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 level of 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 sovereign to repay its debt. The news shocks help account for key differences between emerging markets and developed economies: as the precision of the 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. Strikingly, the model also captures the hump-shaped relationship between default rates and the precision of news obtained from the data. Moreover, the model with news shocks generates higher rate of default in good times, bringing the model closer to the stylized facts established in the literature.

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1 Introduction

News about future fundamentals can be a significant driving force of economic fluctuations. Information about future fundamentals affects agents' expectations, influencing their current decisions. A 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. A second relevant difference across countries relates to sovereign default risk, which is tightly linked to interest rate spreads. Fluctuations in spreads can be a significant factor determining the dynamics of macroeconomic variables in small open economies.

While both news and default risk have been examined separately, there is very little work trying to understand the implications of their joint dynamics. By affecting the incentives to default, news change the economy through the effects on interest rate spreads. Our paper analyzes the extent to which changes in expectations -news- matter for aggregate fluctuations, and whether news can explain the differences in aggregate fluctuations across countries, focusing on the relationship between aggregate fluctuations and country risk.

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. The economy receives a stochastic endowment every period, as well as a noisy signal about the 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, hence interest rate spreads reflect the time varying sovereign default risk. In a quantitative analysis, we calibrate the model without news to a typical emerging market economy following Arellano (2008). We explore how changes in the precision of news about future output affect model implications.

Three key findings emerge from our quantitative analysis. First, we find that the differences in the precision of news on future fundamentals help rationalize differences in the fluctuations of several macroeconomic variables between emerging and industrialized economies.[1] The model economy where there is no news largely captures the dynamics of macro 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

[1] As earlier studies show, emerging market economies are more prone to crises, face higher interest rate spreads, and they can only sustain lower debt-output ratios than their more developed counterparts. In addition, these economies experience more countercyclical trade balances and their sovereign interest rate spreads increase (decrease) in expansions (recessions), making external credit more (less) expensive in bad (good) times.

more scarce or less precise in most middle and low income countries.[2]

Second, 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. This theoretical prediction is confirmed by the data. In particular, the finding is in line with the empirical regularity about how income per capita levels are related to the historical default rates. Using data for 163 countries covering 1950-2003 period, we show that there is a hump-shaped relationship between per capita income levels and the default rates observed in those countries.

Finally, 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 the interaction of news and default risk. Besides having direct effects, news may significantly affect default risk, which in turn alters the fluctuations of several key macro aggregates.

The rest of the paper is organized as follows: Section **??** describes the related literature, Section **??** presents the economic environment and the theoretical framework, and it explains how the news shocks are embedded in the model. Section **??** contains the definition of the equilibrium, Section **??** analyzes the quantitative implications of the benchmark model and Section **??** concludes. Section **??** has the Appendix containing the solution algorithm of the model.

2 Related Literature

Our paper is related to three 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 real business cycle literature, Jaimovich and Rebelo (2008) and Schmitt-Grohe and Uribe (2008)

[2] As we will show, news are more precise in higher income per capita countries. Richer countries have more and better data, and are more closely monitored.

explore 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 is crucial to capture the changes in precautionary savings due to changes in news precision.

Boz, Daude and Durdu (2009) build on the work of Aguiar and Gopinath (2007) with trend growth and transitory shocks. 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. Unlike Boz, Daude and Durdu (2009), our framework does not focus on signals of trend versus permanent shocks and instead considers the interaction between news about future fundamentals and sovereign default risk.

Second, our paper is related to the recent literature on quantitative models of sovereign debt. Following the seminal work of Eaton and Gersowitz (1981), various studies have focused on how default risk affect economic fluctuations. A short list of papers includes Chatterjee et al. (2007), which studies unsecured consumer default; Aguiar and Gopinath (2006), Arellano (2008), Cuadra and Sapriza (2008), Hatchondo, Martinez and Sapriza (2009), Lizarazo (2006) and Yue (2007) among others, which analyze various features of the dynamics of sovereign debt and default in emerging markets. 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. To our knowledge, our paper presents the first effort to integrate news and default risk in a nonlinear dynamic stochastic quantitative model of endogenous default.

Tomz and Wright (2007) document that a significant fraction of defaults have occurred in good times. The previously cited models can not easily account for this empirical evidence. The only paper that accounts for this regularity is Hatchondo, Martinez and Sapriza (2009). Hatchondo et al. (2009) build a model with political uncertainty and characterize the equilibrium dynamics under which default can occur in good times. Unlike their study, our model does not need to resort to political distortions or disagreements between politicians and households regarding consumption during the cycle that can be difficult to measure. Additionally, we examine the model implications quantitatively using direct data. Hence we show the plausibility of our findings not only from a theoretical point but also from a quantitative perspective.

As we highlighted earlier, our model helps to explain cross country heterogeneity based on the

improvement in the precision of news, through its effect on endogenous credit risk dynamics. The probability of default and the associated risk premium in an incomplete markets setting are the major factors in explaining the business cycle fluctuations in these economies. Empirical studies have estimated these probabilities, and have found that incentives to default are higher in recessions.[3] The countercyclicality of interest rate spreads in the model is closely linked to the dynamics of the default probabilities perceived by the market. This is consistent with the empirical evidence documented in Neumeyer and Perri (2005) and Uribe and Yue (2006). These studies show that that the cost of foreign credit is higher in recessions than in expansions. Similarly Cantor and Packer (1996) find that sovereign credit ratings strongly respond to the GDP growth rate.

3 The model

We consider a small open economy model with households, government and foreign lenders. Income is stochastic and agents receive news about future realizations of the income shock. Households are hand-to-mouth consumers. The government maximizes households' utility and has access to foreign borrowing. The only asset traded in international credit markets is a one period non-contingent bond that is available to the government.[4] Debt contracts are not enforceable since the government has the option to default on them. When it defaults, it is temporarily excluded from credit markets and the economy suffers an output loss. Foreign lenders charge a premium to account for the probability of not being paid back by the government.

3.1 Stochastic structure

Denote Θ as the probability space for the endowment. The endowment is assumed to follow a standard Markov chain with probabilities $p(y_{t+1} = m|y_t = j)\ \forall m, j \in \Theta$. 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 conduce 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 Ξ denotes the probability space for the signal.

The sets Θ and Ξ do not necessarily coincide. One may consider the case where the government

[3] See Peter (2002) for a survey of econometric studies on the probability of sovereign default.

[4] Most external debt in developing countries represents 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.

only receives signals regarding some future endowments, in which case $|\Theta| > |\Xi|$. One can also consider the opposite case with $|\Theta| < |\Xi|$. This corresponds to the case in which, for instance, there are signals corresponding to each element in Θ, and in addition there are signals corresponding to joint elements of Θ. In the current paper, we consider $|\Theta| = |\Xi|$ and that for each element in Θ there exists one and only one element in Ξ.

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

$$p(y_{t+1} = l \mid s_t = i, y_t = j) = \frac{p(s_t = i \mid y_{t+1} = l)p(y_{t+1} = l \mid y_t = j)}{\sum_n p(s = i \mid y_{t+1} = n)p(y_{t+1} = n \mid y_t = j)} \tag{1}$$

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:

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

with $l, j, m, l \in \Theta$ and $i, \kappa \in \Xi$. Regarding the signal precision, we examined different parameterizations and formulations. We first assumed the following formulation:

$$p(s_t = i | y_{t+1} = l) = \begin{cases} \eta & \text{if } i = l \\ (1 - \eta)/(|\Xi| - 1) & \text{if } i \neq l \end{cases}. \tag{3}$$

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 check several cases with $1/|\Xi| \leq \eta \leq 1$.

In the formulation above, it is more likely to receive a certain signal than all the others. 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 endowment are observed with equal probability. We also considered an alternative formulation where it would be more likely to observe signals closer to the endowment.

More formally:

$$p(s_t = i|y_{t+1} = l) = \begin{cases} \eta & \text{if } i = l \\ f(i,l) & \text{if } i \neq l \end{cases} \tag{4}$$

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:

$$p(s_t = i|y_{t+1} = l) = \eta / e^{a|i-l|^{b_l}} \tag{5}$$

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 similar with the first and second formulation, and for brevity we only report on the first.

In this paper we also assume that the signal is public information. The government, private agents, and external lenders observe the signal and adjust their actions accordingly. A model where some agents receive more precise signals is interesting but raises issues of assymetric information which are beyond the scope of this paper.

3.2 Households

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

$$E_0 \sum_{t=0}^{\infty} \beta^t u(c_t) \tag{6}$$

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.

3.3 Government

The benevolent government maximizes the utility of the households in the economy and can borrow and lend in international credit markets. Financial markets are incomplete since the government can only save and indebt itself by selling and buying a non contingent one period bond. In order to smooth households' consumption, the government can borrow from abroad.

Each period, conditional on being in good credit standing the government chooses between honoring its outstanding foreign debt or defaulting on it. This decision comes from comparing the

net benefits of the two options. Thus, the government compares the cost of temporary exclusion from credit markets given by the foregone benefits of consumption smoothing and the output loss in autarky, against the direct costs of repayment given by the short-run disutility of lowering current consumption to repay the non contingent loan.

The intertemporal problem of the government can be expressed in a recursive dynamic programming form. Conditional on having access to credit markets, the government has to decide whether to default or not; if default is not optimal then it has to decide how much borrowing or saving to do. If default is optimal then the economy loses access to international credit markets. All these decisions are made given the current income shock, the signal on next period's income and the amount of outstanding foreign assets. Thus, the state variables are the realization for income y, the realization for the signal s, the level of foreign assets B and the credit situation of the country, d, where $d = 1$ if the economy has access to credit markets and 0 if the country is in financial autarky.

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 government has to decide between honoring its debt and defaulting on it, by comparing the value associated with paying back and remaining in the credit market $V^c(B, y, s)$, with the value associated with defaulting and going to temporary autarky $V^d(y, s)$. The problem can be expressed in the following way:

$$V_0(B, y, s) = \max \left\{ V^c(B, y, s), V^d(y, s) \right\} \tag{7}$$

and the optimal default decision of the government is characterized by

$$D(B, y, s) = \begin{cases} 1 & if \quad V^c(B, y, s) > V^d(y, s) \\ 0 & otherwise \end{cases} \tag{8}$$

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

$$\Gamma(B) = \{(y, s) \in \Upsilon : D(B, y, s) = 1\} \tag{9}$$

and a default set $\digamma(B)$ defined as the set of values of the productivity shock such that default is

optimal given asset holding level B,

$$\digamma(B) = \{(y,s) \in \Upsilon : D(B,y,s) = 0\} \tag{10}$$

If there is not default, the economy can issue new debt and finance consumption according to the following restriction:

$$c = y + B - q(B',y,s)B' \tag{11}$$

where $q(B',y,s)$ is the price of the bond that pays one unit of consumption goods the following period if the economy does not default on its debt. When the sovereign borrows, it receives $q(B',y,s)B'$ units of consumption goods from foreign creditors on the current period and promises to pay B' units next period conditional on not defaulting.

In a similar way, if the government purchases a bond of value B', today it lends $q(B',y,s)B'$ units of the good to foreign creditors and it will receive B' units the following period. If foreign creditors borrow from the domestic government, it is assumed that they always pay back, only the domestic government cannot commit to repay its debt. Hence, the bond price reflects the probability of default, which depends on B', y and s.

When the government has access to credit markets it chooses foreign assets, and faces the following maximization problem:

$$V^c(B,y,s) = \max_{B'} \left\{ U(y + B - q(B',y,s)B') + \beta \sum_{y',s,'} V_0(B',y',s')\Pi(y',s',y,s) \right\} \tag{12}$$

where consumption $c = y + B - q(B',y,s)B'$.

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 decreases income to y^{def}, so that consumption $c^d = y^{def}$, and faces the following problem:[5]

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

The economy is excluded from credit markets in the current period but in the next one the country may regain access to external markets with an exogenous probability μ. When the economy

[5]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).

returns to financial markets, it does so with no debt burden, $B = 0$. In this case the continuation value will be $V_0(0, y, s)$. On the other hand, with a probability $1 - \mu$ the country will stay in autarky. In such a case, the continuation value will be $V^d(y, s)$.

3.4 Foreign Lenders

There is a large number of identical, infinitely lived foreign creditors. Each lender can borrow or lend at the risk free rate r_f and participates in a perfectly competitive market to lend to the small open economy.

Lenders are risk neutral and maximize expected profits, which are given by the following equation

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

The first term of 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, where $\lambda(B', y, s)$ is the endogenous probability that the government defaults on its sovereign debt. Therefore, with probability $1 - \lambda(B', y, s)$ lenders will be paid back an amount B'.

Since there is perfect competition in the credit market, a zero profit condition for the foreign creditor is satisfied. The bond price is then[6]:

$$q(B', y, s) = \frac{(1 - \lambda(B', y, s))}{1 + r_f} \tag{14}$$

Thus, the equilibrium bond price $q(B', y, s)$ reflects the probability of default of the government, $\lambda(B', y, s)$, which results from

$$\lambda(B', y, s) = \sum_{y', s' \in \digamma(B')} \Pi(y', s', y, s). \tag{15}$$

so that the default probability is zero when $\digamma(B') = \varnothing$ and it is one when $\digamma(B') = \Upsilon$.

[6] 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 $q = \frac{1}{(1+R)} = \frac{(1-\lambda)}{1+r_f}$.

4 Equilibrium

4.1 Definition

In equilibrium households choose optimal private consumption given government policies and the government determines its optimal default policy and asset holding policy subject to the private sector optimizing and foreign lenders optimizing by satisfying their zero profit condition from the debt contract.

A recursive equilibrium for this small open economy is characterized by

1. A set of value functions V_0, V^c and V^d for the government,
2. A set of policy functions for household's consumption c, c^d ,
3. Policy functions for government's default decision D and optimal asset holdings B',
4. A bond price function q,

such that

1. Given the government policies and the bond price function, the household policies for consumption solve the household's problem,
2. Given the bond price function q and the optimal policies for households, the government's value functions V_0, V^c and V^d and its policy functions D and B' solve (**??**), (**??**) and (**??**):
3. The equilibrium bond price $q(B', y, s)$ is such that international lenders get zero expected profits, (**??**).

4.2 First Order Conditions from the government's problem

The Euler equation for the government is obtained from the first order condition of its dynamic optimization problem and the envelope theorem:

$$u_c(c)\left[q + B'\frac{\partial q}{\partial B'}\right] = \beta \sum_{(y',s')\in\Gamma(B)} u_c\left(c'\right)\Pi(y', s', y, s)$$

The Euler equation is interpreted in terms of marginal benefits and marginal costs of additional lending or borrowing. We consider the case where the government is a net debtor. The marginal benefits and costs can be described as follows:

In terms of effects on current welfare, for each unit of additional borrowing the government could increase the level of consumption by $q + B' \frac{\partial q}{\partial B'}$ units. Additional borrowing would increase the amount of resources available to finance consumption. Since the government is borrowing more it could afford increasing household consumption in q units, but at the same time, if the government is already indebted, additional borrowing would increase the interest rate that it faces in international markets because default probabilities are increasing in foreign debt. The decreasing bond price implies that the government does not obtain as many resources from selling bonds as it would under a constant bond price. The term $B' \frac{\partial q}{\partial B'}$reflects that when evaluating the benefits and costs of additional external borrowing, the government takes into account the fact that issuing more bonds would decrease the price.

The government's borrowing can affect the idiosyncratic bond price that it faces: if the government issues additional bonds, default probabilities will be higher and foreign creditors will demand a lower price, otherwise they will not buy the bonds. Increasing B' can only be optimal if it allows the government to increase c, i.e. if $q + B' \frac{\partial q}{\partial B'} > 0$. In this case the extra resources are used to increase consumption, and thus, current utility. Next period, the government should to repay its debt, which reduces future consumption. However, it only pays back when it is optimal, so consumption only falls in those states where the government does not default and honors its debt.

5 Quantitative analysis

The model is solved numerically and the parameter values for the case without news follow the calibration by Arellano (2008) for a typical developing economy, Argentina. We change the precision of news to show how the simulation results transition from mimicing the empirical regularities described above for developing economies into those of industrialized countries.

5.1 Data

Cross country stylized facts on consumption, net exports are taken from Aguiar and Gopinath (2004), the data on sovereign interest rate correlations with macro 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 growth by income quartile for the period 1950-2003 are constructed using the database of sovereign defaults by Beim and Calomiris (2001) and income data from the IMF.

5.2 Calibration

The calibration involves choosing the functional forms and the parameter values. The parameters are chosen based on existing work by Arellano (2008) for Argentina and are otherwise set to mimic empirical regularities of emerging markets.

The per period utility of households is specified as a CRRA function:

$$u(c) = \frac{c^{1-\sigma}}{1-\sigma}. \tag{16}$$

The income shock is assumed to follow an AR(1) process

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

with $E(\varepsilon) = 0$ and $E(\varepsilon^2) = \sigma_\varepsilon^2$. The process is approximated using a one-period Markov chain, and it is described in detail together with the signal on next period's output in Section **??**.

There is an output loss in autarky. Rose (2005), Arteta and Hale (2006) and Mendoza and Yue (2008) among others, provide a rationale for the loss of output when countries face debt crises. The income factor in autarky $h(y)$, which corresponds y^{def} is specified following Arellano (2008). Thus, it is assumed that default entails some direct output cost of the following form:

$$h(y) = \begin{cases} \phi E(y) & if \quad y > \phi E(y) \\ y & if \quad y \leq \phi E(y) \end{cases},$$

with $\phi \in (0,1)$.

The parameters for the model are shown in Table 1. The construction of the news shocks follow Jaimovich and Rebelo (2009). We consider different parameter values for the precision of these shocks to study their varying impact on the macroeconomic variables of interest.

5.3 Results

This section presents the simulation results and the statistical properties of the model. Table 2 shows the business cycle moments of several macroeconomic variables from the data and from the simulated model. Business cycles statistics are average values over 1000 simulations of 50 realizations each, drawn from a stationary distribution. The simulated series are logged and filtered.

The model economy is able to match several stylized facts in both emerging and developed

markets by considering different levels of precision of news about future income realizations. On the one hand, for low precision levels, the simulation results largely mimic the statistics of developing countries: incentives to default are higher for highly indebted economies, default risk and interest rates are countercyclical, the trade balance is negatively correlated with output and the volatility of consumption is close to ten percent higher than the volatility of output. Additionally, in good times the country borrows more at lower interest rates. On the other hand, when news are more precise, as in developed countries, the economy can anticipate future fundamentals more accurately, and thus, manage debt more efficiently. Lenders factor in the better handling of debt, requiring a lower risk premium for any given amount of debt. At the same time, the lower risk profile induces the economy to increase borrowing, which can raise interest rates. The net effect from the additional borrowing and the lower risk profile influences the equilibrium interest rates. When news are highly accurate, the economy is able to sustain higher borrowing and pay significantly lower interest rate spreads in equilibrium. Consumption becomes less correlated with output, the relative volatility of consumption with respect to output declines, and the macroeconomic dynamics become those of a developed economy.

Figure 1a plots the discount bond price schedule as a function of assets for two values of the productivity shock. As the figure shows, for any given realization of the shock, the bond price is an increasing function of foreign assets. For small levels of foreign debt, the government always pays back its debt, so it borrows from international markets at the world risk free interest rate. However, as the foreign debt increases, there is a threshold level for which the bond price starts to decrease: incentives to default are stronger for highly 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, so the bond price is zero.

The bond price schedules also illustrate that for all levels of debt, the bond price is lower when the economy is hit by an adverse output realization. This result derives from the presence of incomplete asset markets in the model. This market structure makes defaulting on foreign debt more attractive in bad times when output is low since the repayment of non- contingent loans is more costly in recessions. Since productivity shocks are persistent, lending resources to the government in times of low output involves a higher default risk. Thus, risk neutral lenders are willing to lend resources to the government by charging a higher interest rate.

Figure 1 plots the discount bond price schedule as a function of assets for two values of the news shock and a given output realization, and illustrates that for debt levels for which there are some

states where the government defaults, the bond price is lower (higher) when the economy receives good (bad) news. Good news signal a higher next period output, which implies a smaller set of debt levels for which it will be optimal to default tomorrow. Thus, the higher bond price received today.

Figure 2 illustrates the shape of the default region as a function of current debt and news shock realizations for the mean output realization. Consistent with the previous plot, good news, for instance a 5 percent deviation from current output in the graph, imply that next period's output will likely be higher, making repayment will be less costly and thus, more likely. The effect of the news signal on default risk also depends on how credible is the signal. Thus, the impact of the news shock depends not only on its realization but also on the probability with which such future output may occur given the signal. Thus, agents discount the value of the news by such probability. Thus, extreme news will have less value as a signal than news which point to a next period output realization that is relatively closer to the current state. Consequently, extreme news will likely have less of an impact on the default region than news that are closer to the current state. The figure shows this point: if the economy receives an extremely positive news signal pointing toward a next period output 10 percent above the current one, the low probability assigned to such news realization would discount its effect on default risk, making it even lower than a positive news shock of 5 percent. This explains the S-shaped default region as a function of the news shocks depicted in the figure.

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 entices the government to dissave. Additionally, since productivity shocks are persistent, a positive shock today increases the probability of a good shock next period, and the increased likelihood of a higher future income also induces the government to borrow more. Therefore, when debt carries default risk, the economy borrows more in booms than in recessions. Figure 3 shows the borrowing policy function as a function of B and B' given y for two values of the news shock. Good news reduce default risk, and the lower cost of debt induces further borrowing. Thus, news can lead the economy to support more debt and enhance consumption smoothing.[additional intuition on news here]

These results suggest that more precise information about future fundamentals can help emerging market economies move towards the pattern of fluctuations observed in more developed economies.

As highlighted earlier, prominent features of the emerging market business cycle include the higher variability of consumption relative to output, and the strong counter-cyclicality of the trade balance. A number of explanations have been proposed in the literature to explain this regularity. For instance, Aguiar and Gopinath (2007) argue that higher variability of trend shocks relative to transitory shocks can be the driving force that explains these regularities. Garcia-Cicco, Pancrazi and Uribe (forthcoming), however, argue against this view showing evidence for Argentina that the data do not support the hypothesis that trend shocks are more variable in emerging market economies. Reconciling these conflicting evidences, Boz, Daude and Durdu (2009) argue that the greater uncertainty in discerning between trend and transitory shocks faced by agents in emerging markets while formulating expectations can be the main driving force for these stylized facts. The current paper argues, in a quantitative model of endogenous sovereign default, that as agents receive more precise signals about future fundamentals, the consumption variability declines and cyclicality of trade balance. Contrary to previous papers, this work does not need to recourse to trend versus temporary shocks.

The higher volatility of consumption than that of output and a countercyclical trade balance are due to the procyclicality of borrowing. In low income states, borrowing is relatively expensive so the government is constrained, thus consumption decreases similarly to output and the trade balance tends to be positive. In expansions, the cheap foreign credit stimulates borrowing, which induces consumption to rise above income and the trade balance to become negative.[additional intuition on news, fig.8]

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Similarly, consumption is procyclical because it is valued by households and markets are incomplete. Since default is more attractive in bad times, the bond price is low (high) in recessions (expansions). Thus, the asset structure in the model and the countercyclicality of interest rates substantially reduce the ability of the government to smooth consumption and make it highly positively correlated with output.

Figures 10, 12 and 13 show the correlation of output with the interest rate, the default probability, which is closely related to the mean interest rate, and the mean debt-GDP ratio. The plots show a nonmonotonic relationship between these variables and the precision of the news. This nononotonicity is at play because of the two opposing forces highlighted in the policy functions. On one hand, more precise information reduces the future uncertainty, which, in turn, reduces

foreign investors incentives to charge a higher premium. Ceteris paribus, this channel would reduce the default probability, lower the equilibrium interest rate, and the correlation of interest rate with income. However, as the future uncertainty eases, the agents have less incentive to accumulate precautionary wealth; hence, the debt levels increase on impact. Ceteris paribus, higher debt levels lead to an increase in default probability and the risk premium charged by the investors. Figure 12 shows that for the precision levels up to about 0.6, the latter effect dominates the former, hence default probability, the equilibrium interest rate and the correlation of interest rate with income displays nonmonotonicity. Despite this nonmonotonic behavior, higher precision always reduces the variability of consumption relative to output as well as the correlation of the trade balance with income (See Figures 8 and 9).

Another dimension that news shocks help to explain is the fraction of default occurring in good times. As Figure 13 illustrates, as the precision of the news shock improves, the percentage of default in good state of nature increases. The main mechanism that drives this finding is that although the economy is in a good state of nature, an adverse shock that hit the economy can worsen the agents ability to repay debt. Once agents receive signals about likelihood of those adverse states realizing, the agents willingness to repay the current debt diminishes and the agents default as a result. Tomz and Wright (2007) indicate that countries do not always default in good states of nature. Hatchondo, Martinez and Sapriza (2009) provide an explanation for this finding by focusing on borrowers' heterogeneity (political risk). The present paper provides an alternative explanation: it shows that news about future ability may affect the willingness to repay debt, accounting for the regularity put forward by Tomz and Wright.

6 Conclusions

In this paper, we build a model of sovereign debt in which default risk, interest rates, and level of debt are affected by both 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 sovereign to repay its debt. Besides having direct effects, news may significantly affect default risk, which in turn alters the fluctuations of several key macro aggregates.

In a series of quantitative exercises, we show that the news shocks help account for key differences between emerging markets and developed economies: as the precision of the 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. In addition, the model also captures the hump-shaped relationship between default rates and the precision of news obtained from the data. Last but not least, the model with news shocks generates higher rate of default in good times, bringing the model closer to the stylized facts established in the literature.

7 Appendix

7.1 Algorithm

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, use the inverse of the risk free rate. For the initial values of the value functions, $(V_0)_0$ and $(V^d)_0$, start with 0 matrices, then the following algorithm is used:

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 (**??**), (**??**) and (**??**) 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 $\digamma(B)$, compute the probability of default $\lambda(B', y, s)$ using (**??**).

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:

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

where ϵ is a small number.

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Table 1: Real earnings

Parameter	Notation	Value
Risk Aversion	σ	2
Discount Factor	β	0.953
Re-entry Probability	μ	0.282
Default Penalty	ϕ	0.969
Risk Free Interest Rate	r_f	0.017
Autocorrelation of Output	ρ	0.945
Standard deviation of Output	σ_ϵ	0.025
News Shock	s	[0, 0.99]

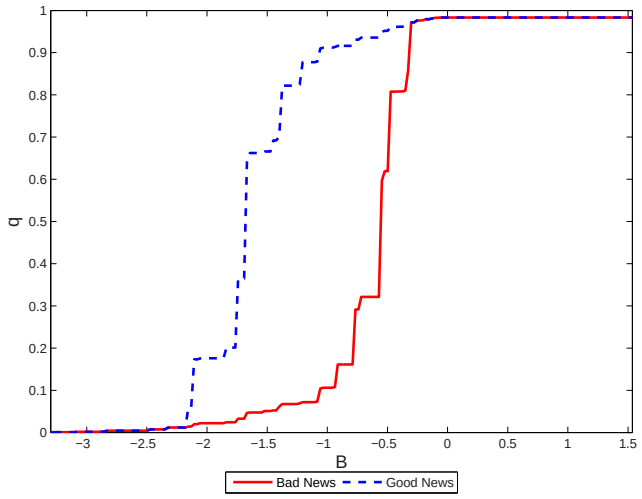
Table 2: Business Cycle Moments

	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

Table 3: Simulation Results

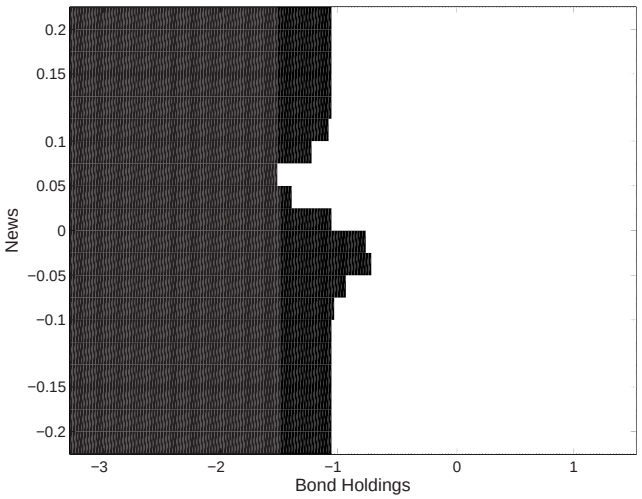
	No News	With News, s 0.9
$\sigma(c)/\sigma(y)$	1.10	1.03
$\rho(y, c)$	0.97	0.89
$\rho(y, tb)$	-0.23	0.17
$\rho(y, Spread)$	-0.28	-0.13

Figure 1: News and Bond Price Schedule



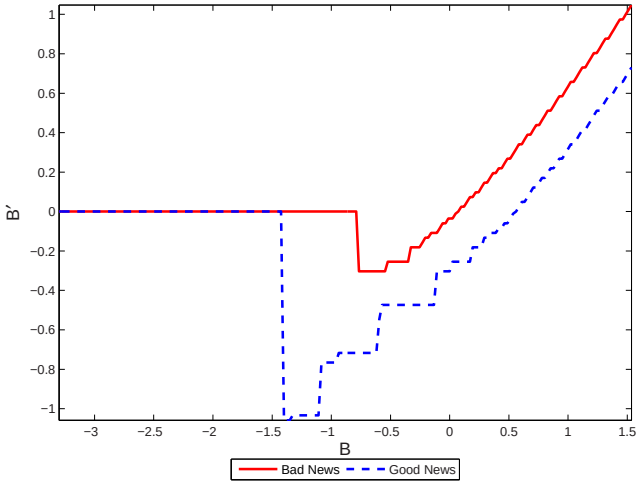
Note: Graphs are shown for the precision level, s, 0.5.

Figure 2: News and Default Region



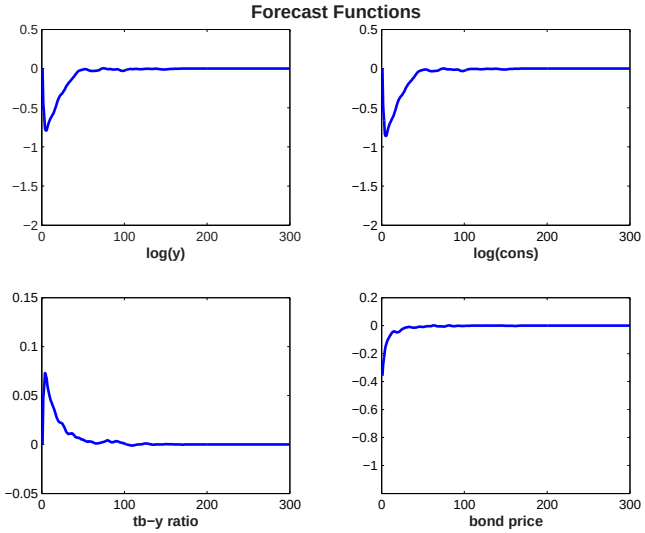
Note: Graphs are shown for the precision level, s, 0.5.

Figure 3: News and Savings Policy



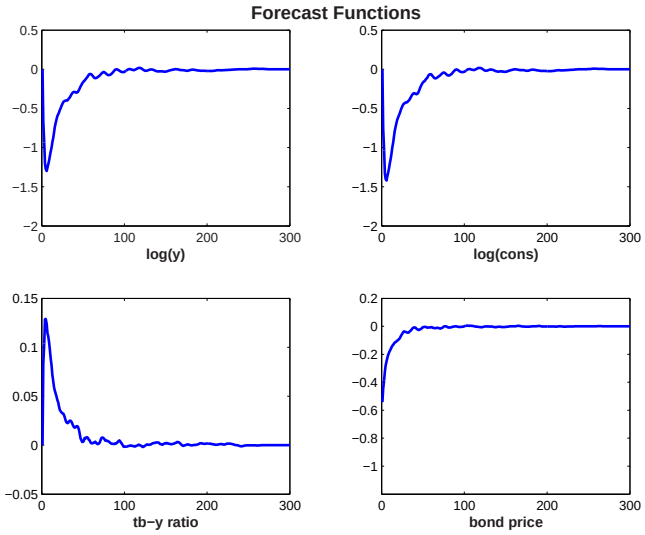
Note: Graphs are shown for the precision level, s, 0.5.

Figure 4: Forecast Functions with News Precision, s 0.25



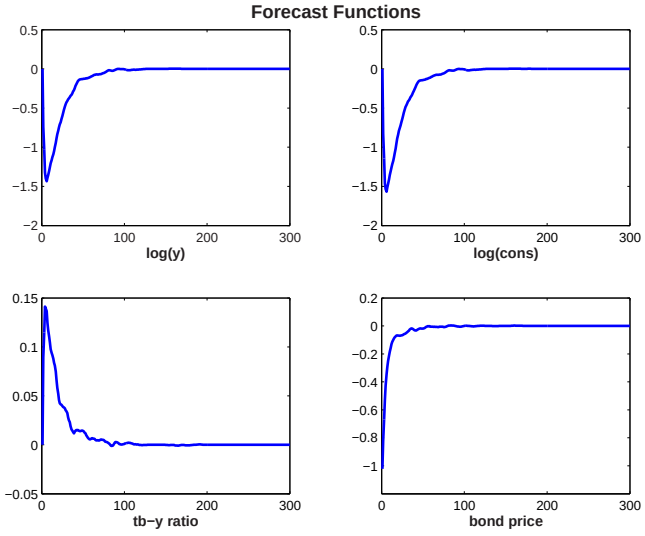
Note:

Figure 5: Forecast Functions with News Precision, s 0.50



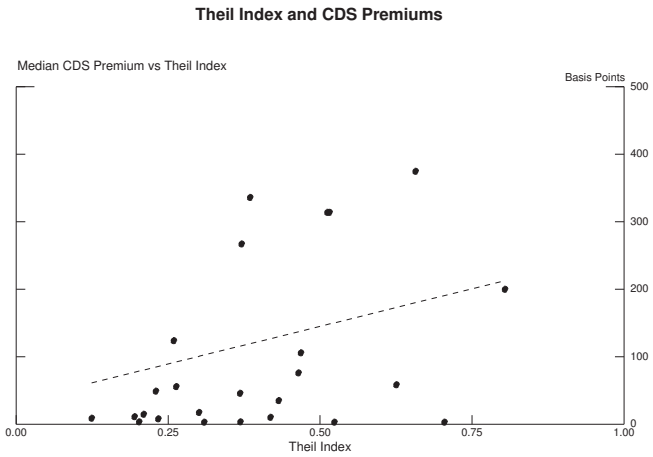
Note:

Figure 6: Forecast Functions with News Precision, s 0.75



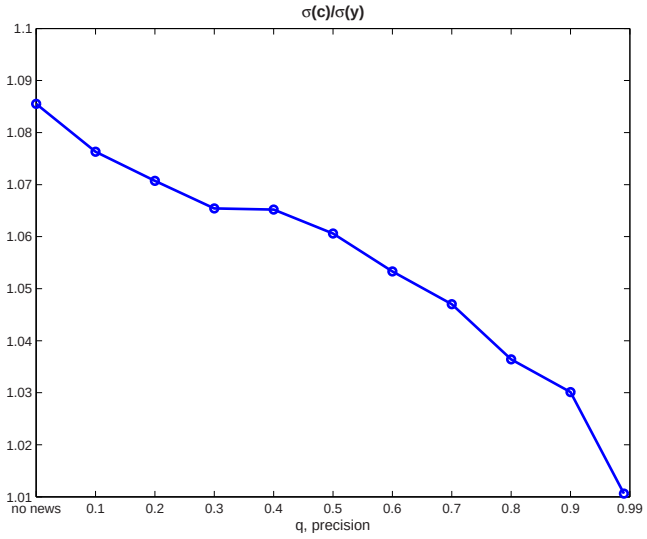
Note:

Figure 7: Theil Index and CDS Premiums



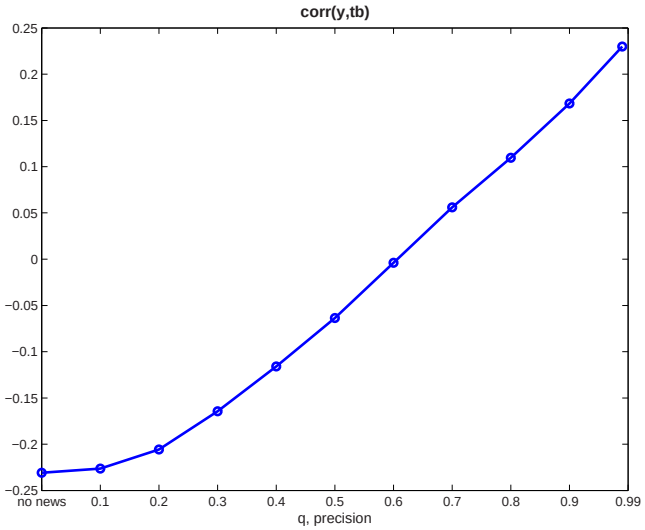
Note:

Figure 8: Relative Variability of Consumption



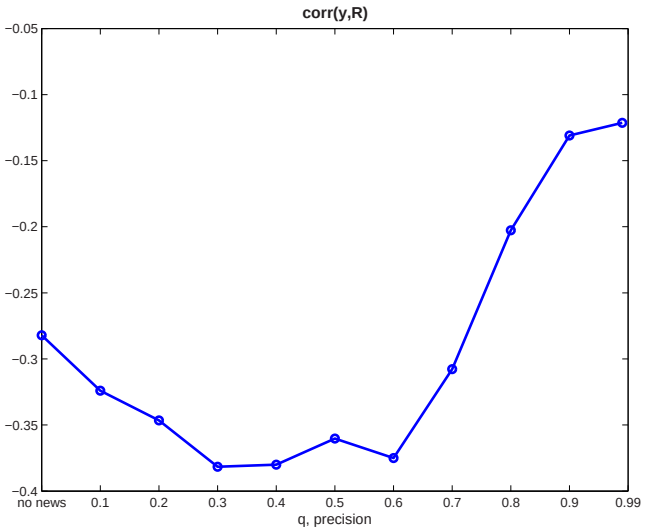
Note:

Figure 9: Correlation of Trade Balance with Output



Note:

Figure 10: Correlation of Interest Rate with Output



Note:

Figure 11: Default Rates and Income per Capita Brackets

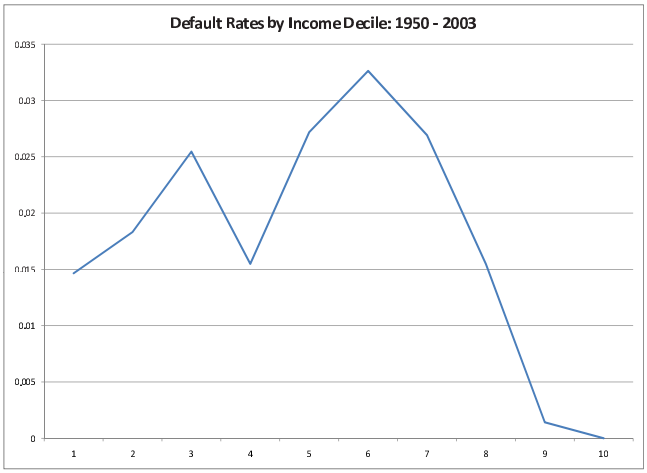
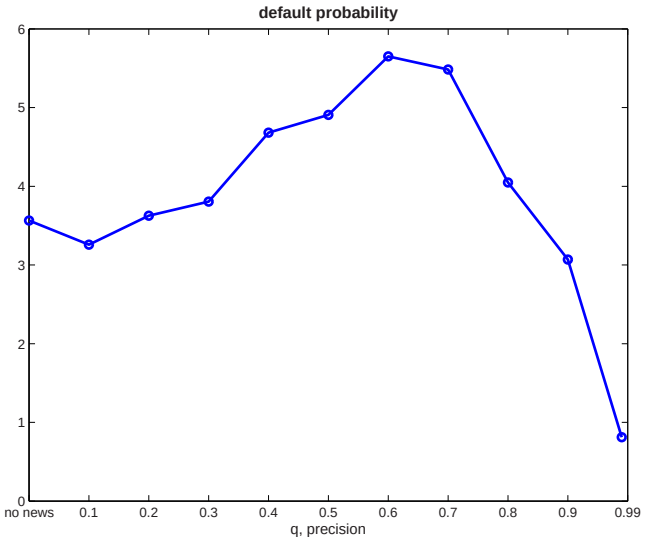
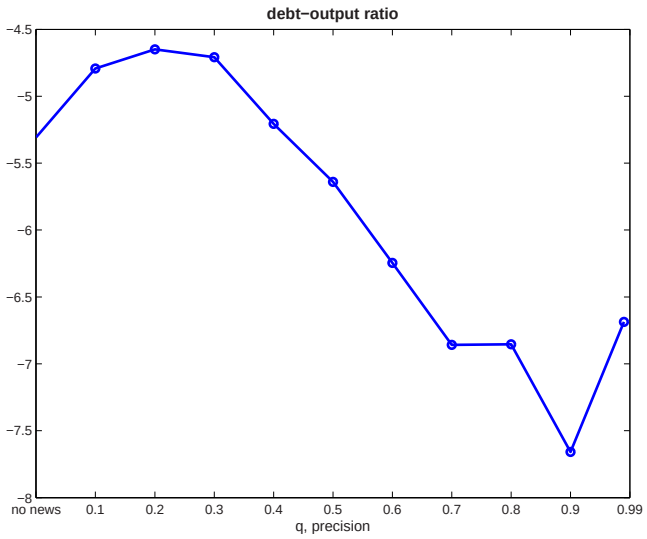


Figure 12: Default Probability



Note:

Figure 13: Debt-GDP Ratio



Note: