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Persistent Gaps and Default Traps

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Persistent Gaps and Default Traps[*]

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Abstract

We show how vicious circles in countries' credit histories arise in a model where output persistence is coupled with asymmetric information between borrowers and lenders about the nature of output shocks. In such an environment, default creates a pessimistic outlook about the borrower's output path. This translates into higher debt-to-expected-output ratios, pushing up interest rates and hence debt servicing costs. By raising the cost of future repayments, this creates "default traps". We provide empirical support for the model by building a long and broad cross-country dataset spanning over a century. This data is used to provide evidence on the existence of a history-dependent "default premium" and to show that the effect of output persistence on sovereign creditworthiness is significant and consistent with the model's predictions after controlling for other determinants of sovereign risk.

JEL Classification: F34, G15, H63, N20.
Keywords: Sovereign default, spreads, persistence

1   Introduction

A major stylized fact about the history of sovereign borrowing is the pervasiveness of 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 – clearly suggestive of substantial persistence in creditworthiness patterns. While these probability estimates are not conditioned on countries' fundamentals, evidence provided in Rogoff, Reinhart, and Savastano (2003) indicates that serial default is only loosely related to countries' indebtedness levels and other fundamentals. They show that 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 – involving 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.

An associated 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 some time. 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, 2006; 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

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[1]A notable exception is Eaton (1996), who constructs a model where an endogenous bond re-pricing creates a deterrent mechanism. Earlier studies have also well acknowledged the problems associated with the assumption of strict market exclusion, including that of coordination problems among multiple lenders (Kletzer, 1984), and borrowers' retained ability to invest in risk-free international assets after default, which would render default-free lending unsustainable without other penalties (Bulow and Rogoff, 1989).

[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' enforcement technology is so weak that country spreads may become prohibitively large for any borrowing to take place.

This paper argues that two structural features that 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. These range from domestic institutions (Acemoglu et al., 2005), commodity specialization (Blattman et al., 2007) 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 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, such a separation is important as well because there are distinct macroeconomic mechanisms behind shock persistence in emerging-market economies. These include the presence of short-run supply-side inelasticities that make primary commodity price

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While there is some debate about whether recalcitrant borrowers are consistently punished with higher spreads (Eichengreen and Portes, 1986; Ozler, 1993), broader historical data that we present in this paper indicates that bond yields typically do rise in the wake default events and remain higher than average (albeit declining) for several years after those events. This is also consistent with evidence provided in Flandreau and Zumer (2004) on the behavior of spreads during the pre-WWI period.

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

shocks long-lasting,[4] the various frictions (political as well as economic) which make fiscal policy more procyclical in these countries[5], as well as financial and institutional frictions that typically magnify the sensitivity of domestic credit to loan collateral values and balance sheet mismatches; as the latter can induce prolonged spirals of output contraction or expansion, including painful episodes of debt deflation (see, e.g., Calvo, 1998; Mendoza, 2006), they tend to exacerbate overall output persistence.

[Tables 1 and 2 here]

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. Using data spanning the century-and-quarter period from dawn of international bond financing in the 1870s through 2004, 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, defaulting countries typically display higher volatility and persistence than non-defaulting countries on average. Further, these cross-country differences appear to be typically even higher between serial defaulters and non-defaulters, and are consistently observed for certain countries over the entire 1870-2004 period. The postulated relationship also appears to be robust to potential reverse causality emanating from the effects of defaults on the volatility and persistence of output

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[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.

[5]In a recession, a contractionary fiscal stance tends to delay recovery, which exacerbates shock persistence. 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").

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.

Against this background, the aim of this paper is twofold. The first is to lay out a model that shows how, in the presence of informational asymmetry, the combined effects of volatility and persistence of output shocks can generate some path dependence in countries' credit history. In particular, when borrowers are better informed than lenders about the persistence of their output shocks, repayment choice – default vs. repayment – can trigger a discrete shift in expectations about the borrower's future output path: upon observing default, lenders might end up "assuming the worst" about the repayment prospects on future loans. If so, fresh lending is likely to be at significant higher interest rates. In contrast, repayment of past loans creates a more favorable outlook for future repayment and justifies future lending at lower interest rates. The difference between interest rates that the sovereign borrower faces after default relative to those following repayment can be viewed as a *default premium*. Ex-ante such a default premium constitutes a deterrent 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 Kanczuk, 2005). Ex-post, such a default premium raises the cost of future repayments beyond what is justified by other fundamentals (including past history of output volatility and persistence), and thus exacerbates the likelihood of future defaults. We use the notion of *default traps* to capture the idea that, in the presence of fragile expectations, the impact of a negative output shock on country risk can be amplified and throw an otherwise solvent country on the path of serial default. More precisely, a country can fall into a default trap in that, once it defaults, it is more likely to default again in the future, compared to another country with identical fundamentals.

The second contribution of the paper is to provide empirical evidence for the model's results. Since the underlying volatility and persistence of output tend to be slowly-evolving structural features that can vary widely from country to country, having a cross-sectionally broad and time-wise long country panel is an important requirement to test the model's main propositions. To this end, we construct a uniquely long and broad cross-country panel spanning the first globalization era in the 1870s – when international financial integration and sovereign bond financing began to climb to unprecedented

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historical levels – to 2004. This database is not only longer than previous historical studies on sovereign risk (e.g. Obstfeld and Taylor, 2003) but also has better output data for some countries and encompasses a wider set of variables (See Appendix 2). Our results clearly 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 results, we also find evidence of a significantly positive default premium and of such a premium being rising with the underlying persistence of deviations between actual and expected output - the so-called output gap. This offers one explanation for why country spreads (measured relative to the risk-free interest rate) react strongly to default announcements even after controlling for changes in other fundamentals. Such a significant and typically long-lasting rise in spreads in turn makes countries more likely to fall prey to default traps.

Our findings relate to those of previous studies. Aguiar and Gopinath (2006) find that greater output persistence tends to raise sovereign default risk. Their model does not rely on asymmetry of information between borrowers and lenders and default is penalized by exclusion, with exogenous market re-entry probabilities after default, rather than alter price of borrowing. Whilst their analysis does not focus on serial default, it does follow from it that countries with typically higher persistence of output shocks are more prone to serial default. Other studies have examined the role of volatility in default risk also under symmetric information (e.g., Arellano, 2006; Catão and Kapur, 2006), showing that higher output volatility also tends to raise sovereign spreads. As long as high output volatility remains an endemic structural feature of a given country or group of countries, this class of models can also help rationalize serial default. Yet, neither paper can explain why a country with similar fundamentals as others is prone to fall into a default trap once it has defaulted once; nor can any of the studies cited above explain the existence of an empirically observable default premium and the attendant fact that sovereign spreads typically shoot up following default announcements (even after controlling for other fundamentals including past output history), declining only gradually afterwards with subsequent repayments. Allowing for the presence of information asymmetries between borrowers and lenders on the nature of the output shock buys us precisely the capacity to explain these two phenomena in a way that is consistent with the broad historical evidence, as we show below.

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Other papers have explored the implications of informational asymmetries in models of sovereign debt.[6] Typically, in these papers, observed default provides a signal about some unobservable borrower characteristic that is relevant to the lender's payoff. For instance, if borrowers differ unobservably in their discount rates, default may reveal the borrower to be relatively short-termist. However, these models do not fully develop the implications of these signals on price of future debt, so effectively overlook the default premium mechanism outlined in this paper. Eaton (1996) is notable exception: he develops a model in which sovereign borrowers differ in the vulnerability to the enforcement technology, rendering one less likely to default than the other, and this does affect the price of future debt. However, to the extent that the asymmetry of information in our paper relates to the borrower's output process, it allows us to examine directly the effects of output persistence on country risk, allowing us to discuss the possibility of default traps.

The plan of the paper is as follows. Section 2 lays out the model, our main theoretical results and discusses their robustness. Section 3 reports the econometric results. The paper concludes with a summary of the main findings and a brief discussion of the policy implications in Section 4. Appendix 1 presents proofs of the theoretical propositions while Appendix 2 describes the data.

2   Model

2.1   The Sovereign Borrower

A sovereign borrower issues bonds in international capital markets to finance investment in one-period projects. We develop our model in a simple setting that involves three periods, $t = 0, 1$, and 2. The sovereign invests in periods 0 and 1. Investment I_t at $t = 0, 1$ returns expected output $\bar{Y}_t = f(I_t)$ in period $t + 1$, where f is concave. The country's actual output is stochastic due to two sources of output uncertainty: a persistent shock and a transient shock. Specifically, output at $t = 1, 2$ is given by:

$$\tilde{Y}_1 = f(I_0) + \tilde{\epsilon}_1 + \tilde{\omega}_1 \tag{1}$$

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[6]See, for instance, Kletzer (1984), Atkeson (1991), Calvo and Mendoza (2000), Alfaro and Kanczuk (2005), Fostel (2005), Sandleris (2006), and D'Erasmo (2007).

$$\tilde{Y}_2 = f(I_1) + \rho\tilde{\epsilon}_1 + \tilde{\omega}_2 \tag{2}$$

Here random variable ϵ_1 is a persistent shock, with mean 0 and standard deviation σ_ϵ. Let $\Phi(\epsilon)$ denote the distribution of persistent shocks and $\phi(\epsilon)$ the associated density function. The parameter $\rho \in (0,1)$ measures the persistence of the shock from period 1 to period 2. Random variables ω_t denote transient shocks: these are independent with mean 0 and standard deviation σ_ω.[7]

For tractability we begin by assuming that investment levels I_0 and I_1 are exogenously given. This allows us to focus on the central concern in our model: the sovereign borrower's repayment decisions in periods 1 and 2, for bonds issued in the previous periods. As the assumption may seem strong, we later provide theoretical justification for it and examine the implications of relaxing it.

The sovereign's utility function is linear in payoffs. When making its period-1 repayment choice, the sovereign maximizes $E(\tilde{y}_1 + \beta\tilde{y}_2)$, where $\tilde{y}_t$ denote its output net of any repayments and $\beta \leq 1$ is a discount factor. With this linear specification, the sovereign cares only about expected future payoff associated with its current choices, an assumption that makes the analysis tractable.

Investment is entirely financed by borrowing. To fund its investment requirement I_t at t, the sovereign must issue one-period bonds of face value D_{t+1}, where

$$p_t D_{t+1} = I_t, \tag{3}$$

and p_t denotes the issue price of bonds.

2.2   Bond Markets and Sovereign Spreads

The bond market is competitive, with risk-neutral lenders who are willing to subscribe to bonds at a price that allows them to break-even. The issue price of bonds, determined endogenously in the model, depends on the perceived likelihood of default. We assume that in the event of default, bondholders

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[7]The shock variances are such that $\bar{Y}_t < \tilde{\epsilon}_t + \tilde{\omega}_t$ is a negligible probability event, so that there is no 'involuntary default' caused by non-positive or extremely low output realizations. This is consistent with empirical evidence that overwhelming majority of defaults occur in countries with (positive) debt-to-GDP ratios below 100% and often at moderate levels of indebtedness (Reinhart et al., 2003; D'Erasmo, 2007).

can enforce partial recovery obtaining a proportion $c < 1$ of the face value of outstanding debt. If the sovereign is expected to default at $t + 1$ with probability π_{t+1}, the expected return to a bond of unit face value is $\pi_{t+1}c + (1 - \pi_{t+1})$. A risk-neutral lender who acquires a unit bond at price p_t at time t expects to break even in period $t + 1$ if

$$[\pi_{t+1}c + (1 - \pi_{t+1})] = p_t R_f, \tag{4}$$

where $R_f = 1 + r_f$ is the exogenously-given gross risk-free interest rate. The competitive market-clearing price of bonds is

$$p_t = \frac{1 - \pi_{t+1}(1 - c)}{R_f}. \tag{5}$$

As $p_t \in [c/R_f, 1/R_f]$, the bond price is positive as long as $c > 0$. The price of bonds $p_t(\pi_{t+1})$ is decreasing in the anticipated probability of default.[8]

Bond yields, as conventionally defined,

$$i_t = \frac{R_f}{1 - \pi_{t+1}(1 - c)} - 1 \tag{6}$$

are increasing in the probability of default, as is the sovereign spread over the risk-free rate of interest, which equals $(i_t - r_f)$.

2.3 Asymmetric Information and Default Premium

We assume that while $\bar{Y}_t$, ρ, and the distribution of shocks are common knowledge, only the sovereign borrower observes the magnitude of its period-1 shocks directly. Bondholders do not, but make an inference about its likely realization by observing the sovereign's repayment decision in period 1. The updated beliefs are used to form expectations of future output, and hence the probability of future default.

In order to show how this information structure gives rise to the existence of a default premium, we provide an informal discussion of the sequence of

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[8]Eaton and Gersovitz (1995) provide an interesting argument as to why the probability of default is unlikely to be greater than half for any credible debt contract. Also see Rose and Spiegel (2004) for a similar assumption. We adopt this assumption for analytical convenience. A restriction on default probabilities is also consistent with our empirical approach where, like many others (e.g. Obstfeld and Taylor, 2003), we eliminate data points that have spreads over 1000 basis points.

events and equilibrium before we state our formal result in the next sub-section. At time $t = 0$, the sovereign issues one-period bonds with face value D_1 to meet its initial investment requirement I_0, so that $p_0 D_1 = I_0$. The issue price p_0 of these bonds is determined endogenously, based on expected default risk. At time $t = 1$, the sovereign observes its output shock and chooses between default, d, or repayment, r. The period-1 repayment "history" is denoted by $h \in \{d, r\}$.

On observing the sovereign's repayment history in period 1 bondholders update their beliefs in accordance with Bayes' rule. The repayment decision affects bondholders' beliefs about the sovereign's future output and, hence, the probability of future default denoted as π_2^h, varies with history h. The sovereign then issues new bonds at $t = 1$, at price $p_1^h \equiv p_1(\pi_2^h)$ to finance its period-1 investment requirement I_1. It requires

$$p_1^h D_2^h = I_1. \tag{7}$$

Given the fixed investment requirement I_1, if the issue price depends on h, so does the required nominal bond issue, D_2^h.

Finally, at $t = 2$ the sovereign chooses whether or not to repay its debt obligation D_2^h. 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, at $t = 2$ the sovereign 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 $\tilde{Y}_2$.[9] Figure 1 depicts the sequence of events.

[Figure 1 here]

Our analysis begins, as is standard, from the final period. Given the enforcement technology, repayment will be rational in the final period if and only if the cost of sanctions exceeds any direct gain from reneging on

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[9] As in Sachs and Cohen (1985) and Obstfeld and Rogoff (1996) we assume that bond-holders 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. We show that the borrower repays at $t = 2$ if and only if the debt-to-output ratio exceeds a critical threshold.

The borrower's repayment choice in period 1 depends on a comparison of the benefit and cost of default. Default has benefits in terms of repayments avoided (except some which is captured). Default is costly because to the extent it alters market perceptions of future default risk, the cost of financing fresh investment rises. Given this trade-off, we show formally that the optimal repayment rule in period 1 also satisfies a threshold property: the borrower will repay in at $t = 1$ if and only if the realization ϵ_1 of the persistent shock is above some threshold, e_1. The equilibrium value of this threshold will be denoted as e_1^*.

The informational asymmetry between the borrower and bondholders translates into differences in beliefs about the sovereign's second-period output. The sovereign, who observes the realization of the persistent shock ϵ_1, expects $\tilde{Y}_2$ to be distributed with mean $f(I_1) + \rho \epsilon_1$ and standard deviation σ_ω. Let the associated (cumulative) distribution function be $F_{|\epsilon_1}(\tilde{Y}_2)$. Bondholders, on the other hand, do not observe ϵ_1 but only the repayment history h. Let $G_h(\tilde{Y}_2 | e_1)$ denote the lenders' distribution over $\tilde{Y}_2$ if they observe history h and if they believe the borrower's repayment threshold to be e_1. The distributions $F_{|\epsilon_1}$ and G_h summarize the information asymmetry. Together $\{e_1, \Phi, F_{|\epsilon_1}, G_h\}$ denote the evolution of beliefs over time.

In this setting, default in period 1 signals the realization of an adverse output shock and, given persistence, creates a pessimistic outlook regarding the sovereign's future output and default risk. On the other hand, repayment generates a more favorable outlook. This translates into higher conditional probability of future default: that is, we have $\pi_2^d > \pi_2^r$. Using equation (5), this implies that p_1^r (the issue price of new bonds contingent on repayment at $t = 1$) exceeds p_1^d (the corresponding value contingent on default). Expressing the same idea in term of bond yields, a country with a history of default is required to offer higher bond yields i_1^d to attract funds than it would have had to pay with a sound repayment history, i_1^r.

We refer to the difference $i_1^d - i_1^r$ (or equivalently, the difference in prices $p_1^r - p_1^d$) as the *default premium*. Note that this default premium is purely a consequence of asymmetric information: if lenders could observe the realization of output shocks, there would be no informational content in the act of default per se, so that the default premium would vanish. The existence

of a positive default premium is a key feature of our model. This feature is formally shown in the equilibrium described below.

2.4 Default Traps Equilibrium

We model the interaction between the borrower and lenders as a game. For descriptive purposes, it is convenient to consider the mass of lenders as a single player: this 'lender' sets the bond price so that the expected return on bonds equals the opportunity cost of capital. Thus the lender's strategy is given by prices (p_0, p_1^r, p_1^d) that allow it to break even, given the perceived likelihood of default $(\pi_1, \pi_2^r, \pi_2^d)$.

A strategy for the sovereign borrower involves the following elements: bond issuance D_1 at $t = 0$, repayment choice $h \in \{r, d\}$ followed by history-contingent bond issuance D_2^h at $t = 1$, and, finally, the repayment choice at $t = 2$.

Beliefs in the game are specified by the critical threshold e_1 which determines the the borrower's repayment choice in period 1, the prior distribution Φ of persistent shocks, and the posterior distributions $F_{|\epsilon_1}$ and G_h over the final period output.

We consider a Perfect Bayesian Equilibrium (PBE) of this game, at which players choose strategies that are optimal given their beliefs and other player's strategies, and beliefs are consistent with strategies and observed actions. Proposition 1 describes such an equilibrium.

Proposition 1 *There exists an e_1^* such that the following is a PBE of the game:*

1. *The borrower's repayment decision at $t = 1$ is given by*

$$h(\epsilon_1) = \begin{cases} r & \text{if } \epsilon_1 \geq e_1^* \\ d & \text{if } \epsilon_1 < e_1^* \end{cases}$$

   The borrower repays at $t = 2$ if and only if $\tilde{Y}_2 \geq [(1-c)/s]D_2^h$.

2. *The lender's strategy is given by (p_0, p_1^r, p_1^d) at which it breaks even each period given its beliefs. Moreover, $p_1^r - p_1^d > 0$: that is, the equilibrium default premium is positive.*

3. *The lender's beliefs in period 0 are given by the prior distribution $\Phi(\epsilon_1)$. At $t = 1$, if it observes default, beliefs are given by the density function*

$$\gamma_d(\epsilon_1|e_1^*) = \begin{cases} \frac{\phi(\epsilon_1)}{\Phi(e_1^*)} & \text{if } \epsilon_1 < e_1^* \\ 0 & \text{otherwise} \end{cases}$$

If, instead, the lender observes repayment

$$\gamma_r(\epsilon_1|e_1^*) = \begin{cases} \frac{\phi(\epsilon_1)}{1-\Phi(e_1^*)} & \text{if } \epsilon_1 \geq e_1^* \\ 0 & \text{otherwise.} \end{cases}$$

The proof of this Proposition is provided in Appendix 1, but we highlight two key features of the equilibrium. First, the equilibrium suggests the possibility of what we refer to as *default traps*. Second, the positive default premium constitutes an endogenous deterrence mechanism that can support repayment of debt even in the absence of other penalties.

Given the information asymmetry, the borrower's period-1 choice – default vs. repayment – can be quite informative. Default triggers a discrete shift in expectations as the lender infers that the realization of the persistent shock ϵ_1 must lie below the critical e_1^*, that is, in the lower tail of distribution Φ. In effect, the lender 'assumes the worst' about the future output path of a borrower who defaults. Such pessimism, combined with the lender's need to break-even, implies that fresh borrowing is sustainable only at significantly higher spreads, or equivalently, lower bond prices. If, as in our model, the investment requirement is relatively inelastic, the required volume of issued debt needs to be even higher to compensate for low issue prices. This, in turn, raises the risk of future default. In contrast, a good credit history creates a more favorable outlook, with higher bond prices, lower nominal debt requirements and significantly lower risk of future default.

Notice first that, once the impact of default on expectations is factored in, the default premium can be quite large, which constitutes a deterrence mechanism that induces countries to repay even in the absence of other penalties.

Second, such a default premium raises the cost of future repayments beyond what is justified by other fundamentals (including past history of output volatility and persistence), and thus exacerbates the likelihood of future defaults. We use the notion of default traps to capture the idea that, in the presence of fragile expectations, the impact of a negative output shock on

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country risk can be amplified and throw an otherwise solvent country on the path of serial default. More precisely, a country can fall into a default trap in that, once it defaults, it is more likely to default again in the future, compared to another country with identical fundamentals. The underlying mechanism is entirely symmetric, with a good repayment history creating a virtuous cycle of lower spreads, smaller borrowing requirements and significantly lower risk of default.

2.5   Comparative Statics

The deterrence mechanism allows us to explore how the equilibrium varies with the degree of persistence. To appreciate this mechanism, note that beliefs must be such that the borrower is just indifferent between default and repayment at the threshold e_1^*. The gain from repayment comes from the more favorable terms of access to future borrowing. Let V_2^r denote the continuation payoff for the borrower following repayment and V_2^d be the continuation payoff following default. These continuation values depend on ϵ_1 (as it conditions the borrower's beliefs $F_{|\epsilon_1}$ about future output), and on expectations e_1 regarding the repayment threshold (as that conditions the lender's posterior beliefs). The difference $V_2^r - V_2^d$ captures the anticipated future gain from repayment relative to default. The direct cost of repayment is given by $(1-c)D_1$. Given the prior distribution $\Phi(\epsilon_1)$, the ex-ante likelihood of default at $t = 1$ equals $\Phi(e_1)$. Recall that for risk-neutral lenders to break even we must have

$$[1 - (1-c)\Phi(e_1)]D_1 = R_f I_0. \tag{8}$$

Figure 2 captures the trade-off between the cost and benefit of repayment. The upward-sloping curve represents the direct cost of repayment, $CR(e_1) \equiv (1-c)D_1(e_1)$, as function of e_1. As the solution $D_1(e_1)$ to (8) is increasing in e_1, so is $CR(e_1)$. The downward-sloping curve represents the discounted value of the future benefit from repayment, $BR(e_1) \equiv \beta[V_2^r - V_2^d]$. The proof of Proposition 1 shows that $BR(e_1)$ is decreasing in the repayment threshold e_1.[10] At the equilibrium, the value of e_1 must be such that $BR(e_1^*) = CR(e_1^*)$.

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[10] The proof also shows that BR is increasing in the realization of the shock ϵ_1, so that the borrower is more likely to repay when output is high. This is not inconsistent with the feature that the gain from repayment is decreasing in the repayment threshold e_1, which is in effect a strategy in the game.

[Figure 2 here]

Both benefit and costs vary with the other parameters of the model, so variations in these will affect the equilibrium. Proposition 2 examines the impact of changes in the persistence parameter ρ.

Proposition 2 *An increase in the persistence parameter ρ raises the equilibrium default premium and the ex-ante probability of default in period 1.*

Once again, Appendix 1 provides a formal proof but the intuition is simple. Greater persistence implies that future output shocks are more closely related to period 1 shock ϵ_1, so that the informational value of observed default is greater. The future gain from repayment relative to default would be larger for any given repayment threshold e_1, or in term of our graphical representation, the downward sloping curve must be higher everywhere for a larger persistence parameter. At e_1^*, the gain from repayment now exceeds the gain from default. To restore the balance between the gain from repayment and default, equilibrium beliefs regarding the threshold needs to adjust to a new, higher value (call it e_1^{**}). This implies a higher ex-ante probability of default and, by the break-even condition, higher sovereign spread at $t = 0$.

To put it differently, the strength of the deterrence mechanism determines the riskiness of the loans that can be made. Stronger deterrence can support debt contracts with larger nominal value, which in our setting tend to be associated with greater probability of default.

Clearly, for persistence to play such a role in exacerbating the default trap mechanism, volatility of output shocks must be relatively large. As discussed in Section 1, what makes many emerging markets more prone to default traps is not just high output gap persistence (a feature shared by many advanced countries and non-serial defaulters) but the combined effects of persistence with high conditional variance of output shocks. Such amplifying effects of volatility on default risk have been documented elsewhere (Aguiar and Gopinath, 2006; Arellano, 2006; and Catão and Kapur, 2006) even in the absence of asymmetric information. The logic of these results carry over to our setting. To see this, consider the lender's break-even condition as in equation (8). Given that the repayment function is a step-function (the borrower pays D_1 if $\epsilon_1 \geq e_1^*$ and cD_1 otherwise), higher dispersion of ϵ_1 depresses the expected return to the lender. If so, the break-even condition

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requires the issue price of bonds to go down or, equivalently, the country spread $(i_t - r_f)$ to widen.

A similar result holds for bonds issued in period 1. The probability of default in period 2 is given by $\pi_2^h(D_2^h) = G_h((\frac{1-c}{s})D_2^h)$, which is increasing in the volatility of distribution G_h. For the lender to break, the bond issue D_2^h must satisfy $[1 - (1-c)\pi_2^h(D_2^h)]D_2^h = R_f I_1$. Higher volatility then is associated with higher probability of default and lower bond prices. The only potentially attenuating effect of higher volatility on default risk in our information asymmetry setting is that the precision of borrower's signal (default vs. repayment) is lower when the volatility of output shocks is high. The extent to which such a potentially attenuating mechanism interacts with credit history to affect the first-order positive effect of output volatility on spreads is ultimately an empirical matter which we examine in Section 3.

2.6 Discussion

Endogenous Investment and Default Costs

While period-2 output is vulnerable to exogenous shocks in our model, it overlooks the possibility that default may cause endogenous loss of output. Our model circumvents this possibility by assuming investment levels I_0 and I_1 to be exogenously given. The crucial restriction is the assumption that investment levels are invariant to repayment history h, or equivalently that $I_1^r = I_1^d$.

Our assumption may have proximate theoretical justification. Consider the borrower's choice of investment level in period 1 (an analogous argument applies to period 0). The net expected return to real investment I_1 is

$$f(I_1) - D_2[1 - \pi_2(1 - c)]. \tag{9}$$

The above expression incorporates the borrower's belief that in the event of default it shall end up repaying only cD_2 rather than its nominal debt obligation D_2. Using equations (5) and (3) this can be written as[11]

$$f(I_t) - R_f I_t, \tag{10}$$

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[11] Alternatively, it can be written as $f(p_1 D_2) - D_2 p_1 R_f$. This suggests that, for instance, lower bond prices raise the cost of capital but allowing for default also lowers the expected cost of servicing the debt. The latter effect reflects the standard moral hazard associated with use of borrowed funds.

with first-order condition for an interior maximum

$$f'(I_1^*) - R_f = 0. \tag{11}$$

Thus the optimally-chosen investment path I_t^* depends only on the risk-free rate. Crucially, the argument suggests that investment is independent of the history-dependent bond prices, or that $I_1^d = I_1^r$. This serves as justification for our working assumption.

Nonetheless empirical evidence suggests that default does tends to affect investment and output. This could be due to factors that are not captured in our model. A typical channel through which this could occur is a drop in investment due to the increase in borrowing costs triggered by default.[12] Following capital, disruptions to trade and access to working capital may lower the productivity of capital, which would reinforce the adverse effect of higher borrowing costs. Mendoza and Yue (2007) point out that following default, the cost of financing imported inputs rises with the country spread, inducing firms to shift to lower-cost domestic inputs that are less productive, causing output to fall. In terms of our model, $\tilde{Y}_2^d < \tilde{Y}_2^r$. Indeed, avoiding such disruption reinforces the case for repayment, reinforcing the deterrence mechanism in our model. On the other hand, the impact of default-induced increases in spreads on the investment funding requirement depends, on the price elasticity of investment. Even when $I_1^d < I_1^r$, as long as investment is not too price elastic (this is especially the case when investment is necessary for critical sectors), our central arguments are robust.[13]

Shock to trend or shock to cycle

Finally, since our model is a three-period model, until now we did not need to take a stand about the nature of the persistent shock. Is ϵ a shock to cycle (ultimately mean revertible) or a shock to trend (which will therefore alter the level of output permanently)? This question has a clear bearing on the empirical strategy for testing of the comparative statics.

Assume, first, that the persistent shock amounts to a shock to trend. In this case, a negative shock entails a permanent reduction in future levels of

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[12]See, for example, Cohen (1992), Obstfeld and Rogoff (1996) and Calvo (2000). If circumstances following default weaken access to trade credit or cause other financial disruptions, we may well have the case that investment and hence expected output in period 2 depend on the repayment decision in the previous period.

[13]This is demonstrated in a supplementary appendix.

trend output, so that default today will help explain a default many years into the future. If a negative shock today triggers default, investors will revise down their trend output predictions. As the sovereign is thus seen to be more risky, sovereign spreads will have to rise to enable 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), ϵ_1 can be interpreted as a persistent but still cyclical, mean-revertible shock. In this case, the described mechanism can still explain default traps for two reasons. If investors seek to break even each 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. Intuitively, this is not surprising: countries more prone to long deep recessions will tend to have a harder time in repaying. This has clear cross-sectional testable implications which we examine below. A second reason has to do with investors' gradual learning about the persistence properties of a country's output process. In practice, investors do not know ρ 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.

3 Empirics

In this section we test empirically test four main implications of the above theoretical set-up.

1. *Hypothesis 1:* There is a positive default premium. That is, countries with a previous default history should pay higher spreads relative to the risk-free rate, controlling for other fundamentals. This follows from Proposition 1.

2. *Hypothesis 2:* Countries with higher underlying persistence of output shocks face higher sovereign spreads, all else constant. This follows from Proposition 2.

3. *Hypothesis 3:* The default premium rises with the persistence of output shocks. That is, among countries with the same credit history, those with higher underlying persistence of output shocks should face higher spreads. This, too, follows from Proposition 2.

4. *Hypothesis 4:* Countries with higher conditional volatility of output gaps (that is, those that are more prone to larger shocks) will tend to face higher spreads. This follows directly from the lenders' break-even condition, as discussed in Section 2.5.

As these hypotheses have both cross-sectional and time-series implications, an important requirement for their assessment is the existence of long data series on sovereign spreads on a broad cross-country basis, encompassing a number of default events. Such a 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. With this purpose, a major contribution of this paper is to construct a long dataset that incorporates pre-war data.[14] Our sample starts from the early globalization years of the 1870s through the eve of World War II, covering 33 countries for this period. For the post-1990 period the coverage extends to 60 countries and includes two additional variables, debt maturity and denomination, that we use as additional controls in the later sub-sample.

Our theoretical model suggests a reasonably parsimonious empirical specification for the determinants of default risk, comprising six individual variables: an external risk-free interest rate, the ratio of debt to GDP, the ratio of exports to GDP as an indicator of openness to capture the costs of default

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[14]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 that a more diversified group of emerging markets countries began issuing widely-traded bonds in international capital markets. Unlike its pre-war counterpart used in this paper, this post-1990 series does not encompass the whole gamut of developing and developed countries. We discuss the econometric implications of this sample composition below.

(in terms of trade losses and compromised access to trade-related external financing), measures of volatility and persistence of output shocks, and a credit history indicator so as to account for time-varying shifts in default premia. Further, because the default premium interacts with persistence (Hypothesis 2) and potentially also with volatility (as discussed in Section 2.5), the respective interactive terms are included in the regressions.

The two distinct interpretations of our theoretical set up discussed in Section 2.6 call for distinct estimation approaches for the volatility and persistence parameters. Suppose that the trend is deterministic or nearly deterministic but the cyclical component displays considerable persistence. In this case, 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.[15] In this case, stochastic volatility can be gauged by the standard deviations of the respective regression residuals. 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 typically done in the business cycle literature (see Mendoza, 1995; Williamson et al., 2006; Aiolfi et al., 2006).[16]

Alternatively, if we interpret ϵ_1 as a trend shock, the natural approach is the trend-cycle decomposition proposed by Beveridge and Nelson (1981). It consists of modeling 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:

$$\triangle z_t - \mu = [(1 + \theta_1 + \theta_2 + ... + \theta_q)/(1 - \varphi_1 - \varphi_2... - \varphi_p)] \cdot \epsilon_t,$$

where $\triangle z$ stands for trend output growth (measured as the first difference of the log of output), μ represents its deterministic component (drift), ϵ_t is i.i.d. and $N(0, \sigma^2)$. Persistence is measured as $\rho = [(1 + \theta_1 + \theta_2 + ... + \theta_q)/(1 - \varphi_1 - \varphi_2... - \varphi_p)]$, with θ's and φ's being the respective moving average

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[15]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 countries in our sample.

[16]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. Similar rolling window measures are employed when we construct instrumental variables for real GDP as discussed below.

(MA) and autoregressive (AR) parameters of the underlying ARIMA $(p, 1, q)$ regression of the country's real GDP on a constant plus any significant MA(q) and AR(p) terms. The residual of the respective ARIMA regressions are the measure of the output shocks. Clearly, if $\rho = 0$, then the trend is purely deterministic (expanding at a constant rate μ), 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. The theoretically interesting and more realistic case is thus that where $\rho \neq 0$. Note that since in the Beveridge-Nelson (henceforth, 'BN') decomposition ϵ is both a shock to trend and a shock to the purely transient component of output, there is just one single source of shock in this context.[17]

Starting with the HP-filter measure of cyclical persistence, Table 3 spans the pre-WWI era reporting the pooled OLS regressions of the country spread as the left-hand side variable. The country spread is defined as the (average) interest rate on the respective sovereign bonds relative to the benchmark foreign interest rate of similar maturity (the UK consol for the pre-WII period and the US long bond rate later – see Appendix 2). The reported z-statistics are corrected for heterocedasticity (using the standard White estimator) and for country-specific first-order auto-correlation. Debt to GDP, exports to GDP, volatility, and persistence enter the regression with a one-year lag so as to mitigate endogeneity biases.[18] 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.

[Table 3 about here]

Column (1) in Table 3 reports our baseline specification without a default premium term. This specification could be interpreted as testing the

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[17]As can be seen from the above equation, how much the shock ϵ is attributed to the trend vs. to the transient component in the BN decomposition depends on the persistence parameter ρ. In terms of our model, this amounts to assuming that there is just one shock but investors make inferences about ρ. Working, as we did, with two shocks and a common knowledge assumption about ρ facilitates the theoretical exposition and comparative statics. These approach are equivalent empirical strategies based on the BN decomposition.

[18]The external interest rate could be thought of as exogenous for all but two countries in our sample – the US and the UK. However a specifications with r_f lagged one year dominates the specification with contemporaneous r_f.

symmetric information benchmark version of our model (where the default premium is zero), as well as variants found in other studies discussed above. 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.[19] The respective point estimates show that a one percentage point increase in the conditional volatility implies a 15 basis point increase in sovereign spreads, while a 10 percentage point increase in persistence raises spreads by 4 basis points, all else constant. These effects may appear small by the standards of the 1980s or 1990s, but not so in the pre-WWI context when the average spread was about 200 basis points and the cross-country dispersion of spreads was much tighter.[20]

In light of the potential endogeneity problems, column (2) of Table 3 replaces the output gap-based indicators with an instrument. In order to ensure strict exogeneity, and thus stack the deck against the postulated hypotheses, we do not follow the usual approach of including weakly exogenous variables in the regressions creating these instruments; instead, we construct the country-specific instrument for the output gap indicator by regressing the latter of the respective country's terms of trade, the world interest rate, and an indicator of world output growth.[21] To the extent that these three variables are strictly exogenous to individual country spreads, any remaining endogeneity bias is eliminated. The results of this instrumental variable regression clearly indicate the previous results were robust: all coefficients

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[19]The discrepancy may be due to a variety of reasons. Obstfeld and Taylor (2003) do not control for the volatility and persistence effects considered here; our sample has wider country coverage and for four Latin American countries uses GDP indicators that are deemed to be more reliable than the Maddison data used in their study. See Appendix 2 for details.

[20]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), for a discussion of these trends.

[21]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.

retain a very similar order of magnitude of the regressions in column and are statistically significant at 1%.

Column (3) of Table 3 introduces a default history variable. This country-specific credit history indicator gauges how much of the default premium percolates into the country spread. In other words, we now test the extent to which the borrower's action (default vs. repay) helps explain the evolution of spreads over and above the information contained in other fundamentals. Our indicator of default history is defined as the number of years in default since the beginning of the sample, so as to captures this time-dependence. As such, this boost to the spread from the default premium decays over time with successive repayments and bounces back up every time a new default occurs, as entailed by the model.[22] As per Hypothesis 1, we expect this variable to be positively correlated with current spreads and statistically significant. Table 3 shows that this is the case. Its point estimate indicates that a country with a default history at the sample mean (0.08) has its spread boosted by over 40 basis points relative to a country that has never defaulted. Once again, since spreads for the 1870-1913 period averaged some 200 basis points, the effect was substantial. In particular, for those countries in the sample which spent up 30 percent of the time incurring arrears on foreign debt, the default premium could exceed 150 basis points.

Results reported in column (4) of Table 3 gauge the direction and extent to which the persistence and volatility of output interact with the default premium. Consistent with Hypothesis 2, conditional upon default, countries with higher persistence tend to have a higher default premium, boosting the respective country spread by another 25 basis points at mean (0.08*0.032) times the persistence parameter (0.5 on average). In contrast, the negative sign on the interactive volatility variable (default history*volatility) indicates that higher conditional output volatility tends to dampen the default premium. This is consistent with the notion discussed in Section 2.5 that greater dispersion of output shocks tends to reduce the information content of default/repayment actions and hence the default premium. It is also consistent with the idea that higher underlying output volatility makes default more excusable in the sense of Grossman and Van Huyck (1988); so spreads do not rise as much following a default announcement relative to baseline. In other words, even though the net effect of volatility on country spreads remain pos-

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

itive,[23] the asymmetric information mechanism working through the default premium measure appears to be dampening this effect somewhat.

Columns (5) to (9) of Table 3 subject these findings to variety of controls. We start with fixed effects associated with differences between developed countries and less developed ones by introducing a "periphery" dummy, which takes a value one for countries in the periphery and zero otherwise (as in Obtsfeld and Taylor, 2003). The aim is to capture a host of structural characteristics not amenable 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, we should expect this catch-all variable to be significantly related to spreads and possibly weaken somewhat the coefficient on the default history indicator. Our empirical results conforms with the theoretical priors.

We also introduce, as Obstfeld and Taylor (2003) did, an "empire" dummy that indicates if a country was part of the British empire – a catch-all proxy for assurances of greater investors' legal protection and arguably better access to relevant country-specific information. In the context of our model, this dummy can be viewed as both capturing a a potential increase in the recovery rate parameter c, which will tend to lower spreads, and also a proxy for lower information asymmetries. As expected, this dummy takes on the expected negative sign, is highly significant statistically, and its inclusion in the regression lowers somewhat the coefficient on the default history variable.

Exchange rate regimes are often perceived to be related to country risk, so it seems important to examine whether our hypotheses 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 "Gold" dummy (taking on the unit value for those on the gold standard) was introduced. The results reported in column (5) are consistent with the findings of Bordo and Rockoff (1996) as well as Obstfeld and Taylor (2003): membership of the gold standard shaved off some 70 basis points in country spreads, consistent with the view of gold standard membership as a 'good housekeeping seal of approval'. Its main effect in the regression is to lower

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[23]This can be seen by multiplying the point estimate of 0.895 by the mean of the default history variable (0.08) which yields 0.072 which is smaller than the coefficient of the volatility term alone (0.122).

the significance of the openness variable, without substantially affecting the size and statistical significance of the model's variables of interest.

The remaining controls in the regressions are the ratio of foreign currency-denominated external debt to total debt (a proxy for 'original sin', as in IADB, 2006), and terms of trade shock: if large enough, the latter may prompt a country into default along the lines of capacity to pay arguments. Neither of these variables are statistically significant. Nor do their inclusion impact on the proximate magnitude and statistical significance of volatility, persistence, and default premium terms. Overall, the results for the pre-WWI period are very consistent with the model's theoretical priors and provide significant support for the hypotheses laid out above.

Table 4 turns to the interwar 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 a result while the country coverage rises to 25 due to greater availability of output data, the number of observations is nearly half of the pre-WWI sample in Table 3. We follow the same empirical strategy as in Table 3, starting with the symmetric information baseline model, before adding the other variables and controls.

Column (1) in Table 4 indicates that the fit of the baseline model is much poorer than its pre-WWI counterpart. Neither the international risk free rate nor the debt to GDP ratio are statistically significant any longer at conventional levels though both retain their expected theoretical signs. As will be seen below, both features of this baseline regression will change drastically as we bring this stripped-down specification closer to our model. Even without doing so, the volatility and persistence indicators remain both significant at 5% and effect of persistence on spreads is now much larger: a 10 percentage point increase in persistence leads to 14 basis point increase in spreads (as opposed to 4 bps in the pre-WWI sample). Instrumenting both variables out as in column (2) halves the respective coefficients, but both variables remain significant at close to 5%.[24]

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[24]This is partly related to the fact that, as most economies in our sample became closer through international trade and financial linkages, our set of instruments (terms of trade, the world interest rate, and world GDP growth) bore a much weaker correlation with GDP in each country from the 1930s world depression onwards. Yet, once again, we preferred

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Column (3) in Table 4 shows that introducing default history has a major impact on the regression fit and also on the statistical significance of the debt to GDP ratio. This may not appear surprising since there were many defaults during this short period. However, the results signals the presence of a positive and large default premium; the existence of which has previously been disputed in the literature on the inter-War period (Eichengreen and Portes, 1989; Jorgensen and Sachs, 1989). Introducing the interactive term between the default history and persistence also brings out results that clearly support Hypotheses 1 and 3, and consistent with those of the pre-WWI sample.

These results remain basically the same after the introduction of a periphery dummy in column (5). However, once the empire dummy is introduced (column 6), its main effect is to bring down the significance of the default history variable. For the reasons discussed in connection with the pre-WWI regressions, this loss in the significance is not surprising: the empire dummy is also proxying for the existence of asymmetric information between borrowers and lenders and, if anything, differences in credit information and enforcement between empire and non-empire countries appear to have become particularly stark in the inter-war era (Eichengreen and Portes, 1989). Further, this tighter multicollinearity effect between the empire dummy and default history should be expected once we take into account the short time span of the inter-war period. The fact that the overall fit of the regression does not change much after the introduction of the empire dummy corroborates this point. No less importantly, however, the coefficient on the stand-alone default history variable still retains the expected positive sign: its size and effect become stronger when interacted with the persistence indicator (the respective coefficient rising from 0.18 to 0.21). In short, once other controls related to the role of asymmetry of information are introduced in the regression model, the main significant effect of default history on country spreads takes place via its interaction with the persistence parameter. Columns (7) and (8) corroborates these results, showing that they are robust to the inclusion of a gold standard dummy and terms of trade shocks. Column (9)

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to stick to the strictly exogenous instruments as in Table 3 (rather than using weakly exogenous instruments including the export to GDP ratio) so as to stack the deck against our inferences.

drops the empire dummy while leaving in other controls, thus driving home the point about the collinearity effects between the default history history and the empire dummy over the inter-war sample.

Table 5 reports the results for the 1994-2004 period. Despite the wider coverage in terms of number of countries, the number of observations in these regressions is considerably lower than the pre-WWII regressions due to the lack of bond spread data for many emerging markets before the late 1990s/early 2000s. The cross-sectional dimension of these regressions far dominates the time-series dimension. Partly reflecting this, the fit is much higher for the baseline regressions relative to the pre-War samples where the baseline model accounting for about half of variations in country spreads. Once again, the persistence and volatility variables are statistically significant as shown in column (1), so are the other two relevant model-dictated variables - the risk-free US interest rate and the debt-to-GDP ratio. Also consistent with our model, there is evidence of a positive and significant default premium, as shown in column (3). This is so even though the 1994-2004 sample is severely biased toward countries that have defaulted serially in the past (mostly issuers of Brady bonds), excluding all advanced countries that were previously present in the two pre-WWII samples. Regression results reflect these two sample limitations – the very limited time-series dimension and the bias towards countries that with higher output volatility and persistence that have default serially in the past. This can be seen from results in column (4), which indicate substantial multicollinearity between the stand-alone default history variable and its interactive terms with conditional output volatility and persistence. Once the three variables are included in the regression, two of them are statistically insignificant and one of them (default history*persistence) yields the opposite sign. Looking at the underlying raw data, the reason is clear: the correlation coefficients between default history and the two interactive terms are 0.89 and 0.92 respectively. In other words, given the post-1993 sample limitations, not much new information can be drawn from such interactive terms once default history, persistence and volatility are already present in the regression. On this basis, we proceed by keeping the default history variable in the regression alone and gradually introduce new controls.

[Table 5 about here]

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The first control pertains to the inclusion of regional dummies rather than a periphery dummy (given that these regressions encompass a more homogenous group of emerging markets), of which only the dummy for Asia is significant (column 4 of Table 5).[25] In contrast with the pre-WWII regressions, column 5 shows that the exchange rate regime does not matter for emerging market countries. Greater data availability for the post-1993 sample now allows us also to test the effects of debt maturity, terms of trade shocks, and international reserve coverage (as a share of broad money, M2), variables often deemed to be important in explaining financial and currency crises (Kaminsky and Reinhart, 1998). Results reported in columns (6) to (8) show that none of them adds to the model's explanatory power on country risk. Finally, columns (9) and (10) drop the default history variable and enter only the respective interactive terms on volatility and persistence. In contrast with pre-WWII results, the default history*volatility term now yields a positive sign. In contrast, persistence-default history interactive variable yields the model's predicted sign and is statistically significant at 1%. Overall, and taking into account the post-1993 sample limitations, we take the results as broadly consistent with the theoretical model and with Hypotheses 1 to 3.

We conclude this section by presenting a similar set of regressions using the Beveridge-Nelson (BN) measure of the "trend gap". Since the ARIMA estimation is more data intensive and one needs longer data series to evalaute trend volatility and better distinguish between shocks to trend vs. shocks to cycle, we report such results only for the inter-war and the post-1993 samples.[26] Starting with the interwar results in Table 6, two main differences with the HP filter-measures of the output gap is that the coefficient on the stand-alone persistence is of an order of magnitude lower and that of volatility considerably higher. Since both sets of regressions span essentially the same observations, the difference seemingly lies on the BN filter's attribution of

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

[26]Results for the pre-WWI containing less than two-thirds of the observations featuring in Table 3 (which uses the HP-gap) are available from the authors upon request. Even though the data requirements for ARIMA estimation leads us to drop several pre-1900 default events, both the default history and the default history*persistence interactive terms yield the right sign, are statistically significant at 5%, and robust to all controls featuring in Table 3.

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output shocks to trend shocks, raising the persistence measure and hence lowering its estimated coefficient, all else constant. This result carries over to the default history-persistence interactive variable. Aside from this main difference, the results are closely in line with those of Table 4 using the HP-gap. This includes some of the dilution of the stand-alone default history variable when the empire dummy is introduced in the regressions, and the strong significance of default history when interacted with the persistence parameter. As in the HP-filter regressions of Table 4, the model's other main predictions are robust to a variety of controls. Likewise, post-1993 results, presented in Table 7 are very similar with their HP-gap counterparts in Table 5.

[Table 6 and 7 about here]

Overall, we conclude from this section that the default trap pricing mechanism postulated in our model is broadly consistent with long-run data on sovereign bond pricing and macroeconomic determinants. In particular, the roles of credit history and output persistence are generally highly significant and robust to a host of controls, including break-downs by period. Last but not least, our main empirical results are likewise robust to two classic de-trending methods, and not an artifact of HP-filter detrending.

4   Conclusion

History tells us that sovereign creditworthiness displays persistence: countries that default once are more likely to do so again, and face higher spreads as a result. This paper has sought to rationalize this stylized fact through the idea of a default premium. A sovereign's decision to default signals that it was likely hit by a large negative output shock which may 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, and hence the borrower's debt burden relative to output, this mechanism makes future default more likely, thus creating default traps.

Three ingredients are key to make this mechanism operative. First, the existence of asymmetric information between borrowers and lenders on the

nature of output shocks – without it, the default premium is zero and spreads do not react to repayment decisions beyond publicly known information about fundamentals. Second, shocks to the gap between actual and expected output (the "output gap") must be reasonably persistent – without persistence default decisions have no informational content on the evolution of debt burden relative to output. Third, output must be sufficiently volatile, so that countries may face output realizations that are low enough to make default optimal.

While previous studies have examined the impact of output volatility and persistence on country spreads and default risk, none of them has, to the best of our knowledge, linked these ingredients together. As a result, while previous theoretical models show that high conditional volatility and persistence of output shocks alone can explain serial default, they cannot account for why two countries with the same fundamentals (including underlying volatility and persistence of output shocks) may face distinct spreads. In this paper, we show that this may happen if they suffer different output realizations at a given point in time that lead one – struck by an adverse shock – to default and the other to repay. Under asymmetric information, the defaulting country will face higher spreads and hence a heavier debt burden in the future, so it is more likely to default again all else constant. As such, our model delivers path dependence in credit history in a way not discussed in previous work. Further, since default in our model reveals new forward-looking information about debt burdens that supplements publicly-known information about fundamentals, our theoretical mechanism also explains the well-known fact that spreads shoot up following default announcements.

The other main contribution of this paper is empirical. Empirical testing of previous theoretical models of default risk has employed more limited data sets than ours. To test the postulated theoretical mechanism, this paper develops a comprehensive cross-country dataset spanning over a century. This is important because default history and the causal mechanisms postulated in our model display significant cross-country differences (due to institutions, commodity specialization, etc.) which are typically structural and hence slowly-evolving; so it is key that a thorough test of the theory be based on a broad cross-country sample with a reasonably long time series dimension.

Three findings consistently stand out across the main sub-periods (pre-World War I, inter-War, and post-1990 years). First, countries that face higher spreads are typically the ones displaying higher conditional volatil-

ity and persistence of output gaps. Second, countries face a substantially positive and statistically significant default premium. Third, such a default premium is rising in the underlying persistence of output shocks. These results are robust to a host of controls featuring in previous studies. They are also very robust to measures of output volatility and persistence based on distinct detrending methods. We interpret this empirical findings as strong evidence that the default trap mechanism postulated in our model is consistent with long-run data on sovereign bond pricing and the macroeconomic determinants. As such, our model provides an additional and complementary mechanism to those postulated in earlier work on the pervasiveness of serial default and "debt intolerance" (Reinhart et al., 2003). On the empirical side, our historical evidence also highlights the important role of historical output volatility and persistence indicators in country spread regressions, particularly for pre-WWII period where the inclusion of these variables has been regrettably absent in previous work.

Some practical implications follow. Plainly, the above results highlight the importance of reforming institutions and changing policy frameworks that typically make many emerging markets slower in recovering from large negative shocks. The above results also suggest that countries with higher underlying dispersion of temporary shocks are more vulnerable to sheer "bad luck" in output realizations. Given that such bad luck can give rise to default traps, two other implications follow. The most obvious is to place special emphasis on the need to mitigated volatile policies and financial structures that exacerbate output volatility in emerging markets. The other is that it may pay off to go an extra mile to ensure debt repayment during bad times - this effort being the more worthwhile the greater the existing asymmetry information about country-specific fundamentals. That said, and insofar as some asymmetry remains and bad luck in output realizations continue play a role, it may also 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. If so, a worthwhile issue for future empirical research is to establish how some countries have managed to get out from default traps in practice.

References

1. Acemoglu D., S. Johnson and J. Robinson, 2005, "Institutions as the Fundamental Cause of Long-Run Growth," in P. Aghion and S. Durlauf (eds.), Handbook of Economic Growth, North Holland: Amsterdam.

2. Aguiar, M. and G. Gopinath, 2006, "Defaultable Debt, Interest Rates and the Current Account," Journal of International Economics, 69(1), 61-89.

3. Aguiar, M. and G. Gopinath, 2007, "Emerging Market Business Cycles: The Cycle is the Trend," Journal of Political Economy, 115(1), 69-102

4. Aiolfi, M., L. Catão, and A. Timmermann, 2006, "Common Factors in Latin America's Business Cycles," IMF working paper 6/49.

5. Alfaro, L., and F. Kanczuk, 2005, "Sovereign Debt as a Contingent Claim: A Quantitative Approach," Journal of International Economics, 65, 297-314.

6. Arellano, C., 2006, "Default Risk and Income Fluctuations in Emerging Economies," mimeo, University of Minnesota.

7. Beveridge, S. and C. Nelson, 1981, "A New Approach to Decomposition of Economic Time Series into Permanent and Transitory Components," Journal of Monetary Economics, 7, 151-74.

8. Blattman, C., J. Hwang, and J. Williamson, 2007, "Winners and Losers in the Commodity Lottery: The Impact of Trade Growth and Volatility in the Periphery 1870-1939," 82(1), 156-179.

9. Bordo, M. and H. Rockoff, 1996, "The Gold Standard as a 'Good Housekeeping Seal of Approval'," Journal of Economic History, 56, 389-428.

10. Bulow, J. and K. Rogoff, 1989, "A Constant Recontracting Model of Sovereign Debt," Journal of Political Economy, 97, 155-78.

11. Calvo, G,, 2000, "Balance of Payments Crises in Emerging Markets: Large Capital Flows and Sovereign Governments," in Paul Krugman (ed.), Currency Crises, Chicago.

12. Calvo, G., and C. Vegh, 1999, "Inflation Stabilization and BOP Crises in Developing Countries," in John Taylor and Michael Woodford (eds.), Handbook of Macroeconomics, Volume C, North Holland, Amsterdam.

13. Calvo, G., and E. Mendoza, 2000, "Capital Markets Crises and Economic Collapse in Emerging Markets: An Informational Frictions Approach," American Economic Review, Papers and Proceedings, March.

14. Cashin, P., Liang, H. and McDermott, C. John, 2000, "How Persistent are Shocks to World Commodity Prices?," IMF Staff Papers, 47, 177-217.

15. Catão, L., 2007, "Sudden Stops and Currency Drops: A Historical Look" in S. Edwards (ed.), The Decline of Latin American Economies: Growth, Institutions and Crises, University of Chicago Press.

16. Catão, L. and S. Kapur, 2006, "Volatility and the Debt Intolerance Paradox," IMF Staff Papers, 56, 195-218.

17. Cohen, D., 1992, "Debt Crisis: A Post-Mortem," NBER Macroeconomics Annual, National Bureau of Economic Research, Cambridge: Mass.

18. D'Erasmo, P., 2007, "Government Reputation and Debt Repayment in Emerging Economies," mimeo, University of Texas at Austin.

19. Eaton, J., 1996, "Sovereign Debt, Reputation, and Credit Terms," International Journal of Finance and Economics, 1, 25-36.

20. Eaton, J., and M. Gersovitz, 1981, "Debt with Potential Repudiation: Theoretical and Empirical Analysis," Review of Economics and Statistics, 48, 284-309.

21. Eaton, J., and M. Gersovitz, 1995, "Some Curious Properties of a Familiar Model of Debt and Default," Economic Letters, 63, 367-371.

22. Eichengreen, B., and R. Portes, 1986, "Debt and Default in the 1930s: Causes and Consequences," European Economic Review, 30, 599-640.

23. Eichengreen, B., R. Hausmann, and U. Panizza, 2003, "Currency Mismatches, Debt Intolerance and Original Sin: Why They Are Not the Same and Why it Matters," NBER working paper 10036.

24. Flandreau, M. and F. Zumer, 2004, The Making of Global Finance 1880-1913, Paris: OECD.

25. Fostel, A., 2005, "A Supply Story: Emerging Markets, High Yield and Primary Market Closures," Yale University PhD dissertation.

26. Gavin, M., and R. Perotti, 1997, "Fiscal Policy in Latin America," NBER Macroeconomics Annual, 11-61 (Cambridge, Mass.: National Bureau of Economic Research).

27. Gelos, G., R. Sahay and G. Sandleris, 2004, "Sovereign Borrowing by Developing Countries: What Determines Market Access?," IMF Working Paper No. 04/221.

28. Grossman, H. and J. Van Huyck, 1988, "Sovereign Debt as a Contingent Claim: Excusable Default, Repudiation, and Reputation," American Economic Review, 78, 1088-1097.

29. Guidotti, P., F. Sturzeneger, and A. Villar, 2004, "On the Consequence of Sudden Stops," Economia 4(2), 171-203.

30. Inter-American Development Bank, 2006, Living with Debt. How to Limit the Risks of Sovereign Finance, Washington DC.

31. Jorgensen, E., and J. Sachs, 1989, "Default and Renegotiation of Latin American Foreign Bonds in the Interwar Period," in Barry Eichengreen and Lindert (eds.), 1989, The International Debt Crisis in Historical Perspective, (Cambridge, Massachusetts: MIT press), 48-85.

32. Kaminsky, G., C. Reinhart, and C. Vegh, 2004, "When It Rains, It Pours: Pro-Cyclical Capital Flows and Macroeconomic Policies," National Bureau of Economic Research (NBER), Working Paper No. 10780.

33. Kaminsky, G. and C. Reinhart, 1999, "The Twin Crises: Causes of Banking and Balance of Payments Problems," American Economic Review, 89(3), 473-500.

34. Kletzer, K., 1984, "Asymmetry of Information and LDC Borrowing with Sovereign Risk," Economic Journal, 94, 287-307.

35. Kletzer, K., and B. Wright, 2000, "Sovereign Debt as Intertemporal Barter," American Economic Association, 90(3), 621-639.

36. Kose, A., E. Prasad and M. Terrones, 2006, "How do Trade and Financial Integration affect the Relationship between Growth and Volatility," Journal of International Economics, 69, 176-202.

37. Levy-Yeyati, E. and U. Panizza, 2006, "The Elusive Cost of Sovereign Default," CIF Working Paper No. 10/2006.

38. Lindert, P.H., and P.J. Morton, 1989, "How Sovereign Debt has Worked," in Jeffrey Sachs (ed.), Developing Country Debt and the World Economy, (Chicago: National Bureau of Economic Research).

39. Mendoza, E., 1995, "Terms of Trade, the Real Exchange Rate, and Economic Fluctuations," International Economic Review, 36, 101-137.

40. Mendoza, E., 2006, "Endogenous Sudden Stops in a Business Cycle Model with Collateral Constraints: A Fisherian Deflation of Tobin's Q," mimeo.

41. Mendoza, E., and V. Yue, 2007, "Solving the Country Risk-Business Cycle Disconnect: Endogenous Output Dynamics in a Model of Sovereign Default," mimeo.

42. Obstfeld, M., and K. Rogoff, 1996, Foundations of International Macroeconomics, MIT Press: Cambridge, Mass.

43. Obstfeld, M. and A. Taylor, 2003, "Sovereign Risk, Credibility and the Gold Standard: 1870-1913 versus 1925-31," Economic Journal, 113, 1-35.

44. Ozler, S., 1993, "Have Commercial Banks Ignored History," American Economic Review, 83, 608-20.

45. Sachs, J. and D. Cohen, 1985, "LDC Borrowing with Default Risk," Kredit und Kapital, 211-35.

46. Reinhart, C.M., K. Rogoff, and M. Savastano, 2003, "Debt Intolerance," NBER Working Paper 9908, National Bureau of Economic Research: Cambridge, Mass.).

47. Rose, A. and M. Spiegel, 2004, "A Gravity Model of Sovereign Lending: Trade, Default and Credit," IMF Staff Papers, 51 (Special Issue), 64-74.

48. Sandleris, G., 2006, "Sovereign Defaults: Information, Investment and Credit," mimeo, Johns Hopkins University.

49. Sturzenegger F., Zettelmeyer J., 2006, "Debt Defaults and Lessons from a Decade of Crises," MIT Press: Cambridge, Mass.

50. Uribe, M. and V. Yue, 2006, "Country Spreads and Emerging Countries: Who drives whom?," Journal of International Economics, 69(1), 6-36.

Appendix 1

Proof of Proposition 1

The proof establishes that the strategies are optimal given beliefs and other player's strategy and beliefs are consistent with observed choices. Step 1 begins by assuming the the optimality of the borrower's repayment choice in period 1, and establishes the optimality of subsequent choices. Step 2 confirms the optimality of period-1 repayment decision rule.

Step 1. Assume that the borrower's decision rule at $t = 1$ is to repay if and only if ϵ_1 exceeds some arbitrary threshold e_1, that is, if $\epsilon_1 \geq e_1$. At $t = 2$, contingent on history h, with repayment obligation D_2^h, the borrowers's net payoff to repayment is $\tilde{Y}_2 - D_2^h$, while sanctions and partial recovery of debt following default leave it with $(1-s)\tilde{Y}_2 - cD_2^h$. Clearly, in period 2 repayment is rational if and only if $\tilde{Y}_2 \geq [(1 - c)/s]D_2^h \equiv Y_{2h}^*$.

If the lender believes, as assumed above, that the borrower repays iff $\epsilon_1 \geq e_1$, it updates its prior beliefs $\Phi(\epsilon_1)$ as follows. Default signals that the persistent shock was drawn from the lower tail of the distribution, truncated at e_1 so that the posterior density function is given by

$$\gamma_d(\epsilon_1|e_1) = \begin{cases} \frac{\phi(\epsilon_1)}{\Phi(e_1)} & \text{for } \epsilon_1 < e_1 \\ 0 & \text{for } \epsilon_1 \geq e_1 \end{cases}$$

If instead, lenders observe repayment

$$\gamma_r(\epsilon_1|e_1) = \begin{cases} 0 & \text{for } \epsilon_1 < e_1 \\ \frac{\phi(\epsilon_1)}{1-\Phi(e_1)} & \text{for } \epsilon_1 \geq e_1 \end{cases}$$

Let $\Gamma_h(\epsilon_1|e_1)$ denote the associated cumulative distribution functions. Observe that $\Gamma_d(\epsilon_1|e_1) = \Phi(\epsilon_1)/\Phi(e_1)$ is decreasing in e_1, while $\Gamma_r(\epsilon_1|e_1) = \Phi(\epsilon_1)/(1 - \Phi(e_1))$ is increasing in e_1. This difference will matter for our results.

The lender's strategy at $t = 0$ is to set a price that allows it to break even given the probability of default $\Phi(e_1)$. Its strategy at $t = 1$ depends on the expected default probabilities, which in turn depend on beliefs about future output consistent with posterior distributions over the persistent shock. Given distributions $G_h(\tilde{Y}_2|e_1)$ (over period-2 output) consistent with the above posteriors and given the borrowers period-2 default rule, we

have $\pi_2^h(e_1) = G_h((\frac{1-c}{s})D_2^h|e_1)$. Substituting in equation (3), which specifies the investment requirement in period 1, the bond issue D_2^h must satisfy

$$[1 - (1-c)\pi_2^h(D_2^h)]D_2^h = R_f I_1. \tag{12}$$

Some useful properties follow directly from the Bayesian updating rule.

Lemma 1 *The default premium is positive.*

To see why note that, given persistence, $G_r(\cdot)$, the distribution of period-2 output conditional on repayment, dominates $G_d(\cdot)$ in the first-order stochastic sense.[27] This implies $\pi_2^r(D_2) < \pi_2^d(D_2)$ for any given D_2. From (12) it follows that $D_2^d > D_2^r$. As default probabilities are increasing in the amount borrowed, we must have $\pi_2^r(D_2^r) < \pi_2^d(D_2^d)$. Finally, using equations (5) and (6), it follows that bond prices are lower contingent on default ($p_1^d < p_1^r$), or equivalently the default premium $i^d - i^r$ is positive.

Lemma 2 D_2^d *is decreasing in e_1 while D_2^r is increasing in e_1.*

Note that D_2^h depends on e_1 as this conditions Γ_h and, through that, G_h. Observe that $\Gamma_d(\cdot|e_1') \leq \Gamma_d(\cdot|e_1)$ for $e_1' > e_1$ and so also $G_d(\cdot|e_1') \leq G_d(\cdot|e_1)$. This implies π_2^d is decreasing in e_1 and consequently D_2^d is decreasing too. In contrast, for $e_1' > e_1$ the distribution $\Gamma_r(\cdot|e_1') \geq \Gamma_r(\cdot|e_1)$, and so also $G_r(\cdot|e_1') \geq G_r(\cdot|e_1)$: this implies that π_2^r and D_2^r are increasing in e_1.

Step 2. We now establish the existence of an e_1^* consistent with Step 1, and the optimality of the borrower's repayment decision rule in period 1. Consider any arbitrary threshold e_1 such that the borrower defaults in period 1 if $\epsilon_1 < e_1$. The continuation payoff following action h for realization ϵ_1 is

$$V_2^h(\epsilon_1, e_1) = \int \max[\tilde{Y}_2 - D_2^h, (1-s)\tilde{Y}_2 - cD_2^h]dF_{|\epsilon_1}(\tilde{Y}_2). \tag{13}$$

Note that V_2^h depends on ϵ_1 (as borrowers condition the distribution $F_{|\epsilon_1}(\tilde{Y}_2)$) of future income on the known realization of the persistent shock) and on the threshold for default e_1 (as this affects D_2^h). When choosing h in period 1, the borrower takes into account the immediate payoff and the discounted value of the continuation payoff, V_2^h. Thus repayment has payoff

$$V_1^r(\epsilon_1, e_1) = (\tilde{Y}_1 - D_1) + \beta V_2^r(\epsilon_1, e_1), \tag{14}$$

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[27]A distribution $A(x)$ is said to dominate distribution $B(x)$ in the first-order stochastic sense if $A(x) < B(x)$ for all x.

while default has payoff

$$V_1^d(\epsilon_1, e_1) = (\tilde{Y}_1 - cD_1) + \beta V_2^d(\epsilon_1, e_1). \tag{15}$$

Define $g(\epsilon_1, e_1) = V_1^r - V_1^d = \beta[V_2^r(\epsilon_1, e_1) - V_2^d(\epsilon_1, e_1)] - (1-c)D_1(e_1)$. Note that $\beta[V_2^r(\epsilon_1, e_1) - V_2^d(\epsilon_1, e_1)]$ represents the gains from repayment in terms of future financial savings (given a positive default premium). On the other hand $(1-c)D_1(e_1)$ represents the gains from default in terms of current savings. To prove the optimality of the borrower's strategy we show that (i) $g(\epsilon_1, e_1)$ is increasing in its first argument, ϵ_1; (ii) there exists an e_1^* such that $g(e_1^*, e_1^*) = 0$. Together these imply that $g(\epsilon_1, e_1^*) \geq 0$ for $\epsilon_1 \geq e_1^*$, so that $\beta[V_2^r(\epsilon_1, e_1) - V_2^d(\epsilon_1, e_1) \geq (1-c)D_1(e_1)$. That is, it is rational to repay iff $\epsilon_1 \geq e_1^*$.

(i) As $(1-c)D_1(e_1)$ does not vary with ϵ_1, it is sufficient to show that $\beta[V_2^r(\epsilon_1, e_1) - V_2^d(\epsilon_1, e_1)]$ is increasing in ϵ_1. Consider the following partition of the support of $\tilde{Y}_2$, conditional on ϵ_1. Define $E_L = \{\tilde{Y}_2 : \tilde{Y}_2 < Y_{2r}^*\}$ as the set of realizations of future output for which the borrower will default in period 2 regardless of previous history; for $E_H = \{\tilde{Y}_2 : \tilde{Y}_2 \geq Y_{2d}^*\}$, the borrower repays regardless of default history, and $E_M = \{\tilde{Y}_2 : Y_{2r}^* \leq \tilde{Y}_2 < Y_{2d}^*\}$, the realization in which prior repayment induces future repayment and prior default induces future default. Evaluating $\beta[V_2^r - V_2^d]$ in each element of this partition, we obtain

$$\beta\left[\int_{E_L} c[D_2^d - D_2^r]dF + \int_{E_M} [s\tilde{Y}_2 + cD_2^d - D_2^r]dF + \int_{E_H} [D_2^d - D_2^r]dF\right]$$

$F_{|\epsilon_1}(\cdot)$ is increasing in ϵ_1. Further, each of the integrands in the above expression is positive and increasing. Since the default premium is positive with fixed borrowing needs we have that $D_2^d - D_2^r > 0$. Finally, notice that $\tilde{Y}_2 - D_2^r > (1-s)\tilde{Y}_2 - cD_2^r > (1-s)\tilde{Y}_2 - cD_2^d$, hence the integrand in the middle region is also positive. This proves that $g(\epsilon_1, e_1)$ in increasing in ϵ_1.

(ii) We prove the existence of an e_1^* such that $g(e_1^*, e_1^*) = 0$ in three steps.

(ii.a) The immediate gain from default, $(1-c)D_1(e_1)$, is increasing in e_1. It is bounded below by $(1-c)R_f I_0$ (when the probability of default tends

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to zero) and from above by $((1-c)/c)R_f I_0$ (when default is almost sure event). This follows from equation (8).

(ii.b) The future gain from repayment, $\beta[V_2^r(\epsilon_1, e_1) - V_2^d(\epsilon_1, e_1)]$ is decreasing in e_1. First, observe that, from by definition (13), $V_2^h(\epsilon_1, e_1)$ is decreasing in D_2^h. Next, by Lemma 2, D_2^d is decreasing in e_1 while D_2^r is increasing in e_1. Combining these two, we have V_2^r decreasing in e_1 and V_2^d increasing in e_1, so $\beta[V_2^r - V_2^d]$ is decreasing in e_1.

(ii.c) Since the functions $(1-c)D_1(e_1)$ and $\beta[V_2^r(\epsilon_1, e_1) - V_2^d(\epsilon_1, e_1)]$ are continuous, a value e_1^* exists provided only that that β is not too low relative to other parameters.[28]

Proof of Proposition 2

For any given e_1 an increase in ρ increases the informational value of default. To see why note that the lender's distribution $G_d(\tilde{Y}_2^d; \rho)$, written as a function of ρ satisfies the following property: $G_d(\tilde{Y}_2^d; \rho) \geq G_d(\tilde{Y}_2^d; \rho')$ for $\rho > \rho'$. In words, observed default in period 1 leads to greater pessimism about future returns to bondholders for $\rho' > \rho$. This implies a higher π_2^d, so required D_2^d is increasing in ρ. On the other hand, $G_r(\tilde{Y}_2^r; \rho) \leq G_r(\tilde{Y}_2^r; \rho')$ for $\rho > \rho'$, so that π_2^r and D_2^r are decreasing in ρ: Observed repayment suggests a more optimistic outlook for future repayments. Thus, for given e_1, a higher value of ρ is associated with a higher $\beta[V_2^r(\epsilon_1, e_1) - V_2^d(\epsilon_1, e_1)]$. Finally, remember that by definition (13) $V_2^h(\epsilon_1, e_1)$ is decreasing in D_2^h, and that from equation (3), D_2^h is decreasing in p_1^h. All these facts together imply that an increase in ρ generates an increase in the default premium as stated.

From the above argument an increase in ρ implies that at the equilibrium e_1^* the gain from repayment exceeds the gain from default. Given that the gain from default, $(1-c)D_1(e_1)$, is increasing in e_1, in order to restore equilibrium, the equilibrium threshold e_1^* must rise. The probability of default in period 1, given by $\Phi(e_1^*)$ rises as well. By the break-even condition, this implies that sovereign spreads in period 0 must rise.

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[28]For an 'interior' solution to exist, informational content from default should be sufficiently valuable – this is the case when future investment needs I_1 are large relative to I_0. Our simulations, not reported here, suggest that equilbria can be found for a plausible range of parameters.

Appendix 2: Data and Sources

Pre-World War II data

Our pre-WWII sample spans 32 countries: Australia, India, Japan, and New Zealand in Asia; Egypt in Africa; Argentina, Brazil, Chile, Mexico, Peru, Venezuela, Uruguay in Latin America; Canada and the US in North America; Austria (including the Austro-Hungarian Empire before 1914), Belgium, Denmark, Finland, France, Germany, Greece, Hungary (after WWI), Italy, Netherlands, Norway, Portugal, Spain, Russia, Serbia, Sweden, United Kingdom, and Turkey.

Sovereign Bond Yields and Spreads. Bond yields on long-maturity sterling denominated bonds were taken from Obstfeld and Taylor (2003) for all countries except for Peru, Venezuela, Hungary, and Yugoslavia. Pre-WWI data for Peru and Venezuela are from Kelly, Trish "Ability and Willingness to Pay in the Age of Pax Britannica, 1890-1914," *Explorations in Economic History*, 1998, 35, 31-58, and were kindly provided by the author. Interwar data for all four countries were compiled from the League of Nations, *Statistical Yearbook*, Geneva, several issues. Country spreads calculated as the difference between the respective country's bond yields and the yield on UK consols, the latter taken from Holmer, Sidney and Richard Sillas, 1996, *A History of Interest Rates*, Rutgers. From the latter source also comes our two measures of the short-term world interest rate, i^*, used in the regressions (The UK discount rate on short-term commercial paper) which we deflated by the UK wholesale price index provided in Mitchell, Brian, 2005, *International Historical Statistics: Europe*, London.

GDP. Real GDP data are from Maddison, Angus, *The World Economy: Historical Statistics*, Paris, 2003 except in the following cases:

- Argentina, Brazil, Chile and Mexico: from Aiolfi, Catão, and Timmermann (2006), who present a variety of robustness tests to show that their estimates are superior to those provided by Maddison.

- Greece: new estimates provided by George Kostelenos, based on his earlier research (*Money and Output in Modern Greece, 1858-1938*, Athens, 1995).

- Russia: the net national product estimate from Paul Gregory, *Russian National Income, 1885-1913* (Cambridge: Cambridge University Press, 1983), Table 3.1, 56-7, ("variant 1").

- Spain: Prados de la Escosura, Leandro 2003, *El Progreso Economico de España, 1850-2000* (Madrid: Fundacin BBVA), Table A. 9.1 and A.13.5, pp. 517-22 and 681-82.

- Venezuela: Baptista, Asdrúbal, 1997, *Bases Cuantitativas de la Economia Venezolana, 1830-1995*, Caracas.

Nominal GDP from Obsfeld and Taylor (2003) except for the above countries (sources as above), New Zealand (from Rankin, Keith, 1992, New Zealand's Gross National Product, Review of Income and Wealth, 38(1), 49-6), and for Hungary and Yugoslavia (from Mitchell, Brian, 2003, *International Historical Statistics: Europe*, New York).

Public Debt

- Argentina, Brazil, Chile and Mexico: from Aiolfi et al. (2006).

- Peru and Venezuela: Kelly (1998) and League of Nations, op. cit., several issues.

- Greece: Lazaretou, Sophia, 1993, "Monetary and Fiscal Policies in Greece: 1833-1914", *Journal of European Economic History*, 22, 2.

- Venezuela: Baptista, Asdrúbal, 1997, op cit.

- All other countries from Obstfeld and Taylor (2003), Flandreau and Zumer (2004), and the League of Nations, op. cit., several issues. The last two sources provide a breakdown between domestic and foreign currency debt.

Foreign Trade

- Export values from Brian Mitchell's *International Historical Statistics: The Americas, Asia and Oceania, and Europe*, London.

- Terms of Trade from Blattman, C, J Hwang, and J Williamson, 2006, "How do Trade and Financial Integration affect the Relationship between Growth and Volatility", *Journal of International Economics*, 69, 176-202, kindly provided by the authors. Exceptionally, the series for Argentina, Brazil, Chile and Mexico are from Aiolfi et al. (2006).

Post-World War II data

Our post-WWII includes all countries of the pre-WWII sample except for Serbia, and adds the following 29 countries: Botswana, Gabon, Jordan, Morocco, Oman, South Africa; China, Indonesia, Korea, Malaysia, Pakistan, Philippines, Singapore, Thailand; Bolivia, Colombia, Costa Rica, Dominican Republic, El Salvador, Guatemala, Jamaica, Panama, Paraguay; Bulgaria, Czech Republic, Poland, Romania; Iceland, and Switzerland.

Sovereign Bond Yields and Spreads. JP Morgan Emerging Market Bond Index (EMBI). Our measure of the world risk-free interest rate, r_f, is the 3-month US T-Bill rate taken from IMF's International Financial Statistics (IFS) and deflated by the US WPI provided in the same source.

GDP. International Financial Statistics.

Public Debt and other Fiscal Data. Luis A.V. Catão and Marco E. Terrones, 2005, "Fiscal Deficits and Inflation, *Journal of Monetary Economics*, 52, 529-554. Updated through 2005 using data from the IFS, IMF's World Economic Outlook (WEO), and the World Bank's Global Development database (GDD).

Foreign Trade, International Reserves, Real Exchange Rates, and Monetary Aggregates. IFS, WEO, and GDD.
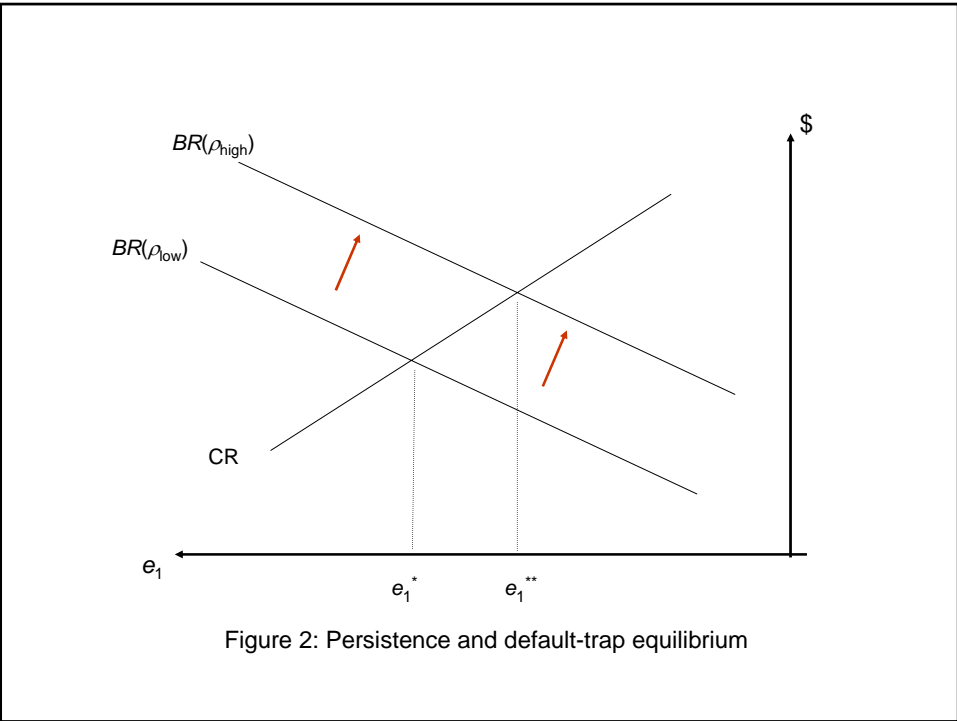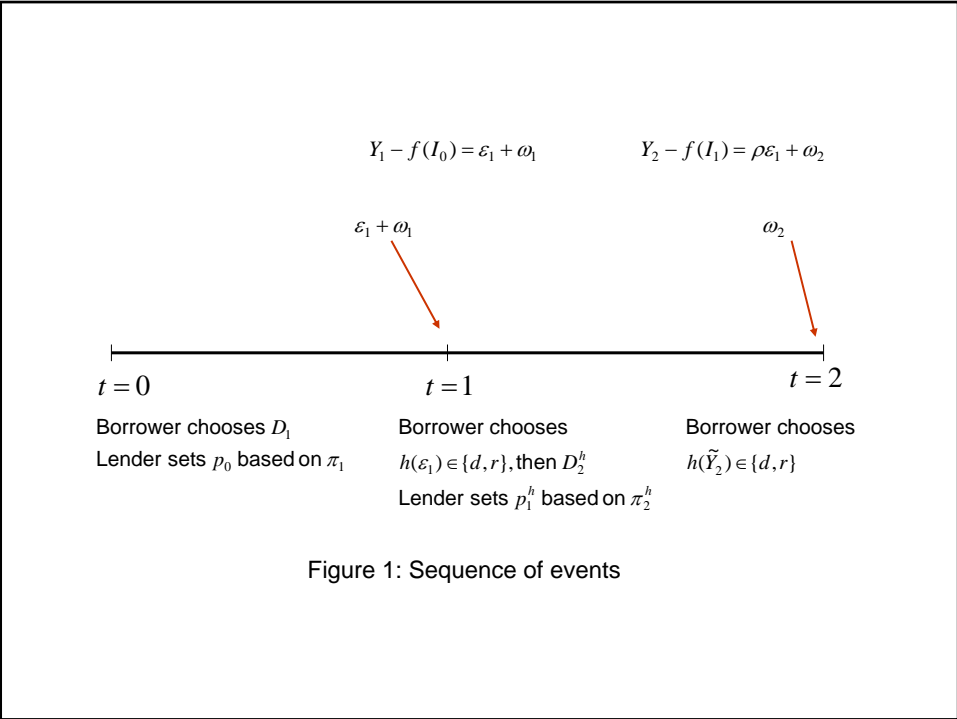
$$Y_1 - f(I_0) = \varepsilon_1 + \omega_1 \qquad\qquad Y_2 - f(I_1) = \rho\varepsilon_1 + \omega_2$$

$\varepsilon_1 + \omega_1$ $\qquad\qquad\qquad\qquad\qquad\qquad$ ω_2

$t = 0$ $\qquad\qquad\qquad\qquad$ $t = 1$ $\qquad\qquad\qquad\qquad$ $t = 2$

Borrower chooses D_1 $\qquad$ Borrower chooses $\qquad\qquad$ Borrower chooses

Lender sets p_0 based on π_1 $\quad$ $h(\varepsilon_1) \in \{d, r\}$, then D_2^h $\qquad$ $h(\widetilde{Y}_2) \in \{d, r\}$

$\qquad\qquad\qquad\qquad\qquad$ Lender sets p_1^h based on π_2^h

Figure 1: Sequence of events

\$

$BR(\rho_{\text{high}})$

$BR(\rho_{\text{low}})$

CR

e_1

e_1^{*} $\qquad$ e_1^{**}

Figure 2: Persistence and default-trap equilibrium

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

| | 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)
Latin America	1.4	0.057	0.662	0.056	0.659	0.7	0.091	0.582	0.056	0.554
Asia	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 Repayment Records

(in deviations from HP trend, group medians)

1960-2004

		Incl. Defaults			Excl. Defaults	
	Def. Freq.	Std. Dev.	AR(1)		Std. Dev.	AR(1)
Latin America	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
HP-filter measures of the output gap.

	1	2	3	4	5	6	7	8	9
UK real interest rate	0.013 (2.43)**	0.011 (2.62)***	0.012 (2.38)**	0.012 (2.38)**	0.013 (2.40)**	0.014 (2.41)**	0.013 (2.36)**	0.013 (2.32)**	0.013 (2.30)**
Debt/GDP	0.01 (13.06)***	0.015 (22.17)***	0.012 (12.14)***	0.012 (13.26)***	0.013 (15.17)***	0.011 (12.42)***	0.011 (14.25)***	0.011 (14.23)***	0.011 (14.35)***
Export/GDP	-0.005 (-2.05)**	-0.011 (-8.09)***	-0.011 (-3.37)***	-0.01 (-2.99)***	-0.011 (-3.38)***	-0.01 (-3.48)***	-0.003 (-1.06)	-0.003 (-1.11)	-0.002 (-0.73)
Volatility	0.151 (9.52)***		0.109 (6.52)***	0.122 (6.47)***	0.116 (5.97)***	0.127 (6.48)***	0.149 (7.36)***	0.149 (7.41)***	0.148 (7.72)***
Persistence	0.004 (5.63)***		0.003 (3.14)***	0.002 (2.47)**	0.002 (2.80)***	0.003 (3.93)***	0.003 (2.68)***	0.003 (2.65)***	0.003 (2.93)***
Volatility instrument		0.18 (5.57)***							
Persistence instrument		0.004 (4.12)***							
Default history			0.059 (9.91)***	0.065 (6.44)***	0.061 (6.15)***	0.046 (4.11)***	0.021 (2.69)***	0.021 (2.62)***	0.022 (2.73)***
Default history * volatility				-0.895 (-3.80)***	-0.892 (-3.98)***	-0.983 (-4.00)***	-0.831 (-3.77)***	-0.816 (-3.65)***	-0.861 (-3.71)***
Default history * persistence				0.032 (3.67)***	0.032 (3.57)***	0.033 (3.82)***	0.033 (3.57)***	0.033 (3.56)***	0.031 (3.38)***
Periphery dummy					0.014 (8.52)***	0.019 (10.22)***	0.016 (9.54)***	0.015 (9.39)***	0.016 (7.07)***
Empire dummy						-0.017 (-15.59)***	-0.014 (-14.18)***	-0.014 (-14.10)***	-0.015 (-15.32)***
Gold Standard dummy							-0.007 (-14.20)***	-0.007 (-14.06)***	-0.007 (-11.77)***
Terms of Trade[1]								0.001 (0.58)	
External Debt/Total Debt									0.001 (0.57)
Observations	619	598	570	570	570	570	570	570	567
Number of countries	23	22	21	21	21	21	21	21	21
R-squared	0.24	0.23	0.27	0.28	0.28	0.31	0.35	0.35	0.35

Robust z-statistics in parentheses with all regressions adjusted for country-specific autocorrelation. The 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.
1. Measured as deviation from trend.
* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 4. Determinants of Sovereign Spreads: 1925-1939
HP-filter measures of the output gap.

	1	2	3	4	5	6	7	8	9
UK real interest rate	0.005 (0.53)	0.005 (0.66)	0.006 (0.69)	0.005 (0.58)	0.006 (0.77)	0.007 (0.81)	0.009 (1.29)	0.011 (1.61)	0.01 (1.45)
Debt/GDP	0.004 (1.54)	0.001 (0.23)	0.008 (5.44)***	0.009 (7.00)***	0.009 (7.02)***	0.01 (4.84)***	0.01 (5.79)**	0.011 (4.99)***	0.009 (5.80)***
Export/GDP	-0.057 (-4.61)***	-0.051 (-3.97)***	-0.039 (-4.99)***	-0.04 (-5.02)***	-0.032 (-3.83)***	-0.034 (-3.10)***	-0.023 (-2.82)**	-0.021 (-2.26)**	-0.016 (-2.08)**
Volatility	0.333 (3.93)***		0.187 (4.19)***	0.305 (4.02)***	0.355 (5.25)***	0.186 (2.30)**	0.139 (2.18)**	0.174 (2.38)**	0.309 (5.56)***
Persistence	0.014 (2.20)**		0.009 (2.61)***	0.01 (3.28)***	0.013 (3.57)***	0.009 (2.30)**	0.009 (2.24)**	0.01 (2.27)**	0.011 (2.94)***
Volatility instrument		0.168 (2.95)***							
Persistence instrument		0.007 (1.81)*							
Default history			0.099 (18.70)***	0.192 (3.16)***	0.183 (3.02)***	0.067 (1.18)	0.062 (0.99)	0.064 (1)	0.163 (2.44)**
Default history * volatility				-3.447 (-3.49)***	-3.315 (-3.21)***	-2.07 (-1.96)**	-2.003 (-1.96)**	-2.019 (-1.95)*	-3.311 (-3.21)***
Default history * persistence				0.183 (3.25)***	0.177 (3.27)***	0.205 (3.66)***	0.202 (3.42)***	0.2 (3.40)***	0.196 (3.35)***
Periphery dummy					0.004 (2.91)***	0.013 (3.21)***	0.012 (3.66)***	0.012 (3.41)***	0.006 (3.95)***
Empire dummy						-0.013 (-3.14)***	-0.013 (-4.00)***	-0.011 (-3.36)***	-0.011 (-3.36)***
Gold Standard dummy							-0.007 (-6.63)***	-0.007 (-6.69)***	-0.007 (-6.97)***
Terms of Trade[1]								0.002 (0.89)	-0.007
Observations	305	305	305	305	305	305	305	295	305
Number of countries	25	25	25	25	25	25	25	24	25
R-squared	0.12	0.11	0.62	0.64	0.65	0.65	0.69	0.69	0.68

Robust z-statistics in parentheses with all regressions adjusted for country-specific autocorrelation. The 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.

1. Measured as deviation from trend.

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

Table 5. Determinants of Sovereign Spreads: 1994-2004

HP Filter measures of the output gap.

	1	2	3	4	5	6	7	8	9	10
US real interest rate	0.161 (2.14)**	0.161 (2.26)**	0.177 (2.33)**	0.175 (2.30)**	0.175 (2.24)**	0.178 (2.22)**	0.168 (2.26)**	0.172 (2.39)**	0.163 (2.19)**	0.173 (2.30)**
Debt/GDP	0.024 (3.28)***	0.023 (2.94)***	0.04 (4.07)***	0.049 (4.63)***	0.048 (4.90)***	0.047 (3.92)***	0.046 (4.08)***	0.05 (4.73)***	0.049 (4.48)***	0.051 (4.54)***
Export/GDP	-0.044 (-5.49)***	-0.039 (-4.21)***	-0.055 (-6.37)***	-0.055 (-6.37)***	-0.054 (-6.50)***	-0.065 (-5.71)***	-0.053 (-5.84)***	-0.056 (-6.54)***	-0.056 (-6.46)***	-0.057 (-6.12)***
Volatility	0.552 (3.87)***	0.621 (3.85)***	0.265 (5.72)***	0.609 (4.17)***	0.626 (4.03)***	0.688 (3.21)***	0.643 (4.35)***	0.602 (4.12)***	0.592 (3.93)***	0.321 (2.12)**
Persistence	0.02 (3.32)***	0.019 (2.39)**	0.028 (5.29)***	0.02 (3.56)***	0.019 (3.53)***	0.018 (2.67)***	0.019 (3.66)***	0.021 (3.72)***	0.02 (3.05)***	0.022 (3.84)***
Default history		0.044 (1.97)**	0.09 (1.16)	0.053 (3.11)***	0.054 (3.16)***	0.052 (2.77)***	0.061 (3.99)***	0.051 (3.24)***	0.051 (3.05)***	0.061 (3.05)***
Default history * volatility			-0.138 (-1.51)							
Default history * persistence			0.415 (0.32)							
Asian dummy				0.02 (3.49)***	0.019 (3.55)***	0.023 (2.98)***	0.021 (3.76)***	0.019 (3.37)***	0.018 (3.17)***	0.019 (2.88)***
Terms of Trade[1]							-0.018 (-1.27)	-0.031 (-1.27)		
Reserves/M2									0.061 (2.84)***	
Short term debt/Total Debt					0 (0.23)	0 (0.22)				
Exchange rate regime										1.544 (2.51)**
Observations	189	189	189	189	189	181	189	189	189	189
Number of countries	28	28	28	28	28	26	28	28	28	28
R-squared	0.51	0.52	0.57	0.55	0.55	0.56	0.55	0.56	0.57	0.55

Robust z-statistics in parentheses with all regressions adjusted for country-specific autocorrelation. The 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.

1. Measured as deviation from trend.

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

Table 6. Determinants of Sovereign Spreads: 1925-1939
Beveridge-Nelson measures of the trend gap.

	1	2	3	4	5	6	7	8	9
UK real interest rate	0.005 (0.59)	0.006 (0.72)	0.004 (0.43)	0.004 (0.51)	0.002 (0.31)	0.004 (0.68)	0.005 (0.82)		0.006 (0.94)
Debt/GDP	0.005 (1.72)*	0.009 (0.43)	0.011 (7.61)***	0.013 (6.07)***	0.013 (5.67)***	0.012 (6.32)***	0.011 (5.63)***	0.012 (8.01)**	0.014 (6.57)***
Export/GDP	-0.054 (-3.77)***	-0.04 (-4.28)***	-0.039 (-4.26)***	-0.027 (-2.86)***	-0.036 (-3.42)***	-0.029 (-4.23)***	-0.031 (-4.43)***	-0.016 (-2.57)**	-0.029 (-3.96)**
Volatility	0.385 (3.80)***	0.208 (4.45)***	0.45 (7.39)***	0.434 (7.62)***	0.254 (3.24)***	0.329 (4.33)***	0.168 (3.35)***	0.481 (8.37)***	0.39 (4.47)***
Persistence	0.004 (2.99)***	0.002 (2.23)**	0.003 (4.25)***	0.003 (4.05)***	0.002 (2.66)***	0.002 (2.54)**	0.002 (2.13)**	0.002 (3.14)***	0.002 (1.97)**
Default history		0.1 (19.47)***	0.259 (5.02)***	0.208 (4.31)***	-0.041 (-0.61)	0.013 (0.21)		0.201 (4.08)***	0.05 (0.72)
Default history * volatility			-3.481 (-4.44)***	-3.114 (-4.17)***	-0.461 (-0.48)			-3.332 (-4.77)***	
Default history * persistence						-1.059 (-1.22)			-1.51 (-1.65)*
Periphery dummy			0.061 (5.30)***	0.072 (7.05)***	0.091 (11.04)***	0.086 (12.46)***	0.046 (9.14)***	0.084 (12.27)***	0.087 (12.51)***
Empire dummy				0.007 (3.11)***	0.017 (4.20)***	0.014 (4.85)***	0.015 (5.08)***	0.009 (5.47)***	0.013 (4.08)***
Gold Standard dummy					-0.02 (-4.81)***	-0.015 (-4.67)***	-0.02 (-5.28)***	-0.008 (8.84)***	-0.012 (-3.83)***
Terms of Trade[1]						-0.007 (7.87)***	-0.007 (6.99)***		0.001 (0.38)
Observations	302	302	301	301	301	301	301	301	291
Number of countries	25	25	25	25	25	25	25	25	24
R-squared	0.12	0.62	0.63	0.65	0.68	0.74	0.72	0.72	0.75

Robust z-statistics in parentheses with all regressions adjusted for country-specific autocorrelation. The 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.

1. Measured as deviation from trend.

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

Table 7. Determinants of Sovereign Spreads: 1994-2005
Beveridge-Nelson measures of the trend gap

	1	2	3	4	5	6	7	8	9	10
US real interest rate	0.15 (2.06)**	0.161 (2.13)**	0.149 (2.01)**	0.165 (2.03)**	0.165 (1.99)**	0.158 (2.03)**	0.16 (1.99)**	0.163 (2.08)*	0.164 (2.17)**	0.156 (2.00)**
Debt/GDP	0.039 (3.69)***	0.038 (3.55)***	0.038 (4.23)***	0.041 (4.01)***	0.04 (4.11)***	0.041 (3.53)***	0.038 (3.40)***	0.042 (4.11)***	0.043 (4.14)***	0.038 (3.74)***
Export/GDP	-0.044 (-4.91)***	-0.036 (-4.42)***	-0.043 (-4.84)***	-0.05 (-6.03)***	-0.049 (-6.43)***	-0.065 (-4.70)***	-0.047 (-5.18)***	-0.051 (-6.03)***	-0.052 (-5.59)***	-0.051 (-6.66)***
Volatility	0.49 (3.21)***	0.45 (2.53)**	-0.187 (0.71)	0.57 (3.58)***	0.609 (3.84)***	0.838 (4.00)***	0.579 (3.70)***	0.539 (3.37)***	0.376 (2.75)***	0.68 (3.57)***
Persistence	0.006 (2.66)***	0.005 (2.38)**	0.007 (1.96)**	0.006 (2.48)**	0.006 (2.45)**	0.006 (2.50)**	0.006 (2.42)**	0.007 (2.60)***	0.007 (2.87)***	0.005 (1.76)*
Default history		0.045 (2.13)**	-0.091 (-1.34)	0.056 (3.18)***	0.058 (3.35)***	0.065 (3.71)***	0.061 (3.79)***	0.051 (3.28)***	0.051 (1.76)*	
Default history * volatility			3.475 (2.07)**							0.031 (3.28)***
Default history * persistence			-0.002 (-0.08)						1.896 (3.72)***	
Asian dummy				0.021 (3.42)***	0.02 (3.88)***	0.03 (4.12)***	0.021 (3.38)***	0.02 (3.19)***	0.024 (4.21)***	0.022 (3.79)***
Terms of Trade[1]								-0.032 (-1.27)		
Reserves/M2							-0.017 (-1.01)			
Short term debt/Total Debt										
Exchange rate regime					0 (0.1)	0 (1.29)				
Observations	185	185	185	185	185	177	185	185	185	185
Number of countries	28	28	28	28	28	26	28	28	28	28
R-squared	0.58	0.54	0.66	0.53	0.55	0.56	0.54	0.54	0.55	0.6

Robust z-statistics in parentheses with all regressions adjusted for country-specific autocorrelation. The 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.

1. Measured as deviation from trend.

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

Supplementary Appendix

Allowing for endogenous variations in investment

There are various ways to weaken the model structure that fixes investment level (see equation (10)). It could be that default lowers the productivity of all investment (that is, affects function f). Alternatively, countries in default may face more stringent sanctions that cause it to lose a fraction s of the output $f(I_t)$. If so, the net return to the investment is

$$(1 - s\pi_{t+1})f(I_t) - R_f I_t, \tag{16}$$

with first order condition

$$(1 - s\pi_{t+1})f'(I_t) - R_f = 0. \tag{17}$$

With a concave utility function, it implies that optimally-chosen investment level is decreasing in default probability π. For instance, if $\pi_2^d > \pi_2^r$, we will have $I_2^d < I_2^r$. This may fit data better: empirical evidence suggests that investment does fall in default-struck economies.

Whether our results are robust to this weakening depends on what happens to the size of the bond issue, D_2^h. Recall that if I_1 is exogenously fixed, and if as equation (3) specified, $p_t D_{t+1} = I_t$, then p_t and D_{t+1} necessarily move in opposite directions: ie. if $p_1^r > p_1^d$ then $D_2^r < D_2^d$. Put differently, if investment I_1 is inelastic, the elasticity of the required bond issue D_2 with respect to price p_1 must be -1.

Our central results in the paper – Proposition 1 in particular – are preserved in a more general setting, at least as long as the elasticity of investment with respect to bond prices is less than 1. This restriction on elasticity buys us the relationship $D_2^r < D_2^d$. In that case our existence result goes through with only minor modifications. This note describes the necessary modifications.

Notice that second period output will depend on the variable level of investment. We have

$$\tilde{Y}_2^r = f(I_1^r) + \rho\tilde{\epsilon}_1 + \tilde{\omega}_2,$$
$$\tilde{Y}_2^d = f(I_1^d) + \rho\tilde{\epsilon}_1 + \tilde{\omega}_2,$$

with $\tilde{Y}_2^r > \tilde{Y}_2^d$ as $I_1^r > I_1^d$. The modification of the proof of Proposition 1 is as follows.

In Step 1 of the proof, we have the following modification. At $t = 2$, contingent on history h, repayment is rational if and only if $\tilde{Y}_2^h \geq [(1-c)/s]D_2^h \equiv Y_{2h}^*$. Repayment is even more likely given a previous history of repayment as output is boosted by the greater investment income. In other words, π_2^r is lower than it would be with fixed investment and π_2^d is higher. If previous default has real consequences for investment and output, the implied default premium is going to be even larger. This modification actually reinforces the incentive to repay.

In Step 2 we had established the optimality of the repayment decision rule in period 1. Critically, we need to show that (i) $\beta[V_2^r(\epsilon_1, e_1) - V_2^d(\epsilon_1, e_1)]$ is increasing in ϵ_1, so that repayment occurs above some threshold.

Consider, in the same spirit as before, a partition of the support of $\tilde{Y}_2$, conditional on ϵ_1. Define $E_L = \{\tilde{Y}_2 : \tilde{Y}_2 < Y_{2r}^*\}$ as the set of realizations of future output for which the borrower will default in period 2 regardless of previous history; for $E_H = \{\tilde{Y}_2 : \tilde{Y}_2 \geq Y_{2d}^*\}$, the borrower repays regardless of default history, and $E_M = \{\tilde{Y}_2 : Y_{2r}^* \leq \tilde{Y}_2 < Y_{2d}^*\}$, the realization in which prior repayment induces future repayment and prior default induces future default.

Recall that when evaluating $[V_2^r - V_2^d]$ in each element of this partition for the cased with fixed investment (i.e. when $Y_2^r = Y_2^d$), we had

$$\left[\int_{E_L} c[D_2^d - D_2^r]dF + \int_{E_M} [s\tilde{Y}_2 + cD_2^d - D_2^r]dF + \int_{E_H} [D_2^d - D_2^r]dF \right]$$

Now the corresponding terms in the three elements of the partition are

- $(1-s)(Y_2^r - Y_2^d) + c(D_2^d - D_2^r)$, in E_L;

- $(1-s)(Y_2^r - Y_2^d) + s\tilde{Y}_2 + cD_2^d - D_2^r$, in E_M;

- $Y_2^r - Y_2^d + D_2^d - D_2^r$, in E_H.

In each case we have added a positive (and non-decreasing from E_L to E_H) term to each of the integrands in the previously-discussed case. That is sufficient for the formal results.

More generally, note that the possibility of endogenous reduction in output following default (i.e., $Y_2^d < Y_2^r$) reinforces the deterrence mechanism. A sovereign borrower would be more inclined to repay to avoid the output

losses associated with default, as well as to avoid sending out a signal that triggers an increase in interest rates. The 'utility cost' of higher interest rates may be lower if investment collapses, but would be positive nonetheless. A theoretical model would be unable to resolve the relative costs of default (those due to output losses vs those due to higher borrowing costs) without resorting to specific functional forms. Our aim in the paper is to show how the default premium can generate deterrence even in the absence of the inevitable output losses.