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# PERSISTENT GAPS, VOLATILITY TYPES, AND DEFAULT TRAPS

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# Persistent Gaps, Volatility Types and Default Traps

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**Abstract**

We show that cross-country differences in the underlying volatility and persistence of macroeconomic shocks help explain two historical regularities in sovereign borrowing: the existence of "vicious" circles of borrowing-and-default ("default traps"), as well as the fact that recalcitrant sovereigns typically face higher interest spreads on future loans rather than outright market exclusion. We do so in a simple model where output persistence is coupled with asymmetric information between borrowers and lenders about the borrower's output process, implying that a decision to default reveals valuable information to lenders about the borrower's future output path. Using a broad cross-country database spanning over a century, we provide econometric evidence corroborating the model's main predictions - namely, that countries with higher output persistence and conditional volatility of transient shocks face higher spreads and thus fall into default traps more likely, whereas higher volatility of permanent output tends to dampen these effects.

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Two main stylized facts permeate the history of sovereign borrowing. The first is serial default. Lindert and Morton (1989) find that countries that defaulted over the 1820-1929 period were, on average, 69 percent more likely to default in the 1930s, and that those that incurred arrears and concessionary schedulings during 1940-79 were 70 percent more likely to default in the 1980s. While these estimates are not conditioned on countries' fundamentals, evidence provided by Reinhart, Rogoff and Savastano (2003) indicates that serial default is only loosely related to countries' indebtedness levels and other fundamentals. They show that such serial defaulters have lower credit ratings and face higher spreads at relatively low indebtedness levels – a phenomenon they call "debt intolerance". The experience of such debt-intolerant countries – which embark upon a "vicious circle" of borrowing, defaulting and being penalized with higher interest rates – stands in sharp contrast with that of countries that manage to undergo a "virtuous circle" of borrowing and repayment with declining sovereign spreads.

A second notable empirical regularity is that default rarely entails complete exclusion from international capital markets but mainly a re-pricing of country risk (higher spreads), at least for sometime. This regularity is at odds with much of the theoretical literature: in early models (notably Eaton and Gersovitz, 1981) it is the threat of permanent exclusion from capital markets which is crucial to sustain sovereign lending; later models allowed for this exclusion to be temporary but with random re-entry rules which are not price-dependent (Aguiar and Gopinath, 2005; Arellano, 2006).[1] In practice, default is often "punished" not through outright denial of credit or fixed re-entry rules but a worsening of the terms on which the country can borrow again.[2] Provided that borrowing needs are not too price elastic, the

[1] Earlier work had already noted, however, that punishment through market exclusion is problematic, particularly when lenders are heterogenous and coordination is non-trivially costly (Kletzer, 1984). Later work has examined the circumstances under which equilibrium with default risk is shaped by post-default debt renegotiation and market exclusion becomes an inefficient punishment (Cohen, 1991; Yue, 2005). Bulow and Rogoff (1989) further pointed out that exclusion alone is not a sufficient condition for international lending if borrowers retain the ability to invest in international assets. More recently, Kletzer and Wright (2000) provide a qualified reinstatement of the original Eaton and Gersovitz exclusion-based result, relying on a "cheater of the cheater" game-theoretical argument.

[2] In fact, not only is permanent exclusion quite rare, but even temporary loss of market access tends to be relatively short-lived: recent estimates using micro data on international loans and bond issuance put it at 2.5 years for the post-1980 period (Gelos et al., 2004).

sovereign will continue to tap the market – absolute exclusion representing only the limiting case in which lenders' "capture technology" is so weak that country spreads may become prohibitively large for any borrowing to take place.

This paper argues that two structural features which are typically found in emerging markets help explain both stylized facts. These structural features are that output shocks are not only typically large, thus producing high cyclical variability about trend growth, but also highly persistent.

That output volatility is generally high among emerging markets is a well-documented phenomenon (see, for instance, Kose, et. al., 2006). Recent work has related such volatility to a number of long-lasting structural features, ranging from domestic institutions (Acemoglu et al, 2004), commodity specialization (Blattman et al, 2006) to imperfections in international capital markets that limit these countries' ability to issue domestic-currency denominated sovereign debt, thus rendering them more vulnerable to currency fluctuations (Eichengreen et al. 2003).

What has received less attention in the literature, however, is the fact that such output volatility is often coupled with considerable persistence of output shocks. For a given dispersion of shocks (conditional output volatility), higher persistence implies that associated output fluctuations will be larger;[3] so, the same unconditional output volatility may be generated by different combinations of persistence and dispersion of shocks. Yet, as we show below, it is important to disentangle the effects of these distinct parameters on sovereign risk. On a broader analytical level as well, such a separation is important because there are distinctive macroeconomic mechanisms behind shock persistence in emerging-market economies. One is the presence of short-run supply-side inelasticities which make primary commodity price shocks long-lasting; to the extent that primary commodities remain key export items for many such countries, sizeable persistence in output and terms-of-trade is not surprising.[4] Second, various frictions, political as well

[3] To see this, let $y_{i,t} = \rho y_{i,t-1} + \omega_{i,t}$ where $y_{i,t}(y_{i,t-1})$ is output of country $i$ in period $t$ (and $t-1$), $\rho$ is the persistent parameter and $\omega$ is an iid shock. Then we have that the unconditional output volatility is $\sigma_{y_{i,t}} = \frac{\sigma_{\omega_{i,t}}}{\sqrt{1-\rho^2}}$.

[4] See Cashin et al. (2000) and references therein for empirical evidence on the persistence of commodity price shocks. Mendoza (1995) finds that terms of trade variations typically account for up to one-half of business cycle fluctuations in developing countries.

as economic, make fiscal policy more procyclical in these countries than others.[5] In a recession, a contractionary fiscal stance tends to delay recovery, which exacerbates shock persistence. Third, financial and institutional frictions in emerging markets typically magnify the sensitivity of domestic credit to loan collateral values. As a result, the credit-transmission mechanism can induce more prolonged spirals of output contraction or expansion, including painful episodes of debt deflation. Insofar as such frictions often coupled with protracted balance-sheet adjustments stemming from currency-denomination mismatches (see, e.g., Calvo, 1998; Mendoza, 2005), they also help explain higher shock persistence in those economies.

This begs the question as to whether, and to which extent, output has indeed been typically more volatile and persistent among defaulters and serial defaulters.Tables 1 and 2 provide suggestive evidence.[6]Using data spanning the century-and-quarter period from dawn of international bond financing in the 1870s through 2005, the Tables report the standard deviation as well as the first autoregressive coefficient of HP-filter de-trended output for each country over the three main sub-periods delimited by the World Wars. As is immediately apparent from group medians at the bottom of the two tables, defaulting countries typically display higher volatility and persistence than non-defaulting countries on average. Further, these cross-countries differences appear to be typically even higher between serial defaulters and non-

[5]Gavin and Perrotti (1997) and Kaminsky et al. (2004) provide empirical evidence. Talvi and Vegh (2005) examine the role of political frictions in creating such procylicality. Eichengreen, Hausmann and Panizza (2005) explain greater fiscal procyclicality in developing countries in terms of the incompleteness of international financial markets. As this incompleteness limits long-term external borrowing in these countries' own currency, when bad shocks hit (which typically entail a currency depreciation or devaluation), the cost of public borrowing rise accordingly; this in turn forces these countries to undergo contractionary fiscal adjustment or at least limits the scope for counter-cyclical fiscal policies. Guidotti et al. (2005) provide empirical evidence consistent with this theoretical story, in that more "dollarized" countries tend to display slower recoveries following capital account shocks ("sudden stops").

[6]The shorter cross-sectional dimension of the pre-World War II sample is entirely determined by the availability of output data. The post-World War II sample includes countries that tapped from international capital markets during the period and excludes those where lending has been mostly concessionary (including direct official lending and lending through multilateral institutions). Since output data for these lower-income developing countries also tend to be less reliable, their exclusion from the sample can be justified on these grounds as well.

defaulters, and are consistently observed for certain countries over the entire 1870-2004 period. Tables 1 and 2 also suggest that the postulated relationship appears to be robust to potential reverse causality emanating from the effects of defaults on the volatility and persistence of output shocks: when we eliminate from the sample all default events and their immediate aftermaths, defaulters continue to display greater output volatility and shock persistence relative to their more virtuous peers.

We lay below a simple model to examine the effects of volatility and persistence of output shocks on sovereign risk. The main novelty relative to previous studies is to combine these two "structural" features of output growth in most emerging markets with asymmetric information between borrowers and lenders about the nature of output shocks. In a companion paper (Catão, Fostel and Kapur, 2007), we establish how such asymmetry of information ensures an equilibrium pricing mechanism- relative to the symetric information benchmark- which is relevant because it can account for the two stylized facts described above, working as follows. Once sovereign borrowers are better informed about the output shock than lenders, the borrower's action (default vs repayment) can be highly informative: default triggers a discrete shift in expectations about the future repayment flows so that lenders tend to " assume the worst" about the future output path. Such pessimism-combined with lenders' need to (at least) break-even period by period- implies that fresh borrowing is sustainable only at much higher interest rate spreads. Ex-ante such a "default premium" constitutes a deterrant mechanism that induces countries to pay even in the absence of output penalties featuring elsewhere (e.g., Sachs and Cohen, 1985; Obstfeld and Rogoff, 1996; Alfaro and Kanuzck, 2005). Ex-post, however, the attendant rise in spreads associated with such "default premium" increases the cost of future borrowing. Provided that borrowing needs are not overly elastic to the hike in spreads, the ratio of debt service to (expected) output will rise, thereby raising the cost of future repayments, all else constant. Thus, a sufficiently large negative shock once combined with some output persistence and asymmetric information between borrowers and lenders about the nature of the shock, tends to create "default traps".

In this paper we study how this default trap mechanism is exacerbated (or tempered) by output persistence and volatility. Since output volatility and persistence tend to be structural (and hence slowly-evolving) macroeconomic features that vary from country to country, the mechanism just described entails clear-cut testable propositions about sovereign bond pricing on a cross-country basis. Three main theoretical results are derived in this connection.

First, countries that display higher underlying persistence of output shocks face higher sovereign spreads, all else constant. This occurs irrespective of whether the country has defaulted or not in the past; a previous history of default(s) further exacerbate(s) this effect. In other words, higher persistence increases country risk both before and after default relative to baseline. This helps explain why certain countries may face systematically higher spreads than others at lower debt ratios and even after after controling for other fundamentals.

Second, countries with higher volatility of the temporary component of output tend to face higher spreads including those with a clean credit history.

Third, and tempering the preceding results, we find that higher volatility of the persistent component of the output shock dampens the "default premium" – that is, the difference in borrowing rates between default and non-default states after the realization of a given shock. The intuition is that, under asymmetric information, default by a high volatility country is more "excusable", to use Van Huyck and Grossman's (1988) jargon: that is, it generates a less pessimistic outlook for the borrower's future output path relative to a less volatile economy that also defaults; so, the default premium does not rise as much in the former case. This result, which follows from the asymmetry of information assumption, is to the best our knowledge new in the literature.

These theoretical findings relate to previous studies. Aguiar and Gopinath (2006) also study the effect of output persistence on default risk. They develop an infinite-horizon model where sovereign borrowing is motivated by consumption-smoothing and default triggers a temporary exclusion from financial markets. While they also find that greater output persistence tends to raise default risk, the underlying mechanism differ. They rely on the conventional penalty of exclusion with exogenously fixed re-entry probabilities to deter default. In contrast, our main deterrent is an endogenous pricing mechanism (increase in spreads). Further, while their analysis focuses on shocks to trend, our model shows that persistent cyclical shocks as well as shocks to trend both can greatly affect default risk in the presence of asymmetric information.

Several other studies have examined the role of volatility in default risk. Our first result regarding the volatility of temporary shocks mirrors that of Aguiar and Gopinath (2005), Arellano (2006), Catão and Kapur (2006), where higher output volatility is shown to raise spreads. In contrast, we also find here that higher trend volatility lowers the default premium, a result not found in these studies. As such, this paper's findings build some bridge between the Eaton and Gersovitz (1981) story - where volatility is negatively related to default risk - and the results of more recent work.

The other main contribution of this paper to the literature is to provide empirical evidence on the theoretical results that we derive. We do so using a long and broad cross-country database spanning the first globalization era in the 1870s - when international financial integration and sovereign bond financing began to climb to unprecedented historical levels (see Obstfeld and Taylor (2005) for detailed evidence on this) – to date. We use this database both to highlight a number of stylized facts on sovereign defaults that are consistent with our model, as well as to provide econometric evidence on the effects of conditional volatility and persistence of output shocks on sovereign risk. The results indicate that countries with more volatile and persistent output shocks are likely to face higher ex-ante interest spreads and thus more likely to be caught into default traps. Consistent with our theoretical findings, we also find that, conditional upon actual default, default interest premium of countries with historically higher output volatility tend to be lower than less volatile countries, all else constant. We show that these empirical results are robust to a host of other controls on the determinants of sovereign risk.

The plan of the paper is as follows. Section 2 presents the model and the comparative statics results. Section 3 summarizes key stylized facts about sovereign defaults relevant to our model and presents our main econometric results. Section 4 concludes. Appendix 1 presents the proofs to the theoretical propositions.

# 1 Model

A sovereign borrower issues bonds in international capital markets to finance investment in long-term projects. We can think of these as physical infrastructure and/or human capital development (e.g. education and health). We develop our argument in the simplest setting, which involves three periods, $t = 0, 1$, and 2. The project's investment requirements, $I_0$ in period 0 and $I_1$ in period 1, are exogenously given. To finance this requirement, the sovereign issues one-period bonds in $t = 0$ and $t = 1$. In periods 1 and 2, the sovereign decide whether or not to redeem bonds issued in the previous period. Bonds are held by competitive-risk neutral lenders and the issue price of bonds is determined endogenously in each period, based on the perceived likelihood of sovereign default.

In our model, the likelihood of default depends on the sovereign's indebtedness relative to its stochastic output. There are two sources of output uncertainty, one involves a persistent shock and the other a transient shock. Specifically, output in $t = 1, 2$ is given by:

$$\tilde{Y_1} = \bar{Y_1} + \tilde{\epsilon_1} + \tilde{\omega_1} \tag{1}$$

$$\tilde{Y_2} = \bar{Y_2} + \rho\tilde{\epsilon_1} + \tilde{\omega_2} \tag{2}$$

where $\bar{Y_t}$, the path of expected output, allows for secular growth. $\omega_t$ denotes transient or temporary shocks: these are i.i.d., with mean 0 and standard deviation $\sigma_\omega$. Random variable $\epsilon_1$ is a persistent shock, with mean 0 and standard deviation $\sigma_\epsilon$. The parameter $\rho \in (0, 1)$ measures the persistence of the shock from period 1 to period 2. Let $\Phi(\epsilon)$ denote the distribution of persistent shocks and $\phi(\epsilon)$ the associated density function.

The model builds on an informational asymmetry between the sovereign borrower and lenders. We assume that, while $\bar{Y_1}, \bar{Y_2}$, $\rho$ and the distribution of shocks are common knowledge, only the sovereign observes the magnitude of its period-1 shock directly. Bondholders do not,[7] but make an inference about

[7]Informational asymmetry is common in many models of debt. In the present context, it could be argued that publicly-available information on a country's output and/or the sovereign income is subject to statistical inaccuracies, and in the short run at least, vulnerable to deliberate obfuscation. Other forms of informational asymmetry in sovereign markets have been studied by Kletzer (1984), Atkeson (1991), Calvo and Mendoza (2000), Alfaro and Kanczuk (2005), Fostel (2005) and Catão, Fostel and Kapur (2007)

its distribution by observing the sovereign's repayment decision in period 1. This updated beliefs are used to calculate future probability of default.

The sequence of events is as follows. At time $t = 0$, the sovereign issues one-period bonds to meet its initial investment requirement $I_0$. The issue price of these bonds is determined endogenously: it reflects expected future default risk. At time $t = 1$, the sovereign observes its output and chooses between default, $d$, or repayment, $r$. On observing the sovereign's repayment choice in period 1, bond holders update their beliefs about the sovereign's future output using Bayes' rule. The sovereign then issues new bonds in period 1 to finance its period-1 investment requirement $I_1$. Once again, the issue price reflects perceived future default risk. In the final period, the sovereign chooses whether or not to repay its debt.

The bond market is competitive, with risk-neutral lenders who are willing to subscribe to bonds at any price that, given their beliefs, allows them to break-even. For modeling simplicity we treat the mass of lenders as a single lender who chooses a price that, given the perceived default risk, just allowing it to break even. As the risk of default depends on future output and indebtedness, so does the price of bonds.

Let $p_0$ be the market-clearing price in period 0 of a bond with unit face value in period 1. To meet the investment requirement $I_0$, the sovereign must issue $D_1$ bonds where:

$$p_0 D_1 = I_0. \tag{3}$$

The implied yield on these bonds is $i_0 = (D_1/I_0) - 1$.

We assume that in the event of default, bondholders can enforce partial recovery $cD_1$; here $c < 1$ is the recovery rate and hence $1 - c$ is the "haircut" inflicted on bondholders. If the sovereign is expected to default in $t = 1$ with probability $\pi_1$, the expected return to bond holders is $[\pi_1 c + (1 - \pi_1)]D_1$. For a risk-neutral lender to break even in expected term, we require

$$[\pi_1 c + (1 - \pi_1)]D_1 = R_f I_0, \tag{4}$$

where $R_f$ is the exogenously-given gross risk-free interest rate. Combining the last two equations the market-clearing price of bonds is:

$$p_0 = \frac{1 - \pi_1(1-c)}{R_f} \tag{5}$$

which indicates that the issue price of bonds is decreasing in the anticipated probability of default. Note that $p_0 \in [c/R_f, 1/R_f]$ so the bond price is positive as long as $c > 0$.

Likewise, bonds issued in period 1 must meet investment requirement $p_1 D_2 = I_1$. As the payment history $h \in \{r, d\}$ in period 1 affects the probability of future default, it affects the issue price $p_1^h$ and the size $D_2^h$ of the bond. Hence, the price of bonds issued in period 1 depends on the anticipated probability of default in period 2, so that:

$$p_1^h = \frac{1 - \pi_2^h(1-c)}{R_f} \tag{6}$$

where $\pi_2^h$ is the history-contingent probability of default in the final period.

Given our choice of a finite-horizon framework, partial capture provides insufficient deterrence against default in the final period. In the absence of other penalties, in period 2 the borrower will default with probability one. To avoid the trivialities associated with this case, we assume that default in the final period is also punished with sanctions that cause the sovereign to lose a fraction $s$ of its current output $\tilde{Y}_2$.[8] If so, repayment will be rational in the final period if and only if the cost of sanctions exceeds any direct gain from reneging on repayments.

We model the interaction between the borrower and lenders as a game. A strategy for the sovereign borrower involves the following elements: bond issuance $D_1$ in period 0, repayment choice $h \in \{r, d\}$ followed by history-contingent bond issuance $D_2^h$ in period 1, and, finally, the repayment choice in period 2. For simplicity, we assume that the sovereign's utility function is linear in payoffs. When making its period-1 choice, the sovereign maximizes $E(\tilde{y}_1 + \beta\tilde{y}_2)$, where $\tilde{y}_t$ denote its output net of any (voluntary or enforced)

[8]As in Sachs and Cohen (1985) and Obstfeld and Rogoff (1996) we assume that bondholders do not appropriate any benefit from these sanctions. Alternatively we might interpret these as endogenous loss of output due to disruptions following default, as in (Cohen, 1992), Calvo (2000).

repayments and $\beta \leq 1$ is a discount factor. With this linear specification, the sovereign cares only about expected future payoffs. If so, the decision to default or repay in period 1 does not depend on the transient component of the shock, $\omega_1$, as this does not affect expected future payoff, $E(\tilde{y}_2)$.[9]

A strategy for the lender involves prices $(p_0, p_1^r, p_1^d)$ that allow it to break even in each period for every history. Alternatively, we can represent these prices in terms of the bond yields $(i_0, i_1^r, i_1^d)$ that capture the risk spreads needed to break even. We say that the default premium is positive if default lowers the issue price of new bonds (that is, if $p_1^d < p_1^r$) or equivalently, it causes the interest rate spread to rise ($i_1^d > i_1^r$).

Finally, since the lender does not observe the realization of shocks directly, we need to specify the beliefs based on the commonly-known prior distribution of shocks and on the borrower's observed choice.

In a companion paper (Catão, Fostel and Kapur (2007)), we prove the existence of a Perfect Bayesian Equilibrium of this model. There, we also show how asymmetry of information ensures an equilibrium pricing mechanism in contrast to the symmetric information benchmark. In the rest of this section we will study how key parameters, persistence and volatility, affect the price mechanism present in that equilibrium. Before moving to the comparative statics, let us briefly describe the equilibrium.

The borrower's optimal strategy in each period has a cut-off property. It will repay in period 1 if and only if the realization of the persistent shock variable is above some threshold, $e_1^*$. In the second period it will repay only if the debt to output ratio do not exceed a value which depends on output losses and haircuts associated to default. The lender, on the other hand, charges a price for bonds such that the expected return equals the opportunity cost of funds. The key property of the equilibrium is that there is a positive default premium, this is, $p_1^r - p_1^d > 0$. So the price charged after a repayment history is always higher than the price charged after a default history.

[9]The linear specification rules out the possibility of "involuntary" default: for instance, a large negative shock, combined with low inter-temporal elasticity of substitution, would imply high marginal utility of current consumption in times of crises, compelling the borrower to default. If so, the borrower's repayment choice may depend not just on the persistent shock but also on temporary shock.

Obviously, the expected return depends on lender's beliefs which in period 1 depend on the borrower's observed repayment choice. Given the borrower's repayment strategy, default signals that the realization of the persistent shock must be below the threshold (that is, in the lower tail of the distribution) while repayment reveals it to be above the threshold. Thus, in period 1, after observing default, lender's beliefs are given by

$$\gamma(\epsilon_1|e_1^*, d) = \begin{cases} \frac{\phi(\epsilon_1)}{\Phi(e_1^*)} & \epsilon_1 < e_1^* \\ 0 & \epsilon_1 \geq e_1^* \end{cases}$$

If instead, lenders observe repayment

$$\gamma(\epsilon_1|e_1^*, r) = \begin{cases} \frac{\phi(\epsilon_1)}{1-\Phi(e_1^*)} & \epsilon_1 \geq e_1^* \\ 0 & \epsilon_1 < e_1^* \end{cases}$$

In words, given the borrower's strategy, default in period 1 creates a more pessimistic outlook for future output, translating into lower prices (higher spread) for further bond issues. The positive default premium captures the increase in future borrowing costs that follow from default (relative to repayment). Default triggers an increase in borrowing costs that affects future borrower's payoffs. The continuation payoff for the borrower following default, call it $V_2^d$, is lower than the continuation payoff following repayment, $V_2^r$. The difference between these value functions measures the anticipated future loss from default, in terms of the higher cost of financing the current investment requirement. The immediate gain from default is the avoided repayment, which in net terms equals $(1-c)D_1$. At $e_1^*$, the discounted value of future loss from default is just balanced by the immediate gain from default:

$$\beta(V_2^r(e_1^*) - V_2^d(e_1^*)) = (1-c)D_1(e_1^*) \tag{7}$$

As shown in (Catão, Fostel and Kapur (2007)), that the borrower repays for realizations above this threshold follows from the fact that the future gain from repayment is decreasing whereas the immediate gains from default is increasing in the chosen value of the threshold. To understand the intuition, note that for very low values of $e_1^*$, bondholders consider default in period 1 very unlikely. But if this unlikely event actually occurs, the bondholders expectations about future output levels face a large downward correction (given persistence), translating into a wide divergence between $V_2^r$ and $V_2^d$. For high values of $e_1^*$, the ex-ante probability of default is very high, and hence actual default in period one will not trigger big ex-post corrections. On the other hand, the immediate gain from default in period 1, given by $(1-c)D_1 = (1-c)(I_1/p_0)$ is increasing, since $p_0$ is a decreasing function of the probability of default, and hence of $e_1^*$. At the equilibrium repayment threshold $e_1^*$, the gain from repayment is just matched by the direct gain from default. The choice of this threshold is depicted in Figure 2.

The equilibrium just discussed explains the two stylized facts mentioned before. First, it gives an ex-ante endogenous mechanism, through the positive default premium, that punishes default without the need of exogenous exclusion rules. Second, this pricing mechanism allows the possibility of default traps. An adverse shock in period 1, if it triggers default, can make bond issuance more expensive, increasing the probability of future default. All things equal, a previous defaulter will need good luck in the period 2 shock ($\omega_2$) not to default again, and thus be able to get out of the *default trap.*

Next, we move towards the goal of the present paper: to consider how the default traps mechanism just described varies with key parameters - the persistence and volatility of temporary and persistent shocks.

**Proposition 1: Persistence and Default Traps.**

*An increase in the persistence of output shocks have the following effects:*

1. *Increases the probability of default at period 1.*
   *This is, $\triangle\rho$ implies $\triangle\pi_1$.*

2. *Increases the default premium. This is, $\triangle\rho$ implies $\triangle(p_1^r - p_1^d)$*

Consider the impact of an increase in the persistence parameter $\rho$ observable by all agents. Given the borrower's strategy, $e_1^*$, higher $\rho$ will translate into higher default premium. This is because greater persistence implies that future output shocks are more closely related to current shocks, so that the informational value of default is greater. Hence, the impact on future financing costs will be more severe. For a given $e_1^*$, the gain from repayment now exceeds the gain from default. If so, the borrower's strategy $e_1^*$ is no longer optimal. To restore the balance between the gain from repayment and default, the threshold needs to increase to a new higher value (call it $e_1^{**}$), as shown in Figure 2. Note that this new equilibrium is associated with a higher probability of default in the initial period.

In short, higher persistence exacerbates the default traps mechanism described in (Catão, Fostel and Kapur (2007)). Note that this result of higher probability of default *ex ante* may seem counterintuitive, since one would expect that a higher default premium would deter default. However the greater deterrence against default, in equilibrium, can support debt transactions that carry greater risk of default.

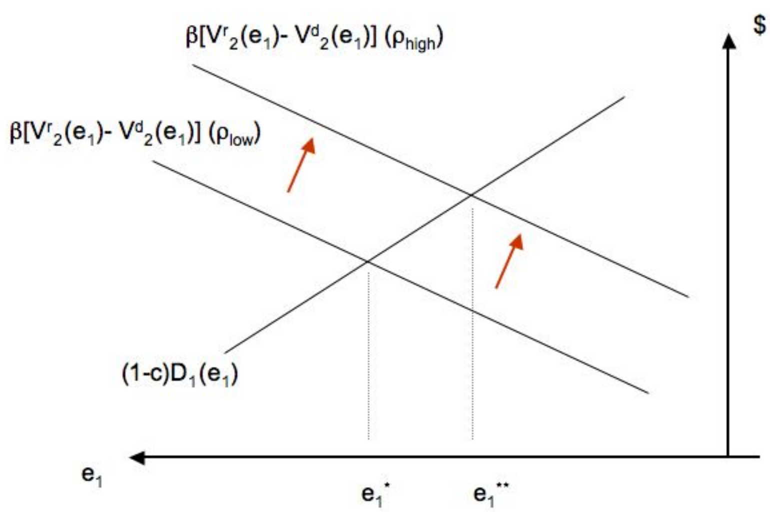


Figure 1: Default Traps and Persistence.

The impact of variations in the volatility of shocks is more complicated. Proposition 2 and 3 explore these effects.

**Proposition 2: Transient Volatility and Default Traps.**

*An increase in the transient shock' volatility results in a decrease in the issue price of bonds, i.e. if* $\triangle\sigma_{\omega_2}$ *then* $\nabla p_1$.

The intuition behind this proposition is as follows. Given that the debt repayment function that lenders face is a step function (recall that lenders recover $cD$ upon default, where $c < 1$), they lose more when output is low than what they gain when output is high.[10] Hence, an increase in the variance of temporary shocks will lower the price enough to account for this.[11] This result is consistent with other studies on the impact of volatility on default risk as Aguiar and Gopinath (2006), Arellano (2006) and Catao and Kapur (2006). What has not been emphasized before is that volatility may have an opposite effect of risk as the following proposition states.

**Proposition 3: Permanent Volatility and Default Traps.**

*Assume that the persistent shock is distributed uniformly. Then an increase in the volatility of the persistent shock results in a decrease in the default premium, i.e., if* $\triangle\sigma_{\epsilon_1}$ *then* $\nabla(p_1^r - p_1^d)$.

High volatility of the persistent shock will reduce the informational content of any action in period 1. This is because the more volatile output is, the higher the range of output realizations that make default optimal. In other words, borrowers have the same number of signals, default and repayment, to convey information about a wider set of outcomes. Once lenders know this, default will not trigger as pessimistic expectations about the future as in the less volatile case. To use the jargon Grossman and Van Huyck (1998) there is more “excusability” in default. So, while $p^r$ and $p^d$ will both decrease, $p^d$ will decrease less. That is, the default premium will decrease.

Propositions 2 and 3 together help to reconcile very different views on the effect of volatility on sovereign risk. Proposition 3, which follows from the

[10] A similar result obtains under different repayment functions provided that they display some concavity. See, e.g. Catão and Kapur, 2006.

[11] This effect is obviously reinforced by risk aversion, as discussed below.

asymmetry of information assumption, is not only novel to the best of our knowledge, but also builds some bridge between the Eaton and Gersovitz' s(1981) story and the findings of the recent studies cited above.

Summing up the results in this section, default traps are exacerbated with persistence and volatility of the transitory component. However, when the precision of persistent shock decreases, the mechanism is weaker.

Since our model is a 3-period model, until now we didn't need to take a stand about the interpretation of the persistent shock. Is $\epsilon$ a shock to cycle (ultimately mean revertible) or a shock to trend (which will therefore alter the level of output permanently)? And, what does our model explain in each of these cases? However, we need to answer these questions before considering the empirical testing of the comparative statics just described.

Assume first that the persistent shock amounts to a shock to trend. In this case where a negative shock entails a permanent reduction in future levels of trend output, then a default today will help explain a default many years into the future. This is because, following a negative shock today that is accompanied by default, investors will revise down their trend output predictions and see debt servicing costs rising relative to expected output many years down the line. As the sovereign is thus seen to be more risky, sovereign spreads will have to rise so as to allow lenders to break-even ex-ante. As debt servicing costs rise, so will the cost of future repayments, leading to default traps.

On the other hand, if the cyclical component is broadly defined as sufficiently long (as often the case for some emerging markets - see Aiolfi et al. 2006), $\epsilon$ can be interpreted as a persistent but still cyclical, mean-reversible shock. In this case, the described mechanism also works but obviously is weaker. However, it can still explain default traps. There are two main reasons for this. One is that, once investors seek to break even period by period, a country with higher persistence of cyclical shocks will always face a higher spread; when the same negative shock hits all countries with the same borrowing needs relative to output, those paying higher spreads and hence higher debt servicing costs will be more prone to default. So, differences in cyclical persistence help explain why certain countries are more prone to fall prey of default traps. This has clear cross-sectional testable implications which we examine below. Another interpretation has to do with investors' gradual learning about the persistence properties of a country's output process. Assume that investors do not know $\rho$ but learn it. In this case, an Argentine default in 1983, for instance, will indicate to investors that Argentina is a high persistence country and thus will have to face higher spreads on a permanent basis. If so, future debt servicing costs will rise notwithstanding the fact that output eventually returns to trend. This may lead to default traps through the same mechanism just described.

# 2 Empirics

In this section we empirically evaluate four main testable implications that follow from the above theoretical set-up, namely

1. *Hypothesis 1:* Countries that display higher underlying persistence of output shocks face higher sovereign spreads (or equivalently lower prices of their discount bonds), all else constant. This follows from proposition 1 above.

2. *Hypothesis 2:* Countries with higher conditional volatility of output gaps (i.e. those that are more prone to larger shocks) will tend to face higher spreads. This follows directly from the first part of proposition 2.

3. *Hypothesis 3:* Conditional upon previous default, we expect countries to face a positive "default premium". Further, their spreads will be higher (relative to those countries did not default at that same point in time) than other defaulting countries with lower degrees of shock persistence. This follows from propositions 1.

4. *Hypothesis 4:* To the extent that excessive volatility decreases the informational content of default the default premium should be negatively related to volatility. This follows from the second part of proposition 3.

As these hypotheses have both cross-sectional and time series implications, an important requirement for their assessment is the existence of relatively long data series on sovereign spreads on a broad cross-country basis, which also encompasses a number of default events. A long and cross-sectionally large dataset will allow for more robust inferences about the response of spreads and repayment decisions to the evolution of persistence and the variance of shocks over time. Historical data uncovered by economists and economic historians in recent years allows us to overcome the limitations of the short time-series data series on sovereign bond spreads available for the post-1990 period, and to incorporate also pre-war data to gauge such relationships.[12] Our sample starts from the early globalization years of the 1870s – when international bond markets began to witness unprecedented expansion and integration – through the eve of World War II, covering 33 countries for this period. In light of the data limitations just described our post-1993 sample spans 60 countries. Our theoretical model suggests a parsimonious empirical specification for the determinants of default risk consisting of five variables: an external "risk-free" interest rate, the ratio of debt to GDP, an indicator of openness to capture the costs of defaults in terms of associated trade losses (consistent with Rose's (2002) empirical results), and measures of volatility and persistence of output shocks.

The distinct interpretations of our theoretical set up clearly call for distinct estimation approaches for volatility and persistence parameters. Should we interpret $\epsilon$ as a trend shock, a natural trend-cycle decomposition approach is the classical method proposed by Beveridge and Nelson (1981). It consists of modelling output as an ARIMA (p,1,q), where p and q can be chosen by usual likelihood-based criteria. In this case, we can define the "trend gap" as:

$$\triangle z_t - \mu = [(1 + \theta_1 + \theta_2 + ... + \theta_q)/(1 - \phi_1 - \phi_2 - ... - \phi_p)] \cdot \epsilon_t,$$

where $\triangle z$ stands for overall trend growth, $\mu$ represents its deterministic component (drift), and $\epsilon$ is i.i.d. $(0, \sigma^2)$. Clearly, if $\sigma^2 = 0$", then the trend

[12] In the post-war period, a consistent series on emerging market sovereign bond indices (EMBIs) is only available from 1994 onwards and, even then, suffers from a sample selection bias in the first few years. This is because the countries issuing internationally traded bonds (Bradies) were the ones with tarnished recent history of sovereign default. It was not until later in the 1990s when a more diversified group of sovereign emerging markets began issuing widely traded bonds in international capital markets that comprise the currently available EMBI series. Unlike its pre-war counterpart used in this paper, this post-1990 series does not encompass the whole gamut of developing and developed countries.

is purely deterministic (expanding at a constant rate $\mu$),and the "trend gap" vanishes. In this case, default relays no information on the future output path; so the postulated mechanism in the model is no longer operative in such an environment with a deterministic trend and purely transient stationary shocks. The theoretically interesting and arguably more realistic case is thus that where $\sigma^2 \neq 0$, as will be seen below.

Alternatively, if the trend is deterministic (or nearly deterministic) but the cyclical component displays considerable persistence, a standard widely-used measure of stochastic persistence is the slope coefficient of a regression of detrended real GDP - the so-called "output gap", as obtained by say the standard HP-filter method - on its first-order lag.[13] In this case, stochastic volatility can then be gauged by the standard deviations of the respective regression residuals – a similar procedure used in previous studies on business cycle volatility. To allow for gradually evolving changes in volatility and persistence, we compute both measures recursively over a 10-year or 20-year rolling window, consistent with what is also typically done in the business cycle literature (Mendoza, 1995; Williamson et al., 2006; Aiolfi et al., 2006)).[14] Similar rolling window measures are employed for the real GDP instrument discussed below.

Starting with the pre-WWII evidence and the HP-filter measure of cyclical persistence, column (1) of Table 3 reports the pooled OLS results with t-ratios corrected for heterocedasticity (using the standard White estimator) and for country-specific first-order auto-correlation. All right-hand side variables enter the regression with a one-year lag so as to mitigate endogeneity biases.[15] As in Obstfeld and Taylor (2003), we drop from all regressions observations corresponding to spreads above 1,000 basis points so as to eliminate non-traded bonds and bonds of countries in default; as such, Table

[13] As standard, we set the HP-filter smoothing factor to 100 with annual data. This yields considerable smoothness in trend growth in the long annual series for the various countries in our sample.

[14] To avoid throwing away information on pre-1890s defaults in our sample, we use a 10-year rolling volatility window in the pre-WWI sub-sample and then a 20-year window in the interwar and post-WWII sub-samples.

[15] The external interest rate could be thought of as exogenous for all but two countries in our sample – the US and the UK. So, one could plausible enter i* without lags but it turns out that lagging i* of one year dominates the specification with contemporaneous i*.

1 regressions are mainly testing the empirical relevance of the comparative static mechanism described in Figure 2 and layed out in Hypothesis 1. As typical in country spread regressions, the R-square is relatively low reflecting the fact that spreads are known to be sensitive to news and uncorrelated shocks. Yet, all the estimated coefficients yield signs that are consistent with those of the theoretical model and are statistically significant at 5 percent, including the debt-to-GDP variable which was not found to be significant by Obstfeld and Taylor (2003) in their pre-WWI regressions.[16] The respective point estimates show that a 1 percentage point increase in conditional volatility ("$\sigma_{\omega,t}$" ) implies a 15.2 basis point increase in sovereign spreads, while a 10 percentage point increase in persistence (i.e., as "$\rho$" moves from, say, 0.5 to 0.6) raised spreads by 4 basis points, all else constant. These effects may appear small by today's standards, but were not so in the pre-WWI context when the cross-country dispersion of spreads was much tighter.[17]

In light of the potential criticism that our output shock volatility and persistence measures may be (weakly) endogenous to spreads, the second column of Table 3 replaces the output gap-based indicators with an instrument. The latter is constructed by regressing the output gap of each country on its terms of trade, the world interest rate, and an indicator of world output growth.[18] To the extent that all these three variables are exogenous to individual country spread, any remaining endogeneity bias is eliminated. The results of this instrumental variable regression clearly indicate the the previous results were robust: all coefficients retain a similar order of magnitude of the regressions in column and are statistically significant at 1%.

[16] Apparent reasons for this discrepancy are that in their regressions Obstfeld and Taylor (2003) do not control for the volatility and persistence effects considered here, plus the fact that our sample has wider country coverage and uses GDP indicators for four Latin American countries (Argentina, Brazil, Chile, and Mexico) that are deemed to be more reliable than the Maddison figures used in their study. See the Appendix for details.

[17] Furthermore, cross-country spread dispersion declined dramatically during the period as capital markets became more internationally integrated. By the eve of WWI, the cross-country standard deviation of spreads was down to 91 basis points. See Flandreau and Zumer (2004, chapter I), for a discussion of these trends.

[18] These estimate of world output growth was constructed as a weighted average of real GDP in eight countries (Australia, Canada, France, Germany, Italy, UK and the US) in 1990 dollars, as provided in Maddison (2003). In these instrumental regression we allowed for up to one lag of each independent variable.

Columns (3) to (8) of Table 3 introduce various controls to the baseline model regression which capture neverthless important aspects of our model. We start with fixed effects associated with differences between developed countries and less developed ones (a "periphery" dummy, "Dper"), the same control featuring in Obtsfeld and Taylor (2003) spread regressions. The rationale is to capture a host of structural characteristics not ammemable to easy measurement, such as quality of institutions and degrees of financial development. To the extent that quality of institutions and financial maturity are also proxies for the degree of information asymmetries between borrower and lenders in our model, we should expect this catch-all variable to be significantly related to spreads. As the dummy takes the value of 1 for "peripheral" countries and zero otherwise, the positive sign of the estimated coefficient in column (3) of Table 3 conforms to our theoretical priors. Its main effect on the other estimated coefficients is to detract from the significance of export/GDP ratio in explaining spreads – which is hardly surprising given that the two variables bear considerable multicolinearity.[19] The other fixed effect control, also considered in Obstfeld and Taylor (2003), is whether the country formally belonged to the British empire - inter alia a catch-all proxy for assurances of greater investors' legal protection and arguably preferential access to British markets. In the context of our model, this dummy variable ("Demp") can thus be thought of as a potential increase in the recovery rate parameter c, which will tend to lower spreads. Accordingly, the results reported in columns (4) to (8) of Table indicate that this dummy takes on the expected negative sign and is highly significant statistically. Its main effect is to reduce the coefficients of the volatility and persistence variables, though without rendering them insignificant.

Exchange rate regimes are often perceived to be related to macroeconomic risk, so it seems important to examine whether our hypotheses regarding the roles of volatility and shock persistence on sovereign spreads stand up to such a control variable. In the pre-WWII era, the main dichotomy is that between countries that were on the gold standard and those that were not, so a dummy ("Gold") taking on the unity value (and zero otherwise) was introduced in the regressions. The results reported in column (5) are consistent with the findings of Bordo and Rockoff (1996) as well as Obstfeld and Taylor (2003):

[19] This is because, in the context of the pre-WWI international division of labor, international trade was a main driving force of GDP growth in the peripheral economies which thus tend to display high openness coefficients.

membership of the gold standard shaved off some 60 basis points in country spreads, consistent with the view of gold standard membership as a good housekeeping seal of approval. Interestingly, both the size and the statistical significance of the persistence variables shrink after the introduction of this exchange rate regime control, though remaining statistically significant at 10%. This is not surprising in light of well-known theoretical reasons to expect that fixed exchange rate regimes tend to exacerbate shock persistence by both fostering balance sheet mismatches and/or slowing the relative price adjustment process.

Another important set of non-fixed effect controls include the respective country's default history. According to our model, this variable should be expected to be positively correlated with current spreads and quite significant statistically. This is because repayments and defaults entail new information about the country's output process in addition to what is entailed by its history of output realizations (which are captured by $\sigma_\omega$ and $\rho$). In other words, if a country defaults, this implies that the mean of its output distribution should shift to left of $e^*$ (relative to its previous output history), so investors become more pessimistic about its future capacity to repay and thus average spreads should adjust upwards, all else constant. The way the indicator "Def. history" is constructed captures this time-dependence as it is defined as the number of years in default relative since the beginning of the sample; as such, this extra-kick effect of defaults on spreads decays over time.[20] Table 3 shows that this variable is highly statistically significant and takes on the correct positive. Thus, in as predicted by the model, previous credit history matters over and above the actual history of output realizations. As before and consistent with the summary statistics of Tables 1 and 2, this result is robust to the exclusion of default aftermath observations from the sample (or to the use of instruments for real GDP) so as to minimize the potentially negative feedback of default on output.

The remainder controls in the regressions are the ratio of foreign currency-denominated external debt to total debt (a proxy for "original sin" considerations), and terms of trade shock which, if large enough, may prompt a country into default along the lines of capacity to pay arguments.[21]Neither

[20] A similarly constructed indicator is used in Reinhart et al (2003).

[21] This latter variable is computed as the residual of HP-detrended terms of trade on its first order lag.

of these variables undermine the statistical significance of our volatility and persistence proxies, nor default risk although they do weight down on the estimated size of the persistence coefficient. This, again, is not surprising since currency mismatches are found to exacerbate the severity of debt and financial crises thus making shocks more persistent (IADB, 2006). Likewise, as persistence is a very slowly moving indicator and bound to be highly correlated with default history if our model is correct, one would expect considerable colinearity between default history and persistence. Overall, though, the results are very consistent with the model's theoretical priors and provide significant support for the hipotheses laid out above.

Table 4 reports a similar set of regressions using the Beveridge-Nelson (BN) measure of the "trend gap". While the fit improves considerably in these regressions relative to Table 3, this is mostly due to fewer observations.[22] But more importantly, all the relevant coefficients have the correct sign and are significantly throughout. Regarding the magnitude of the effects, while the coefficient on the volatility variable is broadly similar using the HP output gap or the BN trend gap, persistence effects are often twice as large on HP gap measure. This suggests that cyclical persistence does a better job in explaining sovereign risk relative to the view that attributes much of the stochastic output variations to trend shocks.

Turning to the inter-war period, we follow Obstfeld and Taylor (2003) in focusing on the post-1924 years, thereby dropping from the sample the early post-WWI spell - when war dislocations, hyperinflations, and Britain's delay in re-joining gold had far-reaching effects on international bond issuance. As result, while the country coverage is essentially the same, the number of observations is less than half of the pre-WWI sample in Table 3. As before, we start by reporting regression estimates for the HP-gap measures in Table 5. As is typically the case with inter-war regressions, the fit of the model is much poorer than its pre-WWI counterpart and the international risk free rate is no longer statistically significant at coventional levels, though it retains its expected theoretical sign. However, the volatility and persistence indicators

[22]Because the computation of the Beveridge-Nelson decomposition is far more data intensive than HP-filter measures, we often had to broaden our estimation window beyond 20 years to ensure convergence, depending on the curvature of the likelihood function of the various country specific regression. As a result, the 1870-1913 sample becomes a lot smaller in these regressions. Results ot Table 3 regressions using this smaller sample are available from the authors upon request.

remain both significant at 5% in the baseline model of column (1), with the significance of the volatility indicator dropping in some alternative specifications. Further, the effect of persistence on spreads is now much larger: an 10 percentage point increase in persistence leads to 20 basis point increase in spreads (as opposed to 4 bps in the pre-WWI sample). Instrumenting both variables out as in column (2) dampens the respective coefficients, but variables remain significant at close to 5%. This appears to be partly related to the fact that, as most economies in our sample became closer to international trade and financial linkages, our set of instruments (terms of trade, the world interest rate, and world GDP growth) bore a weaker correlation with GDP in each country; that is, we no longer have such good instruments as in the pre-WWI period. Columns (3) to (8) in Table 5 reports the results for the same set of controls as in the pre-WWI regressions (see Table 3). The main quantitative difference is that now the debt/GDP ratio regains statistical significance only after some controls are added, whereas our volatility variable looses it. Persistence remains significant thoughout at 5% . These inferences are broadly the same with the BN trend gap measures, as reported in Table 6. As with the pre-WWI period, the main difference is that the effect of persistence on sovereign spreads is stronger when HP gap measure is used relative to the BN measure.

Tables 7 and 8 report the results of a similar specification and controls for the 1994-2005 period. As noted above, despite the wider country coverage, the number of observations in these regressions is considerably lower than the various pre-WWII regressions due to the lack of spread data for many emerging markets until later in the 1990s/early 2000s. This means that the cross-sectional dimmension of these regressions dominate the time-series dimmensions. Partly reflecting that, the fit is higher overall and considerably so for the baseline model of column (1) in both tables, where the basic model accounts for about half of variations in country spreads. Once again, the persistence variable ? is economically and statistically significant throughout, whereas volatility is significant in nearly all of them. A main difference with the pre-war regressions is the inclusion of regional dummies (given that this regressions encompasses the more homogenous group of emerging markets), of which only the dummy for Asia is significant in the majority of cases.[23]

[23]This is likely because of Asian crisis governments in the late 1990s did not formally go into default with the exception of Indonesias debt renegotiation but the havoc in these countries clearly weighed down on spreads.

Interestingly, neither exchange rate regimes, nor debt maturity or currency composition stand out as significant in explaining spread variations. Yet, and consistent with first-generation currency crisis models and related empirical evidence on twin crisis (Kaminsky and Reinhart, 1998), international reserve coverage (as a share of broad money, M2) does matter. Similar inferences obtain with the BN decomposition, reported in Table 8 - a main difference being again the weaker and less precisely estimated (semi)elasticity of spreads to the persistence parameter $\rho$, compared with the HP-filter gap specification of Table 7.

A final and important set of predictions in our model regarding both persistence and volatility pertains to their effects on the "default premium" – the difference in spreads between a country that defaults and others that do not (once differences in fundamentals between the defaulter and the non-defaulter are controlled for). Our model indicates that the default premium should rise on persistence, whereas a rise in volatility may temper some of this effect since higher volatility implies that default in t=1 is less informative on the country's future prospects. The various regression results reported in Tables 9 and 10 indicate that these predictions find broad support in the data. In both regressions, the dependent variable is now the difference between defaulters and non-defaulters' spreads at any given year. Clearly, the default premium rises on persistence as the model predicts, while being negatively affected by volatility - consistent with the view that higher volatility makes the act of defaulting less informative about a country's future output. This result holds once the various additional controls akin to our model are contemplated -default/repayment history in particular. So, once again, this result is consistent with the models prediction that both underlying output moments and repayment history matter for actual sovereign bond pricing. Overall, the default trap pricing mechanism postulated in our model thus appears to be broadly consistent with the evidence from long-run macroeconomic data.

# 3 Conclusion

History tells us that sovereign creditworthiness displays persistence: countries that default once are more likely to do so again, face higher spreads as a result, which in turn tends to lower future default costs. This paper has sought to rationalize how differences in underlying persistence and volatility of output shocks help explain why certain countries are more prone to fall prey to such "default traps". We study the effects of these parameters on sovereign bond pricing in a model combining three key ingredients that have featured in previous models either separately or in pairs but not all together - namely, transient and persistence output shocks, as well as asymmetric information between borrowers and lenders about the extent of shock persistence. While the first two factors alone can make default optimal for a range of output realizations, asymmetric information amplifies this spread mechanism in our model: a default decision signals that the country was likely hit by a large negative output shock which will persist, thus raising future debt-to-output ratios above the expected baseline. As competitive lenders seek to break even and the sovereign continues to tap the market given its financing needs, this gives rise to a positive default premium. By increasing country spreads further, and hence the borrower's debt burden relative to output, this mechanism makes future default more likely; in other words, it creates default traps.

In this setting, higher shock persistence and greater volatility of transient shocks exacerbate this spread mechanism. Hence default traps are more likely to bite in countries with such charateristics in their growth profile. In contrast, our model also indicates that higher volatility in the persistent or trend component of output tends to lower the default premium, thus dampening this default trap mechanism.This dual effect of volatility on sovereign risk had not been contemplated in previous work and has some interesting practical implications, as discussed below.

To the extent that these three parameters display significant cross-country differences (due to institutions, commodity specialization, etc.), and as these differences are structural and hence slowly-evolving, they should translate into distinct sovereign bond pricing and hence distinct credit histories. Using an unprecedentally comprehensive database spanning 135 years and up to 62 countries, we have shown that countries which faced higher spreads are typically the ones displaying higher conditional volatility and persistence of output gaps - such effects being statistically and economically significant over and above a variety of controls. Likewise consistent with the model is the result that the default premium tends to be damped by the volatility of the permanent or trend component of output. These inferences are also robust to detrending methods: whether one measures persistence as shocks to trend (thus creating a "trend gap") or shocks to cyclical output (thus creating an output gap which may persist for several years but is ultimately mean revertible), the postulated spread mechanism finds broad support in the data.

Our results add to the literature in three ways. First, by helping explain default traps and its converse (virtuous circles in borrowing and repayment) our model also helps rationalizes "debt intolerance" phenomenon documented in Reinhart et al. (2003): that is, how a sizeable group of countries face much higher spreads and more stringent borrowing constraints than others with far higher debt to income ratios. Rather than the standard causality running from higher debt ratios to higher credit risk along a steady upward sloping supply curve (see Sachs, 1984; Sachs and Cohen, 1985), our findings suggest that it is the perceived riskiness of some countries – as determined by intrisically high volatility and persistence of output shocks – which shifts the investors' supply curve inwards limiting the borrower from taking or "tolerating" as much debt. Thus, the combination of higher volatility and shock persistence helps account for both default traps and debt intolerance.

Second, our results reinforce the empirical evidence from previous studies showing that underlying output volatility tends to increase default risk and hence increase spreads. Unlike previous studies, however, we have shown that, conditional upon default, volatility tends to dampen the default premium. To the best of our knowledge, this subtle effect of conditional output volatility on country spreads has not been developed in the literature.

A third contribution of this paper to the empirical literature is to highlight the previously neglected role of historical output volatility and persistence indicators in country spread regressions. Clearly, the volatility and persistence indicators in our model and regressions are, in a deeper sense, catch-all variables that stem from underlying economic mechanisms which can be quite complex in practice. For analytical purposes of singling out the issue at hand, we chose in the paper to take them as exogenous. But insofar as both indicators are readily observed by agents, then there is also a case to study their effects as if they were indeed parameters actually taken into account by investors.

Finally, some practical implications follow from this paper's results. Plainly, they highlight the importance of reforming institutions and changing policy frameworks that typically make many emerging markets slower in recovering from large negative shocks. At the same time, our findings also suggest that countries with higher underlying dispersion of temporary shocks are more vulnerable to sheer "bad luck": given that these are countries with a wider region of output realizations over which they cannot pay, and that a default may be misperceived by lenders as strategic and due to a highly persistent shock, default traps can be more easily activated. If so, unless an improvement in fundamentals dramatically narrows the variance of output shocks, it may take more than improvements in fundamentals to escape from a default trap: once investors are imperfectly informed about how persistent is the shock and the sovereign's borrowing needs remain high, good luck in output realizations may turn out to be just as important.

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# 5 Appendix 1

## 5.1 Proof of Proposition 1

For fixed $e_1^*$, higher $\rho$ increases the informational value of default. To see why, note that with greater persistence, observed default in period 1 leads to greater pessimism about future returns to bondholders, (and hence a higher $\pi_2^d$) so required $D_2^d$ is increasing in $\rho$. On the other hand, observed repayment suggests a more optimistic outlook for future repayments (and hence a lower $\pi_2^r$), justifying a lower $D_2^r$. Thus, for fixed $e_1^*$, a higher value of $\rho$ is associated with a greater default premium and hence a higher $\beta[V_2^r(\epsilon_1, e_1) - V_2^d(\epsilon_1, e_1)]$. So at $e_1^*$ the gain from repayment is higher than the gain from default. In Catão, Fostel and Kapur (2007) we proved that the gain from default, given by (1-c)$D_1(e_1^*)$ is increasing in $e_1^*$. Hence, to restore equilibrium, the equilibrium value of $e_1^*$must rise. This in turn, implies that the probability of default in period 1 rises as well.

## 5.2 Proof of Proposition 2

Let $\omega_2^*$ be the threshold such that above it the borrower repays and let $G(\omega_2)$ the distribution function. By the lender's breaking even condition we have that, $\int^{\omega_2^*} cD_1 dG(\omega_2) + \int_{\omega_2^*} D_1 dG(\omega_2) = R_f I_1$. Hence, $(1 - G(\omega_2^*)(1-c))D_1 = R_f I_1$.$(*)$ Now, suppose that $\omega_2^* < 0$ (for a related assumption see Eaton and Gersovitz (1996)). Consider an increase in volatility, so that $H$ is a mean preserving spread of $G$. In particular, $H(\omega_2) > G(\omega_2)$ for all $\omega_2 < 0$. Then, since $\omega_2^* < 0$, we have that $(1 - H(\omega_2^*)(1-c)) < (1 - G(\omega_2^*)(1-c))$. Hence, from (*) we have that $D_2^H > D_2^G$, and hence the associated equilibrium price with $H$ needs to be smaller.

## 5.3 Proof of Proposition 3

First we prove that an increase in volatility of the permanent shock will decrease the $p_0$. We assume uniform distribution and without loss of generality that $\bar{Y}_1 = 0$ and $\omega_1 = 0$. Now suppose the volatility of the $\epsilon_1$ shock increases so that $\epsilon_1$ is uniform $[-\alpha\epsilon, \alpha\epsilon], \alpha > 1$. Using the lender's break even condition we have that $\frac{\epsilon - \epsilon^*}{2\epsilon}.D_1 + \frac{\epsilon^* + \epsilon}{2\epsilon}.cD_1 = R_f$ and $\frac{\alpha\epsilon - \epsilon^*}{2\alpha\epsilon}.kD_1 + \frac{\epsilon^* + \alpha\epsilon}{2\alpha\epsilon}.ckD_1 = R_f$ have to hold in equilibrium. Doing some algebra we can get that $k = \frac{\alpha(A-B)}{\alpha A - B}$, where

$A = (1+c)\epsilon$ and $B = \epsilon^*(1-c)$. The derivative $k'(\alpha) = \frac{(A-B)(\alpha A-B)-\alpha(A-B).A}{(\alpha A-B)^2}$. Hence the sign of the derivative of $k$ with respect to $\alpha$ will be positive provided that $\epsilon^* < 0$. This proves that an increase in $\alpha$ induces a decrease in the price. The second step is to prove that this induces a decrease in the premium as well. Note that from equation (5) an increase in $\alpha$ also induces an increase in the probability of default. This must mean, therefore, that in equilibrium there must be an increase of $e_1^*$. In Catão, Fostel and Kapur (2007) we proved that the default premium is decreasing in $e_1^*$, hence, this induces a decrease in the premium as wanted.

**Table 1: Real GDP Volatility and Persistence and Countries' Repayment Records, 1870-1939**
(in deviations from HP trend)

| | 1870-1913 | | | | | 1919-1939 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Incl. defaults | | Exc. defaults | | | Incl. defaults | | Exc. defaults | |
| | Def. Freq. | Std. Dev. | AR(1) | Std. Dev. | AR(1) | Def. Freq. | Std. Dev. | AR(1) | Std. Dev. | AR(1) |
| ARG | 2 | 0.0640 | 0.7160 | 0.0637 | 0.8920 | 0 | 0.0387 | 0.5540 | 0.039 | 0.554 |
| BRA | 1 | 0.0437 | 0.7950 | 0.0414 | 0.7210 | 1 | 0.0423 | 0.5820 | 0.038 | 0.346 |
| CHL | 1 | 0.0491 | 0.6080 | 0.0486 | 0.5960 | 1 | 0.1270 | 0.6470 | 0.102 | 0.769 |
| MEX* | 2 | 0.0410 | 0.7910 | 0.0410 | 0.8930 | 1 | 0.0557 | 0.6520 | 0.056 | 0.652 |
| PERU | 1 | . | . | . | . | 1 | 0.1214 | 0.3270 | 0.123 | 0.172 |
| URU | 1 | 0.0812 | 0.3800 | 0.0814 | 0.4140 | 1 | 0.0914 | 0.4600 | 0.053 | 0.358 |
| VEN | 2 | 0.0914 | 0.2480 | 0.0694 | 0.2630 | 0 | 0.1316 | 0.7760 | 0.132 | 0.776 |
| AUS | 0 | 0.0466 | 0.3070 | 0.0466 | 0.3070 | 0 | 0.0618 | 0.7770 | 0.062 | 0.777 |
| EGY | 1 | 0.0305 | 0.2700 | 0.0304 | 0.2710 | 0 | 0.0280 | 0.5870 | 0.028 | 0.587 |
| IND | 0 | 0.0396 | -0.0032 | 0.0396 | -0.0032 | 0 | 0.0237 | -0.0420 | 0.024 | -0.042 |
| JAP | 0 | 0.0247 | -0.1459 | 0.0247 | -0.1459 | 0 | 0.0522 | 0.4430 | 0.052 | 0.443 |
| NZL | 0 | 0.0410 | 0.2360 | 0.0410 | 0.2360 | 0 | 0.0672 | 0.5497 | 0.067 | 0.550 |
| TUK | 1 | . | . | . | . | 1 | 0.0753 | 0.3810 | 0.075 | 0.380 |
| AHU | 0 | 0.0193 | 0.2110 | 0.0193 | 0.2110 | . | . | . | . | . |
| BEL | 0 | 0.0200 | 0.9500 | 0.0200 | 0.9500 | 0 | 0.0534 | 0.5226 | 0.053 | 0.523 |
| DEN | 0 | 0.0137 | 0.2350 | 0.0137 | 0.2350 | 0 | 0.0404 | 0.5080 | 0.040 | 0.508 |
| FIN | 0 | 0.0371 | 0.7470 | 0.0371 | 0.7470 | 0 | 0.0564 | 0.5205 | 0.056 | 0.521 |
| FRA | 0 | 0.3950 | 0.3720 | 0.3950 | 0.3720 | 0 | 0.0919 | 0.6734 | 0.092 | 0.673 |
| GER | 0 | 0.3460 | 0.9580 | 0.3460 | 0.9580 | 1 | 0.0969 | 0.5420 | 0.103 | 0.408 |
| GRE | 2 | 0.6760 | 0.2990 | 0.0698 | 0.3790 | 1 | 0.0847 | 1.0760 | 0.030 | 1.380 |
| HUN | . | . | . | . | . | 1 | 0.0510 | 0.1710 | 0.059 | 0.125 |
| ITA | 0 | 0.2680 | 0.0650 | 0.2680 | 0.0650 | 0 | 0.0569 | 0.4440 | 0.057 | 0.444 |
| NET | 0 | 0.0266 | 0.4240 | 0.0266 | 0.4240 | 0 | 0.0606 | 0.6298 | 0.061 | 0.630 |
| NOR | 0 | 0.0185 | 0.6560 | 0.0185 | 0.6560 | 0 | 0.0412 | 0.1830 | 0.041 | 0.183 |
| PT | 1 | 0.0240 | 0.5780 | 0.0210 | 0.4590 | 0 | 0.0497 | 0.1160 | 0.050 | 0.116 |
| SPA | 1 | 0.0369 | 0.3020 | 0.0358 | 0.2480 | 0 | 0.0780 | 0.6570 | 0.078 | 0.657 |
| RUS | 0 | 0.0645 | 0.3270 | 0.0645 | 0.3270 | . | . | | . | |
| SWE | 0 | 0.0271 | 0.4910 | 0.0271 | 0.4910 | 0 | 0.0424 | 0.6288 | 0.042 | 0.629 |
| Serbia | 1 | . | . | . | . | 1 | 0.5450 | 0.6660 | 0.045 | 0.750 |
| UK | 0 | 0.0224 | 0.5490 | 0.0224 | 0.5490 | 0 | 0.0753 | 0.4940 | 0.075 | 0.494 |
| CAN | 0 | 0.0449 | 0.4820 | 0.0449 | 0.4820 | 0 | 0.1080 | 0.7581 | 0.108 | 0.758 |
| US | 0 | 0.0373 | 0.3094 | 0.0373 | 0.3094 | 0 | 0.0900 | 0.7692 | 0.090 | 0.769 |
| **LA median** | **1.4** | **0.057** | **0.662** | **0.056** | **0.659** | **0.7** | **0.091** | **0.582** | **0.056** | **0.554** |
| **Asian median** | **0.0** | **0.040** | **0.133** | **0.040** | **0.134** | **0.0** | **0.052** | **0.550** | **0.052** | **0.550** |
| **Non-def Europe** | **0.0** | **0.027** | **0.458** | **0.027** | **0.458** | **0.0** | **0.057** | **0.522** | **0.057** | **0.514** |
| **Def. Europe** | **1.2** | **0.037** | **0.302** | **0.036** | **0.379** | **0.7** | **0.075** | **0.519** | **0.059** | **0.380** |
| **North America** | **0.0** | **0.041** | **0.396** | **0.041** | **0.396** | **0.0** | **0.099** | **0.764** | **0.099** | **0.764** |
| **Developing** | **1.0** | **0.046** | **0.443** | **0.045** | **0.455** | **1.0** | **0.075** | **0.582** | **0.053** | **0.554** |
| **Developed** | **0.0** | **0.042** | **0.318** | **0.041** | **0.318** | **0.0** | **0.069** | **0.534** | **0.072** | **0.508** |
| **Defaulters** | **1.3** | **0.046** | **0.479** | **0.045** | **0.437** | **0.6** | **0.088** | **0.562** | **0.057** | **0.534** |
| **Serial Defaulters** | **2.0** | **0.064** | **0.593** | **0.064** | **0.528** | **0.7** | **0.091** | **0.647** | **0.065** | **0.604** |
| **Non-defaulters** | **0.0** | **0.037** | **0.350** | **0.037** | **0.350** | **0.0** | **0.057** | **0.571** | **0.056** | **0.571** |

**Table 2. Real GDP Volatility and Persistence and Countries' Repayment Records**
(in deviations from HP trend)

| | 1960-2004 | | | | |
|---|---|---|---|---|---|
| | | Incl. Defaults | | Excl. Defaults | |
| | Def. Freq. | Std. Dev. | AR(1) | Std. Dev. | AR(1) |
| Argentina | 2 | 0.048 | 0.464 | 0.038 | 0.489 |
| Bolivia | 1 | 0.029 | 0.833 | 0.023 | 0.850 |
| Brazil | 1 | 0.034 | 0.436 | 0.029 | 0.277 |
| Chile | 2 | 0.054 | 0.623 | 0.051 | 0.587 |
| Colombia | 0 | 0.023 | 0.619 | 0.023 | 0.619 |
| Costa Rica | 1 | 0.033 | 0.577 | 0.032 | 0.543 |
| Dominican R. | 1 | 0.044 | 0.490 | 0.047 | 0.516 |
| Ecuador | 2 | 0.043 | 0.620 | 0.044 | 0.729 |
| El Salvador | 0 | 0.042 | 0.807 | 0.042 | 0.807 |
| Guatemala | 0 | 0.027 | 0.804 | 0.027 | 0.804 |
| Jamaica | 1 | 0.035 | 0.584 | 0.037 | 0.672 |
| Mexico | 1 | 0.031 | 0.585 | 0.027 | 0.766 |
| Panama | 1 | 0.049 | 0.625 | 0.039 | 0.672 |
| Paraguay | 0 | 0.037 | 0.767 | 0.037 | 0.767 |
| Peru | 1 | 0.052 | 0.623 | 0.033 | 0.560 |
| Uruguay | 2 | 0.048 | 0.606 | 0.046 | 0.532 |
| Venezuela | 2 | 0.041 | 0.519 | 0.036 | 0.442 |
| China | 0 | 0.065 | 0.255 | 0.065 | 0.255 |
| Korea | 0 | 0.031 | 0.428 | 0.031 | 0.428 |
| India | 0 | 0.022 | 0.248 | 0.022 | 0.254 |
| Indonesia | 1 | 0.041 | 0.649 | 0.035 | 0.821 |
| Malaysia | 0 | 0.049 | 0.580 | 0.049 | 0.580 |
| Pakistan | 1 | 0.023 | 0.504 | 0.023 | 0.484 |
| Philipines | 1 | 0.034 | 0.711 | 0.025 | 0.921 |
| Singapore | 0 | 0.043 | 0.673 | 0.043 | 0.673 |
| Thailand | 0 | 0.042 | 0.748 | 0.042 | 0.748 |
| Botswana | 0 | 0.057 | 0.726 | 0.057 | 0.726 |
| Egypt | 1 | 0.037 | 0.627 | 0.039 | 0.619 |
| Gabon | 1 | 0.088 | 0.500 | 0.089 | 0.680 |
| Jordan | 1 | 0.071 | 0.627 | 0.067 | 0.662 |
| Morocco | 1 | 0.032 | 0.002 | 0.033 | 0.004 |
| Oman | 0 | 0.070 | 0.511 | 0.070 | 0.511 |
| South Afrca | 1 | 0.019 | 0.526 | 0.018 | 0.544 |
| Turkey | 1 | 0.034 | 0.409 | 0.033 | 0.333 |
| Bulgaria | 1 | 0.076 | 0.816 | 0.080 | 1.005 |
| Czech Rep. | 0 | 0.029 | 0.651 | 0.029 | 0.651 |
| Hungary | 0 | 0.041 | 0.656 | 0.041 | 0.656 |
| Poland | 1 | 0.059 | 0.667 | 0.055 | 0.768 |
| Romania | 1 | 0.052 | 0.758 | 0.051 | 0.701 |
| Russia | 2 | 0.074 | 0.861 | 0.065 | 1.064 |
| US | 0 | 0.019 | 0.531 | 0.019 | 0.531 |
| UK | 0 | 0.020 | 0.613 | 0.020 | 0.613 |
| Australia | 0 | 0.017 | 0.472 | 0.017 | 0.472 |
| Austria | 0 | 0.016 | 0.533 | 0.016 | 0.533 |
| Belgium | 0 | 0.016 | 0.563 | 0.016 | 0.563 |
| Canada | 0 | 0.020 | 0.609 | 0.020 | 0.609 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Denmark | 0 | 0.019 | 0.471 | | 0.019 | 0.471 |
| Finlan | 0 | 0.033 | 0.720 | | 0.033 | 0.720 |
| France | 0 | 0.015 | 0.679 | | 0.015 | 0.679 |
| Germany | 0 | 0.025 | 0.615 | | 0.025 | 0.615 |
| Greece | 0 | 0.020 | 0.398 | | 0.020 | 0.398 |
| Iceland | 0 | 0.039 | 0.628 | | 0.039 | 0.628 |
| Ireland | 0 | 0.024 | 0.640 | | 0.024 | 0.640 |
| Italy | 0 | 0.019 | 0.464 | | 0.019 | 0.464 |
| Japan | 0 | 0.197 | 0.451 | | 0.197 | 0.451 |
| Netherlands | 0 | 0.040 | 0.505 | | 0.040 | 0.505 |
| New Zealand | 0 | 0.024 | 0.526 | | 0.024 | 0.526 |
| Norway | 0 | 0.017 | 0.605 | | 0.017 | 0.605 |
| Portugal | 0 | 0.030 | 0.600 | | 0.030 | 0.600 |
| Spain | 0 | 0.024 | 0.724 | | 0.024 | 0.724 |
| Sweden | 0 | 0.021 | 0.584 | | 0.021 | 0.584 |
| Switzerland | 0 | 0.025 | 0.666 | | 0.025 | 0.666 |
| | | | | | | |
| **LA** | **1.00** | **0.041** | **0.619** | | **0.037** | **0.619** |
| **Asia def** | **1.00** | **0.029** | **0.577** | | **0.024** | **0.653** |
| **Asia non-def** | **0.00** | **0.043** | **0.504** | | **0.043** | **0.504** |
| **Africa def** | **1.00** | **0.037** | **0.526** | | **0.039** | **0.619** |
| **Africa non-def** | **0.00** | **0.057** | **0.511** | **#** | **0.057** | **0.511** |
| **EEU def** | **1.00** | **0.059** | **0.758** | | **0.055** | **0.768** |
| **EEU non-def** | **0.00** | **0.024** | **0.600** | | **0.024** | **0.600** |
| | | | | | | |
| **Developing** | **1.00** | **0.042** | **0.622** | | **0.038** | **0.653** |
| **Developed** | **0.00** | **0.021** | **0.592** | | **0.021** | **0.592** |
| | | | | | | |
| **Defaulters** | **1.00** | **0.044** | **0.620** | | **0.038** | **0.619** |
| **Serial Defaulters** | **1.19** | **0.042** | **0.623** | | **0.038** | **0.672** |
| **Non-defaulters** | **0.00** | **0.024** | **0.605** | | **0.024** | **0.605** |

**Table 3. Determinants of Sovereign Spreads: 1870-1913 1/**
(HP-filter measures of the output gap )

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| **ir*** | 0.013 | 0.011 | 0.013 | 0.014 | 0.013 | 0.014 | 0.014 | 0.013 |
| | (2.41)** | (2.62)*** | (2.42)** | (2.12)** | (2.18)** | (2.15)** | (2.11)** | (2.16)** |
| **Debt/GDP** | 0.01 | 0.015 | 0.009 | 0.007 | 0.008 | 0.007 | 0.007 | 0.008 |
| | (12.88)*** | (22.17)*** | (8.48)*** | (7.19)*** | (8.10)*** | (8.32)*** | (8.22)*** | (10.36)*** |
| **X/GDP** | -0.005 | -0.011 | 0.002 | -0.001 | 0.003 | 0.005 | 0.005 | -0.003 |
| | (-2.02)** | (-8.09)*** | (0.66) | (-0.32) | (1.77)* | (2.69)*** | (2.67)*** | (-1.00) |
| **std_$\omega_t$** | 0.152 | | 0.111 | 0.099 | 0.13 | 0.145 | 0.146 | 0.12 |
| | (9.73)*** | | (7.40)*** | (5.66)*** | (8.13)*** | (8.36)*** | (8.42)*** | (7.22)*** |
| $\rho_t$ | 0.004 | | 0.004 | 0.002 | 0.001 | 0.002 | 0.002 | 0.003 |
| | (5.66)*** | | (5.06)*** | (2.91)*** | (1.69)* | (2.07)** | (2.02)** | (2.97)*** |
| **std_ins($\omega_t$)** | | 0.18 | | | | | | |
| | | (5.57)*** | | | | | | |
| $\rho_{t\ (vins)}$ | | 0.004 | | | | | | |
| | | (4.12)*** | | | | | | |
| **Dper** | | | 0.02 | 0.025 | 0.022 | 0.019 | 0.019 | 0.014 |
| | | | (11.15)*** | (10.25)*** | (11.42)*** | (10.88)*** | (10.85)*** | (5.93)*** |
| **Demp** | | | | -0.023 | -0.019 | -0.015 | -0.015 | -0.017 |
| | | | | (-11.22)*** | (-11.14)*** | (-10.95)*** | (-10.80)*** | (-11.00)*** |
| **Gold** | | | | | -0.006 | -0.006 | -0.006 | -0.006 |
| | | | | | (-9.69)*** | (-11.2)*** | (-11.12)*** | (-10.66)*** |
| **Def. history** | | | | | | 0.041 | 0.042 | 0.038 |
| | | | | | | (8.77)*** | (8.64)*** | (8.74)*** |
| **Ext. Debt/Total Debt** | | | | | | | | 0.005 |
| | | | | | | | | (3.11)*** |
| **TOT shock** | | | | | | | 0.0 | |
| | | | | | | | (0.27) | |
| Observations | 619 | 598 | 619 | 619 | 619 | 619 | 619 | 588 |
| R-squared | 0.24 | 0.23 | 0.26 | 0.31 | 0.36 | 0.37 | 0.37 | 0.31 |

1/ Robust t-ratios in parentheses. Dependent variable is the respective country's interest rate on long-term bonds minus the UK consol interest rate. A constant is included in all regressions. All explanatory variables except for TOT shock enter the regression one period lagged, as discussed in the main text.

* significant at 10%; ** significant at 5%; *** significant at 1%

**Table 4. Determinants of Sovereign Spreads: 1870-1913 1/**
(Beveridge-Nelson measures of the trend gap)

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| **ir*** | 0.004 | 0.004 | 0.004 | 0.002 | 0.003 | 0.002 | 0.002 | |
| | (0.72) | (0.58) | (0.63) | (0.3) | (0.36) | (0.31) | (0.34) | |
| **Debt/GDP** | 0.014 | 0.015 | 0.014 | 0.013 | 0.013 | 0.013 | 0.013 | 0.014 |
| | (11.52)*** | (11.62)*** | (9.01)*** | (9.95)*** | (9.45)*** | (9.41)*** | (9.16)*** | (9.04)*** |
| **X/GDP** | -0.012 | -0.018 | -0.022 | -0.016 | -0.017 | -0.017 | -0.019 | -0.02 |
| | (-3.20)*** | (-4.00)*** | (-4.20)*** | (-3.84)*** | (-3.72)*** | (-3.71)*** | (-3.59)*** | (-3.81)** |
| **std_$\omega_t$** | 0.159 | 0.117 | 0.106 | 0.119 | 0.132 | 0.13 | 0.128 | 0.127 |
| | (6.20)*** | (4.34)*** | (4.08)*** | (4.77)*** | (5.44)*** | (5.31)*** | (4.95)*** | (4.96)** |
| **$\rho_t$** | 0.002 | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| | (5.58)*** | (4.17)*** | (2.96)*** | (3.06)*** | (2.52)** | (2.60)** | (2.98)*** | (2.95)*** |
| **Dper** | | 0.014 | 0.019 | 0.016 | 0.014 | 0.014 | 0.006 | 0.006 |
| | | (10.31)*** | (9.82)*** | (11.74)*** | (11.89)*** | (11.91)*** | (3.12)*** | (2.91)*** |
| **Demp** | | | -0.02 | -0.015 | -0.014 | -0.014 | -0.018 | -0.018 |
| | | | (-11.02)*** | (-12.49)*** | (-12.51)** | (-12.29)** | (-11.10)*** | (-10.45)*** |
| **Gold** | | | | -0.01 | -0.008 | -0.008 | -0.009 | -0.009 |
| | | | | (-9.61)*** | (-9.01)** | (-9.00)** | (-9.46)*** | (-9.21)*** |
| **Def. history** | | | | | 0.03 | 0.03 | 0.031 | 0.032 |
| | | | | | (10.01)*** | (10.05)*** | (8.98)*** | (8.41)*** |
| **Ext. Debt/Total Debt** | | | | | | | 0.01 | 0.011 |
| | | | | | | | (4.06)*** | (4.10)*** |
| **TOT shock** | | | | | | 0.003 | | |
| | | | | | | (1.39) | | |
| Observations | 424 | 424 | 424 | 424 | 424 | 424 | 413 | 413 |
| R-squared | 0.39 | 0.39 | 0.42 | 0.48 | 0.46 | 0.47 | 0.46 | 0.46 |

1/ Robust t-ratios in parentheses. Dependent variable is the respective country's interest rate on long-term bonds minus the UK consol interest rate. A constant is included in all regressions. All explanatory variables except for TOT shock enter the regression one period lagged, as discussed in the main text.

* significant at 10%; ** significant at 5%; *** significant at 1%

**Table 5. Determinants of Sovereign Spreads: 1925-1939 1/**
(HP-filter measures of the output gap )

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| **ir*** | 0.005 | 0.005 | 0.005 | 0.005 | 0.006 | 0.008 | 0.01 | |
| | (0.53) | (0.66) | (0.64) | (0.57) | (0.80) | (1.08) | (1.35) | |
| **Debt/GDP** | 0.004 | 0.001 | 0.003 | 0.004 | 0.004 | 0.009 | 0.009 | 0.008 |
| | (1.54) | (0.23) | (0.68) | (1.18) | (1.24) | (5.64)*** | (4.58)*** | (5.67)*** |
| **X/GDP** | -0.057 | -0.051 | -0.052 | -0.045 | -0.042 | -0.028 | -0.026 | -0.03 |
| | (4.61)*** | (-3.97)*** | (4.77)*** | (3.53)*** | (3.94)*** | (3.84)*** | (3.01)*** | (4.48)*** |
| **std_$\omega_t$** | 0.333 | | 0.503 | 0.329 | 0.205 | 0.083 | 0.119 | 0.085 |
| | (3.93)*** | | (4.47)*** | (3.01)*** | (2.25)** | (1.51) | (1.75)* | (1.55) |
| $\rho_t$ | 0.02 | | 0.022 | 0.018 | 0.017 | 0.01 | 0.01 | 0.009 |
| | (3.89)*** | | (4.09)*** | (3.38)*** | (3.51)*** | (2.14)** | (2.29)** | (2.08)** |
| **std_ins($\omega_t$)** | | 0.168 | | | | | | |
| | | (2.95)** | | | | | | |
| $\rho_{t\ (yins)}$ | | 0.007 | | | | | | |
| | | (1.81)* | | | | | | |
| **Dperiphery** | | | 0.018 | 0.028 | 0.029 | 0.015 | 0.015 | 0.015 |
| | | | (5.43)*** | (5.57)*** | (6.06)*** | (3.04)*** | (2.97)*** | (3.09)** |
| **Dempire** | | | | -0.027 | -0.025 | -0.017 | -0.016 | -0.017 |
| | | | | (5.00)*** | (4.33)*** | (3.22)*** | (3.15)*** | (3.27)*** |
| **Gold** | | | | | -0.007 | -0.007 | -0.007 | -0.007 |
| | | | | | (5.01)*** | (6.46)*** | (6.31)*** | (6.92)** |
| **Def. history** | | | | | | 0.08 | 0.079 | 0.079 |
| | | | | | | (4.29)*** | (4.59)*** | (4.30)*** |
| **Ext. Debt/Total Debt** | | | | | | | | |
| **TOT shock** | | | | | | | 0.001 | |
| | | | | | | | (0.51) | |
| Observations | 305 | 305 | 305 | 305 | 305 | 305 | 295 | 305 |
| R-squared | 0.12 | 0.11 | 0.19 | 0.23 | 0.33 | 0.52 | 0.53 | 0.52 |

1/ Robust t-ratio in parenthesis. Dependent variable is the respective country's interest rate on long-term bonds minus the UK consol interest rate. A constant is included in all regressions. All explanatory variables except for TOT shock enter the regression one period lagged, as discussed in the main text.

* significant at 10%; ** significant at 5%; *** significant at 1%

**Table 6. Determinants of Sovereign Spreads: 1925-1939 1/**
(Beveridge-Nelson measures of the trend gap)

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| **ir*** | 0.004 | 0.005 | 0.004 | 0.005 | 0.005 | 0.007 | 0.016 | |
| | (0.45) | (0.53) | (0.43) | (0.71) | (0.88) | (1.15) | (1.95)* | |
| **Debt/GDP** | 0.002 | 0.003 | 0.008 | 0.006 | 0.01 | 0.01 | 0.036 | 0.01 |
| | (0.78) | (0.76) | (2.29)** | (2.40)** | (6.06)*** | (5.09)*** | (7.82)*** | (6.10)*** |
| **X/GDP** | -0.053 | -0.05 | -0.048 | -0.043 | -0.037 | -0.038 | -0.029 | -0.038 |
| | (-4.43)*** | (-3.71)*** | (-3.93)*** | (-5.01)*** | (-5.41)*** | (-4.54)*** | (-1.16) | (-5.82)*** |
| **std_$\omega_t$** | 0.084 | 0.384 | 0.309 | 0.272 | 0.128 | 0.149 | 0.18 | 0.128 |
| | (1.67)* | (3.78)*** | (2.57)** | (2.99)*** | (2.55)** | (2.37)** | (1.36) | (2.57)** |
| **$\rho_t$** | 0.015 | 0.004 | 0.004 | 0.004 | 0.002 | 0.002 | 0.004 | 0.002 |
| | (2.12)** | (3.03)** | (3.32)** | (2.98)** | (2.12)** | (2.01)** | (2.34)** | (2.06)** |
| **Dperiphery** | | 0.021 | 0.029 | 0.026 | 0.014 | 0.015 | 0.021 | 0.014 |
| | | (4.69)** | (5.24)** | (6.17)** | (3.13)** | (3.02)** | (1.26) | (3.13)*** |
| **Dempire** | | | -0.031 | -0.027 | -0.02 | -0.021 | -0.007 | -0.02 |
| | | | (-4.72)*** | (-4.97)*** | (-3.92)*** | (-3.84)*** | (-0.81) | (-3.93)*** |
| **Gold** | | | | -0.008 | -0.007 | -0.007 | -0.007 | -0.007 |
| | | | | (-5.25)** | (-6.67)** | (-6.53)** | (-4.87)*** | (-7.04)*** |
| **Def. history** | | | | | 0.079 | 0.077 | 0.104 | 0.079 |
| | | | | | (4.24)*** | (4.42)*** | (9.85)*** | (4.23)*** |
| **Ext. Debt/Total Debt** | | | | | | | -0.019 | |
| | | | | | | | (-1.67)* | |
| **TOT shock** | | | | | | 0.001 | | |
| | | | | | | (0.49) | | |
| Observations | 302 | 302 | 302 | 302 | 302 | 292 | 100 | 302 |
| R-squared | 0.12 | 0.17 | 0.28 | 0.41 | 0.56 | 0.53 | 0.56 | 0.56 |

1/ Robust t-ratios in parentheses. Dependent variable is the respective country's interest rate on long-term bonds minus the UK consol interest rate. A constant is included in all regressions. All explanatory variables except for TOT shock enter the regression one period lagged, as discussed in the main text.

* significant at 10%; ** significant at 5%; *** significant at 1%

**Table 7. Determinants of Sovereign Spreads, 1994-2005 1/**
(HP-filter measures of the output gap )

| | (1) | (2) | (3) | (4) | (7) | (5) | (6) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| **ir*** | 0.217 | 0.210 | 0.215 | 0.207 | 0.205 | 0.210 | 0.218 | 0.222 | 0.180 |
| | (1.57) | (1.51) | (1.51) | (1.53) | (1.54) | (1.57) | (1.54) | (1.53) | (1.31) |
| **Debt/GDP** | 0.124 | 0.123 | 0.125 | 0.125 | 0.134 | 0.126 | 0.124 | 0.126 | 0.105 |
| | (3.98)** | (3.82)** | (4.10)** | (5.12)** | (6.22)** | (4.22)** | (4.24)** | (3.85)** | (3.63)** |
| **X/GDP** | -0.157 | -0.152 | -0.156 | -0.156 | -0.158 | -0.149 | -0.149 | -0.158 | -0.162 |
| | (4.85)*** | (4.71)*** | (5.23)*** | (4.48)*** | (5.06)*** | (5.10)*** | (4.07)*** | (5.18)*** | (4.81)*** |
| **std_$\omega_t$** | 1.118 | 1.163 | 1.643 | 1.554 | 1.584 | 1.455 | 1.689 | 1.600 | 1.795 |
| | (1.61) | (1.63) | (2.37)** | (2.08)** | (2.19)** | (2.03)** | (2.58)*** | (2.27)** | (2.81)*** |
| **$\rho_t$** | 0.054 | 0.053 | 0.046 | 0.048 | 0.050 | 0.049 | 0.047 | 0.055 | 0.047 |
| | (3.17)*** | (3.01)*** | (2.80)*** | (3.74)*** | (3.51)*** | (3.56)*** | (3.04)*** | (3.07)*** | (3.49)*** |
| **Def. history** | | 0.043 | 0.077 | 0.067 | 0.069 | 0.074 | 0.089 | 0.083 | 0.062 |
| | | (1.59) | (2.71)*** | (2.54)** | (2.42)** | (2.37)** | (2.98)*** | (2.86)*** | (2.20)** |
| **DAsia** | | | 0.023 | 0.025 | 0.027 | 0.018 | 0.026 | 0.019 | 0.012 |
| | | | (1.90)* | (1.98)** | (2.09)** | (1.45) | (2.13)** | (1.53) | (0.97) |
| **FX regime** | | | | 0.003 | | | | | |
| | | | | (0.72) | | | | | |
| **REER misalignment** | | | | | 0.018 | | | | |
| | | | | | (0.48) | | | | |
| **TOT shock** | | | | | | -0.070 | | | |
| | | | | | | (-1.42) | | | |
| **Ext. Debt/Total Debt** | | | | | | | -0.014 | | |
| | | | | | | | (-0.56) | | |
| **% Short-term Debt** | | | | | | | | 0.000 | |
| | | | | | | | | (-0.75) | |
| **Reserves/M2** | | | | | | | | | -0.094 |
| | | | | | | | | | (-3.29)*** |
| Observations | 177 | 177 | 177 | 177 | 177 | 177 | 177 | 171 | 177 |
| Number of countries | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 25 | 26 |
| R-squared | 0.45 | 0.5 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.52 | 0.53 |

1/ Robust t-statistics in parentheses. Dependent variable is the respective country's spread on long-term bonds relative to the US instrument the US instrument of similar maturity (JP Morgan's EMBI index). A constant is included in all regressions. All explanatory are lagged one-year with the exception of terms of trade shock, as discussed in the text.

* significant at 10%; ** significant at 5%; *** significant at 1%

**Table 8. Determinants of Sovereign Spreads, 1994-2005 1/**
(Beveridge-Nelson measures of the trend gap)

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| **ir*** | 0.223 | 0.218 | 0.225 | 0.218 | 0.224 | 0.200 | 0.221 | 0.209 | 0.200 |
| | (1.65) | (1.58) | (1.69)* | (1.66)* | (1.69)* | (1.61)* | (1.58) | (1.53) | (1.53) |
| **Debt/GDP** | 0.124 | 0.124 | 0.122 | 0.120 | 0.134 | 0.131 | 0.133 | 0.135 | 0.106 |
| | (4.24)*** | (4.27)*** | (4.58)*** | (5.11)*** | (6.54)*** | (3.85)*** | (5.12)*** | (4.31)*** | (4.02)*** |
| **X/GDP** | -0.125 | -0.117 | -0.122 | -0.117 | -0.127 | -0.124 | -0.121 | -0.126 | -0.117 |
| | (-3.94)*** | (-3.74)** | (-4.58)** | (-4.28)** | (-4.96)** | (-3.91)** | (-4.12)** | (-3.92)** | (-4.28)** |
| **std_$\omega_t$** | 1.028 | 0.989 | 1.244 | 1.242 | 1.275 | 0.950 | 1.242 | 1.200 | 1.354 |
| | (1.79)* | (1.70)* | (2.03)** | (1.89)* | (2.02)** | (1.49) | (1.93)* | (1.71)* | (2.11)** |
| $\rho_t$ | 0.005 | 0.006 | 0.010 | 0.011 | 0.010 | 0.010 | 0.012 | 0.010 | 0.010 |
| | (1.05) | (1.15) | (1.58) | (1.70)* | (1.47) | (1.66)* | (1.91)* | (1.58) | (1.50)* |
| **Def. history** | | 0.035 | 0.080 | 0.079 | 0.070 | 0.071 | 0.072 | 0.072 | 0.063 |
| | | (1.31) | (2.47)** | (2.51)** | (2.20)** | (1.83*) | (1.90)* | (2.04)** | (1.69)* |
| **DAsia** | | | 0.033 | 0.037 | 0.041 | 0.038 | 0.042 | 0.022 | 0.024 |
| | | | (1.99)* | (2.22)* | (2.22)* | (2.16)* | (2.25)* | (1.14) | (1.10) |
| **FX regime** | | | | 0.003 | | | | | |
| | | | | (0.77) | | | | | |
| **REER misalignment** | | | | | 0.029 | | | | |
| | | | | | (0.76) | | | | |
| **TOT shock** | | | | | | -0.074 | | | |
| | | | | | | (-1.42) | | | |
| **Ext. Debt/Total Debt** | | | | | | | -0.013 | | |
| | | | | | | | (0.46) | | |
| **% Short-term Debt** | | | | | | | | 0.000 | |
| | | | | | | | | (0.31) | |
| **Reserves/M2** | | | | | | | | | -0.074 |
| | | | | | | | | | (-2.74)** |
| Observations | 173 | 173 | 173 | 173 | 173 | 173 | 173 | 167 | 173 |
| Number of countries | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 25 | 26 |
| R-squared | 0.45 | 0.5 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.52 | 0.53 |

1/ Robust t-statistics in parentheses. Dependent variable is the respective country's spread on long-term bonds relative to the US instrument of similar maturity (JP Morgan's EMBI index). A constant is included in all regressions. All explanatory are lagged one-year with the exception of terms of trade shock, as discussed in the main text.

* significant at 10%; ** significant at 5%; *** significant at 1%

**Table 9. Determinants of the Default Premium, 1870-1939 1/**
(HP-filter measures of the output gap )

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| **ir*** | 0.237 | 0.277 | 0.303 | 0.091 | 0.106 | 0.109 |
| | (1.20) | (1.35) | (1.44) | (0.80) | (0.87) | (1.09) |
| **Debt/GDP** | -0.029 | -0.014 | 0.006 | 0.079 | 0.102 | 0.091 |
| | (1.11) | (0.59) | (0.32) | (3.53)*** | (3.45)** | (3.60)** |
| **X/GDP** | -0.004 | -0.003 | -0.003 | -0.009 | -0.056 | 0.069 |
| | (-0.86) | (-0.79) | (-0.76) | (-3.34)** | (-0.38) | (-0.44) |
| **std_$\varepsilon_t$** | -1.046 | -1.271 | -1.483 | -1.659 | -1.654 | -1.765 |
| | (-1.71)* | (-1.89)* | (-1.98)** | (-2.27)** | (-2.25)** | (-2.27)** |
| $\rho_t$ | 0.125 | 0.163 | 0.262 | 0.171 | 0.169 | 0.083 |
| | (1.66)* | (1.84)* | (2.36)** | (2.51)** | (2.52)** | (1.68)* |
| **Dperiphery** | | -0.072 | -0.112 | -0.218 | -0.244 | -0.283 |
| | | (-2.30)** | (-2.76)** | (-3.14)*** | (-3.03)*** | (-2.79)*** |
| **Gold** | | | 0.104 | -0.035 | -0.034 | -0.051 |
| | | | (-1.98)** | (-0.84) | (-0.63) | (-1.54) |
| **Def. history** | | | | 0.402 | 0.447 | 0.395 |
| | | | | (2.56)** | (2.53)** | (2.67)*** |
| **TOT shock** | | | | | -0.288 | -0.258 |
| | | | | | (-2.17)** | (-2.11)** |
| **Ext. Debt/Total Debt** | | | | | | 0.133 |
| | | | | | | (1.76)* |
| Observations | 66 | 66 | 66 | 66 | 63 | 74 |
| R-squared | 0.15 | 0.17 | 0.19 | 0.35 | 0.40 | 0.41 |

1/ Robust t statistics in parentheses. In all regressions, the dependent variable is the difference between the spread of a country in default and the mean spread of all other countries not in default in that year.

* significant at 10%; ** significant at 5%; *** significant at 1%

**Table 10. Determinants of the Default Premium, 1870-1939 1/**

(Beveridge-Nelson measures of the trend gap)

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| **ir*** | 0.397 | 0.482 | 0.474 | 0.287 | 0.311 | 0.31 |
| | (1.50) | (1.60) | (1.58) | (1.97)** | (2.13)** | (2.06)** |
| **Debt/GDP** | -0.058 | -0.05 | -0.04 | 0.06 | 0.078 | 0.078 |
| | (-1.43) | (-1.40) | (-1.25) | (3.82)*** | (4.24)*** | (4.21)*** |
| **X/GDP** | -0.328 | -0.18 | -0.341 | 0.831 | 0.802 | 0.806 |
| | (-1.80)* | (-0.86) | (-1.11) | (-1.77)* | (-1.74)* | (-1.79)* |
| **std_$\varepsilon_t$** | -0.989 | -1.224 | -1.23 | -1.776 | -1.772 | -1.771 |
| | (-1.75)* | (-1.79)* | (-1.79)* | (-2.53)** | (-2.55)** | (-2.53)** |
| $\rho_t$ | 0.105 | 0.144 | 0.166 | 0.146 | 0.15 | 0.15 |
| | (1.68)* | (1.75)* | (1.74)* | (2.21)** | (2.26)** | (2.23)** |
| **Dperiphery** | | -0.103 | -0.133 | -0.309 | -0.335 | -0.333 |
| | | (-1.69)* | (-1.67)* | (-2.64)*** | (2.81)*** | (2.52)*** |
| **Gold** | | | 0.08 | -0.283 | -0.269 | -0.271 |
| | | | (1.05) | (2.26)** | (2.16)** | (2.23)** |
| **Def. history** | | | | 0.678 | 0.694 | 0.697 |
| | | | | (2.60)*** | (2.66)*** | (2.77)*** |
| **TOT shock** | | | | | -0.215 | -0.215 |
| | | | | | (-2.35)** | (-2.33)** |
| **Ext. Debt/Total Debt** | | | | | | -0.005 |
| | | | | | | (-0.08) |
| Observations | 64 | 64 | 64 | 64 | 64 | 64 |
| R-squared | 0.24 | 0.26 | 0.27 | 0.49 | 0.53 | 0.53 |

1/ Robust t statistics in parentheses. In all regressions, the dependent variable is the difference between the spread of a country in default and the mean spread of all other countries not in default in that year.

* significant at 10%; ** significant at 5%; *** significant at 1%