

# News and sovereign default risk in small open economies\*

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## Abstract

This paper builds a model of sovereign debt in which default risk, interest rates, and debt depend not only on current fundamentals but also on news about future fundamentals. News shocks affect equilibrium outcomes because they contain information about the future ability of the government to repay its debt. First, in the model with news shocks not all defaults occur in bad times, bringing the model closer to the data. Second, the news shocks help account for key differences between emerging markets and developed economies: as the precision of news improves, the model predicts lower variability of consumption, less countercyclical trade balance and interest rate spreads, as well as a higher level of debt more in line with the characteristics of developed economies. Finally, the model also captures the hump-shaped relationship between default rates and the precision of news obtained from the data.

**JEL classification:** F34, F41.

**Keywords:** sovereign default risk; news shocks; endogenous borrowing constraints

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# 1 Introduction

News about future fundamentals can be a significant driving force of economic fluctuations, since they can influence agents' expectations and their current decisions.<sup>1</sup> One key source of country heterogeneity lies precisely in the ability to extract news regarding future economic developments that are relevant for forecasting and current decision making. Another relevant cross country difference relates to sovereign default risk and interest rate spreads, which can be a significant factor determining the dynamics of macroeconomic variables in small open economies.

While news and default risk have been examined separately, there is very little work exploring the implications of their joint dynamics. By affecting the incentives to default, news changes the economy through the effects on interest rate spreads. These forces were visibly at play in the 2010 debt crisis affecting some countries in the European Union. On February 3rd 2010, for instance, the Commissioner for Economic and Monetary Affairs Joaquín Almunia made a statement referring to Portugal and Spain – “For instance, those countries [Portugal and Spain] are facing a permanent loss in productivity ...”. These remarks can be interpreted as news in which European Union experts deemed likely that future economic conditions would continue to be relatively unfavorable in these countries. As shown in Figure 1, Credit Default Swaps increased immediately after Almunia's remarks. Statements of international credit agencies also provide examples of news shocks. For instance, in its recent downgrading of Spain's credit rating S&P underscored that “...we cut Spain's credit rating because we expect the Spanish economy to grow only 0.7% on average until 2016, lower than previous forecast...”<sup>2</sup> These remarks also led to an immediate rise in risk premium for Spanish and other European assets.

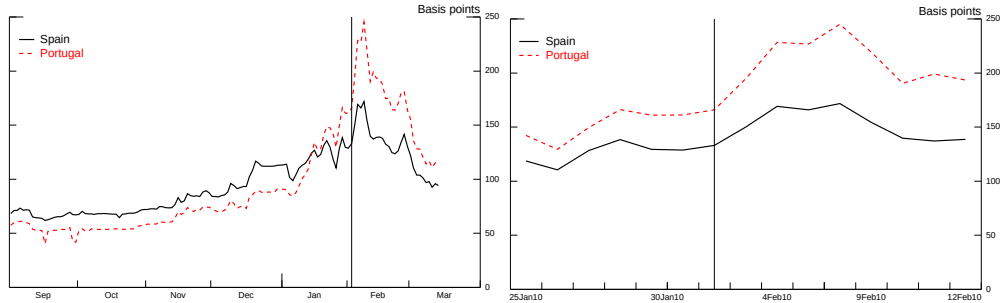
Our paper analyzes the extent to which changes in expectations – due to policy announcements or news in general – matter for macroeconomic fluctuations across countries. To pursue our goal, we build a quantitative dynamic small open economy model of sovereign debt and default subject to both contemporaneous and news shocks. Every period, the economy receives a stochastic endowment, as well as a noisy signal about next period's endowment. Households value private consumption and the government borrows from abroad to smooth consumption. Foreign lenders charge a risk premium that accounts for the default risk they face, so interest rate spreads reflect the time varying sovereign default risk. We examine the model implications quantitatively using direct data. Hence, we show the plausibility of our findings both from a theoretical and a quantitative

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<sup>1</sup>We use the term “news” to refer to “news shocks.”

<sup>2</sup>See Standard and Poor's Global Credit Portal RatingsDirect, Research Update, April 28, 2010.

Figure 1: Five-year CDS Spreads



Notes: The graph on the left shows the 5-year CDS spreads for Spain (solid line) and Portugal (dashed line). The vertical line points to February 3. The graph on the right reflects a more focused version than the one on the left.

perspective. In the quantitative analysis, we calibrate the model without news to a typical emerging market economy following Arellano (2008). We then explore how news about future output affects the predictions of the model.

Our quantitative analysis delivers three key findings. First, we find that introducing news can account for the empirical fact that not all defaults occur in bad times. We find that negative news can lead to a default, even if current output is high. Negative news regarding future fundamentals, increase next period's default risk, which immediately raises the interest rate paid by the sovereign. As the sovereign faces tighter conditions to roll-over debt, she may default in the current period. This mechanism highlights that besides having direct effects, news may significantly impact default risk, which in turn, alters the fluctuations of macro aggregates.

Second, we find that the differences in the precision of news about future fundamentals help rationalize differences in the fluctuations of several macroeconomic variables between emerging and industrialized economies.<sup>3</sup> The model economy where there is no news largely captures the dynamics of macroeconomic variables in emerging markets. As news becomes more informative, the model statistics get closer to those for developed countries. Our first set of findings is consistent with the premise that while agents in industrialized countries can generally rely on information systems that provide relatively accurate news, information is scarcer or less precise in most middle

<sup>3</sup>As earlier studies show, emerging market economies are more prone to crises, face higher interest rate spreads, and can only sustain lower debt-output ratios than their more developed counterparts (see Cantor and Packer (1996), Neumeyer and Perri (2005), Reinhart, Rogoff and Savastano (2003), and Uribe and Yue (2006), among others). In addition, these economies experience more countercyclical trade balances and sovereign interest rate spreads, making external credit more expensive in bad times.

and low income countries.<sup>4</sup>

Finally, the model predicts a hump-shaped relationship between default rates and precision of news. More precise news enable agents to better manage the debt instrument used to smooth consumption, which lowers the country's default rate for any given amount of debt. At the same time, the lower risk profile allows the economy to sustain more debt in equilibrium, which leads to more defaults. As the precision of the news is enhanced from a non informative case, the second effect dominates initially, resulting in higher observed default rates. As the signal conveys more information, the first effect gradually becomes more important, and equilibrium default rates decrease. Hence, default rates and the precision of news exhibit a hump-shape relationship. This theoretical prediction is confirmed by the data. In particular, the finding is in line with the empirical regularity regarding the link between income per capita levels and historical default rates. Using data for 163 countries covering the 1950-2003 period, we document a hump-shaped relationship between per capita income levels and default rates.

Our paper is related to several strands of the literature. First, we borrow from the news and learning literature. Pigou (1927) is among the first to consider that shifts in expectations about future fundamentals are important sources of macroeconomic fluctuations. More recently, Cochrane (1994) and Beaudry and Portier (2004) find that news about total factor productivity or stock prices can explain a significant portion of the forecast variance of consumption, output, and hours. Building on the real business cycle literature, Jaimovich and Rebelo (2008) and Schmitt-Grohe and Uribe (2008) explore the importance of news using log-linear approximation methods. Differently from these papers, we focus on how news shocks interact with default risk in a dynamic stochastic quantitative model of endogenous sovereign debt and default. In addition, unlike those studies, we employ nonlinear approximation methods, which are crucial to capture changes in precautionary savings due to differences in news precision.

Building on the work of Aguiar and Gopinath (2007), Boz et al. (2009) examine the effects of trend growth and transitory shocks in small open economies. When the model economy is subject to greater uncertainty regarding the decomposition of total factor productivity to its trend growth and transitory components, the economy displays characteristics that are more similar to emerging market countries. Complementing these studies, our framework explores how news about future

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<sup>4</sup>News are more precise in higher income per capita countries. In practice, higher income countries are more closely monitored and have more abundant and better quality data. See a formal analysis of this statement in Boz et. al. (2009). For an empirical study on international finance implications of transparency and quality of macroeconomic data, see Gelos and Wei (2005).

fundamentals affects sovereign default risk and macroeconomic fluctuations.

Second, our paper is related to the recent literature on quantitative models of sovereign debt. Following the seminal papers of Eaton and Gersovitz (1981) on international lending and Chatterjee, Corbae, Nakajima and Rios-Rull (2007) on unsecured consumer default, various studies have focused on how default risk affects economic fluctuations. A short list includes Aguiar and Gopinath (2006), Arellano (2008), Cuadra and Sapriza (2008), Hatchondo, Martinez and Sapriza (2009), Lizarazo (2006), Mendoza and Yue (2008), and Yue (2010), among others. Our paper advances on this literature by looking at the implications of news shocks on the behavior of sovereign spreads and international debt flows to small open economies.<sup>5</sup> To our knowledge, our paper presents the first effort to integrate news and endogenous default risk in a nonlinear dynamic stochastic quantitative model.

Our paper highlights the news shocks channel as a plausible explanatory mechanism for the finding by Tomz and Wright (2007) that a significant fraction of defaults have occurred in good times. We argue that adverse news regarding a government's future ability to repay its obligations may deteriorate the country's current borrowing conditions, which can trigger a rise in the country's risk premium before the fundamentals actually worsen.

The changes to the sovereign credit ratings help illustrate the relationship between news and the timing of default decisions. Changes to the sovereign credit ratings provide new information to markets regarding the countries' future ability to repay its obligations. For example, Ferri, Liu and Stiglitz (1999) highlight the importance of the news content of sovereign rating changes on sovereign credit spreads. They document that credit rating agencies aggravated the East Asian crisis by downgrading those countries' ratings beyond what fundamentals would justify. The premature downgrading led agents perceive that these economies would perform worse than previously anticipated, and that they would not be able to repay their debt obligations. This, in turn, exacerbated the cost of borrowing abroad and caused the supply of international capital to evaporate.<sup>6</sup>

The recent default of Ecuador provides a compelling case, which underscores the possibility of a default due to adverse news shocks. Ecuador defaulted on its foreign debt in the last quarter of 2008, although its economy was experiencing positive growth in the preceding quarters. A combination of political factors and the receipt of adverse economic news appear to have led to the

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<sup>5</sup>Mendoza (1991) and Correia, Neves and Rebelo (1995), among others analyze business cycles in small open economies but do not consider default risk.

<sup>6</sup>Parsley and Gande (2005) also analyze the news content and corresponding cross-country sovereign credit market spread implications due to sovereign credit rating changes.

default decision. More specifically, bad news regarding Ecuador’s future performance, including the plummet of oil prices from 140 dollars to just 45 dollars a barrel on the week of the default, the decline in remittances, and the announcement that the government would be running a fiscal deficit of 3.2 billion dollars in 2009, all fueled a jump in interest rate spreads to about 4500 basis points on Ecuador’s external debt obligations. Soon after these developments, the government announced its default.<sup>7</sup>

Hatchondo, Martinez and Saprizza (2009) propose an alternative explanation for sovereign defaults in good times. The authors study a setup with political turnover between policymakers with different levels of impatience. Impatient governments are likely to be associated with unwillingness to repay obligations. Hence, the election of an impatient policymaker might be perceived as bad news to creditors. From this perspective, our mechanism complements Hatchondo et al.’s, since we focus on the information structure related to the fundamentals of the economy. Our study also provides additional insight into the cross-country differences in sovereign debt and credit dynamics in countries with similar political dynamics but different transparency and information structures. In this vein, Gelos and Wei (2005) underscore the importance of country transparency and quality of information – including the timeliness and frequency of macroeconomic data availability as well as transparency in the conduction of macroeconomic policies – on debt flows.

The rest of the paper is organized as follows. Section 2 presents the economic environment and the theoretical framework. Section 3 analyzes the quantitative implications of the benchmark model and Section 4 concludes.

## 2 The model

We consider a small open economy model with households, government, and foreign lenders. We first describe the stochastic structure and the news shocks.

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<sup>7</sup>Nevertheless, we do not claim that the news shocks mechanism is the only or the most important driving force explaining sovereign defaults in good times. Venezuela in late 2002 provides supporting anecdotal evidence to this caveat. Through 2002, the S&P ratings and outlook for Venezuela plunged to a historical low, signaling further deterioration of fundamentals and a very high likelihood of a default event. But in spite of further weakening of economic conditions, the default never materialized and the country’s rating was eventually upgraded.

## 2.1 Stochastic structure and news shocks

The endowment is assumed to follow an AR(1) process

$$\ln(y_t) = \rho \ln(y_{t-1}) + \varepsilon_t, \quad (1)$$

with  $E(\varepsilon) = 0$  and  $E(\varepsilon^2) = \sigma_\varepsilon^2$ . The process is approximated using a discrete one-period Markov chain with probabilities  $p(y_{t+1} = m | y_t = j) \forall m, j \in \Theta$ , where  $\Theta$  denotes the probability space for the endowment. We consider that in any period the government receives a signal ( $s$ ) regarding next period's endowment. Due to the signal's predictive content, it will lead the government to revise its forecast.

Conditional on a future endowment ( $y_{t+1}$ ) we need to specify the probability of receiving a given signal ( $s_t$ ) in the current period. In other words, we need to define  $p(s_t = i | y_{t+1} = l)$ , with  $l \in \Theta$  and  $i \in \Xi$ , where  $\Xi$  denotes the probability space for the signal. The sets  $\Theta$  and  $\Xi$  do not necessarily coincide. One may consider the case where the government only receives signals regarding some future endowments with  $|\Theta| > |\Xi|$ , or the opposite case with  $|\Theta| < |\Xi|$ . In this paper, we consider  $|\Theta| = |\Xi|$ .

The signal ( $s_t$ ) is incorporated into the forecast of next period's endowment ( $y_{t+1}$ ). Following Bayes' theorem, the forecast conditional on current information is given by:

$$p(y_{t+1} = l | s_t = i, y_t = j) = \frac{p(s_t = i | y_{t+1} = l)p(y_{t+1} = l | y_t = j)}{\sum_n p(s_t = i | y_{t+1} = n)p(y_{t+1} = n | y_t = j)} \quad (2)$$

with  $l, j, n \in \Theta$  and  $i \in \Xi$ . For the quantitative analysis, it is convenient to express the Markov chain for the joint evolution of the endowment shock and the signal. This can be implemented with the following formula:

$$\begin{aligned} \Pi(y', s', y, s) &= p(s_{t+1} = \kappa, y_{t+1} = l | s_t = i, y_t = j) = p(y_{t+1} = l | s_t = i, y_t = j) \\ &\quad \sum_m [p(y_{t+2} = m | y_{t+1} = l)p(s_{t+1} = \kappa | y_{t+2} = m)] \end{aligned} \quad (3)$$

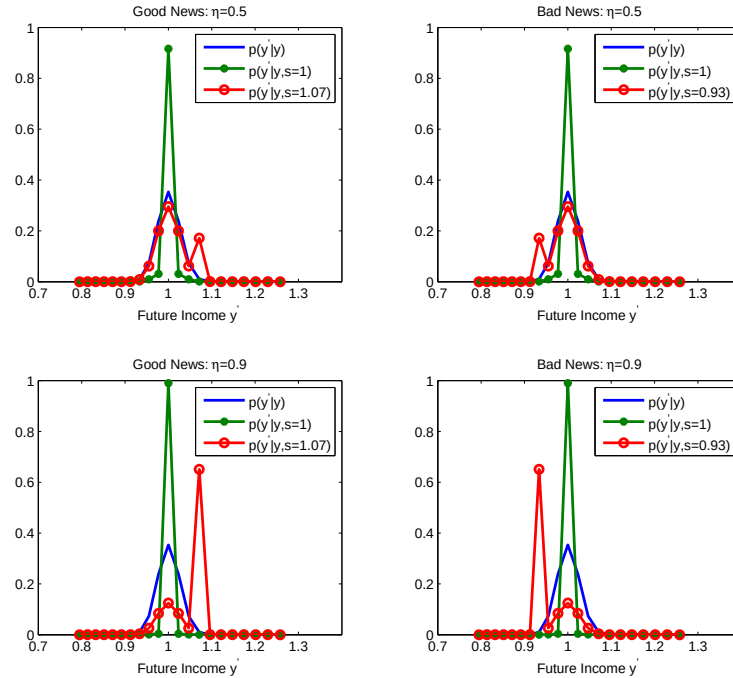
with  $l, j, m, l \in \Theta$  and  $i, \kappa \in \Xi$ . Regarding the signal precision, we examined different parameteri-

zations and formulations. We first assumed that

$$p(s_t = i | y_{t+1} = l) = \begin{cases} \eta & \text{if } i = l \\ (1 - \eta)/(|\Xi| - 1) & \text{if } i \neq l \end{cases} . \quad (4)$$

When  $\eta = 1/|\Xi|$  the signals are not informative, and when  $\eta = 1$  the government can perfectly anticipate the endowment shock one period ahead. In the quantitative analysis, we explore several cases with  $1/|\Xi| \leq \eta \leq 1$ .<sup>8</sup>

Figure 2: Probability Density Functions for Endowment Shocks with Various News Shocks



Notes: Good news panel shows the conditional pdf of  $y'$  at  $y = 1$ ,  $s = 1$  and  $s = 1.07$ , and bad news panels show the conditional pdf of  $y'$  at  $y = 1$ ,  $s = 1$  and  $s = 0.93$ . The unconditional mean of the distribution is  $\bar{y} = 1$ .

News shocks can shift and reshape the probability density function for the output shock, and their effect increases with the precision of the signal, as the panels of Figure 2 illustrate. The upper panels correspond to the case when  $\eta = 0.5$ . If a signal is received corresponding to the mean of the distribution (in this example,  $s_t = 1$  and  $\bar{y} = 1$ ), the standard deviation of the probability distribution is reduced drastically as the probability mass is reassigned toward the mean and the

<sup>8</sup>The results are robust to alternative specifications of the news signal, as described in the Appendix.

tails are thinned symmetrically. If the signal is positive, as the upper left panel shows, the mass of the probability distribution is reallocated from values close to the mean toward such higher future output, skewing the distribution to the right. Such a shift of probability mass results in a two-peaked probability density function for future income. Negative news have a symmetric effect, adding mass to the left. More precise news have a stronger impact on the shape of the probability density function of future output, as shown in the lower panels of Figure 2, which correspond to the case when  $\eta = 0.9$ .

We also assume that the signal is public information, i.e., the government, private agents, and external lenders all observe the same signal and adjust their actions accordingly. A model where some agents receive more precise signals is interesting, but raises issues of asymmetric information that are beyond the scope of this paper.

## 2.2 Households

The representative household is a hand-to-mouth consumer with preferences given by the present value of the sum of instantaneous utility functions:

$$E_0 \sum_{t=0}^{\infty} \beta^t u(c_t) \tag{5}$$

The per-period utility is concave, strictly increasing and twice differentiable. The discount factor is  $\beta \in (0, 1)$  and households derive utility from private consumption  $c_t$ . In the numerical analysis, we use a CRRA per-period utility function  $u(c) = c^{1-\sigma}/(1-\sigma)$ .

## 2.3 Government

The benevolent government maximizes the utility of the households. Financial markets are incomplete since the government can only save and borrow using a non-contingent, one-period bond traded in international capital markets.<sup>9</sup> Given the underlying state of nature, the signal on next period's income, and the amount of outstanding foreign assets, the government chooses in each period whether to repay the current debt or default. If the government chooses to repay, it continues

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<sup>9</sup>Over the last 60 years, most external debt especially in developing countries represented government debt. For example, in 1995 during the Mexican financial crisis, sovereign external debt accounted for almost 70% of the total stock of foreign debt in Mexico. While the last decade has seen a significant increase in private sector debt, its increase was markedly uneven across countries. Despite these increases, government bond issuance in emerging markets still accounted for at least half of the total in 2006 (IMF 2007 Financial Stability Report). Moreover, the 2007-2009 global crisis has made government obligations regain the center stage.

to have access to the capital markets, and decides how much to borrow or save. To be more precise, the state variables are the realization for income ( $y$ ), the realization for the signal ( $s$ ), the level of foreign assets ( $B$ ) and whether the country has access to the credit markets or not ( $D$ ), where  $D = 1$  if the economy has access to credit markets and 0 otherwise.

The government optimization problem can be expressed in a recursive dynamic programming form. The value function when the government has access to international markets and begins the period with an amount of assets  $B$  and shocks ( $y, s$ ) is given by  $V_0(B, y, s)$ . The value associated with paying back and remaining in the credit market is given by  $V^c(B, y, s)$ , whereas the value associated with defaulting and switching to temporary autarky is given by  $V^d(y, s)$ . The problem can be expressed in the following way:

$$V_0(B, y, s) = \max \left\{ V^c(B, y, s), V^d(y, s) \right\} \quad (6)$$

and the optimal default decision of the government is characterized by

$$D(B, y, s) = \begin{cases} 1 & \text{if } V^c(B, y, s) > V^d(y, s) \\ 0 & \text{otherwise} \end{cases}. \quad (7)$$

The default policies determine a repayment set  $\Gamma(B)$  defined as the set of values of the productivity and the news shock such that repayment is optimal given the level of foreign assets  $B$ ,

$$\Gamma(B) = \{(y, s) \in \Upsilon : D(B, y, s) = 1\}. \quad (8)$$

The default set  $F(B)$  is defined as the set of values of the productivity and news shocks such that default is optimal given asset holding level  $B$ ,

$$F(B) = \{(y, s) \in \Upsilon : D(B, y, s) = 0\}. \quad (9)$$

If the government does not default, the economy can issue new debt and finance consumption subject to the following resource constraint:

$$c = y + B - q(B', y, s)B', \quad (10)$$

where  $q(B', y, s)$  is the price of the bond. When the sovereign borrows, it receives  $q(B', y, s)B'$  units

of consumption goods from foreign creditors in the current period and promises to pay  $B'$  units next period conditional on not defaulting. Hence, the bond price reflects the probability of default, which depends on  $B', y$ , and  $s$ .<sup>10</sup> The government maximization problem can be formulated as follows:

$$V^c(B, y, s) = \max_{B'} \left\{ U(y + B - q(B', y, s)B') + \beta \sum_{y', s'} V_0(B', y', s') \Pi(y', s', y, s) \right\} \quad (11)$$

s.t.  $c = y + B - q(B', y, s)B'$ .

When the government defaults on its debt, the country is temporarily excluded from international credit markets. In addition, following Arellano (2008), the economy suffers an output loss that lowers income to  $y^{def}$ , so that consumption  $c^d = y^{def}$ .<sup>11</sup> More specifically we assume the following specification

$$y^{def} = \begin{cases} \phi E(y) & \text{if } y > \phi E(y) \\ y & \text{if } y \leq \phi E(y) \end{cases}, \quad (12)$$

with  $\phi \in (0, 1)$ . As discussed in Arellano (2008), this specification for the output cost allows a higher range for risky borrowing and helps bring the default rates closer to the data. Additionally, Mendoza and Yue (2010) provide a theoretical foundation for this type of exogenous output loss specification. They show that a sovereign default model with production generates an output cost of default that increases endogenously in the state of productivity and is consistent with the shape of the exogenous output cost outlined above.

The value function under default is given by:

$$V^d(y, s) = U(y^{def}) + \beta \sum_{y', s'} \left[ \mu V_0(0, y', s') + (1 - \mu) V^d(y', s') \right] \Pi(y', s', y, s). \quad (13)$$

While in autarky, the country may regain access to external markets with an exogenous probability  $\mu$ . When the economy returns to financial markets, it does so with no debt burden,  $B = 0$ , and with a continuation value  $V_0(0, y, s)$ . Conversely, the country may stay in autarky with a probability  $1 - \mu$ , and the continuation value  $V^d(y, s)$ .

<sup>10</sup>Notice that there is no commitment problem for the foreign creditors. If the foreign creditors borrow from the domestic government, they always repay their debt.

<sup>11</sup>The assumption that default reduces output can be rationalized by the fact that default episodes tend to be associated with disruptions in foreign trade and private sector's access to credit, which entail an output loss. See Rose (2005), Arteta and Hale (2006) and Mendoza and Yue (2008).

## 2.4 Foreign Lenders

There is a large number of identical foreign creditors. Each lender can borrow or lend at the risk free rate  $r_f$  and participates in a perfectly competitive market. Lenders are risk-neutral and maximize expected profits as follows:

$$\Phi = -qB' + \frac{\lambda(B', y, s)}{1 + r_f}0 + \frac{(1 - \lambda(B', y, s))}{1 + r_f}B'.$$

The first term in the equation above shows that when creditors lend to the government in the current period, they buy the discount bond issued by the domestic government at a price  $q$ . Next period, the lenders may receive the face value of the bond depending on whether the government defaults or not. When it defaults, creditors get 0 units of the consumption good. The probability of default  $\lambda(B', y, s)$  is endogenously determined as

$$\lambda(B', y, s) = \sum_{y', s' \in F(B')} \Pi(y', s', y, s), \quad (14)$$

so that the default probability is zero when  $F(B') = \emptyset$  and is one when  $F(B') = \Upsilon$ .

Since there is perfect competition in the credit market, a zero profit condition holds for the foreign creditors.<sup>12</sup> The bond price is then

$$q(B', y, s) = \frac{(1 - \lambda(B', y, s))}{1 + r_f}. \quad (15)$$

## 2.5 Equilibrium Definition

A recursive equilibrium for this small open economy is characterized by a set of value functions for the government,  $V_0, V^c, V^d$ ; a set of policy functions for household's consumption  $c, c^d$ ; policy functions for government's default decision  $D$ ; optimal asset holdings  $B'$ ; and a bond price function  $q$  such that

1. Given the government policies and the bond price function, the consumption policy solves the household's problem,
2. Given the bond price function  $q$  and the optimal policies for households, the government's

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<sup>12</sup>Alternatively, we could assume that foreign lenders have access to two instruments: a risky bond and a risk free bond. Since creditors are risk neutral, they are willing to buy the risky asset as long as its expected return  $R$  equals the return of the risk free asset:  $(1 - \lambda)(1 + R) = 1 + r_f$ , with  $q = \frac{1}{(1+R)} = \frac{(1-\lambda)}{1+r_f}$ .

value functions  $V_0$ ,  $V^c$  and  $V^d$  and its policy functions  $D$  and  $B'$  solve (6), (11) and (13),

3. The equilibrium bond price  $q(B', y, s)$  is such that zero expected profit condition for foreign creditors holds as described in equation (15).

### 3 Quantitative analysis

The calibration follows Arellano (2008) closely as displayed in Table 1. These parameters values are set mainly to mimic the empirical regularities of emerging markets. Table 2 shows business cycle moments of key macroeconomic variables from the data.<sup>13</sup> We now turn to the simulation results and the statistical properties of the model. Table 3 displays a set of moments from the simulated model. The statistics reported are average values of 500 simulations with 2000 periods each. The simulated series are logged and filtered.

Table 1: Calibration

| Parameter                    | Notation          | Value             |
|------------------------------|-------------------|-------------------|
| Risk aversion                | $\sigma$          | 2                 |
| Discount factor              | $\beta$           | 0.953             |
| Reentry probability          | $\mu$             | 0.282             |
| Default penalty              | $\phi$            | 0.969             |
| Risk free interest rate      | $r_f$             | 0.017             |
| Autocorrelation of output    | $\rho$            | 0.945             |
| Standard deviation of output | $\sigma_\epsilon$ | 0.025             |
| News shock                   | $\eta$            | $[1/ \Xi , 0.99]$ |

Table 2: Business Cycle Moments in the Data

|                       | Emerging Markets | Developed Economies |
|-----------------------|------------------|---------------------|
| $\sigma(c)/\sigma(y)$ | 1.45             | 0.94                |
| $\rho(y, c)$          | 0.72             | 0.66                |
| $\rho(y, tb/y)$       | -0.51            | -0.17               |
| $\rho(y, Spread)$     | -0.55            | 0.20                |

<sup>13</sup>Data details and sources are described in the Appendix.

Table 3: Simulation Results

|                       | No News | With News, $\eta = 0.9$ |
|-----------------------|---------|-------------------------|
| $\sigma(c)/\sigma(y)$ | 1.10    | 1.03                    |
| $\rho(y, c)$          | 0.97    | 0.89                    |
| $\rho(y, tb/y)$       | -0.23   | 0.17                    |
| $\rho(y, Spread)$     | -0.28   | -0.13                   |

### 3.1 No news case

The model economy without news is identical to the models of sovereign default analyzed in the literature (e.g., Arellano (2008), among others).<sup>14</sup> The no news economy experiences procyclical borrowing induced by changes in default incentives. The availability of external credit and the interest rate vary with the business cycle: foreign lenders respond to an improvement in the domestic macroeconomic conditions by demanding a lower risk premium, which leads the government to borrow.<sup>15</sup> Therefore, when debt carries default risk, the economy borrows more in booms than in recessions. This translates into countercyclical interest rates and trade balance. In addition, the variability of consumption is close to ten percentage points higher than the variability of output (Table 3).

### 3.2 Effects of news

Figure 3 plots the bond price schedule as a function of assets for two values of the news shock and a given output realization.<sup>16</sup> For all levels of debt, the bond price is lower when the economy is hit by an adverse news shock. Since adverse news shocks about future productivity reveal information about potential difficulties of the government to repay its debt, risk-neutral lenders charge a higher risk premium on impact.

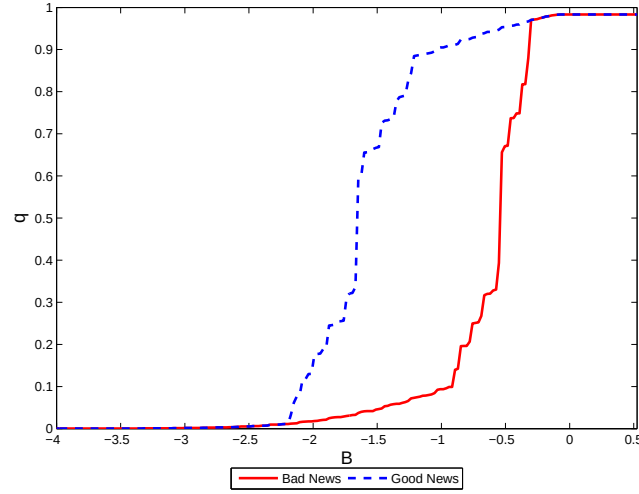
Figure 4 shows the borrowing policy function as a function of  $B$  and  $B'$  given  $y$  for two values of the news shock. The dashed and solid lines show the borrowing policy with good and bad news, respectively. Good news reduces the default risk and lowers the cost of debt, which in turn induces

<sup>14</sup>The model without news refers to the case where no signal  $s_t$  is observed, or equivalently the signal  $s_t$  is observed but has no informational content ( $\eta = 1/|\Xi|$ ).

<sup>15</sup>Additionally, since endowment shocks are persistent, higher future income also induces the government to borrow more.

<sup>16</sup>The bond price is an increasing function of foreign assets. As shown by earlier studies, for small levels of foreign debt, the government always pays back its debt and borrows from international markets at the world risk free interest rate. There is a threshold level of debt for which the bond price starts to decrease reflecting stronger incentives to default for indebted governments. At a sufficiently large debt level the government always defaults regardless of the output realization. At that point, the probability of default is one and the bond price is zero.

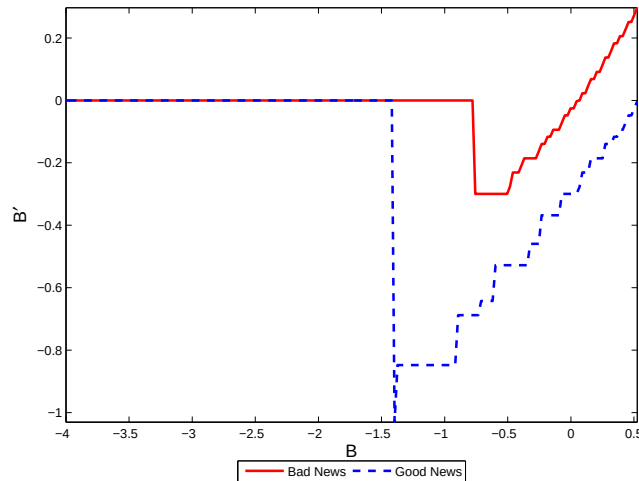
Figure 3: News and Bond Price Schedule



Notes: In the plot,  $\eta = 0.5$  and the current endowment is at steady-state. The good and bad news cases refers to a signal of an increase and a decrease of 2.3% in the endowment, respectively.

the government to borrow more. In addition, good news implies that current output is lower than tomorrow's, which leads the government to borrow more in the current period. Hence, the dashed line with good news remains below the red line with bad news for all initial debt levels in the nondefault region.

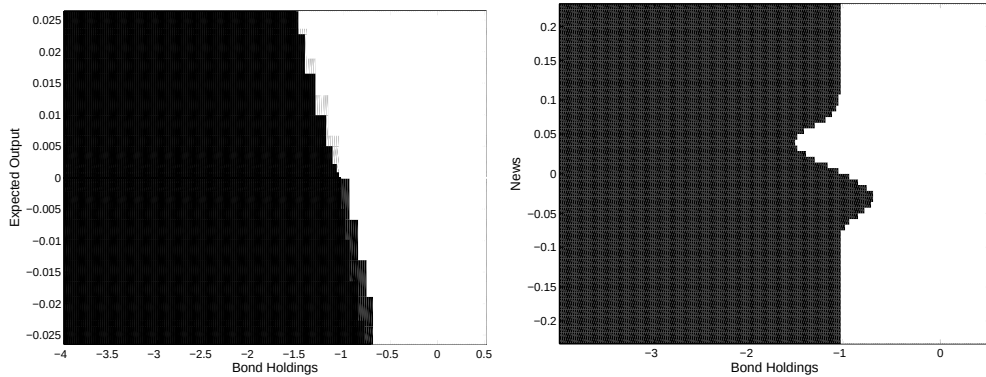
Figure 4: News and Savings Policy



Notes: See notes to Figure 3.

News shocks can affect the decision to default. The left panel of Figure 5 illustrates the shape

Figure 5: News and Default Region



Notes: In the plot,  $\eta = 0.5$  and the current endowment is at steady-state. The dark region indicates default. In both panels, the horizontal axis refers to bond positions. In the left panel, the vertical axis refers to expected output in deviation from steady-state ( $E(\ln(y_{t+1} | s_t, y_{ss})) - \ln(y_{ss}))$  for different news  $s_t$ , and  $y_t$  fixed at steady-state. In the right panel, the vertical axis refers to the news signal  $s_t$  (signaling a future endowment in deviation from steady-state  $\ln(y_{t+1}) - \ln(y_{ss})$ ).

of the default region as a function of current debt and expected future output when output is at steady-state. Expected future output might change depending on the realization of the news shocks. When a relatively low signal is received, expected output for next period decreases and the default region, the dark area in the graph, increases. As we explain in more detail in Section 3.4, if the news signal is sufficiently negative and informative, the economy can experience default episodes even when the current output realizations are above their trend value.

The right panel of Figure 5 also plots the default region, but, in this case, the vertical axis refers to the realization of the news shock ( $s_t$ ). The figure displays an S-shaped pattern. Signals ( $s_t$ ) near the current endowment level impact the default decision, while extreme signals do not. The reason for this observation is that the output process in equation (1) may imply that, given  $y_t$ , certain levels of future output ( $y_{t+1}$ ) might be unlikely to realize. If a signal points out to a realization of output that is very unlikely to occur, then that signal is effectively discounted. We can also see this mechanism in equation (2), where the posterior probability to observe an endowment next period depends on both the signal and current output. If the prior in that equation assigns negligible probabilities for an extreme realization of a future endowment shock ( $p(y_{t+1}|y_t)$ ), then the signal pointing out to the realization of such future endowment ( $p(s_t|y_{t+1})$ ) would have a negligible impact on the posterior probabilities.<sup>17</sup>

<sup>17</sup>This mechanism is absent in Jaimovich and Rebelo (2008) because the authors consider a process for output with only two states.

Starting from a steady state output and a neutral signal (expected value of endowment shock equal to 0 in deviation from steady state), if the economy receives a signal that increases expected future output, the default region decreases as shown on the left panel of Figure 5. This signal would correspond, for instance, to  $s_t = 0.05$  in the right panel, where for that signal realization, the default region also shrinks. However, if the signal received is significantly higher than the current state, for example  $s_t = 0.2$ , the right panel shows that the default region does not change relative to the case of a neutral signal ( $s_t = 0$ ). The reason is that the prior for the output process assigns a small probability to the realization of  $y_{t+1} = 0.2$  and the posterior remains unchanged if the signal  $s_t = 0.2$  is received. Therefore, the expected future output is also unchanged, corresponding on the left panel to an expected output equal to 0 in deviation from steady state.

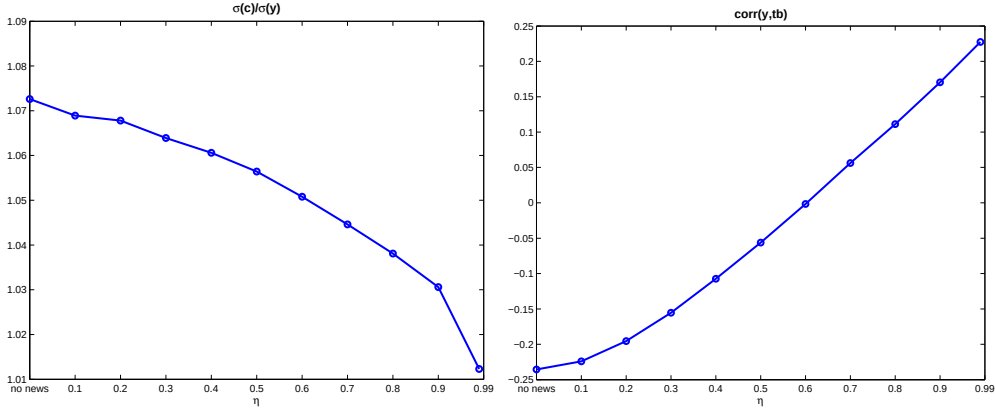
### 3.3 News precision in emerging and developed economies

Emerging markets are distinct from developing countries along several dimensions at the business cycle frequency. Table 2 shows some of the key differences identified in the literature: emerging markets are characterized by a higher variability of consumption relative to output, a higher correlation of consumption with output, a higher and countercyclical interest rate spread, and a countercyclical current account. In addition, developed economies have better information systems and they are more closely monitored than emerging markets. In this section, we highlight that varying the precision of news can help explain these stylized facts.

When news shocks are more precise, agents in the economy can anticipate future fundamentals more accurately and consumption smoothing becomes more effective, reducing the volatility of consumption relative to the volatility of output. In addition, bond prices respond to news in addition to output shocks, dampening the correlations of consumption, trade balance and spreads with current output. To highlight these effects, Table 3 shows the long-run moments of the model with no news precision and  $\eta = 0.9$ . When  $\eta$  is increased to 0.9, all moments move closer to those characterized by developed economies. The variability of consumption drops, the trade balance behaves procyclically, and the spreads becomes less countercyclical.

The table, however, shows these differences only with two different news precision levels. Figure 6 plots the variability of consumption and the correlation of trade balance with output for all possible values of news precision. Consistently with the finding in Table 3, Figure 6 shows that as the news precision increases, the variability of consumption relative to output and the correlation of trade balance with output get closer to those of developed economies.

Figure 6: The Effect of Precision of News on Macroeconomic Variables



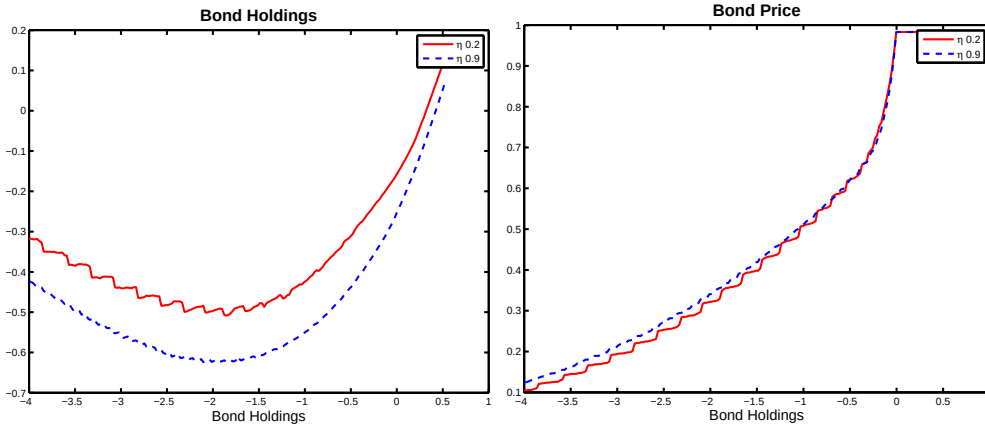
Notes: The graph on the left shows the variability of consumption relative to output, the graph on the right shows the correlation of trade balance with output as a function of the news precision,  $\eta$ .

A higher precision of news about future fundamentals lowers the uncertainty that agents face and partially completes financial markets.<sup>18</sup> If the news shocks were to fully reveal the entire sequence of future income, our framework would effectively be equivalent to models with lack of enforcement and complete markets as in Kehoe and Levine (1993). Kehoe and Levine's model features a lower variability of consumption relative to income and procyclical trade balance. In our setup, as the news precision increases and financial markets function more efficiently, the model gets similar to Kehoe and Levine's setup.

The panels in Figure 7 show the unconditional bond policy functions and the bond price schedule for two distinct economies featuring a low and high precision of news ( $\eta = 0.2$  and  $\eta = 0.9$ , respectively). Both panels underscore that, for any initial level of bond holdings, the economy with more precise signal pays, on average, lower interest rates, borrows more and is able to sustain more debt. With low news precision, the economy is able to borrow a relatively small fraction of income. With high news precision, the interest rate policy function shifts to the left towards the origin, reflecting the better credit conditions available to the economy. With better credit conditions, the economy can increase its debt holdings to better smooth consumption. However, in equilibrium, the increase in debt might lead to an increase in interest rate payment. As the economy operates under even more precise news, credit markets operate more efficiently and the economy is able to sustain more debt in equilibrium and better smooth consumption. Hence, increasing news precision

<sup>18</sup>More precise news does not fully complete markets, because uncertainty about the future fundamentals in two-periods ahead and onward still remains even in the extreme case with news precision approaching to one.

Figure 7: News Precision and Unconditional Policy Functions



Notes: The panel on the left shows the bonds policy function weighted by the implied long-run probabilities of endowment and news shocks for the two different precision levels. The panel on the right shows the bond price schedule for the same case. The figure illustrates how changes in news precision affect equilibrium decision rules.

beyond a threshold will improve the ability to borrow and smooth consumption without increasing equilibrium interest rate payments.

Before moving on to the next section, it is also worth noting the similarities of news shocks with trend shocks à la Aguiar and Gopinath (2006, 2007). First, news shocks carry an economic interpretation similar to trend shocks. For instance, similar to trend shocks, news shocks inform agents about a change in income profile that would realize in subsequent periods. In a setup with endogenous labor choice and Cobb-Douglas preferences, this mechanism implies similar response of labor supply for both of these shocks due to their effect on wealth. Second, news shocks shift the transition probability matrix of the income process just like a “growth-regime switching” model. However, our exercise also differs markedly from that one can obtain with trend shocks. For example, our exercise with varying degrees of news precision does not have an obvious counterpart in a setup with trend shocks. In our setup, increased precision of news brings the model statistics to levels closer to developed economies, whereas higher importance of trend shocks would bring the model statistics to levels closer to emerging economies. Hence, for our experiments, it appears more natural to think of the shock as pure news rather than trend shocks.

### 3.4 Default in good times

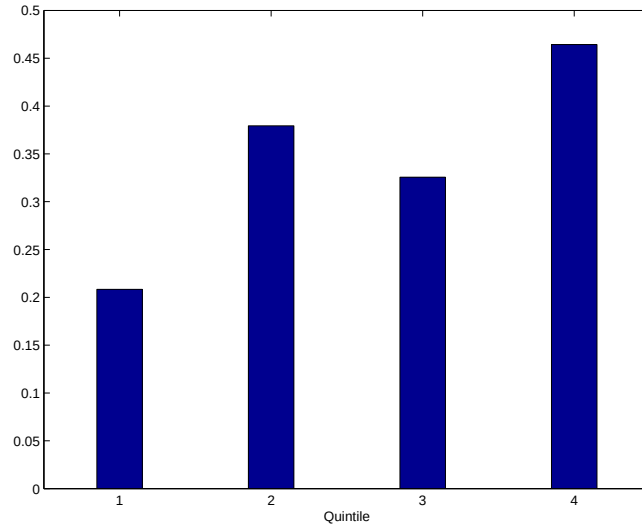
The presence of news shocks is also able to rationalize the finding in the literature that a fraction of defaults occur when output is above trend (see Levy-Yeyati and Panizza (2006), Tomz and Wright (2007)). Complementing these studies, we also examine the default patterns using annual data for 118 countries for 1950-2003 period (section 5.4 of the Appendix includes the entire list of countries and default episodes in our sample). Trend income was calculated by fitting an Hodrick-Prescott filter with a smoothing parameter 100.

Figure 8 separates countries by income quintile and plots the fraction of defaults in good times. The fifth quintile is not shown, since the only default episode in that group corresponds to Slovenia in 1992, less than a year after its independence and with income below trend. The figure establishes that a non-negligible fraction of defaults have occurred when income was above trend for a large set of countries. Moreover, the fraction of the defaults that occurred in good times becomes higher for countries with higher income per capita levels; the new feature of the data that our analysis uncovers.

The quantitative results depicted in Figure 9 show that our model helps rationalize both stylized facts. Bad news can lead to an immediate default because it predicts that future output will be lower, which will make current debt repayments more costly. Hence, bond prices fall, leading to a deterioration in the current financing decisions and bringing forward the default decision. This mechanism can lead the economy to default even though the current state of the economy is positive. As the news precision increases, this channel becomes more effective and leads to higher proportion of defaults when output is above trend.

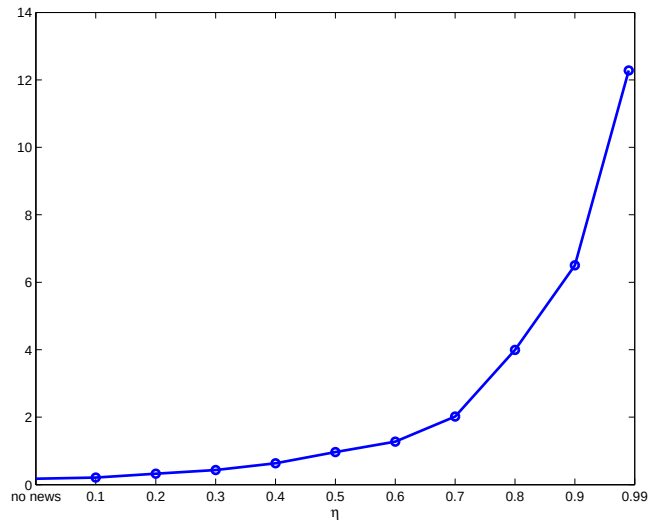
Our finding that as news precision improves, the default rate in good times increases is consistent that more precise news brings the model closer to complete markets. In models with lack of enforcement but complete markets as in Kehoe and Levine (1993), defaults occur in good states of nature. Similarly, in our setup, as the model features more complete markets the default rates in good times also increase. This finding is also related to that in Hatchondo, Martinez and Saprizza (2009), who account for defaults in good times by focusing on borrowers' heterogeneity (political risk). Complementing their study, our paper emphasizes the importance of the differences in the degree of uncertainty prevalent for these countries. In doing so, our mechanism also has an added advantage as it can explain the higher fraction of defaults in good times observed for the higher income per capita economies.

Figure 8: Proportion of defaults in good times by income (1950-2003)



Notes: This figure shows the percentage of defaults that occurred when income was above trend using data for 118 countries covering 1950-2003 period.

Figure 9: Percentage of Default in Good Times



Notes: This figure shows the percentage of defaults occurring in the model when income is above average.

### 3.5 News precision and hump-shaped default pattern

When the economy receives more precise news, forecasts become more accurate and debt management more efficient. Since the signals are public information, international lenders can better assess the likelihood of default conditional on a given debt level. Therefore, the price of debt

is more favorable and the government is induced to borrow more.<sup>19</sup> In addition, the lower risk profile reduces the demand for precautionary savings which also induces the economy to increase borrowing. The left panel of Figure 10 plots the debt level as a function of the news precision. We observe a tendency for more indebtedness as the news precision increases. Such observation is also in line with the data for emerging and developed economies (see for example Mendoza and Oviedo (2006), Mendoza and Ostry (2008), Durdu et al. (2009)). Using data for 22 developed economies and 34 emerging markets over 1970-2005 period, Mendoza and Ostry (2008) find that developed economies hold more debt than emerging economies. During that period, the average debt-GDP ratio for developed economies is about 10 percentage points higher than that in emerging economies.<sup>20</sup>

The right panel of Figure 10 plots the unconditional default probability – the proportion of periods in which default occurs – for different economies characterized by different news precision levels. The relationship between the unconditional default probability and news precision is non-monotonic because of two opposing forces at play. On the one hand, higher precision leads to better forecasting, making the government more able to avoid costly defaults for a given debt level. On the other hand, an increase in the precision of news leads to higher debt, which in turn increases the unconditional default probability. The figure shows that for precision levels above 0.6, the former effect dominates the latter.

The non-monotonic behavior of default rates is also consistent with what a setting with more complete markets would imply. As we discussed earlier, higher precision of news brings the model closer to the complete markets scenario. Consistently, Arellano and Ramanarayanan (2010) also find that in a setup with various maturity structures (more complete financial markets), the equilibrium default rates can increase.

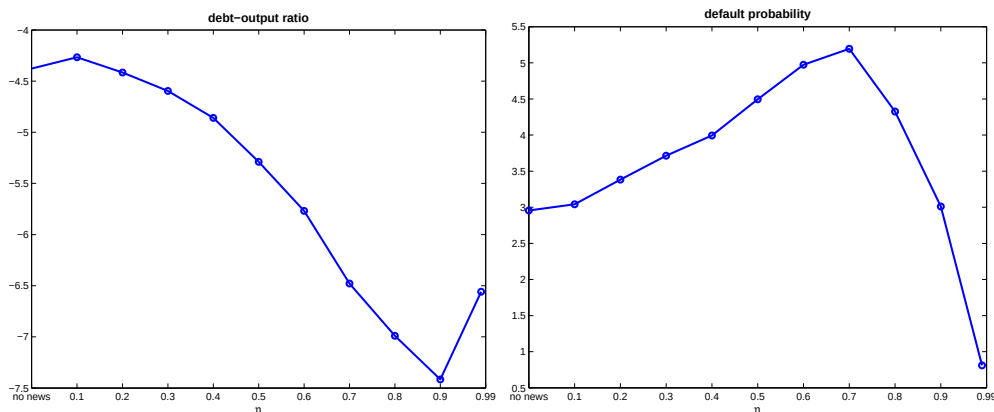
At first sight, Figures 10 and 11 might not look comparable, as we have the precision of news in the former and GDP per capita in the latter. However, the evidence that GDP per capita and precision of news tend to be highly correlated provides empirical support for the comparability of the two figures. We show this high correlation using two separate measures. First, we report the behavior of opacity measures collected by PwC in Figure 12. Second, as in Boz et al. (2007), we examine the behavior of the forecast errors – presumably, forecasts errors should be lower in an environment with better news.

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<sup>19</sup>Following the literature, the calibration of the discount factor and the risk free rate induces the economy into borrowing.

<sup>20</sup>Reinhart, Rogoff and Savastano (2003) document evidence along the same lines.

Figure 10: The Effect of News on Debt Dynamics



Notes: The graph on the left shows the debt-to-output ratio, and the graph on the right shows the equilibrium default probabilities as a function of the news precision,  $\eta$ .

For the opacity measures, we use data for 118 countries covering 1950-2003 as shown in Figure 12. PwC conducted a survey of banks, firms, equity analysts, and in-country staff during the third and fourth quarters of 2000 to generate measures of opacity in five areas: bureaucratic practices (corruption), legal system, government macroeconomic policies, accounting standards and practices, and regulatory regime. PwC aimed at interviewing at least 20 CFOs, five bankers, five equity analysts, and five PwC employees in each country. Overall, this opacity measure appears to be a good proxy for the precision of news in each country in the sample. Figure 12 confirms a strong negative relationship between opacity measures and GDP per capita.

Table 4 summarizes the RMSE of Consensus Forecasts' one quarter ahead forecast errors ( $y_{t+1} - E_t y_{t+1}$ ) for quarterly GDP growth (at annualized rates) for a set of developed and emerging market countries. The sample covers 1998:Q4-2007:Q3.<sup>21</sup> This table suggests that forecast errors for emerging markets are systematically higher than those of developed economies – as evidenced by the RMSE. On average, the RMSE of these errors are 0.95 percentage points for emerging markets and 0.38 percentage points for developed countries.<sup>22</sup> Thus, forecasts are subject to more uncertainty in emerging markets than in developed countries.

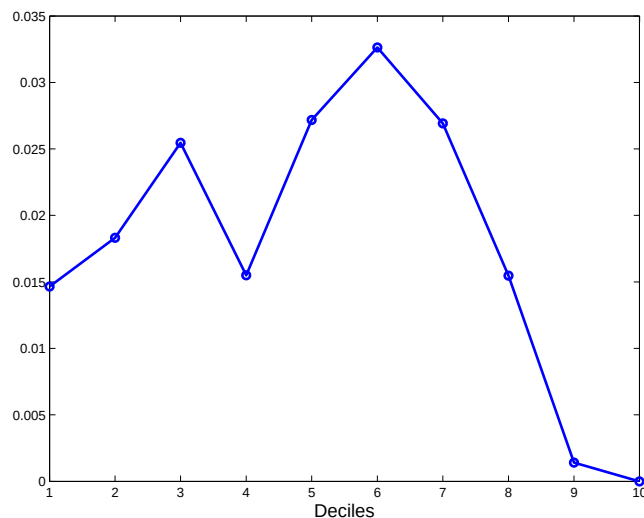
Furthermore, forecast errors are more likely to be inefficient in emerging market economies. The sample mean of forecasting errors differs significantly from zero, which would imply that forecasters

<sup>21</sup>The GDP growth data are taken from Bloomberg and refer to quarterly year-on-year growth rates. We report only those countries for which we have at least 10 quarters of forecasts available.

<sup>22</sup>The same result holds for the the median country for both groups. The emerging markets median value is 0.81 versus 0.39 for developed countries.

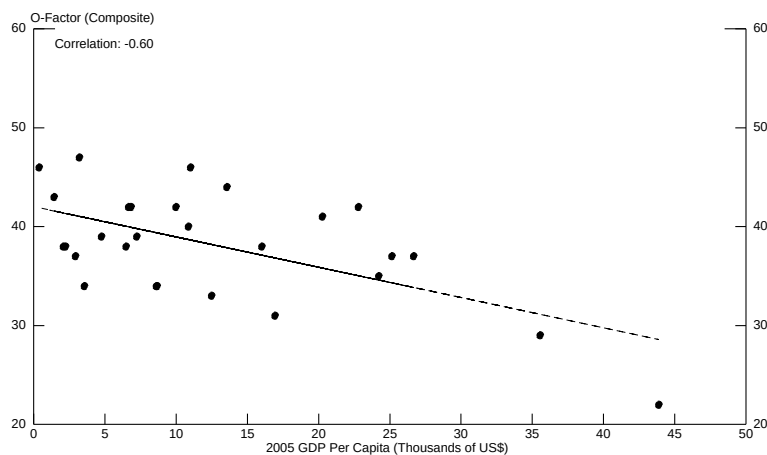
make systematic errors when projecting GDP growth. Note that 8 out of 18 cases, the sample mean of forecast errors differs significantly from zero at a 10% level of significance. For developed countries, there are just two cases out of nine where the forecast errors are biased. Inefficiency of forecasts in emerging markets suggests again that there are serious difficulties in forecasting the relevant economic variables for those countries.

Figure 11: Default Rates by Income per Capita Brackets: 1950-2003



Notes: This figure shows the default rates by income decile that we estimate using data for 118 countries covering 1950-2003.

Figure 12: Composite Opacity Factor vs. GDP per Capita



Notes: This figure shows the opacity measure for 35 countries collected by the accounting and consulting company PwC.

Table 4: Moments of Forecast Errors in EMEs vs. Developed Economies

| Country        | # of obs.    | Mean        | RMSE        |
|----------------|--------------|-------------|-------------|
| <i>DCs</i>     |              |             |             |
| Australia      | 33           | -0.01       | 0.50        |
| Denmark        | 23           | 0.11        | 0.39        |
| Finland        | 11           | 0.35*       | 0.70        |
| France         | 25           | -0.02       | 0.30        |
| Italy          | 18           | -0.11       | 0.39        |
| Netherlands    | 16           | -0.02       | 0.36        |
| Spain          | 20           | 0.04        | 0.15        |
| Switzerland    | 14           | 0.14        | 0.46        |
| UK             | 36           | 0.05*       | 0.14        |
| <b>Average</b> | <b>21.78</b> | <b>0.06</b> | <b>0.38</b> |
| <b>Median</b>  | <b>20.00</b> | <b>0.04</b> | <b>0.39</b> |
| <i>EMEs</i>    |              |             |             |
| Argentina      | 26           | -0.57       | 2.23        |
| Brazil         | 28           | -0.28*      | 0.83        |
| Chile          | 14           | 0.10        | 0.28        |
| China          | 21           | 0.30*       | 0.55        |
| Colombia       | 17           | 0.23        | 0.87        |
| India          | 21           | 0.30        | 0.85        |
| Indonesia      | 20           | 0.18*       | 0.43        |
| Hong Kong      | 26           | 0.70*       | 0.80        |
| Korea          | 23           | 0.23        | 0.86        |
| Malaysia       | 28           | 0.01        | 0.99        |
| Mexico         | 33           | 0.05        | 0.59        |
| Peru           | 61           | 0.43*       | 1.45        |
| Philippines    | 17           | -0.35*      | 0.65        |
| Singapore      | 18           | -0.37*      | 0.46        |
| South Africa   | 23           | -0.01       | 0.80        |
| Taiwan         | 22           | -0.16       | 0.86        |
| Thailand       | 18           | -0.19*      | 0.42        |
| Turkey         | 28           | -0.13       | 3.12        |
| <b>Average</b> | <b>24.67</b> | <b>0.03</b> | <b>0.95</b> |
| <b>Median</b>  | <b>22.50</b> | <b>0.03</b> | <b>0.81</b> |

Source: Bloomberg. \* Significantly different from 0 at 10% level.

## 4 Conclusions

The recent global financial crisis has highlighted the importance of news shocks regarding macroeconomic fundamentals, as evidenced by the developments in the European periphery. To explore the implications of such shocks, we propose a model of sovereign debt in which default risk, interest

rates and debt are affected by current fundamentals and news about future fundamentals. In our framework, news shocks affect equilibrium outcomes because they contain information about the future ability of the government to repay her debt.

The quantitative analysis shows that news shocks contribute to explain key differences in business cycle stylized facts between emerging markets and developed economies. As the precision of news improves, the model predicts lower variability of consumption, less countercyclical trade balance and interest rate spreads, as well as a higher level of debt more in line with the characteristics of developed economies. The setup also captures the hump-shaped relationship between default rates and the precision of news obtained from the data. In addition, the framework with news shocks can generate default episodes in good times, bringing the model closer to the stylized facts established in the literature.

## 5 Appendix

### 5.1 Algorithm

We assume an initial function for the price of the bond  $q_0(B', y, s)$ , as well as initial values for  $V_0$  and  $V^d$ . To calculate the initial value of the bond, we use the inverse of the risk free rate. For the initial values of the value functions,  $(V_0)_0$  and  $(V^d)_0$ , we start with null matrices. We use 3721 points for the shock grid and 200 points for the bond grid, we confirmed that our results are robust to the number of points in the grid. Then we employ the following algorithm:

1. Use  $q_0$  to express the per period utility as a function of  $B, B', y$  and  $s$ , then use  $(V_0)_0$  and  $(V^d)_0$  and equations (6), (11) and (13) to get  $(V_0)_1, (V^d)_1$ , the policy function,  $B'(B, y, s)$  and default function  $D(B, y, s)$ .
2. Given the default function  $D(B, y, s)$ , and the repayment and default sets  $\Gamma(B)$  and  $F(B)$ , compute the probability of default  $\lambda(B', y, s)$  using (14).
3. Update the price of the bond using the following equation:

$$q_1 = \frac{(1 - \lambda(B', y, s))}{1 + r_f}$$

4. Use the updated price of the bond  $q_1$  and the value functions  $(V_0)_1$  and  $(V^d)_1$  to repeat steps 1, 2, 3 and 4 until the following conditions are satisfied:

$$\begin{aligned} \max \{q_0(B', y, s) - q_1(B', y, s)\} &< \epsilon \\ \max \{(V_0(B, y, s))_0 - (V_0(B, y, s))_1\} &< \epsilon \\ \max \{(V^d(y, s))_0 - (V^d(y, s))_1\} &< \epsilon \end{aligned}$$

where  $\epsilon$  is a small number.

In this formulation, we assume that international lenders cannot sustain other types of equilibria based on trigger strategies.<sup>23</sup> In doing so, we follow a formulation and solution algorithm in the spirit of Arellano (2008) and Aguiar and Gopinath (2007), which is also widely used in the subsequent sovereign debt literature. To the best of our knowledge, the sovereign debt literature has not provided a proof of equilibrium uniqueness, and doing so is beyond the scope of this paper.

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<sup>23</sup>This assumption can be rationalized by assuming that international lenders are atomistic and, therefore, unable to coordinate on trigger strategies. Alternatively, international lenders may be unable to sustain long-term relationships because they exit the market after the defaultable debt contract expires at the end of each period.

Since the calibration implies a negative utility, we initialize  $(V_0)_0$  and  $(V^d)_0$  as null matrices such that the contraction property of the Belman equation guarantees convergence to the highest welfare ranked equilibrium.<sup>24</sup>

## 5.2 Data

Cross country stylized facts on consumption and net exports are taken from Aguiar and Gopinath (2007). The data on sovereign interest rate correlations with macroeconomic aggregates is obtained from Neumeyer and Perri (2004). The statistics on default rates by income deciles for the period from 1950 to 2003 and the statistics on the proportion of sovereign defaults that occurred above trend by income deciles for the period 1950-2003 (Figure 11) are constructed using the database of sovereign defaults by Beim and Calomiris (2001) and income data from the IMF.

## 5.3 Alternative parameterization for the news signal

In the parameterization for the signal described in Section 2.1, it is more likely to receive a certain signal than any other. For instance, if the endowment  $(y_{t+1})$  is high there is a corresponding high signal  $(s_t)$  that is more likely to be observed. However, conditional on a high endowment  $(y_{t+1})$ , the signals  $(s_t)$  corresponding to extremely low or very low endowments are observed with equal probability. We also considered an alternative formulation where it would be more likely to observe signals closer to the endowment:

$$p(s_t = i | y_{t+1} = l) = \begin{cases} \eta & \text{if } i = l \\ f(i, l) & \text{if } i \neq l \end{cases}, \quad (16)$$

where  $f(i, l)$  is a function satisfying the property  $f(i, l) > f(j, l) \Leftrightarrow |i - l| < |j - l|$ . In particular, we considered the formula:

$$p(s_t = i | y_{t+1} = l) = \eta / e^{a|i-l|^{b_l}} \quad (17)$$

where  $a, b_l$  are positive constants. The precision of the signal is still determined by  $1/|\Xi| \leq \eta \leq 1$ . The results are qualitatively and quantitatively robust across formulations, and for brevity we only report the first set.

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<sup>24</sup>Additional details are provided in Rustichini (1998).

## 5.4 Default Episodes and Income per Capita Brackets Dataset: 1950-2003

| Country                  | Year of Default* | Income Quintile | Above Trend |
|--------------------------|------------------|-----------------|-------------|
| Czechoslovakia (former)  | 1959             | 4               | 1           |
| Cuba                     | 1960             | 3               | 0           |
| Costa Rica               | 1962             | 4               | 0           |
| Zimbabwe                 | 1965             | 2               | 0           |
| Korea, Dem. Rep.         | 1974             | 3               | 1           |
| Congo, Dem. Rep.         | 1976             | 1               | 0           |
| Peru                     | 1976             | 4               | 1           |
| Iran, Islamic Rep.       | 1978             | 4               | 1           |
| Jamaica                  | 1978             | 3               | 0           |
| Peru                     | 1978             | 3               | 0           |
| Turkey                   | 1978             | 4               | 1           |
| Nicaragua                | 1979             | 3               | 0           |
| Sudan                    | 1979             | 1               | 0           |
| Togo                     | 1979             | 2               | 1           |
| Bolivia                  | 1980             | 3               | 1           |
| Mozambique               | 1980             | 2               | 1           |
| Peru                     | 1980             | 3               | 1           |
| Uganda                   | 1980             | 1               | 0           |
| Cape Verde               | 1981             | 1               | 1           |
| Central African Republic | 1981             | 1               | 0           |
| Costa Rica               | 1981             | 4               | 1           |
| Honduras                 | 1981             | 2               | 1           |
| Jamaica                  | 1981             | 3               | 0           |
| Madagascar               | 1981             | 1               | 0           |
| Poland                   | 1981             | 4               | 0           |
| Romania                  | 1981             | 3               | 0           |
| Senegal                  | 1981             | 2               | 0           |
| Argentina                | 1982             | 4               | 0           |
| Cuba                     | 1982             | 3               | 1           |
| Dominican Republic       | 1982             | 3               | 1           |
| Ecuador                  | 1982             | 3               | 1           |
| Haiti                    | 1982             | 2               | 0           |
| Malawi                   | 1982             | 1               | 0           |
| Mexico                   | 1982             | 4               | 1           |
| Nigeria                  | 1982             | 2               | 0           |

|                          |      |   |   |
|--------------------------|------|---|---|
| Togo                     | 1982 | 1 | 0 |
| Turkey                   | 1982 | 3 | 0 |
| Brazil                   | 1983 | 4 | 0 |
| Burkina Faso             | 1983 | 1 | 0 |
| Central African Republic | 1983 | 1 | 0 |
| Chile                    | 1983 | 4 | 0 |
| Congo, Rep.              | 1983 | 3 | 1 |
| Costa Rica               | 1983 | 4 | 0 |
| Côte d'Ivoire            | 1983 | 2 | 1 |
| Guinea-Bissau            | 1983 | 1 | 0 |
| Morocco                  | 1983 | 3 | 0 |
| Mozambique               | 1983 | 2 | 0 |
| Niger                    | 1983 | 1 | 1 |
| Panama                   | 1983 | 4 | 1 |
| Philippines              | 1983 | 3 | 1 |
| Sierra Leone             | 1983 | 2 | 1 |
| Uruguay                  | 1983 | 4 | 0 |
| Yugoslavia (former)      | 1983 | 4 | 0 |
| Zambia                   | 1983 | 1 | 0 |
| Costa Rica               | 1984 | 4 | 0 |
| Peru                     | 1984 | 3 | 0 |
| Tanzania                 | 1984 | 1 | 0 |
| Angola                   | 1985 | 1 | 0 |
| Cameroon                 | 1985 | 2 | 1 |
| South Africa             | 1985 | 3 | 0 |
| Vietnam                  | 1985 | 1 | 1 |
| Yemen, Rep.              | 1985 | 3 | 0 |
| Bolivia                  | 1986 | 3 | 0 |
| Gabon                    | 1986 | 4 | 0 |
| Gambia, The              | 1986 | 1 | 0 |
| Guinea                   | 1986 | 1 | 0 |
| Morocco                  | 1986 | 3 | 1 |
| Nigeria                  | 1986 | 2 | 0 |
| Paraguay                 | 1986 | 3 | 0 |
| Romania                  | 1986 | 3 | 1 |
| Sierra Leone             | 1986 | 2 | 0 |
| Ghana                    | 1987 | 2 | 0 |
| Iraq                     | 1987 | 3 | 1 |

|                                |      |   |   |
|--------------------------------|------|---|---|
| Jamaica                        | 1987 | 3 | 0 |
| Liberia                        | 1987 | 2 | 0 |
| Panama                         | 1987 | 4 | 1 |
| São Tomé and Príncipe          | 1987 | 2 | 0 |
| Uruguay                        | 1987 | 4 | 1 |
| Malawi                         | 1988 | 1 | 0 |
| Togo                           | 1988 | 1 | 1 |
| Trinidad and Tobago            | 1988 | 4 | 0 |
| Argentina                      | 1989 | 4 | 0 |
| Bolivia                        | 1989 | 3 | 0 |
| Brazil                         | 1989 | 4 | 1 |
| Guatemala                      | 1989 | 3 | 0 |
| Jordan                         | 1989 | 3 | 0 |
| South Africa                   | 1989 | 3 | 1 |
| Bulgaria                       | 1990 | 4 | 1 |
| Senegal                        | 1990 | 2 | 1 |
| Albania                        | 1991 | 2 | 0 |
| Algeria                        | 1991 | 3 | 0 |
| Ethiopia                       | 1991 | 1 | 0 |
| Guinea                         | 1991 | 1 | 0 |
| Russian Federation             | 1991 | 4 | 1 |
| Togo                           | 1991 | 1 | 1 |
| Bosnia and Herzegovina         | 1992 | 3 | 0 |
| Croatia                        | 1992 | 4 | 0 |
| Macedonia, FYR                 | 1992 | 3 | 1 |
| Mauritania                     | 1992 | 1 | 0 |
| Nigeria                        | 1992 | 2 | 1 |
| Senegal                        | 1992 | 2 | 0 |
| Serbia and Montenegro (former) | 1992 | 3 | 0 |
| Slovenia                       | 1992 | 5 | 0 |
| Serbia and Montenegro (former) | 1992 | 3 | 0 |
| South Africa                   | 1993 | 3 | 0 |
| Kenya                          | 1994 | 2 | 0 |
| Myanmar                        | 1997 | 2 | 0 |
| Indonesia                      | 1998 | 3 | 0 |
| Moldova                        | 1998 | 2 | 0 |
| Pakistan                       | 1998 | 2 | 0 |
| Russian Federation             | 1998 | 3 | 0 |

|               |      |   |           |
|---------------|------|---|-----------|
| Ukraine       | 1998 | 3 | 0         |
| Ecuador       | 1999 | 3 | 1         |
| Gabon         | 1999 | 3 | 0         |
| Pakistan      | 1999 | 2 | 0         |
| Côte d'Ivoire | 2000 | 2 | 1         |
| Indonesia     | 2000 | 3 | 0         |
| Seychelles    | 2000 | 4 | 1         |
| Zimbabwe      | 2000 | 2 | 1         |
| Argentina     | 2001 | 4 | 0         |
| Argentina     | 2001 | 4 | 0         |
| Indonesia     | 2002 | 3 | 0         |
| Moldova       | 2002 | 2 | 1         |
| Nigeria       | 2002 | 2 | 0         |
| Paraguay      | 2003 | 3 | 0         |
| <b>Total</b>  |      |   | <b>43</b> |

**\*Note: Two default episodes in the same year indicate a default on syndicated loans and sovereign bonds.**

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