes the possibility of bubbles in housing prices and is calibrated for Colombian data to identify the response of the critical variables in two scenarios: one in which monetary authorities react to the misalignments in housing prices and another in which they do not. Results suggest that policy makers who react directly to housing price bubbles by changing interest rates are less efficient than the ones that only react to deviations of overall expected inflation to the target. The paper recommends that monetary policy be combined with prudential regulation in order to encourage mechanisms that may help contain speculation in asset prices and which send signals to the market regarding potential vulnerabilities.

More recently, Tenjo et al. (2007) examine the linkage between real and financial variables, in the context of financial imbalances and the financial accelerator theory. They do so under a VAR framework and Granger-Causality tests. The authors find that i) asset prices are a key variable in understanding economic cycles and thus contain relevant information for economic authorities; ii) they are related to the behavior of investment, credit and overall economic activity (seen as GDP growth), thus validating the theory behind the financial accelerator; and iii) an upturn in economic activity which may cause the build-up of imbalances in credit markets, asset prices and investment/consumption decisions need not be necessarily followed by a slump in economic growth: there is ample space for countercyclical policies to be carried out.

This paper can be seen as a continuation of the work done by Tenjo et al. (2007) in the sense that it also examines the relationships between financial and real variables under the financial accelerator scope, but take the findings one step further. Not only do we assert that asset prices contain relevant information for economic authorities, but rather seek to exploit it *via* the construction of *early-warning* indicators. In this sense, our work is motivated by their recommendation of creating countercyclical tools for policymakers, being these indicators a first approach to anticipating possible downturns and thus helping to identify specific markets where signs of possible imbalances are present. Once identified, precise actions could be directed towards correcting such imbalances.

Although there seems to be an agreement regarding the relevance that this indicators have over financial stability and economic growth, the debate concerning the policy actions that economic authorities should employ in response to the information embedded in them remains in progress. We describe this debate in the next section.

III. IMPLICATIONS OF BUBBLES ON MONETARY POLICY

A. TO INTERVENE OR NOT TO INTERVENE

As was mentioned in the last section, the debate concerning the optimum intervention of economic authorities in response to the information embedded in asset prices prevails. In fact, the central question in literature is if policy makers should intervene or not to prevent strong swings in these prices.

One branch of the literature supports the hypothesis that expansive policies may compensate the recessive effects of large swings in asset prices. As Meltzer (2003) notes, asset price declines need not be followed by output or consumption recessions. By analyzing several bubble episodes, the author states that the different effects that high asset prices have on an economy are explained by the policy actions implemented by the relevant authorities. Moreover, Cecchetti et al. (2003) suggest that even though asset prices should not belong to the objective function of the Central Bank, misalignments in these prices must be taken into account. The main reason is that asset price bubbles lead to increases in real output and inflation, followed by sharp falls. The authors suggest these effects can be offset with modest movements on the interest rates by policymakers. Nevertheless, they clarify that the decision of reacting to asset price changes should be dependent on the context on which these occur, and not be a mechanical and symmetric response[6].

Given that monetary authorities act mainly by altering a short-term interest rate that directly affects the interbank overnight rate, this literature distinguishes three channels by which monetary policy can affect asset valuations.[7] First, changes in interest rates may affect individual expectations about future behavior of economic growth. Second, monetary policy affects agents' set of discount factors. Finally, they may induce portfolio shifts that affect assets' relative prices.[8]

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6 This decision should contemplate all relevant asset prices, which in their paper include equity and housing prices.

7 These channels are exposed in further detail by Trichet 2003.

8 There are other indirect channels such as wealth effects in investment and consumption that may affect prices via households intertemporal smoothing behavior.

On the other hand, a branch of the literature states that central banks should not react to changes in asset prices. They support their position by arguing that it would be harmful for economic stability to introduce such a volatile indicator into policy decisions. Additionally, asset prices cannot be determined scientifically: as Trichet argues, *what matters is not only the asset price level per se, or the pace of its change, but also its deviation from a highly hypothetical fundamental value, which is hard to determine.*

Another important argument to remain extremely cautious about monetary policy intervention is moral hazard problems: if individuals expect intervention they may take riskier projects in order to magnify their expected returns because they internalize that their losses are limited.

Moreover, Goodfriend (2003) advices that monetary policy should not react directly to asset prices because there can be no theoretical presumption on the correlation between interest rates and equity price movements, and hence on the overall *effectiveness* of the intervention.

B. WHAT CAN MONETARY AUTHORITIES DO?

Although the debate concerning intervention seems endless, there are certain points in which researchers and academics have reached an agreement. For instance, there is consensus regarding the reasons that explain the abnormal behavior of asset prices in the last years. Three facts can be clearly distinguished. First, agents have increased their interest in short-term results. This has magnified price volatility by amplifying the impact of any new information. Second, markets have developed mimetic or herding behavior. That is, agents prefer to be wrong along with everybody else rather than taking the risk of being right alone. This type of conduct leads to massive earnings or losses. Finally, converging risk management techniques have led to contemporaneous homogeneous responses by different market players, increasing the size of trading volumes and magnifying initial shocks.

The above implies that monetary authorities must safeguard financial stability by promoting diversity in financial markets, which in turn may prevent asset price swings. In order to achieve this objective, monetary policy should focus on *i)* strengthening market transparency, ii) preserving the long term perspective of some investors (e.g. pension funds), and iii) promoting the diversification of risk management tools of financial institutions.

Market transparency reduces the mimetic behavior of agents in the market. By reducing incomplete information and uncertainty it gives confidence to investors regarding their own decisions. In this way, an agent would no longer prefer to follow bigger participants, rather than carry on his own analysis, if he believes that all market participants have access to the same information. Additionally, transparency enables better differentiation of a borrower's creditworthiness.[9]

Furthermore, when economic authorities preserve the long-term perspective of pension funds and insurance companies they compensate for the ``short-termism" of other agents, thus reducing the impact of new information in the price formation process. Lastly, diversifying the risk management tools of financial institutions, so that they include more than the massively adopted Value-at-Risk (VaR) measure, can help reduce the mimetic behavior observed in markets. Authorities must promote the use of *stress testing* techniques by all financial institutions, because their results are inherently more diversified than those of the VaR approach,[10] as well as advancing towards more sophisticated risk-measures, such as Expected Shortfall (ES), Extreme Value Theory (EVT) and Spectral Risk Measures (SRM).[11]

Monetary authorities may also openly promote the deepening of existing capital markets and the creation of new ones. For example, in Colombia few firms are listed in the Colombian Stock Exchange,[12] and even fewer issue corporate bonds as means of obtaining financial resources. Policy maker's must strive to create the necessary conditions (i.e. a sound macroeconomic environment, low and stable interest rates, low inflation, quicker and more reliable information systems, efficient legal systems, tax incentives) for firms to effectively consider exploring these new markets. The former would allow for a larger universe of financial assets available to investors,

9 As Trichet (2003) mentions, this may prevent that when one big firm has difficulties all the other firms that belong to that specific sector face credit restrictions.

10 This is simply due to the way in which a *stress test* is conducted. Each institution, by endogenously choosing the *shocks* for the stress test, is revealing its individual perception of an exceptional event in a given market or over a given portfolio of assets. This alone implies a diversity not found in the VaR analysis, where the parameters used are usually calibrated with similar data sets (Trichet, 2003).

11 An intuitive and practical exposition of these risk measures can be found in Dowd (2005).

12 As of July 2006, there are 8,980 listed firms of a total of over 20,000 firms who actively report their balance sheet to the relevant authorities.

thus reducing the high concentration and homogeneity present today in local investors' portfolios, which increases systemic risk.

Other policies that authorities may apply to promote financial diversity are:[13]

- Require companies to disclose periodical information necessary to assess a company's value (that does not compromise competitive secrets). The periodicity of the disclosures could vary depending on the market.

- Each investor should have prompt access to critical information.

- Chief Executive Officers who clearly abused their power should lose their right to serve in any corporate leadership position.

- Enhancing the accountability of corporate leaders to restore trust in the system.

Moreover, there is consensus over the idea that asset prices offer useful information to monetary authorities in the short-run (Goodfriend, 2003), especially because they have important consequences over financial markets. This idea is central to the core of this paper, because it implies that observing financial series may give policy makers vital information regarding the future development of certain segments (or in some cases the whole) of the financial system. This means that a central bank SHOULD use the information that these variables contain in order to ensure and promote the stability of financial markets. In the next section, indicators that may exploit such information and make it useful for political purposes are presented.

IV. EMPIRICAL EXERCISES

A. WHAT CAN BE DONE

Following the spirit of Borio and Lowe (2002, 2003), the central question in this analysis is not whether bubbles exist or not, but rather how much information can be

13 These policies are part of President Bush's 10 Point plan on financial disclosure. For more information see Kroszner, 2003.

derived from asset prices and other real and financial variables concerning financial instability.[14] From a policymaker's perspective, this is probably the relevant issue anyway; even if the bubble question is interesting in its own right, knowing what *combination* of events in the real and financial sectors increase the probability of possible risks materializing is even more so.

Historical experience has taught us that financial distress generally arises as a *combination* of economic imbalances which unwind simultaneously. In this sense, hikes and declines in asset prices, along with rapid credit expansion[15] and —in some cases— above-average capital accumulation, rather than any of these alone, are the most common symptoms of such scenarios. Accordingly, they are an indication of an increase in the likelihood of possible imbalances.

Therefore, in what follows we seek to construct what can be called an *Early-Warning Financial Imbalance Indicator* using *ex ante* Colombian data on credit, investment and asset prices. The credit series was obtained from the Superintendencia Financiera de Colombia (SFC; Financial Superintendency) and includes mortgage, consumer (retail) and commercial loans. Investment was obtained from the national accounts published by the Departamento Administrativo Nacional de Estadística (DANE; Department of National Statistics), and the information related with asset prices was constructed by the Departamento Nacional de Planeación (DNP; National Planning Department) and the Bolsa de Valores de Colombia (BVC; Colombian Stock Exchange).

Based on these variables, *early warning* indicators were constructed for the following: i) ratio of real loans to real gross domestic product (GDP);[16] ii) real investment to real GDP; iii) a general equity index constructed by the BVC; iv) a new housing price index

14 This approach was first proposed by Kaminsky and Reinhart (1999).

15 Much debate exists concerning the criteria that defines adverse credit growth. In this paper, when we refer to *rapid* credit growth we do not think of a higher equilibrium growth level, but rather an expansion related to increased market liquidity, a relaxation in risk assessment and monitoring standards, and indebtment decisions above actual repayment capacities. Hilbers et al. (2005) identify an expansion above 20% in real terms as worrying for countries with low credit to GDP ratios (i.e. below 30%). Credit in Colombia grew 26.5% in real terms during 2006, and the credit/GDP ratio was slightly above 30% for the first time in over 5 years.

16 This ratio is also suggested by Kaminsky and Reinhart (1999), Gourinchas et al. (2001), and Sopanha (2006), among others.

constructed by the DNP; and v) an aggregate price index (API), constructed by the Banco de la República (Colombia's Central Bank).[17] For each indicator, we utilize quarterly data that covers the period between December 1994 and December 2006. Series were chosen given that they integrate information of the financial and real sectors.

Figure 1 plots each series. As can be observed, credit and investment have a similar behavior and the same occurs for the API and the general equity index. The former confirms the close relationship documented in the literature between credit and real economic activity, whilst the latter is explained by the relative importance of equity prices in the aggregate index calculation.

Perhaps most important is to note the mechanism behind the financial accelerator at work. During the period covered between 1995-1999, credit grew buoyantly, leading to high levels of investment (consumption was also high during this period) and an increment in the aggregate level of asset prices (as captured by the API) and especially of real estate.[18] When the crisis materialized, all indicators fell sharply and stayed at relatively low levels until around 2003. From there, one can witness a period of recuperation, with credit expanding vigorously along with the leves of investment and equity prices hiking considerably. Housing prices showed a minor upward trend following 2003 and later stabilized. This could be due to both a lag in the impact of higher liquidity on the real estate market and/or to a lower demand of this asset as a result of the large losses suffered by homeowners during the crisis.[19] Still, the fact of the matter is that, at least at first glance, the data seems to support the notion that periods of credit growth, together with high levels of investment and of asset prices, precede periods of financial imbalance.

The idea behind these indicators is to measure the deviation of each variable from its long-term trend, and then determine if an imbalance was effectively observed after such deviations overcome a specific threshold value. If the above occurs, then the deviations of the variables from their long-run tendencies (which we refer to as

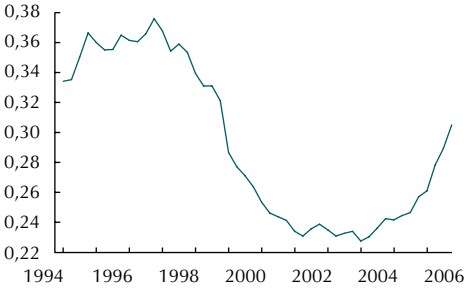
17 Appendix B carefully explains the construction of the aggregate price index.

18 Equity prices are not a good indicator during this first period given the shallowness of the market, both in the number of participants and the volumes traded.

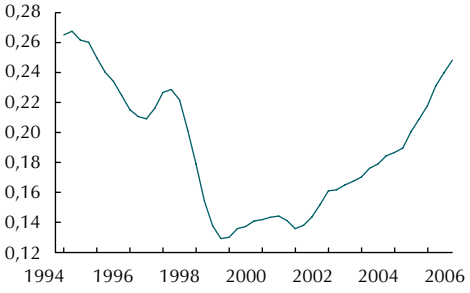
19 Colombia's 1998-1999 crisis was, for the most part, a mortgage-based crisis; Homeowners saw the value of their mortgage debts surpass the value of their assets, thus being forced to loose their houses.

Figure 1
Historical behavior of the constructed variables

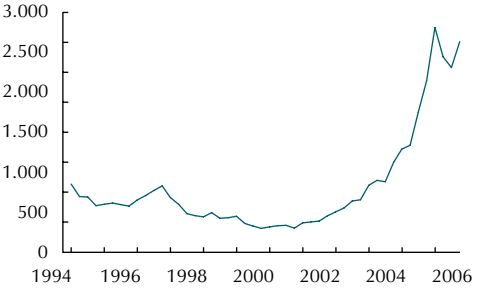
A. Loans to GDP Radio



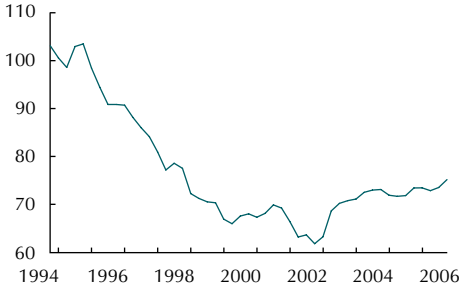
B. Investment to GDP Ratio



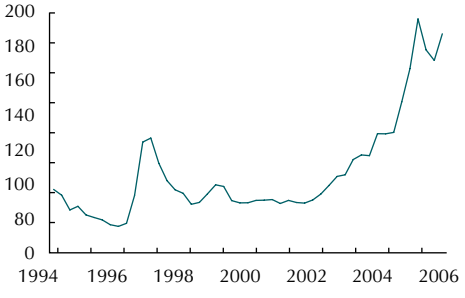
C. General Equality Index
(1994 = 100)



D. New Housing Price Index
(1994 = 100)



E. Agreggate Price Index
(1994 = 100)



Source: Author's calculations.

the *gap* in what follows) can be seen as an *ex ante* indicator of possible financial distress.

The above implies that our indicators focus on cumulative processes, as suggested by Borio and Lowe (2002, 2003), since a large *gap* can develop through either one year of very rapid growth in the relevant variable, or as the result of a number of years of above trend growth. We also follow the authors in that we consider *joint* indicators, to see which combination of real and financial variables provide the most useful signals. Finally, we take into consideration different forecast horizons to recognize the difficulty of predicting the exact time of a financial imbalance.

1. A Simple Caveat

Before explaining the way in which the indicators were constructed and the variables used, a simple caveat concerning the threshold values is necessary. Although highly sophisticated methods could have been used in order to determine the optimal threshold values, the approach followed here is a *parsimony-criteria*. This is done for two reasons. First of all, because it is significantly easier to calculate. Secondly, because we are interested in constructing an *ex ante* indicator for policymakers which provides them with the largest amount of useful information possible. We believe this information set includes different *early-warning* scenarios under a relevant range of threshold values, rather than under one value alone. The criteria used, therefore, is simply to observe for each individual *gap* the threshold value(s) that is/(are) only exceeded prior to times of financial instability.

B. CALCULATING THE EARLY-WARNING INDICATORS

Following Borio and Lowe (2002, 2003) and based on the five indicators constructed we employ a Hodrick and Prescott filter to obtain the long-run trend of these variables[20]. Subsequently, we calculate the deviation of each series with respect to its

20 The filter assumes that the tendency of a series (i.e the long-term component) is determined by technological changes, demographic changes, factor productivity, etc. Thus, variations in the aggregate demand explain the short-run behavior of the series. Therefore, a series can be seen as a combination of two components: the long-term supply component or tendency and the short-term demand component, also called cycle. Under this approach, any series (x_t) can be written as the sum of a trend (g_t) and a cyclical component (c_t):

trend by dividing the observed value in each period by its estimated trend. We shall from this point on refer to these deviations as the *credit gap*, *investment gap*, *equity gap*, *housing gap* and *API gap*, respectively for each of the indicators that were constructed. Figure 2 plots the percentage *gap* for each of the series considered.[21], [22] The shaded region corresponds to the crisis period (i.e. 98-99).

C. RESULTS

As Figure 2 reveals, the credit, investment, equity and API *gap* present high deviations from their long-term trend for the year prior to and/or during the financial crisis of 1998-1999.[23] However, the same is not true for the *housing gap* which does not show a high *gap* for the year before or during the crisis, but rather 3 years earlier (i.e. 1995). This could mean one of two things. Either that housing prices are not a good *early-warning* indicator, or on the contrary, they are the best *early-warning* indicator, because they predict the imbalance first.

Additionally, it is interesting to note that the *credit gap*, *equity gap* and *API gap* showed somewhat similar deviations during the pre-crisis period and the first quarter of 2006. However, they diverge significantly starting the second quarter and up until the end of the year, with the loans to GDP ratio registering its highest deviations (over 10%) with respect to its trend, while both equity prices and the API presented important reductions in theirs (around 20 percentage points). This is not surprising if one keeps in mind that credit grew over 20% in real terms during 2006 (GDP grew 6.8%), a level that has already began to worry supervisory authorities as well as the Central Bank. This has led to important monetary measures to slow-down the rapid

---

$x_t = g_t + c_t, t = 1,...,T$

The authors find the long-term component of a series by minimizing the following expression:

$$\sum_{t=1}^{T}\left(x_t - g_t^2\right) + \lambda \sum_{t=1}^{T}\left[\left(g_{t+1} - g_t\right) - \left(g_t - g_{t-1}\right)\right]^2$$

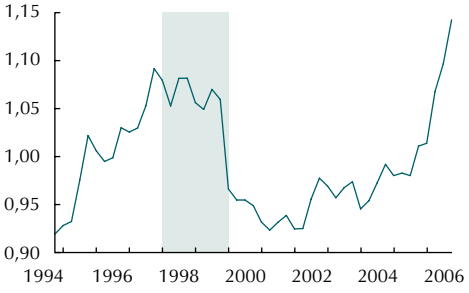
21 A *gap* of 1.2 implies a deviation of 20% between the series and its trend. In other words, the series' value is 20% greater than the long-run trend value.

22 Appendix C includes the graphs for each analyzed series along with the long-term component.

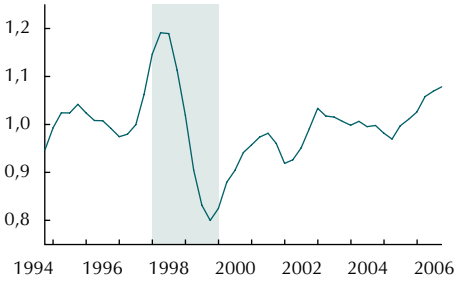
23 This crisis was the must pronounced *shock* the Colombian economy has suffered in the last century, and is actually the only crisis in our data set.

Figure 2
Deviation from the Analyzed Series to Their Long-Term Trend (Gap)

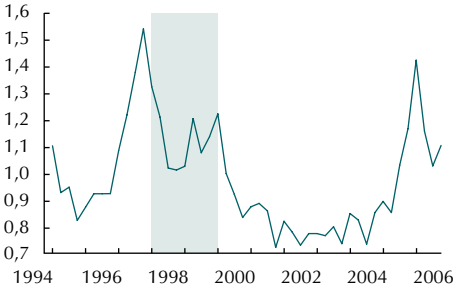
A. Credit Gap



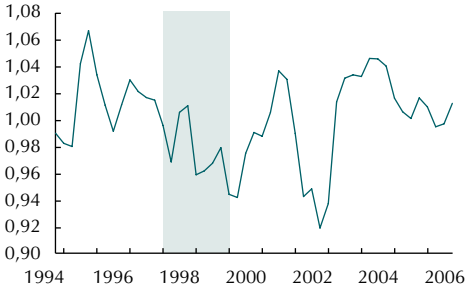
B. Investment Gap



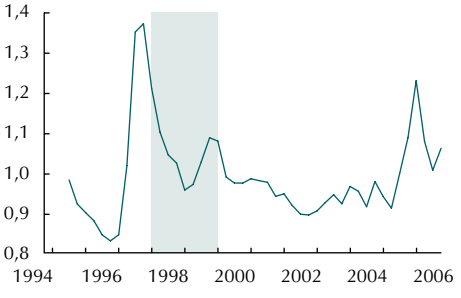
C. General Equality Gap



D. Housing Gap



E. API Gap



Source: Author's calculations.

credit expansion (interest rate hikes, marginal reserve requirements, among others) and the implementation of a new credit-risk model to enhance the current risk measures.[24] The fall in the API and equity prices is explained by the high volatility experienced in local markets during the second quarter of 2006, which increased certain investors' risk aversion and adversely affected their portfolio position in these assets (e.g. pension funds, stock brokers, investment funds, among others).

The *indicators* that we intend to build must give an alert signal when the estimated gaps overcome certain threshold values. In this way, we use a trial-and-error methodology to verify the efficiency of these indicators by checking whether they were able to predict the 1998-1999 economic crisis, how many *false alarms* are detected and whether each indicator identifies a financial imbalance as of December 2006. Obviously, the information may vary depending on the threshold values that are chosen. We construct information tables for the alert signals that the various indicators give for different threshold values and time horizons, we also use *combinations* of indicators. Results are presented in Table 1.

Table 1
Early-Warning Indicators

Threshold Value		Housing Gap		
		Horizon		
		1 year	2 years	3 years
4	N. of correctly predicted	0	0	1
	N. of false alarms	2	2	0
	Predicts imbalance today	No	No	No
5	N. of correctly predicted	0	0	0
	N. of false alarms	0	0	0
	Predicts imbalance today	No	No	No
6	N. of correctly predicted	0	0	0
	N. of false alarms	0	0	0
	Predicts imbalance today	No	No	No

24 The new model is called SARC (for its spanish initials) and is currently operating only for commercial loans. The idea is to extend it to consumption loans by 2008. The central idea behind the model is for banks to have higher provisioning levels during the ascending part of the economic cycle so as to create a reserve fund for the "bad" times. More on this model can be found at <www.superfinanciera.gov.co>.

Table 1 (continued)
Early-Warning Indicators

Threshold Value		Credit Gap Horizon 1 year	2 years	3 years
4	N. of correctly predicted	1	1	1
	N. of false alarms	0	0	0
	Predicts imbalance today	Yes	Yes	Yes
6	N. of correctly predicted	1	1	1
	N. of false alarms	0	0	0
	Predicts imbalance today	Yes	Yes	Yes
7	N. of correctly predicted	1	1	1
	N. of false alarms	0	0	0
	Predicts imbalance today	Yes	Yes	Yes

Threshold Value		Investment Gap Horizon 1 year	2 years	3 years
5	N. of correctly predicted	1	1	1
	N. of false alarms	0	0	0
	Predicts imbalance today	Yes	Yes	Yes
9	N. of correctly predicted	1	1	1
	N. of false alarms	0	0	0
	Predicts imbalance today	No	No	No
10	N. of correctly predicted	1	1	1
	N. of false alarms	0	0	0
	Predicts imbalance today	No	No	No

Table 1 (continued)

Equity Gap			
Threshold Value		Horizon	
		1 year	2 years	3 years
10	N. of correctly predicted	1	1	1
	N. of false alarms	1	1	1
	Predicts imbalance today	Yes	Yes	Yes
20	N. of correctly predicted	1	1	1
	N. of false alarms	0	0	0
	Predicts imbalance today	No	No	No
30	N. of correctly predicted	1	1	1
	N. of false alarms	0	0	0
	Predicts imbalance today	No	No	No

Aggregate Price Index (API) Gap			
Threshold Value		Horizon	
		1 year	2 years	3 years
5	N. of correctly predicted	1	1	1
	N. of false alarms	1	1	1
	Predicts imbalance today	Yes	Yes	Yes
15	N. of correctly predicted	1	1	1
	N. of false alarms	0	0	0
	Predicts imbalance today	No	No	No
25	N. of correctly predicted	1	1	1
	N. of false alarms	0	0	0
	Predicts imbalance today	No	No	No

Joint Indicator (Credit-Investment-Equity-Housing)							
Threshold Value					Horizon		
Credit	Invest.	Equity	Housing		1 year	2 years	3 years
4	5	30	4	N. of correctly predicted	0	0	1
				N. of false alarms	0	0	0
				Predicts imbalance today	No	No	No
4	10	30	4	N. of correctly predicted	0	0	1
				N. of false alarms	0	0	0
				Predicts imbalance today	No	No	No

Table 1 (continued)

Joint Indicator (Credit-Investment-Equity)						
Threshold Value				Horizon		
Credit	Invest.	Equity		1 year	2 years	3 years
4	5	30	N. of correctly predicted	1	1	1
			N. of false alarms	0	0	0
			Predicts imbalance today	No	No	No
4	5	10	N. of correctly predicted	1	1	1
			N. of false alarms	0	0	0
			Predicts imbalance today	Yes	Yes	Yes

Joint Indicator (Credit-Investment-API)						
Threshold Value				Horizon		
Credit	Invest.	API		1 year	2 years	3 years
4	5	15	N. of correctly predicted	1	1	1
			N. of false alarms	0	0	0
			Predicts imbalance today	No	No	No
4	5	5	N. of correctly predicted	1	1	1
			N. of false alarms	0	0	0
			Predicts imbalance today	Yes	Yes	Yes
4	10	5	N. of correctly predicted	1	1	1
			N. of false alarms	0	0	0
			Predicts imbalance today	No	No	No

* The threshold values are expressed as percentage deviations from the trend.
* The horizon is the number of years, prior to the imbalance period, considered to test the predictive power of the indicator.
* An indicator is on if the deviation form the trend is above the chosen threshold level for two or more consecutive quarters at the respective horizon.

In the tables presented, an imbalance is defined as a period in which two or more quarters present deviations above the chosen threshold level[25] at the respective time horizon. A 1 year horizon means that the predictive capacity of the indicator is validated ONLY if an imbalance is present the year immediately prior to the crisis; a 2 year horizon means it is validated if the imbalance is present either the year before

25 This is done in order to eliminate possible "noisy-signals" which arise due to high short-term volatilities under very specific conjunctures in the market.

or two years before, and so on. For the *joint* indicators, ALL the chosen variables must exhibit an imbalance in order for the signal to be ON.

The results from the individual indicators show no apparent surprises. All indicators correctly predict the 98-99 crisis at all horizons for the threshold values chosen, except housing prices. The latter only identifies the crisis when a 3 year horizon is considered. Additionally, only the credit indicator identifies an imbalance *today*, for all threshold values and horizons. The investment, equity and API indicators identify it as well, but only with the lowest threshold values considered. However, the equity and API indicators both give *false signals* when such a threshold is chosen, which is certainly not a desired feature in these type of indicators.

The fact that both the API and equity indicators *fail* to predict an imbalance as of December 2006 is directly related to the volatility period during the second quarter of 2006, which reduced the deviation of each series to its respective trend.[26] However, it is interesting to note that the deviations present during the latter half of 2005 and the first quarter of 2006 did effectively reflect a possible imbalance in those markets; one which corrected abruptly before the end of the first semester.

The *joint* indicators give diverse results. Not surprisingly, when an indicator involves housing prices (Credit-Investment-Equity-Housing), it does not predict a financial imbalance *today* and only correctly predicts the 98-99 crisis when a 3 year horizon is chosen. The second *joint* indicator (Credit-Investment-Equity), correctly predicts the crisis period for the threshold values and horizons considered. Moreover, including a real variable along with equity prices eliminates the *false alarms* present when the latter was taken individually. Whether the indicator predicts an imbalance *today* remains a matter of choice between the two sets of threshold values, and given uncertainty as to whether the next years will effectively feature a financial imbalance, a definite choice cannot be made between the two. The same conclusion holds for the Credit-Investment-API indicator, which is expected given the relative importance of equity price movements in the behavior of this index.

Overall, a definite conclusion cannot be made as to which indicator is *best*. However, there is enough evidence in these indicators regarding the information that asset prices

26 Assuming that the deviation would have continued to increase had there been no such volatility in the market.

(at least equity prices), among with other key variables, have in identifying possible future imbalances (i.e. almost all indicators were ON before the 98-99 crisis). Preliminary results tend to favor both the Credit indicator and the *joint* indicators Credit-Investment-Equity and Credit-Investment-API, as they all correctly predict the crisis period and make no *false alarms*. The strong appeal of the latter lies in that they take into account financial and real variables and theoretically include more market information. The future behavior of the market (i.e. the occurrence or not of a financial imbalance) will more specifically tell us which threshold values work *best*; However, note that the realization of a future imbalance will make a strong case for the Credit indicator, since it is the only *early-warning* signal that is ON regardless of the threshold value chosen. In this more than in any other case, only time will tell.

V. CONCLUDING REMARKS

Asset prices have recently began to experience an academic *boom*, by becoming a common topic in economic debate. However, much time has been spent in determining whether asset prices effectively exhibit a bubble component, a question which although being theoretically appealing deviates from the policy makers needs. For the latter, the fact that asset prices may contain relevant information concerning future market developments is central, and should therefore be exploited.

This paper is a first effort in this direction, aimed towards the construction of *early-warning* indicators using financial (including asset prices) and real variables, both individually and *jointly*. Results show evidence to support that there is relevant information embedded in these series, as ALL indicators (except the new housing price indicator) reveal a significant deviation for the year(s) prior to the 98-99 crisis (i.e. they are ON). Additionally, the exercises here conducted show that the performance of asset price indicators is enhanced by including credit and investment, thus considering a wider range of market information. A definite conclusion regarding the *best* indicator (along with the *best* forecast horizon and threshold level) will unfortunately depend on future market events. They will be the ultimate judge on the predictive power of each indicator.

In terms of policy action, these indicators serve two purposes. Firstly, the individual indicators help identify specific markets where signs of possible imbalances are present. Secondly, the *joint* indicators help to identify specific moments when the promotion of a sounder financial system is MOST NECESSARY (although by no means unique). When the *early-warning* indicators are ON, the role of the policy maker should be *more*

active in the market. Not necessarily in the traditional sense (i.e. altering interest rates), but in communicating with market participants, promoting portfolio diversification, preserving the long-term perspective of institutional investors (e.g. pension funds) and urging financial agents to make the best use of the information (i.e. credit data bases and/or firms balance sheets) and risk management tools that are available to them.[27]

However, as mentioned above, these actions should not be the sole responsibility of the *imbalance* periods, and should be regularly practiced by local authorities (i.e. prudential regulation). Additionally, promoting the creation and deepening of capital markets to increase portfolio diversification is a task that must not be left aside, because the future development of a more shock-resistant financial system will largely depend on the level of maturity of the system as a whole.

In this respect, the Banco de la República has done an immense effort, by openly collaborating with the Superintendencia Financiera in the sophistication and implementation of risk management tools to better face market, credit and liquidity risk. Additionally, by emphasizing in its periodical publications the need to advance in better credit-information data bases for the financial system, alerting banks to keep a close watch on the level of non-performing loans and analyzing asset prices in an effort to identify possible imbalances.

Future research in this field is more than necessary, especially since this is only a first approach to obtaining all the relevant information for policy makers from asset prices. A possible next step would be to follow Coudert and Gex (2006) in utilizing risk aversion indicators (which are constructed using principal component analysis on financial price series) to anticipate financial imbalances.[28] The important issue at hand is that all such efforts, no matter how sophisticated or practical, by being aimed towards granting monetary authorities new tools to prevent pronounced periods of recession, are welcome.

27 An excellent review of the prudential and supervisory measures that can and have been used by policymakers worldwide to undermine possible future financial imbalances is found in Hilbers et al. (2005).

28 The authors use probability models to test this hypothesis.

REFERENCES

1. Bernanke, B.; Gertler, M.; S., Gilchrist. "The Financial Accelerator in a Quantitative Business Cycle Framework", *NBER Working Paper*, no. 6455, Cambridge (MA), 1998.

2. Borio, C.; Lowe, P. Asset Prices, Financial and Monetary Stability: Exploring the Nexus. Paper presented at the BIS Conference on "Changes in Risk Through Time: Measurement and Policy Options", *BIS Working Papers*, no. 114, July, Basel, 2002.

3. Borio, C.; Lowe, P. "Imbalances or 'Bubbles?' Implications for Monetary and Financial Stability", C. Hunter, G. Kaufman and M. Pomerleano (Eds.). *Asset Price Bubbles: The Implications for Monetary, Regulatory and International Policies*. Cambridge (MA), MIT Press, pp. 247-270, 2003.

4. Cecchetti, S.; Genberg, H.; Wadhwani, S. "Asset Prices in a Flexible Inflation Targeting Framework", C. Hunter, G. Kaufman and M. Pomerleano (Eds.), *Asset Price Bubbles: The Implications for Monetary, Regulatory and International Policies*. Cambridge (MA), MIT Press, pp. 227-444, 2003.

5. Cochrane, J. "Explaining the Variance of Price Dividend Ratios", *Review of Financial Studies* 5(2), pp. 243-280, 1992.

6. Collyns, C.; Senhadjy, A. "Lending Booms, Real Estate Bubbles, and the Asian Crisis", C. Hunter, G. Kaufman and M. Pomerleano (Eds.), *Asset Price Bubbles: The Implications for Monetary, Regulatory and International Policies*. Cambridge (MA), MIT Press, pp. 101-125, 2003.

7. Coudert, V.; Gex, M. "Can Risk Aversion Indicators Anticipate Financial Crises?", *Financial Stability Review*, Banque de France, no. 9, December, pp. 67-87, 2006.

8. Dezbakhsh, H.; Demirguc-Kunt, A. "On the Presence of Speculative Bubbles in Stock Prices", *The Journal of Financial and Quantitative Analysis*, no. 25, pp. 101-112, 1990.

9. Diba, B.; Grossman, H. "Explosive Rational Bubbles in Stock Prices?" *American Economic Review*, vol. 78, no. 3, June, pp. 520-530, 1988a.

10. Diba, B.; Grossman, H. "The Theory of Rational Bubbles in Stock Prices" *The Economic* Journal, vol. 98, no. 392, September, pp. 746-754, 1988b.

11. Dowd, K. *Measuring Market Risk*, Chichester, John Wiley & Sons Lt, 2005.

12. Driffill, J.; Sola, M. "Intrinsic Bubbles and Regime Switching", *Journal of Monetary Economics*, vol. 42, no. 2, July, pp. 357-373, 1998.

13. Evans, G. "Pitfalls in Testing for Explosive Bubbles in Asset Prices", *American Economic Review*, vol. 81, no. 4, September, pp. 922-930, 1991.

14. Friedman, M. "Comments on Implications of Bubbles for Monetary Policy", C. Hunter, G. Kaufman and M. Pomerleano (Eds.). *Asset Price Bubbles: The Implications for Monetary, Regulatory and International Policies*, Cambridge (MA), MIT Press, pp. 459-463, 2003.

15. Flood, R.; Hodrick, R.; Kaplan P. "An Evaluation of Recent Evidence on Stock Price Bubbles", Robert Flood and Peter Garber (Eds.). *Speculative Bubbles, Speculative Attacks, and Policy Switching*, Cambridge (MA), MIT Press, pp. 105-133, 1994.

16. Froot, K. and Obstfeld, M. "Intrinsic Bubbles: The Case of Stock Prices" *American Economic Review*, vol. 23, no. 4, December, pp. 1189-1214, 1991.

17. Goodfriend, M. "Interest Rate Policy Should Not React Directly to Asset Prices", C. Hunter, G. Kaufman and M. Pomerleano (Eds.). *Asset Price Bubbles: The Implications for Monetary, Regulatory and International Policies*, Cambridge (MA), MIT Press, pp. 444-457, 2003.

18. Gourinchas, P.; Valdes, R.; Landerretche, O. "Lending Booms: Latin America and the World", *NBER Working Paper*, no. 8249, 2001.

19. Gurkaynak, R.S. "Econometric Tests of Asset Price Bubbles: Taking Stock", *FEDS Working Paper* 2005-04. Available at SSRN: <http://ssrn.com/abstract=658244>, 2005.

20. Hilbers, P.; Otker-Robe, I.; Pazarbasioglu, C.; Johnsen, G. "Assesing and Managing Rapid

Credit Growth and the Role of Supervisory and Prudential Policies", *IMF Working Paper*, WP/05/151, 2005.

21. Kaminsky, G.; Reinhart, C. "The twin crises: the causes of banking and balance-of-payments problems", *American Economic Review*, vol 89, no. 3, June, pp. 473-500, 1999.

22. Kroszner, R. S. "Asset Price Bubbles, Information, and Public Policy", C. Hunter, G. Kaufman and M. Pomerleano (Eds.). *Asset Price Bubbles: The Implications for Monetary, Regulatory and International Policies*, Cambridge (MA), MIT Press, pp. 3-12, (2003).

23. López, M. (2005). "House Prices and Monetary Policy in Colombia", *Working Papers, Central Bank of Chile*, no. 349.

24. McGrattan, E. R.; Prescott, E. Testing for Stock Market Overvaluation/Undervaluation", C. Hunter, G. Kaufman and M. Pomerleano (Eds.). *Asset Price Bubbles: The Implications for Monetary, Regulatory and International Policies*, Cambridge (MA), MIT Press, pp. 271-276, 2003.

25. Meltzer, A. H. "Rational and Nonrational Bubbles", C. Hunter, G. Kaufman and M. Pomerleano (Eds.). *Asset Price Bubbles: The Implications for Monetary, Regulatory and International Policies*, Cambridge (MA), MIT Press, pp. 23-33, 2003.

26. Shiller, R. "Do Stock Prices Move Too Much to be Justified by Subsequent Changes in Dividends?", *American Economic Review*, vol. 71, no. 3, June, pp. 421-436, 1981.

27. Sopanha, S. "Capital Flows and Credit Booms in Emerging Market Economies", *Financial Stability Review*, Banque de France, num. 9, December, pp. 49-66, 2006.

28. Tenjo, F.; Charry, L. F.; López, M.; Ramírez, J. M. "Acelerador financiero y ciclos económicos en Colombia: un ejercicio exploratorio", Borradores de Economía, Banco de la República, num. 451, 2007.

29. Tirole, J. "Asset Bubbles and Overlapping Generations", *Econometrica*, vol. 53, no. 6, November, pp. 1499-1528, 1985.

30. Trichet, J. C. "Asset Price Bubbles and Their Implications for Monteray Policy and Financial Stability", C. Hunter, G. Kaufman and M. Pomerleano (Eds.). *Asset Price Bubbles: The Implications for Monetary, Regulatory and International Policies*, Cambridge (MA), MIT Press, pp. 15-22, 2003.

31. Van Norden, S.; Vigfusson, S. "Avoiding the Pitfalls: Can Regime-Switching Tests Reliably Detect Bubbles?", *Studies in Nonlinear Dynamics and Econometrics*, no. 3, pp. 1-22, 1998.

32. Villar, L.; Salamanca, D.; Murcia, A. "Crédito, represión financiera y flujos de capitales en Colombia", Borradores de Economía, *Banco de la República*, no. 322, 2005.

33. West, K. "A Specification Test for Speculative Bubbles", *The Quarterly Journal of Economics*, num. 102, August, pp. 553-580, 1987.

34. Wu, Y. "Rational Bubbles in the Stock Market: Accounting for the U. S. Stock-Price Volatility", *Economic Inquiry*, no. 35, April, pp. 309-319, 1997.

APPENDIX A
CALCULATING $\bar{\beta}$ AND K

In Section III of this paper a solution for P_t^f is given for the case where income flows are explicitly modelled:

$$P_t^f = \bar{\beta}\, d_t; \quad where \quad \bar{\beta} = \left(\frac{\frac{\phi}{(1+r)}}{1-\frac{\phi}{(1+r)}} \right) \tag{A.1}$$

$$P_t^f = kD_t; \quad where \quad k = \frac{e^{(\mu+\sigma^2/2)}}{(1+r)-e^{(\mu+\sigma^2/2)}} \tag{A.2}$$

In the first case, income flows are modelled as $d_t = \phi d_{t-1} + u_t$. In the second case *log* income flows are assumed to follow a random walk process with drift of the form $d_t = \mu + d_{t-1} + \zeta_t$.

In this appendix, the solutions given in equations (A.1) and (A.2) are explained in detail.

1. CALCULATING $\bar{\beta}$

To obtain $\bar{\beta}$ simply remember that the fundamental price is expressed as:

$$P_t^f = \sum_{i=1}^{\infty} \left(\frac{1}{1+r} \right)^i E_t \left(d_{t+i} \,|\, \Omega_t \right) \tag{A.3}$$

d_{t+i} cannot be observed at time t, but d_t is. Solving d_{t+i} recursively yields:

$$d_{t+i} = \phi d_{t+i-1} + u_{t+i} \tag{A.4}$$

$$= \phi^2 d_{t+i-2} + \phi u_{t+i-1} + u_{t+i} \tag{A.5}$$

$$\vdots \tag{A.6}$$

$$= \phi^i d_t + \sum_{j=0}^{i} \phi^j u_{t+i-j} \tag{A.7}$$

Recall that u_t is a white noise variable (i.e. $N(0, \sigma^2)$) and that the expected value ($E_t[\cdot]$) is a linear operator, such that

$$E_t[\sum_{j=0}^{\infty} u_{t+i-j}] = \sum_{j=0}^{\infty} E_t[u_{t+i-j}] = 0$$

Using the result in equation (A.7), one can rewrite equation (A.3) as:

$$P_t^f = \sum_{i=1}^{\infty}\left(\frac{1}{1+r}\right)^i E_t\left(\phi^i d_t + \sum_{j=0}^{i}\phi^j u_{t+i-j}\right) \tag{A.8}$$

$$= \sum_{i=1}^{\infty}(\frac{1}{1+r})^i \phi^i d_t \tag{A.9}$$

$$= \sum_{i=0}^{\infty}(\frac{1}{1+r})^{i+1} \phi^{i+i} d_t \tag{A.10}$$

$$= dt(\frac{\phi}{1+r})\sum_{i=0}^{\infty}(\frac{\phi}{1+r})^i \tag{A.11}$$

$$= dt\left(\frac{\frac{\phi}{1+r}}{1-\frac{\phi}{(1+r)}}\right) \tag{A.12}$$

$$= d_t\bar{\beta} \tag{A.13}$$

Note that the sum converges as long as $\phi < 1+r$.

2. CALCULATING *K*

Obtaining the *k* parameter is very similar to calculating $\bar{\beta}$. The only significant difference lies in dealing with an exponential function. To start off, recall that the fundamental price is defined as:

$$P_t^f = \sum_{i=1}^{\infty}(\frac{1}{1+r})^i E_t(D_{t+i}) \tag{A.14}$$

Since log income flows (d_t) are assumed to follow a random walk process such that $d_t = \mu + d_{t-1} + \zeta_t$, equation (A.14) can be written as:

$$P_t^f = \sum_{i=1}^{\infty} (\frac{1}{1+r})^i E_t(e^{d_{t+i}}) \tag{A.15}$$

As in the prior case, d_{t+1} cannot be observed at time t, yet d_t is. So once again solving recursively for d_{t+1} one obtains:

$$d_{t+1} = \mu + d_{t+i-1} + \zeta_{t+i} \tag{A.16}$$

$$= \mu + \mu + d_{t+i-2} + \zeta_{t+i-1} + \zeta_{t+i} \tag{A.17}$$

$$\vdots \tag{A.18}$$

$$= i\mu + d_t + \sum_{j=0}^{i} \zeta_{t+i-j} \tag{A.19}$$

So that equation (A.15) can be expressed as:

$$P_t^f = \sum_{i=1}^{\infty} \left(\frac{1}{1+r} \right)^i E_t \left(e^{i\mu + d_t + \sum_{j=0}^{i} \zeta_{t+i-j}} \right) \tag{A.20}$$

$$= \sum_{i=1}^{\infty} \left(\frac{1}{1+r} \right)^i E_t \left(e^{i\mu + d_t + X} \right) \tag{A.21}$$

where $X = \sum_{j=0}^{i} \zeta_{t+i-j}$ Note that X is normal because it is the sum of normal variables (ζ_t is a white noise variable $N(0, \sigma^2)$).

The log-normal distribution has the property that $E_t[e^X]$, where X is a normal variable with mean ν and variance σ^2 is $e^{\nu + \sigma^2/2}$. Since the mean of each ζ_t is equal to 0, the mean of X will be equal to 0 as well (i.e. $\nu = 0$). Given this, the variance of X will simply be the sum of the variances of ζ_t;

$$\sigma_X^2 = var(\sum_{j=0}^{i} \zeta_{t+i-j}) = \sum_{j=0}^{i} var(\zeta_{t+i-j}) = i\sigma^2$$

and $E_t(e^X)$ will be;

$$E_t(e^X) = e^{\nu_X + \sigma_X^2/2} = e^{i\sigma^2/2}$$

Using the above result, equation (A.21) can be expressed in the following way:

$$P_t^f = \sum_{i=1}^{\infty}\left(\frac{1}{1+r}\right)^i e^{i\mu+d_t} e^{i\sigma^2/2} \tag{A.22}$$

$$= D_t \sum_{i=1}^{\infty}\left(\frac{e^{\mu+\sigma^2/2}}{1+r}\right)^i \tag{A.23}$$

$$= D_t \sum_{i=0}^{\infty}\left(\frac{e^{\mu+\sigma^2/2}}{1+r}\right)^{i+1} \tag{A.24}$$

$$= D_t \left(\frac{e^{\mu+\sigma^2/2}}{1+r}\right)\sum_{i=0}^{\infty}\left(\frac{e^{\mu+\sigma^2/2}}{1+r}\right)^i \tag{A.25}$$

$$= D_t \left(\frac{\frac{e^{\mu+\sigma^2/2}}{(1+r)}}{1-\frac{e^{\mu+\sigma^2/2}}{(1+r)}}\right) \tag{A.26}$$

$$= D_t \left(\frac{e^{\mu+\sigma^2/2}}{(1+r)-e^{\mu+\sigma^2/2}}\right) \tag{A.27}$$

$$= kD_t \tag{A.28}$$

The sum converges as long as $r > \mu + \sigma^2/2$.

APPENDIX B
CALCULATING THE AGGREGATE PRICE INDEX

The Aggregate Price Index (API) mentioned in Section 4 of this paper is a ``new" series that has only recently began to be calculated by the Financial Stability Department of the Banco de la República (Central Bank of Colombia). This Appendix describes the methodology and assumptions used in the construction of this index.

The API, in its shortest form, can be written as:

$$API_t = API_{cs,t}\,\phi_1 + API_{hh,t}\,\phi_2 + API_{fs,t}\,\phi_3 \quad ; \quad \sum_{i=1}^{3}\phi_i = 1 \tag{B.1}$$

where API_{CS}, API_{hh} and API_{fs} refer to the aggregate price index of the private Corporate Sector, Households and the Financial Sector. ϕ is the weight given to each sector and is determined by the relative participation of each sectors' assets on total assets. The API for each sector is defined as:

$$API_{cs,t} = IPEN_t\,\delta_{fa,t} + IGBC_t\,\delta_{eq,t} + IPTES_t\,\delta_{gb,t} \quad ; \quad \delta_{fa} + \delta_{eq} + \delta_{gb} = 1 \qquad \text{(B.2)}$$

$$API_{hh,t} = IPVN_t\,\beta_{fa,t} + IGBC_t\,\beta_{eq,t} + IPTES_t\,\beta_{gb,t} \quad ; \quad \beta_{fa} + \beta_{eq} + \beta_{gb} = 1 \qquad \text{(B.3)}$$

$$API_{fs,t} = IPEN_t\,\zeta_{fa,t} + IGBC_t\,\zeta_{eq,t} + IPTES_t\,\zeta_{gb,t} \quad ; \quad \zeta_{fa} + \zeta_{eq} + \zeta_{gb} = 1 \qquad \text{(B.4)}$$

where *IPEN* is an index of new commercial, office and warehouse constructions calculated by DANE (Department of National Statistics) and IPVN is an index of new residential housing prices calculated by DNP (Department of National Planning). Both these indexes are used as the price of fixed assets. IGBC is the general equity price index calculated by the Bolsa de Valores de Colombia (Colombian Stock Exchange) and IPTES is a price index for government bonds calculated at Banco de la República.[29] The choice of simplifying each sector's assets to these three types is based on actual price information availability (e.g. there is not a decent price series for corporate bonds) and the fact that they represent a significant portion of each sectors' assets.[30] All series used in the construction of these indexes are in real terms.

δ_{fa}, δ_{eq} and δ_{gb} represent the relative weights given to fixed assets, equity and government bonds, respectively, for the corporate sector. The β weights for households' API and the ζ weights for the financial sector's API are interpreted accordingly. Each weight is given by the relative importance of each type of asset in the total assets of each economic sector.

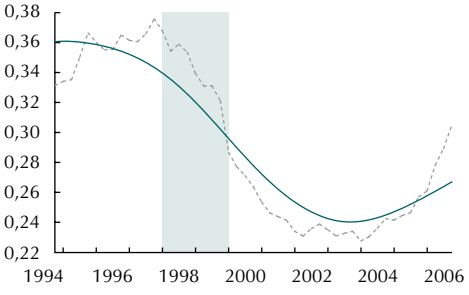
The index was calculated on a monthly basis for the period 1994:1-2006:12. For the purposes of this paper, the index was used on a quarterly basis, where each quarter corresponds to the average of the three relevant months.

29 The specific index used in this paper is for inflation-linked government bonds (called TES UVR).

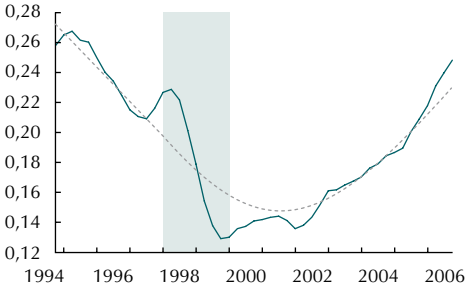
30 This is especially true for the financial sector and households, where these three assets represent more than 60% of total assets. In the corporate sector their participation falls close to 30%.

APPENDIX C
ANALYZED SERIES AND THEIR LONG-TERM TREND

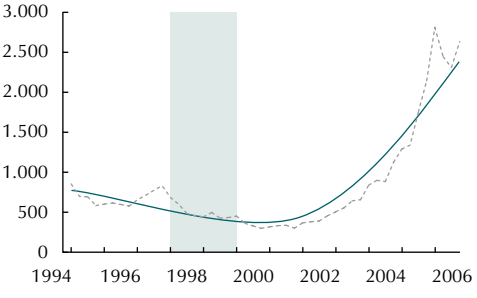
A. Loans to GDP Radio



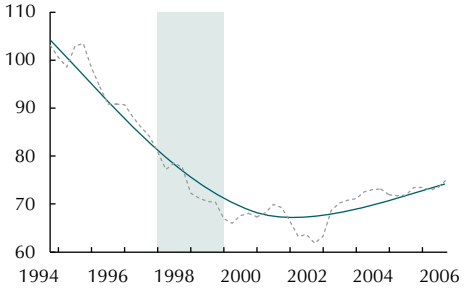
B. Investment to GDP Ratio



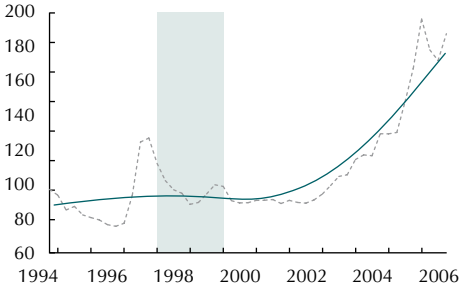
C. General Equality Index



D. New Housing Price Index



E. Agreggate Price Index



Source: Author's calculations.