

# Persistent Gaps and Default Traps\*

Luis A. V. Catão<sup>†</sup>   Ana Fostel<sup>‡</sup>   Sandeep Kapur<sup>§</sup>

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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 about output shocks. In such an environment, default signals the borrower's vulnerability to adverse shocks and creates a pessimistic growth outlook. This translates into higher interest spreads and debt servicing costs relative to income, raising the cost of future repayments, thereby creating "default traps". We build a long and broad cross-country dataset to show the existence of a history-dependent "default premium" and of significant effects of output persistence on sovereign creditworthiness, consistent with the model's predictions.

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<sup>†</sup>IADB and IMF. Corresponding author. Address: Research Department, IADB, 1300 New York Avenue, Stop E1003, Washington DC 20577, USA. *email:* lcatao@iadb.org.

<sup>‡</sup>George Washington University, Washington, DC, USA. *email:* afostel@gwu.edu

<sup>§</sup>Birkbeck, University of London, WC1E 7HX, UK. *email:* s.kapur@bbk.ac.uk

# 1 Introduction

A major stylized fact about the history of sovereign borrowing is the persistence in creditworthiness patterns. 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 those that incurred arrears and concessionary schedulings during 1940-79 were 70 percent more likely to default in the 1980s. Rogoff et al. (2003) show that serial defaulters have lower credit ratings and face higher spreads (relative to the risk-free interest rate) at relatively low indebtedness levels – a phenomenon they call debt intolerance. The experience of such debt-intolerant countries – involving a vicious circle of borrowing, default, and penal interest rates – contrasts with that of countries that manage to achieve 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 over the risk-free rate). Much of the theoretical literature on sovereign default is at odds with this regularity: 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 have allowed for this exclusion to be temporary but with random re-entry rules (Aguiar and Gopinath, 2006; Arellano, in press).<sup>1</sup> In practice, default is often punished not through outright denial of credit but a worsening of the terms on which the country can borrow again.<sup>2</sup> Provided that borrowing needs are not too price elastic, the sovereign will continue to tap the market – absolute exclusion representing only the limiting case and, typically, short-lived.

This paper argues that two structural features typically found in emerging markets can 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). What

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<sup>1</sup>Earlier studies pointed out that strict market exclusion may be hard to achieve due to coordination problems among multiple lenders (Kletzer, 1984, and Wright, 2005), and due to borrowers' retained ability to invest in risk-free international assets after default (Bulow and Rogoff, 1989).

<sup>2</sup>The loss of market access tends to be relatively short-lived: see Gelos et al. (2004) for estimates over the post-1980 period. While there is some debate about whether recalcitrant borrowers are consistently punished with higher spreads (Eichengreen and Portes, 1986; Ozler, 1993), historical data that we present in this paper indicates that bond yields do rise in the wake of default events and remain higher than average (albeit declining) for several years thereafter. This is also consistent with evidence provided in Flandreau and Zumer (2004) on the behavior of spreads during the pre-WWI period.

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.<sup>3</sup> 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 shocks long-lasting,<sup>4</sup> the various frictions (political as well as economic) that make fiscal policy more procyclical in these countries, as well as financial and institutional frictions that typically magnify the sensitivity of domestic credit to loan collateral values and balance sheet mismatches, thus boosting output persistence.<sup>5</sup>

[Tables 1 and 2 here]

This begs the question as to whether, and to what extent, output has indeed been 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 (see Section 3 for data sources and other specifics). As is apparent from comparing 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 robust to potential reverse causality emanating from the effects of defaults on the volatility and persistence of output shocks: when we eliminate from the sample all default events and their immediate aftermaths, defaulters continue to display greater output volatility and shock persistence.

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<sup>3</sup>To see this, let  $y_t = \rho y_{t-1} + \omega_t$  where  $y_t$  is output of a country in period  $t$ ,  $\rho$  is the persistent parameter and  $\omega$  is an i.i.d shock. Then the unconditional output volatility is  $\sigma_y = \sigma_\omega / \sqrt{1 - \rho^2}$ .

<sup>4</sup>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.

<sup>5</sup>See Kaminsky et al. (2004) for cross-country evidence on greater fiscal and monetary pro-cyclicality in emerging markets.

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 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; Alfaro and Kanczuk, 2005). Ex-post, such a default premium raises the cost of future repayments beyond what is justified by other fundamentals 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 empirical. Since the underlying volatility and persistence of output tend to be slowly-evolving structural features that can vary widely from country to country, we provide empirical support for the postulated theory in a long and broad cross-country panel spanning the first globalization era in the 1870s – when international financial integration and sovereign bond financing became widespread – to 2004. This database is not only longer than previous historical studies of sovereign risk (e.g. Obstfeld and Taylor, 2003) but also has better output data for some countries and encompasses a wider set of variables. Our results indicate that countries with more volatile and persistent output shocks are likely to face higher ex-ante interest spreads and thus more likely to be caught into default traps. Consistent with our theoretical results, we also find evidence of a significantly positive default premium, which is increasing in the underlying persistence of deviations between actual and expected output – the so-called output gap. This offers one explanation for why country spreads react strongly to default announcements even after controlling for changes in other fundamentals. In turn, a significant rise in spreads 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 in a model with complete symmetry of information between borrowers and lenders. Default is punished by market exclusion, with exogenous re-entry probability rather than an endogenous effect through prices. Whilst they do not focus on serial default, their model entails 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, in press; 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, none of these studies can explain why a country with similar fundamentals as others is prone to fall into a default trap if it has defaulted once; nor can they explain the existence of a 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. Allowing for the presence of information asymmetries between borrowers and lenders buys us precisely the capacity to explain these two phenomena in a way that is consistent with the broad historical evidence.

Other papers have explored the implications of informational asymmetries in models of sovereign debt.<sup>6</sup> Unlike these paper, in our model the informational asymmetry relates to the output process. This allows us to analyze the interaction between output persistence and the process by which repayment history affects the future price of future debt and debt burden relative to output. This generates a default trap mechanism novel in this literature.

The paper is organized as follows. Section 2 lays out the model, our main theoretical results and discusses their robustness. Section 3 reports the econometric results. Section 4 concludes. Proofs of the theoretical propositions are in the Appendix.

## 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

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<sup>6</sup>See, for instance, Kletzer (1984), Alfaro and Kanczuk (2005), Eaton (1996), Fostel (2005), and Sandleris (2006).

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:

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

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

Here random variable  $\epsilon_1$  is a persistent shock, with mean 0 and standard deviation  $\sigma_\epsilon$ . Let  $\Phi(\epsilon_1)$  denote the distribution of persistent shocks and  $\phi(\epsilon_1)$  the associated density function. The parameter  $\rho \in (0, 1)$  measures the persistence of the shock from period 1 to period 2. Random variables  $\omega_t$  denote transient shocks: these are independent with mean 0 and standard deviation  $\sigma_\omega$ .

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. We justify this assumption later.

The sovereign's utility function is linear in payoffs. With this specification, the sovereign cares only about expected future payoff associated with its current choices. 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.

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  $D_{t+1}$ , and

$$p_t D_{t+1} = I_t, \quad (3)$$

where  $p_t$  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 can enforce partial recovery obtaining a proportion  $c < 1$  of the face value of outstanding debt (see Sturzenegger and Zettelmeyer, 2007, for empirical evidence). Suppose the sovereign is expected to default at  $t + 1$  with probability  $\pi_{t+1}$ . 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

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

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

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

Since  $p_t \in [c/R_f, 1/R_f]$ , the bond price is positive as long as  $c > 0$ .<sup>7</sup> The bond price  $p_t$  is decreasing in the anticipated probability of default  $\pi_{t+1}$ . Bond yields, as conventionally defined,

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

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  $\bar{Y}_t, \rho$ , 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.<sup>8</sup> The updated beliefs are used to form expectations of future output, and hence the probability of future default.

To show how this information structure gives rise to a default premium, we begin with an informal discussion of the sequence of events and equilibrium. 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,

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<sup>7</sup>In this setting, outright exclusion ( $p_t = 0$ ) requires that  $\pi_{t+1} = 1$  and  $c = 0$ , so a strictly positive capture rate preclude exclusion. Eaton and Gersovitz (1995) provide an argument as to why the probability of default is less than half for any credible debt contract. We adopt this assumption for analytical convenience.

<sup>8</sup>For instance, bondholders may acquire information about output shocks only with a time lag, with imprecision (as corroborated by frequent and sometimes large revisions to published statistics) and in extreme cases, subject to obfuscation. All this is especially true for emerging market economies. In contrast, the sovereign borrower itself has more direct and immediate access to such information. Further, as we explain below, the formal arguments of the model can be modified to capture alternative sources of informational asymmetry, say, about the persistence parameter  $\rho$ .

the probability of future default denoted as  $\pi_2^h$ , varies with history  $h$ . The sovereign then issues new bonds  $D_2^h$  at price  $p_1^h \equiv p_1(\pi_2^h)$  to finance its period-1 investment requirement  $I_1$  at  $t = 1$ . This requires  $p_1^h D_2^h = I_1$ : 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 punished with sanctions that cause the sovereign to lose a fraction  $s$  of its current output  $\tilde{Y}_2$ , in addition to  $cD_2^h$ .<sup>9</sup>

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 repayments. We show that the borrower defaults 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 (net of penalties). At the same time, default is costly because, by altering market perceptions of future default risk, it raises the cost of financing fresh investment. 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  $\epsilon_1$  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  $\epsilon_1$ , expects  $\tilde{Y}_2$  to be distributed with mean  $f(I_1) + \rho\epsilon_1$  and standard deviation  $\sigma_\omega$ . Let the associated (cumulative) distribution function be  $F_{|\epsilon_1}(\tilde{Y}_2)$ . Bondholders, on the other hand, do not observe  $\epsilon_1$  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

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<sup>9</sup>Sanctions can be imposed through direct action (see Mitchener and Weidenmier, in press) or could be interpreted as endogenous loss of output due to disruptions following default, as in Cohen (1992) or Calvo (2000). As is standard – see Obstfeld and Rogoff (1996) – we assume that bondholders do not appropriate any benefit from sanctions.

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,  $\pi_2^d > \pi_2^r$ . 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 key to the postulated default trap mechanism.

## 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 repayment threshold  $e_1$ , the prior distribution  $\Phi$  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 repays at  $t = 1$  if and only if  $\epsilon_1 \geq e_1^*$ . It 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 the Appendix. Here 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.

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  $\epsilon_1$  must lie below the critical  $e_1^*$ , that is, in the lower tail of distribution  $\Phi$ . 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 large. 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 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.

Finally, while the persistence parameter  $\rho$  is deterministic and common knowledge, in our setup overall persistence is captured in the term  $\rho\epsilon_1$ . As

lenders do not observe  $\epsilon_1$  but make inferences about its magnitude from observing the default/repayment decisions, the borrower's credit history provides information about overall persistence. Alternative formulations of this mechanism could model  $\rho$  as stochastic and not directly known to lenders, or – even more generally – assume that both  $\rho$  and  $\epsilon_1$  are unknown to lenders. Since our default trap equilibrium requires informational asymmetry only about the composite term  $\rho\epsilon_1$ , our broad results are robust to these alternative formulations. We have chosen the present setup because it is empirically plausible and delivers the cleanest presentation of the model's comparative statics.

## 2.5 Comparative Statics

To explore how the equilibrium varies with the degree of persistence, 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  $\epsilon_1$  (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

$$[1 - (1 - c)\Phi(e_1)]D_1 = R_f I_0. \quad (7)$$

Figure 1 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 (7) 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  $e_1$ . At the equilibrium, the value of  $e_1$  must be such that  $BR(e_1^*) = CR(e_1^*)$ .

[Figure 1 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  $\rho$ .

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

The Appendix provides a formal proof but the intuition is simple. Greater persistence implies that future output shocks are more closely related to period 1 shock  $\epsilon_1$ , 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 terms 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.

For persistence to play such a role in exacerbating the default trap mechanism, the 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, in press; 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 (7). 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  $\epsilon_1$  lowers the expected return to the lender. If so, the break-even condition 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

In assuming that investment levels  $I_0$  and  $I_1$  are exogenously given, do we overlook the possibility that the increase in the cost of borrowing following default could affect investment choices and output?

Our assumption may be rationalized as follows. 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

$$f(I_1) - D_2[1 - \pi_2(1 - c)]. \quad (8)$$

This 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<sup>10</sup>

$$f(I_t) - R_f I_t, \quad (9)$$

with first-order condition for an interior maximum  $f'(I_1^*) - R_f = 0$ . Thus the optimally-chosen investment path  $I_t^*$  depends only on the risk-free rate, lending support to our assumption that investment is independent of the history-dependent bond prices (that  $I_1^d = I_1^r$ ).

Nonetheless empirical evidence suggests that default does tend to affect investment and output. This could be due to factors that are not captured in our model. Following default, disruptions to trade and financial intermediation may lower productivity of capital (Mendoza and Yue, 2008) and overall output (Cohen (1992), Obstfeld and Rogoff (1996), and Calvo (2000)) which would reinforce the losses associated with higher borrowing costs. Avoiding such disruption reinforces the case for repayment, and hence strengthens the deterrence mechanism in our model.

### Shock to trend or shock to cycle

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  $\epsilon$  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 test strategy which will be discussed below. Here we highlight how either type of shock can create default traps.

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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<sup>10</sup>Alternatively, it can be written as  $f(p_1 D_2) - D_2 p_1 R_f$ . This reveals that the possibility of default raises the cost of capital but also lowers the expected cost of servicing the debt. The latter effect reflects the standard moral hazard associated with use of borrowed funds.

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),  $\epsilon_1$  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 to default traps. Intuitively, this is not surprising: countries more prone to long deep recessions will find it harder to repay. 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 gap. In practice investors are uncertain about  $\rho$  but can learn it based on default/repayment decisions. For instance, a country X's default in time  $T$  indicates to investors that X is a high persistence country and as such should face higher spreads in the future as postulated in the model. Hence X's spreads will rise even when output eventually returns to trend and other fundamentals remain the same. Such a long-lasting rise in spreads and in attendant debt servicing costs will then generate default traps through the same mechanism described above.

### 3 Empirics

We empirically test four main implications of our theoretical setup.

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 will tend to face higher spreads. This follows directly from the lenders' break-even condition, as discussed in Section 2.5. Further, to the extent that such volatility reduces the informational content of default, default premium should fall with volatility.

These hypotheses have both cross-sectional and time-series implications, requiring sufficiently long data series encompassing a number of default events. A main contribution of this paper is to construct such a dataset which starts from the early globalization years of the 1870s through 2004.<sup>11</sup> The respective sources and specifics of the data are provided in a separate appendix.<sup>12</sup>

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 (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 history 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.<sup>13</sup>

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<sup>11</sup>Our pre-WWII sample spans 33 countries but lack of series on some covariates for some of them implies that effective coverage drops to 25 or so countries in the regressions below. For the post-WWII sample, our database spans around 60 countries, but data on spreads are only available for about half of them and from 1994 onwards. Further, the associated series on emerging market sovereign bond indices (EMBIs) suffers from a sample selection bias for the first few years since the countries issuing internationally traded bonds (Bradies) were then 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, this post-1990 series does not encompass the whole gamut of developing and developed countries. We discuss the econometric implications below.

<sup>12</sup>See [www.iadb.org/res/files/CATAO-DefaultTraps-data.pdf](http://www.iadb.org/res/files/CATAO-DefaultTraps-data.pdf)

<sup>13</sup>As standard, we set the HP-filter smoothing factor to 100 with annual data.

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).<sup>14</sup>

Alternatively, if we interpret  $\epsilon_1$  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:

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

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

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 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.<sup>15</sup> 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.

[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

<sup>14</sup>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.

<sup>15</sup>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. The respective point estimates show that a one percentage point increase in the conditional volatility implies a 14 basis point increase in sovereign spreads, while a 10 percentage point increase in persistence raises spreads by 5 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.

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.<sup>16</sup> 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 retain a very similar order of magnitude 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 following the borrower's action (default vs. repayment) helps explain the evolution of spreads over and above the information contained in other fundamentals. Our indicator of default history is defined as the share of years in default since the beginning of the sample, so as to capture this time-dependence.<sup>17</sup> As such, a positive default premium decays over time with successive repayments and bounces back up every time a new default occurs, as entailed by the model. 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

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<sup>16</sup>In these instrumental regressions we allowed for up to one lag of each independent variable.

<sup>17</sup>A similarly constructed indicator is used in Reinhart et al. (2003).

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 ( $0.08 \times 0.032$ ) 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 Hypothesis 4, that greater dispersion of output shocks tends to reduce the information content of default/repayment actions and hence the default premium. In other words, even though the net effect of volatility on country spreads remain positive,<sup>18</sup> 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 Obstfeld and Taylor, 2003). The aim is to capture a host of structural characteristics, such as quality of institutions and degrees of financial development. To the extent that they 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 results support this theoretical prior.

We also introduce an “empire” dummy that indicates if a country was part of the British empire – a catch-all proxy for 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 an increase in the recovery rate parameter  $c$ , which tends 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 between

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<sup>18</sup>This can be seen by multiplying the point estimate of 0.869 by the mean of the default history variable (0.08) which yields 0.07 which is smaller than the coefficient of the volatility term alone (0.11).

countries that were on the gold standard and those that were not, so “Gold” dummy (taking on a 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 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 tip 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-related dislocations affected 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%.<sup>19</sup>

[Table 4 about here]

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<sup>19</sup>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, hence the halving of the respective coefficients.

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, 1986; 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), the significance of the default history variable drops. For reasons discussed in connection with the pre-WWI regressions, this 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. Further, this tighter collinearity between the empire dummy and default history should be expected given the short time span of the inter-war period. The fact that the overall fit of the regression does not change 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) corroborate these results, showing that they are robust to the inclusion of a gold standard dummy and terms of trade shocks. Column (9) drops the empire dummy while leaving in other controls, highlighting the collinearity issue.

Table 5 reports the results for the 1994-2004 period. Despite the wider country coverage, the number of observations in these regressions is considerably lower than the pre-WWII regressions due to the lack of bond spread data; so the cross-section dimension of this regression far dominates the time-series one. 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 (2). 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. Re-

gression results in column (3) 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. The resulting multicollinearity between the stand-alone default history variables and its interactive terms with conditional output volatility and persistence renders them statistically insignificant individually at 5%, when included together in the regression, although yielding the expected sign. Looking at the underlying 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, 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]

The first control pertains to the inclusion of regional dummies rather than a periphery dummy (since these regressions do not include core countries), of which only the dummy for Asia is significant (column 4 of Table 5). 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 and international reserve coverage (as a share of broad money, M2), variables often deemed to be important in explaining financial and currency crises. Results reported in columns (6) to (8) show that none of the extra controls 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%.

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, eating the pre-WWI series, we report such results only for the inter-war and the post-1993 samples. Starting with the interwar 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 output shocks to trend shocks, raising the persistence measure and hence lowering its estimated coefficient. 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. Likewise, post-1993 results, presented in Table

7, are similar to their HP-gap counterparts in Table 5, with the exception of a switch in signs of the interaction terms, reflecting the multicollinearity problem alluded earlier.

[Tables 6 and 7 about here]

Overall, we conclude that the default-trap mechanism postulated in our model is broadly consistent with long-run data on sovereign bond pricing. 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 and alternative de-trending methods.

## 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 explains this stylized fact through the ideas of default premium and default traps. A sovereign's decision to default signals that it was likely hit by a large negative output shock which persists, 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. Whilst this default premium could eventually disappear as the persistent shock dies away, to the extent that investors' perceive that defaulting countries are the more likely ones to be hit by such persistent shocks, spreads will be higher on a permanent basis. By increasing the sovereign's interest burden, this mechanism makes future default more likely. This creates 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 default risk, none of them has, to the best of our knowledge, linked these ingredients together. Previous theoretical models show how high conditional volatility and persistence of output shocks alone can explain serial default, but 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 – that struck by an adverse shock – to default and the other one 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. 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. To test the postulated theoretical mechanism, this paper develops a broader, longer, and (for some countries) better-quality cross-country dataset spanning over more than one and a quarter 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.

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 volatility and persistence of output gaps. Second, there is evidence of a substantially positive and statistically-significant default premium. Third, such a default premium is increasing in the underlying persistence of output shocks. These results are robust to a host of controls featuring in previous studies and to alternative measures of output volatility and persistence based on distinct detrending methods. We interpret these empirical findings as strong evidence that the postulated default trap mechanism is consistent with long-run data on sovereign bond pricing.

Important implications follow. In terms of the literature on the determinants of sovereign risk, our historical evidence highlights the significance of output volatility and persistence indicators in country spread regressions, which has been regrettably absent in previous work. On a policy level, these regression results underscore the importance of reforming institutions and changing policy frameworks that typically make many emerging markets more vulnerable to large shocks and slower recoveries from negative ones.

This paper's theoretical and empirical findings also have important implications for the assessment of the costs of default. First, the existence of a positive default premium – which we have shown to be empirically significant and long-lasting controlling for other factors – suggests that the interest cost of defaults is clearly non-trivial, over and above the output costs documented elsewhere. Second, to the extent that defaults are informative of the degree of structural output persistence of a country, they tend to have permanent

positive effects on country risk. This in turn raises debt-servicing burdens and thus creates default traps.

Finally, because emerging market countries typically have a higher underlying dispersion of temporary shocks, they are also more vulnerable to sheer ‘bad luck’ in output realizations. Since such bad luck can induce default traps, going an extra mile to ensure debt repayment during bad times is likely to pay off – this effort being all the more worthwhile the greater the existing asymmetry of information about country-specific fundamentals. An issue for future empirical research is thus to establish how some countries that defaulted in the past have eventually managed to evolve out of default traps through distinct combinations of strengthening fundamentals, greater transparency, and good luck.

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## Appendix

### 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 optimality of the borrower's repayment choice in period 1, and establishes the optimality of subsequent choices. Step 2 confirms the optimality of the period-1 repayment decision rule.

*Step 1.* Assume that the borrower's decision rule at  $t = 1$  is to repay iff  $\epsilon_1$  exceeds some arbitrary threshold  $e_1$ . At  $t = 2$ , contingent on history  $h$ , the borrower's net payoff to repayment is  $\tilde{Y}_2 - D_2^h$ , while sanctions and partial recovery of debt leave it with  $(1 - s)\tilde{Y}_2 - cD_2^h$  following default. 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 expects the borrower to repay iff  $\epsilon_1 \geq e_1$ , it updates 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 posterior density is  $\gamma_d(\epsilon_1|e_1) = \phi(\epsilon_1)/\Phi(e_1)$  for  $\epsilon_1 < e_1$  and 0 otherwise. If instead, lenders observe repayment, the posterior is  $\gamma_r(\epsilon_1|e_1) = \phi(\epsilon_1)/(1 - \Phi(e_1))$  for  $\epsilon_1 \geq e_1$  and 0 otherwise. Let  $\Gamma_h(\epsilon_1|e_1)$  be the associated cumulative distribution function. Note 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  $e_1$ .

The lender's strategy is to set prices that allow it to break even given the probability of default. At  $t = 1$  the expected default probabilities depends on beliefs about future output. Given distributions  $G_h(\tilde{Y}_2|e_1)$  over period-2 output, consistent with the above posteriors about the persistent shock and the borrower's period-2 default rule, we have  $\pi_2^h(e_1) = G_h((\frac{1-c}{s})D_2^h|e_1)$ . Given bond prices (5) and the investment requirement  $p_1^h D_2^h = I_1$ , we have

$$[1 - (1 - c)\pi_2^h(D_2^h)]D_2^h = R_f I_1. \quad (\text{A.1})$$

Some useful properties follow directly from the Bayesian updating rule.

**Lemma 1** *The default premium is positive.*

Given persistence,  $G_r(\cdot)$ , the distribution of period-2 output conditional on repayment, dominates  $G_d(\cdot)$  in the first-order stochastic sense. This implies  $\pi_2^r(D_2) < \pi_2^d(D_2)$  for any given  $D_2$ . From (10) 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  $e_1$ .*

$D_2^h$  varies with  $e_1$  as  $e_1$  conditions distribution  $G_h$ . 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  $\pi_2^d$  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  $\pi_2^r$  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  $\epsilon_1$  is

$$V_2^h(\epsilon_1, e_1) = \int \max[\tilde{Y}_2 - D_2^h, (1-s)\tilde{Y}_2 - cD_2^h] dF_{|\epsilon_1}(\tilde{Y}_2). \quad (\text{A.2})$$

Note that  $V_2^h$  depends on  $\epsilon_1$  (since the borrower conditions the distribution  $F_{|\epsilon_1}(\tilde{Y}_2)$  of future income on  $\epsilon_1$ ) 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,  $V_2^h$ . The respective payoffs to repayment and default are

$$V_1^r(\epsilon_1, e_1) = (\tilde{Y}_1 - D_1) + \beta V_2^r(\epsilon_1, e_1), \quad (\text{A.3})$$

$$V_1^d(\epsilon_1, e_1) = (\tilde{Y}_1 - cD_1) + \beta V_2^d(\epsilon_1, e_1). \quad (\text{A.4})$$

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 savings given the positive default premium), while  $(1-c)D_1(e_1)$  represents the immediate gain from default. To prove the optimality of the borrower's strategy we show that (i)  $g(\epsilon_1, e_1)$  is increasing in its first argument,  $\epsilon_1$ ; (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 it is rational to repay iff  $\epsilon_1 \geq e_1^*$ .

- (i) As  $(1-c)D_1(e_1)$  does not vary with  $\epsilon_1$ , it is sufficient to show that  $\beta[V_2^r(\epsilon_1, e_1) - V_2^d(\epsilon_1, e_1)]$  is increasing in  $\epsilon_1$ . Partition of the support of  $\tilde{Y}_2$ , conditional on  $\epsilon_1$ , as follows: 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  $E_M = \{Y_{2r}^* \leq \tilde{Y}_2 < Y_{2d}^*\}$ , the realizations for 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  $\epsilon_1$ . 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  $g(\epsilon_1, e_1)$  is increasing in  $\epsilon_1$ .

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

First, note that 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 to zero) and from above by  $((1-c)/c)R_f I_0$  (when default is almost sure event). This follows from equation (7).

Second, 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 (10),  $V_2^h(\epsilon_1, e_1)$  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  $e_1$ .

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  $\beta$  is not too low relative to other parameters.

## Proof of Proposition 2

For any given  $e_1$  an increase in  $\rho$  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  $\rho$  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  $\pi_2^d$ , so required  $D_2^d$  is increasing in  $\rho$ . On the other hand,  $G_r(\tilde{Y}_2^r; \rho) \leq G_r(\tilde{Y}_2^r; \rho')$  for  $\rho > \rho'$ , so that  $\pi_2^r$  and  $D_2^r$  are decreasing in  $\rho$ : Observed repayment suggests a more optimistic outlook for future repayments. Thus, for given  $e_1$ , a higher value of  $\rho$  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 (10)  $V_2^h(\epsilon_1, e_1)$  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  $\rho$  generates an increase in the default premium as stated.

Thus an increase in  $\rho$  implies that at any 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.

<b>Table 1: Real GDP Volatility and Persistence and Countries' Repayment Records, 1870-1939</b> (in deviations from HP trend, group medians)										
	<b>1870-1913</b>					<b>1919-1939</b>				
	<b>Incl. defaults</b>			<b>Exc. defaults</b>		<b>Incl. defaults</b>			<b>Exc. defaults</b>	
	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

<b>Table 2. Real GDP Volatility and Persistence and Repayment Records</b> (in deviations from HP trend, group medians) <b>1960-2004</b>					
	<b>Incl. Defaults</b>			<b>Excl. Defaults</b>	
	Def. Freq.	Std. Dev.	AR(1)	Std. Dev.	AR(1)
<b>Latin America</b>	<b>1.00</b>	<b>0.041</b>	<b>0.619</b>	<b>0.037</b>	<b>0.619</b>
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
<b>UK real interest rate</b>	0.012 (2.51)**	0.010 (2.63)***	0.012 (2.46)**	0.012 (2.46)**	0.012 (2.46)**	0.013 (2.53)**	0.013 (2.48)**	0.013 (2.44)**	0.013 (2.30)**
<b>Debt/GDP</b>	0.01 (14.21)***	0.015 (23.31)***	0.012 (12.97)***	0.013 (13.98)***	0.013 (14.36)***	0.011 (12.33)***	0.011 (13.47)***	0.011 (13.39)***	0.011 (14.35)***
<b>Export/GDP</b>	-0.004 (-1.98)**	-0.010 (-8.02)***	-0.010 (-3.37)***	-0.009 (-2.93)***	-0.011 (-3.51)***	-0.012 (-3.84)***	-0.004 (-1.55)	-0.004 (-1.55)	-0.002 (-0.73)
<b>Volatility</b>	0.136 (9.27)***		0.092 (6.30)***	0.110 (6.27)***	0.119 (6.45)***	0.134 (6.98)***	0.156 (7.87)***	0.156 (7.93)***	0.148 (7.72)***
<b>Persistence</b>	0.005 (5.91)***		0.003 (3.76)***	0.003 (3.04)**	0.003 (2.89)***	0.003 (4.47)***	0.003 (3.26)***	0.003 (3.23)***	0.003 (2.93)***
<b>Volatility instrument</b>		0.140 (4.90)***							
<b>Persistence instrument</b>		0.004 (3.90)***							
<b>Default history</b>			0.054 (9.30)***	0.067 (6.37)***	0.061 (6.05)***	0.048 (4.10)***	0.021 (2.53)***	0.021 (2.47)***	0.022 (2.73)***
<b>Default history * volatility</b>				-0.869 (-3.77)***	-0.883 (-3.86)***	-0.977 (-4.10)***	-0.824 (-3.67)***	-0.808 (-3.55)***	-0.861 (-3.71)***
<b>Default history * persistence</b>				0.032 (3.53)***	0.032 (3.59)***	0.033 (3.90)***	0.032 (3.47)***	0.032 (3.46)***	0.031 (3.38)***
<b>Periphery dummy</b>					0.013 (7.49)***	0.017 (11.67)***	0.014 (10.39)***	0.015 (10.44)***	0.016 (7.07)***
<b>Empire dummy</b>						-0.017 (-18.22)***	-0.014 (-15.90)***	-0.014 (-15.78)***	-0.015 (-15.32)***
<b>Gold Standard dummy</b>							-0.007 (-13.72)***	-0.007 (-13.59)***	-0.007 (-11.77)***
<b>Terms of Trade<sup>1</sup></b>								0.001 (0.61)	
<b>External Debt/Total Debt</b>									0.001 (0.58)
<b>Observations</b>	652	631	603	603	603	603	603	603	567
<b>Number of countries</b>	24	23	22	22	22	22	22	22	21
<b>R-squared</b>	0.24	0.24	0.27	0.28	0.28	0.32	0.36	0.36	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 (1.00)	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)***	0.20 (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)***	
Gold Standard dummy							-0.007 (-6.63)***	-0.007 (-6.69)***	-0.007 (-6.97)***
Terms of Trade <sup>1</sup>								0.002 (0.89)	
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)***	(0.05) (5.72)***	-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 (1)	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)***		
Default history * volatility			-0.138 (-1.51)						0.061 (2.84)***	
Default history * persistence			0.415 (0.32)							1.544 (2.51)**
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 <sup>1</sup>								-0.031 (-1.27)		
Reserves/M2							-0.018 (-1.27)			
Short term debt/Total Debt						0 (0.22)				
Exchange rate regime					0 (0.23)					
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
<b>UK real interest rate</b>	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)
<b>Debt/GDP</b>	0.005 (1.72)*	0.009 (6.27)***	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)***
<b>Export/GDP</b>	-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)**
<b>Volatility</b>	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)***
<b>Persistence</b>	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)**
<b>Default history</b>		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)
<b>Default history * volatility</b>			-3.481 (-4.44)***	-3.114 (-4.17)***	-0.461 (-0.48)	-1.059 (-1.22)		-3.332 (-4.77)***	-1.51 (-1.65)*
<b>Default history * persistence</b>			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)***
<b>Periphery dummy</b>				0.007 (3.11)***	0.017 (4.20)***	0.014 (4.85)***	0.015 (5.08)***	0.009 (5.47)***	0.013 (4.08)***
<b>Empire dummy</b>					-0.02 (-4.81)***	-0.015 (-4.67)***	-0.02 (-5.28)***		-0.012 (-3.83)***
<b>Gold Standard dummy</b>						-0.007 (7.87)***	-0.007 (6.99)***	-0.008 (8.84)***	-0.007 (-8.28)***
<b>Terms of Trade<sup>1</sup></b>									0.001 (0.38)
<b>Observations</b>	302	302	301	301	301	301	301	301	291
<b>Number of countries</b>	25	25	25	25	25	25	25	25	24
<b>R-squared</b>	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
<b>US real interest rate</b>	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)**
<b>Debt/GDP</b>	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)***
<b>Export/GDP</b>	-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)***
<b>Volatility</b>	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)***
<b>Persistence</b>	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)*
<b>Default history</b>		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)***		
<b>Default history * volatility</b>			3.475 (2.07)**						1.896 (3.72)***	
<b>Default history * persistence</b>			-0.002 (-0.08)							0.031 (3.28)***
<b>Asian dummy</b>				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)***
<b>Terms of Trade<sup>1</sup></b>								-0.032 (-1.27)		
<b>Reserves/M2</b>							-0.017 (-1.01)			
<b>Short term debt/Total Debt</b>						0 (1.29)				
<b>Exchange rate regime</b>					0 (0.10)					
<b>Observations</b>	185	185	185	185	185	177	185	185	185	185
<b>Number of countries</b>	28	28	28	28	28	26	28	28	28	28
<b>R-squared</b>	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%.

Figure 1: Persistence and default-trap equilibrium

