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Measuring financial market integration over the long run: Is there a U-shape?

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June 2011

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Using long time series for sovereign bond markets of fifteen industrialized economies from 1875 to 2009, I find that financial market integration by the end of the 20th century was higher than in earlier periods and exhibited a J -shaped trend with a trough in the 1920s. The main reason for the higher financial integration seen today is the recent extensive globalization. Around the turn of the 20th century, countries frequently drifted apart. Conversely, in recent years, the bond markets of most countries have moved together. Both policy variables and the global market environment play a role in explaining the time variation in integration, while "unexplained" changes in the overall level of country risk are also empirically important. My methodology, based on principal components analysis, is immune to outliers and accounts for global and country-specific shocks and, hence, can capture trends in financial integration more accurately than standard techniques such as simple correlations.

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Abstract

Using long time series for sovereign bond markets of fifteen industrialized economies from 1875 to 2009, I find that financial market integration by the end of the 20th century was higher than in earlier periods and exhibited a J-shaped trend with a trough in the 1920s. The main reason for the higher financial integration seen today is the recent extensive globalization. Around the turn of the 20th century, countries frequently drifted apart. Conversely, in recent years, the bond markets of most countries have moved together. Both policy variables and the global market environment play a role in explaining the time variation in integration, while "unexplained" changes in the overall level of country risk are also empirically important. My methodology, based on principal components analysis, is immune to outliers and accounts for global and country-specific shocks and, hence, can capture trends in financial integration more accurately than standard techniques such as simple correlations.

1 Introduction

The extent of international financial integration has important implications for economic theory and policy debates. The relative degree of financial integration during the two capital market booms, before World War I and after the collapse of the Bretton Woods system, remains subject to disagreement. Typical measures of integration include proxies for intensity of legal restrictions on cross-border capital flows, price-based criteria, and quantity-based criteria.[1] Quinn (2003) argues that financial markets were more integrated during the pre-WWI era,

[1]Price-based criteria include various interest parity conditions or the purchasing power parity condition, while quantity-based criteria are based on the volume of capital flows and the stocks of external assets and liabilities. See Kose et al. (2009) for a discussion of advantages and disadvantages of various measures.

whereas Mauro et al. (2002) find that they are more integrated post-Bretton Woods. Others, including Obstfeld and Taylor (2003; 2004) and Goetzmann et al. (2005), argue that financial markets demonstrate a U-shape and hence an equal amount of integration before 1914 and after 1971. It is important to know which period has been associated with a higher degree of capital market integration because these periods differ drastically in terms of the economic environment and policies.

I argue that mixed results in the literature are a result of studies using different methodologies and the failure to differentiate between global or country shocks. To address these concerns, I propose a systematic methodology based on the method of principal components that has several advantages. First, it accounts for several dimensions of integration including market comovement and segmentation, within a straightforward statistical methodology that is widely used in microeconomic research. Second, it is robust to the presence of outliers or heavy-tailed distributions. Third, the current method is robust to the choice of a reference country (such as the United States or Great Britain). Fourth, the methodology has a clear theory-based interpretation. Finally, using this method I was able to account for global shocks while several other methodologies spuriously interpret large global shocks as integration because common global shocks make financial variables move together.

The focus of this paper is on financial markets integration from the prospective of investors in financial assets or financial arbitrageurs, as opposed to integration of commodity markets or markets for real assets. Standard no-arbitrage theory predicts that, when investors in financial markets are neutral to exchange (or currency) risk and market frictions are negligible, free international capital flows (*financial* arbitrage) result in the Uncovered Interest Parity (UIP) condition. This result implies that similar assets in different locations have the same expected nominal rate of return regardless of exposure to the exchange risk. However, literature has accumulated abundant evidence of non-negligible exchange, default, and political risk across countries and over time. Further, these risks may result in persistent and volatile risk premia and hinder the ability of countries to tap into international capital markets. If these risks depend on, or are correlated with, legal restrictions to capital flows or the underdevelopment of financial markets, international arbitrage opportunities may also be limited. These combined factors reduce financial integration.

I do not expect to find perfect capital mobility anywhere in history given all the evidence from the literature. Rather, I intend to concentrate on a weaker notion of integration characterized by smaller and more stabile risk premia that would result in a higher *comovement* (but not necessarily equalization) of a country's financial returns.[2] Even if a greater comovement is driven by common global shocks, the fact that such shocks propagate across countries and these shocks are frequent might also be a sign of greater interconnection between individual economies (Bordo et al., 2001). I also verify how comovement of returns has changed over time conditional on time-varying determinants of the risk premia.

My empirical methodology is based on principal component analysis (PCA). The PCA is a non-parametric empirical methodology used to reduce the dimensionality of data and describe common features of a set of economic variables. This method transforms the observed data vectors into new variables referred to as *components*, which are are linear combinations of the original data that maximize variance.[3] The goal of the method is to capture most of the observed variability in the data in a lower-dimensional object and, thereby, filter out noise. Often, a single component summarizes most of the variation of the original data.

I argue that the "first" principal component (with the components ordered according to how much of the data-variation they capture) has a natural interpretation when the PCA is applied to a comparable series (prices, returns, etc.) across markets. When the observed economic variables have a high signal-to-noise ratio, which would be the case under economic integration, a few principal components with larger variance would capture the dynamics that will be informative of the extent of market integration. This result should also be consistent with the standard no-arbitrage theory that implies if the majority of countries are integrated into the world financial markets, their interest rates move together with the world rate. The proportion of total variation in individual returns explained by the first principal component serves as an *index of integration*. I estimate the index of integration over the long-run dynamically via rolling windows. Using the dynamic PCA in the context of market integration is an innovation of this paper as it reveals important trends in integration and country- or group-specific shocks

[2]Clarida and Taylor (1997) demonstrate that the nominal interest rate differential is stationary even if we allow for deviations from the simple efficient markets hypothesis due to risk premia and deviations from rational expectations if the resulting deviations from UIP are themselves stationary.

[3]See Jolliffe (2002) for a more detailed treatment of the PCA.

hidden when a single estimate corresponding to the entire period is reported.[4] Furthermore, using individual country weights (called "loadings" in PCA) on the first principal component, I developed two complementary *indices of segmentation*, which summarize country or group-specific effects, to investigate possible reasons for the changing degree of integration.

Being a price-based measure, the PCA-based index of integration has several practical advantages. The first advantage is the reliance on historic price data, which has a better quality compared to the volume of capital flows used to construct quantity-based measures (Obstfeld and Taylor, 2004). Second, issues that plague price-based measures over the short-term would not affect the results as much when we look at very long time periods.[5] Finally, the long historic context allows researchers to compare the *relative* degree of integration in the present and during previous periods rather than to test for "full integration" or "no integration" which necessitates the choice of some questionable benchmarks and creates difficulty when the absolute values of these measures have to be interpreted.

My primary data are monthly series of sovereign bond yields from 1875 to 2009 available in the *Global Financial Database* (GFD). The sample includes 15 economies whose sovereign debt was continuously traded in a major international financial center (London) and was available in other locations as early as the mid-19th century.[6] Historically, sovereign bonds have been the most actively traded segment of financial markets.[7] In contrast to the stock market indices, the characteristics of the underlying instruments in bond markets (maturity, coupon payments, the identity of the issuer, etc.) are similar across countries and over time. This comparability makes these data attractive for long-term study of the dynamics of financial integration. I prefer using bonds payable in national currency and do not convert the data into a single currency or constant prices because I take the prospective of an investor in international financial markets

[4]Due to problems with interpretation, the PCA has not found a widespread application in the integration literature. To best of my knowledge, all existing studies do not explore the dynamic integration pattern.

[5]If two countries share the same technologies, tastes and endowments asset prices in these locations might be identical even with the most stringent barriers to capital flows (Obstfeld and Taylor 2004, p. 46). Such "coincidence" is not likely to persist over the long-run however. Separately, the recent research on the UIP condition in developed countries surveyed by Alper et al. (2009) finds unfavorable evidence mostly at short horizons.

[6]The largest sample includes Austria, Belgium, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom, and the United States. The motivation for this sample is described in Section 5.1.

[7]Obstfeld and Taylor (2004) also stress that long-term bond yields are most appropriate for a study of the international capital mobility because they are most directly related to the financing costs for capital investments.

and want to analyze all possible reasons for changes in comovement (currency and country risk, cross-border frictions, and other limits to arbitrage). Prior to World War II, the database reports multiple bond series, while the unified series became available from the 1920s onward. I carefully select those early bond series that are most comparable with the subsequent series in order to minimize breaks and make the long-term series consistent.

I estimate the index of integration over 1875–2009 using a relatively wide rolling window of 156 months (13 years), which makes the results relatively immune to short-term noise and to conditional heteroskedasticity in returns. Over the very long-term, the evidence points to higher financial market integration at the end of the 20th century compared to earlier periods. Therefore, the integration followed a J-shaped trend with a trough as early as the 1920s rather than a U-shape as documented by Obstfeld and Taylor (2004) and others. This pattern is also confirmed by time-series regression analysis. According to the indices of segmentation, around the turn of the 20th century countries frequently drifted apart while in the recent years the most countries move together. This uncovers the changed nature of shocks prevalent in the two eras of globalization. Finally, I find that both policy variables (average inflation, government deficit, and, in Bretton Woods period, the exchange-rate regime) and the global market environment (proxied by average trade openness) play a role in explaining the time variation in the index of integration, while "unexplained" changes in overall level of country risk are also empirically important.

For illustrative purposes, Figure 1 presents a smoothed estimate of the index of integration over 130 years. As illustrated in this figure, and consistent with the literature, the dynamics of integration have not been even throughout history. Specifically, integration grew from the late 19th century up to 1914, when World War I began. Following that period, the trend in integration turned negative and reached a historic low around the time of the Great Depression in the 1930s. The partial recovery of international financial linkages in the 1920s is invisible in the graph since it was short-lived. After World War II, the trend in integration turned positive and continued its upward crawl almost uninterrupted to a historic high by the end of the 20th century. It is clear that integration reached levels comparable to the Gold Standard era as early as the late 1960s. This evidence is consistent with the view expressed by Kose et al. (2009) that evaluating integration based on the de jure government restrictions on capital flows may be misleading because capital controls could be avoided, as was the case in the 1960s, which was characterized by rapid expansion of trade, offshore banking, and Eurocurrency markets.[8] This result casts a serious doubt on the Macroeconomic Trilemma paradigm: clearly, during the Bretton-Woods era of tight controls some capital flows were possible in spite of fixed exchange rates and monetary policy that was designed to keep rates fixed.

[insert Figure 1 here]

My measure of integration does not rely on any particular underlying model; nevertheless this measure has a clear theory-based interpretation. In the case of countries' interest rates, the first principal component may naturally be interpreted as the "world" rate. Figure 2 illustrates the individual country yields used in this study with the values on the left axis and the estimated world return on the right axis. This figure demonstrates that the world return captures the dynamics of individual rates remarkably well while it is not affected by country-specific shocks. This is because the world return uses country weights based on features of the data and not subjectively asserted by the researcher. This proxy also reflects the continuously changing individual counties' influence on the world return. For example, when a country shuts down its capital markets, its domestic financial market behavior diverges from the world market. First principal component will immediately capture this decoupling, which will show up as a lower loading that corresponds to this country.

[insert Figure 2 here]

The remainder of this paper is organized as follows. The following section discusses related literature. In Section 3, I lay out a conceptual framework that motivates the empirical analysis and helps interpret the results. Section 4 discusses the methodology used to quantify integration in various markets. Section 5 describes the data and the pattern of integration. Section 6 offers some explanations of the observed pattern. Finally, Section 7 concludes.

[8] While Eichengreen (1996, pp 120-122) cites some evidence that the capital controls still mattered in the 1960s to keep covered interest differential relatively large, he stresses that with the relaxing of current-account restrictions it became easy to over- and under-invoice trade and channel money abroad. The growth of multinational corporations also helped undermine capital controls. Krugman and Obstfeld (2009) textbook discusses some anecdotal evidence. Eurodollars were introduced in the 1950s to support the needs of the growing international trade; after the late 1950s offshore markets for other currencies emerged when these currencies became increasingly convertible. Official regulations and political concerns further contributed to growth of Eurocurrency trading and undermined the official controls.

2 Historic integration patterns: Evidence in the literature

Researchers have not yet reached an agreement regarding the extent of international integration in the 1990s-2000s compared to the first era of globalization, prior to World War I. Quinn (2003), Bordo and Flandreau (2003), and Bordo and Murshid (2006) argue that financial markets were more integrated during the pre-WWI era. Quinn (2003) compiles an indicator of official restrictions on international financial transactions from 1890–1999. He documents that virtually all (industrialized and developing) countries were almost completely open by the late 19th century and concludes that financial globalization was deeper in 1890-1913 than subsequently. Bordo and Flandreau (2003) argue that the recent integration is largely an advanced country phenomenon, whereas it was relatively easier for "periphery" countries to borrow in "core" countries currencies before 1914.[9] Finally, Bordo and Murshid (2006) focus on the transmission of shocks and currency crises and find that financial shocks were more globalized before 1914 compared to the present.

In contrast, Bordo et al. (1999b, 2001), Mauro et al. (2002), and Quinn and Voth (2008) find that the markets are more integrated post-Bretton Woods. Bordo et al. (1999b) point out that the globalization of commodities and financial markets is deeper and broader now, if we take into account such impediments as transportation costs, the degree of contract enforcement, government trade barriers, and information asymmetries. While in the past long-term capital flows were large relative to the size of the world economy, the commodities trade was much smaller relative to countries' outputs. Today's trade and direct investments span previously "non-traded" sectors including services, retail trade, and public utilities. Bordo et al. (2001) analyze the 120-year history of financial (banking, currency, and twin) crises and find that these incidences are more frequent today due to unprecedented capital mobility (especially of short-term capital) and higher risk-taking aided by modern financial safety nets. Today's prevalence of more disruptive twin crises also points on the larger breadth of financial integration; however, in general, today's crises are not more severe in terms of length and output losses.[10] Mauro et

[9] Obstfeld and Taylor (2004) also stress large (compared to the size of their economies) external liabilities of the "periphery" countries then.

[10] Kose et al. (2005) provide the evidence that the common factor explains a larger fraction of output, consumption, and investment volatility of the Group of Seven countries compared in the globalization period 1986–2003 than in the Bretton Woods period 1960–1972.

al. (2002) study bond market correlations and Quinn and Voth (2008) focus on stock market correlations and find that, from the early 1990s, these correlations are at the historic high, even compared to the pre-World War I period—the period of zero restrictions according to the Quinn's capital restrictions measure. Mauro et al. attribute sharp changes in bond spreads to global events in the 1990s and to country-specific events in 1870–1913.

The third group, represented by Obstfeld and Taylor (2003; 2004) and Goetzmann et al. (2005), argues that there is a U-shape and hence an equal amount of integration before 1914 and after 1970. Obstfeld and Taylor (2003; 2004) arrive at this conclusion using a variety of price and quantity criteria of integration. Goetzmann et al. (2005) confirm the U-shape in the historic stock markets correlations; however, they also document the changing number of equity markets, which defines investment opportunity set. While they find that today the average correlation among the *available markets* is lower, the *number* of world markets available for the international investor is larger. This explains why we do not see a larger comovement of today's stock markets with average correlations.[11]

The examples above demonstrate that, methodologically, the existing literature mostly draws conclusions about financial integration from one or a few metrics of integration. Researchers seem to lack a uniform measure of integration (an "integration index") that is theory-based and transparently and clearly reflects the extent and dynamics of integration in a particular market. One solution suggested by Goetzmann et al. (2005) and Obstfeld and Taylor (2003) is to explore the changes in time-series correlations of returns across countries over time. Obstfeld and Taylor admit, however, that a higher correlation among markets might be the result of common shocks among a group of countries and not necessarily evidence of globalization. To overcome this problem Obstfeld and Taylor (2003; 2004) investigate the pattern of financial integration based on a *combination* of price and quantity criteria. In my view, it is important to pursue a more systematic study—more in spirit of Obstfeld and Taylor (2003; 2004)—to quantify integration, explore its dynamics, and capture episodes of market segmentation.

[11] Several papers provide indirect evidence that financial integration was high both in the past and today. Clemens and Williamson (2000) study historical British capital flows and find that both prior World War I and recently integration of capital markets was sufficient to eliminate the influence of international market failures on capital flows. Rajan and Zingales (2003) show that financial development is positively correlated with a country's openness to trade, both in the beginning of the century (1913) and towards the end of the century (the late 1990s).

3 Conceptual Issues

The financial literature has a long tradition of measuring financial markets integration (or market efficiency) by comparing returns on similar financial assets. The standard no-arbitrage theory predicts that free international capital flows result in the UIP condition between expected rates of return of two countries, expressed in a common currency, such that $1 + i_{t,k} = (1 + i^*_{t,k})S^e_{t,k}/S_t$ or, as log-approximation, $i_{t,k} - i^*_{t,k} = \Delta^e_k s_t$ where $i_{t,k}$ and $i^*_{t,k}$ are the nominal interest rate on domestic asset (in domestic currency) and foreign asset (in foreign currency), S_t and $S^e_{t,k}$ are today's and expected future spot exchange rate k periods ahead, quoted as the domestic-currency price of one unit of foreign currency, and $\Delta^e_k s_t \equiv s^e_{t+k} - s_t$ (with the lower-case exchange rates being in logs). Under the UIP, a domestic investor's exchange risk exposure is uncovered.[12] By extension, in the multi-country case, perfect capital mobility would preclude local asset prices to deviate from global prices.

The international macroeconomics literature has established that "frictions" associated with national borders are the reason for having lower integration in the recent decades than what we would expect in theory.[13] Explicit government trade and capital controls, sovereign and default risk, information asymmetries, poor institutions, and high price of physical capital are examples of such cross-border frictions (see Wei 2000; Reinhart and Rogoff, 2004; Alfaro et al., 2008; Caselli and Feyrer, 2007). Obstfeld and Taylor (2004) conclude that the changes in quantity and price indicators of financial integration over the last 150 years have been caused by changes in barriers to international capital flows (or changes in arbitrage opportunities) over time, not by the structural changes within economies. Obstfeld and Taylor and also Eichengreen (1996) further emphasize the dramatic political, economic and intellectual changes over the course of the century and stress the political economy considerations behind the changes in integration over time in accordance with the Macroeconomic Policy Trilemma.

[12] This "basic" UIP condition assumes that the number of international investors is sufficiently large, the investors are exchange-risk-neutral, transaction costs are negligible, and assets located in different countries are identical with respect to liquidity, maturity, political and default risk. UIP hypothesis can be empirically tested by estimating a regression $\Delta_k s_t = s_{t+k} - s_t = \alpha + \beta(i_{t,k} - i^*_{t,k}) + u_{t+k}$ and testing the joint hypothesis of $\alpha = 0$, $\beta = 1$, and u_{t+k} is orthogonal to the information available at t. Such test assumes the rational expectations by which $s_{t+k} = E(s_{t+k}|I_t) + u_{t+k}$ and the forecast error u_{t+k} is independent of the information at time t.

[13] The manifestations of low international financial integration include home bias in equity holdings (French and Poterba, 1991; Tesar and Werner, 1995), high correlation between country savings and investment (Feldstein and Horioka, 1980), lower cross-country consumption correlations than output correlations (Backus et al., 1992), lack of flows of capital from rich to poor economies (Lucas, 1990).

According to the Trilemma hypothesis, growing political tensions at home pushed national governments toward a greater macroeconomic activism in the 1920s–1930s compared to prior to World War I, when government policies were subject to maintaining the "rules of the game" of international Gold Standard arrangement.

Consequently, the UIP with risk is a natural benchmark to study the relationship between the degree of international financial integration and economic policies, fundamentals, and international market environment, all of which determine the "risk" for an international investor. Theoretically, the deviations from the basic UIP condition could be attributed to the non-rationality of market expectations, risk aversion of investors (by which investors would demand a premium for holding assets they consider risky), existence of transaction costs, market frictions, government interventions, and limits to speculation (investors engage in arbitrage only if the excess return per unit of risk is large enough). Retaining the assumption of rational expectations, the deviation from the basic UIP can be represented as:

$$i_{t,k} - i^*_{t,k} - \Delta^e_k s_t = \rho_t \tag{1}$$

where ρ_t is the time-varying risk premium (broadly defined). Risk premium is positive if domestic interest rate is higher than the level predicted by the UIP.[14] To see various sources of the risk premium consider some options for an international investor from 1880–1913.[15] The investor could purchase the Danish 3.5% Internal Debt Loan of 1887 denominated in kronor floated in Copenhagen and paying $i_{t,k}$, the Danish 4% Loan of 1912 in British pounds floated in Copenhagen and paying $i^{£}_{t,k}$, the Danish 3% Gold Loan of 1897 in pounds floated in London and paying $i^{£,Lon}_{t,k}$, or the British consol bond in pounds floated in London and paying $i^*_{t,k}$. Using this notation, the equation (1) can be decomposed into:

$$\begin{aligned} i_{t,k} - i^*_{t,k} &= \Delta^e_k s_t + (i_{t,k} - i^{£}_{t,k} - \Delta^e_k s_t) + (i^{£,Lon}_{t,k} - i^*_{t,k}) + (i^{£}_{t,k} - i^{£,Lon}_{t,k}) && (2) \\ &= \Delta^e_k s_t + \rho^E_t + \rho^D_t + \rho^P_t && (3) \end{aligned}$$

[14] With the failure of the rational expectations assumption, the expected depreciation term $\Delta^e_k s_t$ in (1) could be represented by the actual exchange-rate change $\Delta_k s_t$ plus a forecast error ν_{t+k} that depends on the information exploitable at time t. Sarno and Taylor (2002) stress the importance of risk premia, expectations, and the use of survey data in testing of the UIP. See Alper et al. (2009) for a recent survey.

[15] The following historical example follows similar UIP decomposition in Frankel (1992) and Alper et al. (2009) with the information on Danish bonds obtained from Bordo and Flandreau (2003).

The term $i_{t,k} - i^{£}_{t,k} - \Delta^e_k s_t$ reflects the exchange risk ρ^E_t because the assets it represents are identical in terms of the issuer and the jurisdiction (Denmark) but different by the currency denomination. The assets in the term $i^{£,Lon}_{t,k} - i^*_{t,k}$ differ by the issuer country but both are in the foreign currency and floated in foreign market from the prospective of Denmark. This term represents the default risk ρ^D_t. The assets in the third term $i^{£}_{t,k} - i^{£,Lon}_{t,k}$ differ by the jurisdiction but are the same in terms of currency (the pound) and the issuer (Denmark), reflecting the political risk ρ^P_t of shifting the capital across borders. The nominal interest differential then equals to an anticipated change in the exchange rate plus the sum of the exchange risk ρ^E_t, the default risk ρ^D_t, and the political risk ρ^P_t. Hence, in general, risk-neutral investors (who care only about expected returns) would ask for the country-risk premium $\rho^D_t + \rho^P_t$, and risk-averse investors would in addition require the exchange-risk premium ρ^E_t.[16]

One approach to the study of financial integration within the UIP-with-risk paradigm is to identify the degree of integration with the risk premium and analyze its time-series pattern and properties (see Lothian, 2002 for a group of industrial countries over the long-term; Holtemöller, 2005 for the EU accession countries). The second approach consists primarily of country studies and relates the total risk premium or its components to macroeconomic fundamentals, transaction costs, or monetary policy (see Alper et al., 2009 for the survey).[17] As Obstfeld and Taylor (2004) stress, we always face the problem that "every test [for capital mobility] is usually a matter of degree," and the choice of benchmark to which today's integration should be compared is difficult. Furthermore, the data availability often poses a challenge to the direct studies of the UIP over the long-term. Considering this, I combine these approaches to face the challenges experienced by previous researchers. Similarly to the first literature, I study the deviations from UIP indirectly by looking at *comovement* of the nominal returns over time.

I also follow the second strand of literature and verify how the comovement of returns changed over time, *conditional* on time-varying determinants of risk premia. In the classical Heckscher-Ohlin-Mundell trade theory, trade and finance are substitutes since trade integration

[16]In case of government bonds, ρ^D_t and ρ^P_t represent the "country risk" as defined by Frankel (1992) which captures "all barriers to integration of financial markets across national boundaries: transactions costs, information costs, capital controls, tax laws that discriminate by country of residence, default risk, and risk of future capital controls."

[17]Alternatively, the capital asset pricing models (CAPM) suggest that only non-diversifiable "systematic" risk can be interpreted as a risk premium. According to the CAPM literature, if exchange and country risks cannot be (completely) diversified they are the part of the systematic risk and hence would explain return differentials.

equalizes factor prices reducing, or altogether eliminating, the incentives for capital to flow into capital-scarce countries. However empirical evidence, supported by alternative theories, suggests that international capital flows often follow trade patterns, making them complements (see for example Lane and Milesi-Ferretti, 2004).[18] Rose and Spiegel (2004) argue that creditors might systematically lend more to countries with which they share closer trade links if the threat of trade sanctions could effectively prevent sovereign default as in the "default penalties" model of Bulow and Rogoff (1989).[19] The complementarity can also be explained by goods or asset market frictions (trade costs, information asymmetry) as in the models of Obstfeld and Rogoff (2000) and Martin and Rey (2004). Aviat and Coeurdacier (2007) stress the role of scale economies emerging from market size and argue that a large volume of trade between two countries would make the foreign exchange market more liquid and more efficient and thus reduce transaction costs for financial investments. In the model with financial frictions by Antras and Caballero (2009) and in political economy "interest groups" theory by Rajan and Zingales (2003), both trade and capital flows become market mechanisms to promote financial development and correct the misallocation of capital induced by financial frictions.

The second set of variables to condition on includes measures of domestic economic policy and macroeconomic fundamentals. These variables could give investors an idea about the extent of debt burden or laxity of lending standards in a given country. Policies that historically contributed to financial integration include the adherence to the Gold Standard prior to the 1913 (Bordo and Rockoff, 1996), the credibility of this commitment (Mitchener and Weidenmier, 2009), the reestablishment of the Gold Standard at pre-World War I parity in the 1920s (Bordo et al., 1999a), the return to gold at a devalued parity plus prudent government fiscal policy and country reputation with respect to previous defaults (Obstfeld and Taylor, 2003; 2004), stable economic and political environment (Flandreau and Zúmer, 2004; Ferguson and Schularick, 2008), and avoidance of excessive borrowing (Reinhart and Rogoff, 2009). Flandreau and Zúmer (2004) point that investors prior to 1913 assigned a secondary

[18] Recently Kalemli-Ozcan and Nikolsko-Rzhevskyy (2010) provide evidence for the complementarity between trade and financial flows of Germany, France, and the UK to the Ottoman Empire over 1859–1913, with the causality running from trade to financial flows even conditional on the Ottoman sovereign default and following the "supersactions" imposed.

[19] Mitchener and Weidenmier (2005) examine the role of various sanctions in promoting debt repayment during the classical gold standard period, and find a significant decline in trade as a result of default only when gunboat diplomacy or fiscal control (the "supersanctions") was used by creditor countries.

or indirect role to fiscal and monetary variables. Bordo et al. (1999a) find that inflation became important in explaining return spreads during the interwar period. Fixed exchange rate regimes were an important part of international monetary arrangements throughout the history, and, depending on the degree of policy credibility, such rule-based monetary policy could be stabilizing for globalization, as was the case during the Gold Standard (Bordo and Rockoff, 1996), or disruptive, as seen in the late 1920s (see Bordo and Schwartz, 1999), around the collapse of Bretton Woods, and during the early years of the European Monetary System. Hence, their effect is ambiguous. The explicit capital controls and other restrictions on current and capital account transactions are implemented by the governments in the effort to tame the international capital flows. The effectiveness of these measures is an empirical question. Ferguson and Schularick (2008) find that pre-WWI foreign investors in developing nations paid more attention to these countries' vulnerability to economic and political shocks than to their commitment to a rules-based arrangement, such as the Gold Standard. The poorer developing countries often lacked the credibility to convince lenders that they would stick to the standard despite a formal commitment to it. Therefore, my third set of variables includes proxies for economic shocks such as financial and economic crises or hyperinflation episodes.

4 Empirical Methodology

4.1 Correlations as measures of integration: A critical assessment

Interpreting a high correlation of economic series as evidence of substantial integration has several issues.[20] First, the literature often measures correlations of return spreads relative to a particular economy. Over relatively long time periods, the choice of the reference country, and thus the trends of its returns, might affect conclusions drawn from the correlations of spreads versus that country. This is indeed the case in my data as Figure 3 shows where the correlations of spreads versus the U.S. and Great Britain demonstrate the opposite pattern. Second, while the conventional Pearson product-moment correlation coefficients do not require that data is normally distributed, it is defined in terms of moments (covariance and the standard deviations) that must exist. As such, one can always compute a sample correlation if the range

[20] In historical studies of equity market integration this measure was used, among others, by Goetzman et al. (2005), Obstfeld and Taylor (2003), and Quinn and Voth (2008).

of the distribution is bounded. However, the sample correlation is not a robust statistics in the presence of outliers or a heavy-tailed distribution (see Wilcox, 2005; Huber and Ronchetti, 2009). Third, conclusions about integration drawn from correlations may be biased by the conditional heteroskedasticity of market returns, or the hypothesis that cross-market correlations depend on market volatility, as argued by Boyer et al. (1999), Forbes and Rigobon (2002), and Longin and Solnik (2001) among others. Boyer et al. (1999) demonstrate that one cannot correct the problem by comparing an estimated correlation conditioned on the observed (or ex post) realization of market returns because the conditional correlation is highly nonlinear with respect to the level of return on which it is conditioned. Forbes and Rigobon (2002) focus on clearly-defined episodes when a crisis in one market increases market volatility elsewhere. They argue that in such cases conventional correlation coefficients are biased upward and suggest a correction that crucially relies on certain statistical assumptions including that the shock originates in a clearly identified market, there are no exogenous global shocks and feedback from the other markets, the variance of the noise in links between countries remains the same. Not only are these assumptions fairly restrictive in general, but we also need to identify a clear exogenous event that could have caused a change in market volatility. Longin and Solnik (2001) show that the correlation of market returns is mainly affected by market trends, not the high volatility of returns per se. Correlations seem to increase only when asset prices fall (bear markets); however, not when they are expected to rise (bull markets). These issues are inherent flaws of correlations and the literature seemingly has not reach a consensus on how to correct this problem in general. Fourth, and related to the previous, if the financial markets are affected by a global shock in a similar fashion, the correlation across countries might be high even without substantial integration. One cannot distinguish high integration and a common shock as both may show up as a higher value of correlation. The adjustment by Forbes and Rigobon (2002) breaks down when a high cross-market volatility results from the aggregate shock that is much larger than an idiosyncratic shock transmitted to a country's neighbors.

[insert Figure 3 here]

These interpretational and statistical issues make correlation coefficient an inadequate measure of *integration*. Very often, the observed differences in correlations result from the changes in statistical properties of a sample rather than from actual economic links. Therefore, the study of integration over time should be complemented with an analysis of the shocks pertinent to a group of countries in corresponding time periods.

4.2 Principal component analysis

I use principal component analysis to overcome the limitations of correlations in measuring integration. This method is valid without needing specific assumptions regarding the particular distributions of the data except that it does require the data is interval-level.[21] This is the first obvious advantage over the correlation, which is not a robust statistic in the presence of heavy-tailed distributions observed in financial series.

Assume $\mathbf{X_{n\times 1}} = \{x_i\}_{i=1}^{n}$ is a set of a relatively large number n of observed variables, and we are interested in reducing the dimensionality of the data while retaining most of the information about their variation. One Principal component analysis is a non-parametric empirical methodology used to reduce the dimensionality and describe common features of the data (see Jolliffe, 2002 for more details). The principal components are weighted linear combinations of the original variables x_i represented by the matrix system $\mathbf{F_{n\times 1}} = \boldsymbol{\alpha}_{\mathbf{n\times n}}\mathbf{X_{n\times 1}}$ where, for example, the first line of the system takes the form $f_1 = \mathbf{a_1'x} = \alpha_{11}x_1 + \alpha_{12}x_2 + \ldots + \alpha_{1n}x_n$. The coefficients $\alpha_{11}, \alpha_{12}, \ldots, \alpha_{1n}$, are called scoring coefficients or *loadings* by the original series x_i on the component f_1. They are calculated in a way to guarantee the maximum sample variance of f_1. The restriction is imposed on $\mathbf{a_1} = (\alpha_{1i}) = (\alpha_{11} \quad \alpha_{12} \quad \ldots \quad \alpha_{1n})'$ such that the $\mathbf{a_1'a_1} = 1$ since otherwise the variance of f_1 can be artificially increased by picking larger α_{1i}. Each subsequent component is orthogonal to the previous one (e.g., $\mathbf{a_1'a_2} = 0$) and also has the maximum variance. Hence, f_2 explains maximum of the residual variation after the previous component f_1 is removed form the data, and so forth. Technically, the coefficients α_{ji} are the elements of an eigenvector of the sample covariance matrix $\mathbf{Z}$ corresponding to the j-th largest eigenvalue, λ_j. With the above restriction on $\mathbf{a_1}$ to be a unit-length vector, the variance of the component f_j are the corresponding j-th eigenvalue of $\mathbf{Z}$. In case when the variables x_i have different scales, the variables with larger standard deviations might have larger weight by construction. In such case it is advisable to calculate the components from

[21] The data is interval-level if there is a meaningful continuous scale of measurement such that equal differences in the scale correspond to equal differences in the physical quantities they measure.

the sample correlation matrix which is analogous to standardizing all the variables prior to calculation. The components are then ranked by their variance, with the first component having the largest variance.[22] The lower-order components typically yield a larger variance compared to the original series. Additionally, each component of a higher order "explains" most of the *residual* variation in the data that is not captured by the previous component, and so on. As a result, a smaller number of components, often just the first component, summarizes most of the observed variation in the data and filters out noise.

A few available papers have used the PCA to complement other techniques of measuring financial integration. Most notably, Mauro et al. (2002) find that the first principal component explains a large proportion of variation of sovereign bond spreads for a group of emerging market countries from 1877–1913 and an even larger proportion in the 1990s. Earlier, Nellis (1982) used PCA to compare interest rate comovement among industrialized countries before and after the move to a floating exchange rate regime in the early 1970s and Gagnon and Unferth (1995) examined their trends in 1977–1993. These studies look at the proportion of the total variation in economic series described by the first principal component arguing that a single variable explaining most of the variation in the data would indicate market integration. Nellis (1982, p.346) cautions against the mechanical interpretation of the first principal component as a measure for integration, however, does not explore this issue further. A high and growing degree of integration among *a subset* of countries might generate a strong component; therefore, we would find financial interdependence within that subset, but not integration in the entire sample.[23] The existence of several factors, each affecting only a subset of countries in the total, would imply market segmentation according to Bordo and Murshid (2006). They study the first three principal components in sovereign bond spreads and find sharp distinctions in the patterns between advanced and emerging countries in the 1990s.

As such, the existing studies limit the use of PCA to calculating the principal components

[22]The total variance of n standardized data vectors x_i is n. The proportion explained by, say, the first component is calculated as a ratio of its variance (the first eigenvalue of $\mathbf{Z}$) and the data total variance, n.

[23]The indicators of such possibilities include the following: (1) the first principal component does not affect all countries uniformly (this means that correlation of individual variables with first principal component differs a lot among countries), and (2) the remaining factors explain considerable amount of the residual variation after the first component is accounted for.

over a particular time period. In extension of the previous literature, I propose a systematic methodology based on the method of principal components to measure economic integration over time. The details of practical implementation are discussed in the working paper Volosovych (2011). The combined approach I advocate differs from the previous literature along several dimensions. First, I estimate principal components with rolling windows. In doing so, I use the proportion of the total variation in the level of individual returns explained by the first principal component as a *dynamic* measure of integration in a group of countries. This *index of integration* can be plotted over time to provide a visual illustration of the time path of integration and be used to explain the discovered patterns in a regression framework.

Second, I recognize that the extraction of principal components from spreads requires the choice of a reference country. The resulting patterns are benchmark-specific, and this could affect the interpretation of results. In contrast to the studies by Mauro et al. (2002) and Bordo and Murshid (2005), who work with bond return spreads, I apply PCA to the *levels* of financial returns. In this case, assuming some integration across markets, the the first principal component may naturally be interpreted as the unobserved "world" return since this factor captures the most variation in individual returns. Of note, spreads versus this estimate of world return are independent of a particular reference country, which is an advantage. Similar interpretation is applicable to other markets with available price data, i.e., to the markets where the notion "world price" exists.

The third consideration involves capturing possible group divergencies or country-specific shocks. A high and growing degree of integration among a subset of countries, or simply peculiar characteristics of a group, might generate a component with large variance. This is why Bordo and Murshid (2005), who studied the data for advanced and emerging markets, discover several components with large variance. The interpretation of the higher-order components is generally theoretically difficult. For this reason, I analyze country, or group-specific effects using two complementary *indices of segmentation* computed from country weights on the first component. Tying financial integration and segmentation to the estimated world return has a solid theoretical interpretation related to the UIP condition.

The final consideration involves the treatment of conditional heteroskedasticity. This issue is an inherent flaw of correlations; however, is not known to plague the results of PCA, which is a more outlier-resistent and distributionally robust method. Still, I choose a relatively wide window to guard against the short-term noise and possible issues of conditional heteroskedasticity in returns.

5 Evidence from the index of integration

5.1 Historic sovereign bond data

Data availability and quality are the major challenges for empirical studies of integration over the long-run. For example, to directly test for UIP or to estimate risk premia in (2), one would need a relatively long time series of returns on comparable (in terms of currency, maturity, liquidity, risk) assets, spot and forward exchange rates, determinants of risk, and reliable estimates of market expectations. For the majority of countries such data is largely not available or non-existent over the long run. Historical studies of integration focus on asset data in the same currency and priced in a single market. As seen in (2), using such data allows researchers to isolate country risk (if assets are in foreign currency) and default risk (if they are also floated in a foreign financial center).[24] This approach is appropriate if one studies only the time period when the corresponding instruments are available; however, this might be problematic over the long-term as pointed out by Obstfeld and Taylor (2003, 2004) who argue that one cannot credibly compare two periods when the data are not consistent.

I use monthly bond data over 1875–2009 from the *Global Financial Database* (GFD). This database contains monthly financial data from about 100 countries with bond and equity series for some countries beginning as early as the 18th century. The GFD reports bond yields for comparability. I make the following decisions to achieve data consistency (**??** provides details on bond data), referring to the descriptions of particular historical bond issues in the GFD manual, *Kimber's Record of Government Debts and other Securities*, published in 1920 and 1922, Bordo and Flandreau (2003), and other sources. First, I focus on long-term sovereign bonds. Historically, this is the most actively traded segment of internationally financial markets.[25] In contrast to stock market indices, the characteristics of the underlying financial

[24] Examples are secondary market yields on long-term government bonds in London (Bordo and Rockoff, 1996; Mauro et al., 2002; Obstfeld and Taylor, 2003, 2004) or the yields at the moment of new bond floatation in New York that became an important bond market in the interwar period (Bordo et al., 1999a).

[25] Obstfeld and Taylor (2004) also stress that long-term bond yields are most appropriate for a study of the

instruments (e.g., maturity, coupon payments, the identity of the issuer, and so on) are similar across countries and remain relatively stable over time. Second, I choose the series with fewest breaks. Most governments started to publish the unified indices of bond yields only in the 1920s.[26] The breaks in the series are sometimes present when historic series are spliced in GFD with the subsequent modern series. When multiple historical bond series are available I choose the earlier series most comparable with the subsequent series. Third, where possible, I use the series of bonds payable in national currency, even when some issues were floated in London, because my goal is to analyze all possible reasons for changes in comovement including exchange, political, default risk, cross-border frictions, and other limits to the arbitrage discussed in Section 3. The later series are always payable in national currency. Fourth, I use a fairly homogenous but representative sample of 15 relatively advanced economies whose sovereign debt was continuously traded in the major international financial center (London) as early as the mid-19th century. It is reasonable to assume that all these countries had similar structural or institutional conditions, at least in relation to the development of financial markets, if not the level of overall economic development. With a few exceptions, there were no major defaults on government debt by these countries that would create discontinuities in the time series. Countries include Austria, Belgium, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom, and the United States.[27] For the longest time period, I use a sub-sample of 11 countries with appropriate yield data available for the entire time period.[28] I decided to exclude British Empire countries since colonial ties with the UK influenced their spread behavior (i.e., over the 1880–1930, the Empire countries typically had interest rates within two percentage points of British rates; see Obstfeld and Taylor, 2004).

Figure 2 illustrates the individual country returns used in this study with the values on the

international capital mobility because they are most directly related to the financing costs for capital investments.

[26]The League of Nations began to compile the internationally comparable financial data in 1920, but the coverage improved only by the late 1920s. Goetzmann, et al. (2005) say that this was roughly the case for the stock market indices.

[27]Obstfeld and Taylor (2004) study similar set of countries and refute the idea that these countries faced different "shocks to technology" over the century. Bordo and Schwartz (1996) classify Austria, Denmark, Italy, Japan, Spain and the U.S. to be emerging countries in pre-World War I period.

[28]I exclude Austria, Finland, Japan, and Switzerland whose consistent bond yield series start in the GFD after World War I. For example, for Switzerland the only data available before 1925 is the average of 12 state and federal railway bonds. In other cases, I only have the data for the sovereign bonds payable in gold until the late 1920s, which does not allow to investigate the currency risk.

left axis and the estimated "world" return (the first principal component) on the right axis. Table 1 presents the summary statistics for bond returns across exogenous periods according to prevailing international monetary arrangements as defined by Bordo and Schwartz (1999). With slight modifications these periods include (1) Classical Gold Standard, 1875:01–1914:07; (2) Interwar Period, 1919:01–1939:08; (3) Bretton Woods System, 1945:06–1971:07; (4) Modern Float, 1971:08–1990:12; and (5) Modern Globalization, 1991:01–2008:09 (I also combine the latter two periods into a single Post-Bretton Woods period).[29] The first two columns report the average return and corresponding standard deviation for each country over the entire time period. The remainder of the table reports the average returns across five historical periods. For all the countries, bond returns remained low and stable throughout the first half of the 20th century. Following World War II, the returns rose continuously reaching double digits in the 1970s–80s, then turned down sharply in the 1990s. The 1971–1990 period was also exceptional as evidenced by the highest variability or returns. Volatility decreased somewhat in the 1990s; however, did not reach the low pre-World War II level. A similar pattern is observed in the behavior of cross-section variability of returns. Specifically, both unadjusted and mean-adjusted cross-section standard deviations imply a hump-shaped pattern of variability with the top during the Bretton Woods and Modern Float and the tendency for convergence during the last period. The general ranking of countries in terms of levels of returns is approximately preserved over time despite some important changes in individual yields over time.

[insert Table 1 here]

5.2 Trend in bond markets integration

Before turning to my method, I follow a few existing studies and calculate the proportion of total variation in 11 bond returns explained by the first principal component over the pre-defined periods. The proportion is equal to 76% over 1875–1913, 55% over 1919–1939, 84% over 1945–1971, 60% over 1971–1990, and 95% over 1991–2008.[30] Based on this measure, the

[29] I omit the years of two world wars because then markets were usually inactive and reliability of data is questionable. I also define the sub-periods to obtain the maximum coverage across countries. Sometimes I have to fill the missing values with linear interpolation but preferred not to do interpolation where the data were missing in the beginning of the sub-sample for a particular country. In such case the series for this country is started from first available observation.

[30] The pattern is similar for 15-country sample with Austria, Finland, Japan, and Switzerland over four periods starting 1919.

comovement of bond markets is higher "now" than ever before. In addition, the comovement was relatively high from the end of World War II until the collapse of the Bretton Woods system and was interrupted by the turbulent 1970s–80s. Still, a single factor explained more than a half of the variation in bond yields over the five periods, and 83% over the entire period from 1875 to 2008. These findings are broadly consistent with the other studies, however, mask interesting dynamics.

The dynamic approach outlined in Section 4 reveals shorter-run patterns in comovement that are obscured when comparing only two exogenously-chosen (and arguably ad hoc) periods of globalization. I estimate principal components for 11 bond series using 156 month centered rolling window.[31] The graph of the total variation in returns explained by the first principal component, the index of integration, is presented in Figure 4 together with a smoothed trend line. Based on this figure, we can draw the following conclusions. First, consistent with the literature, the dynamics of integration was not even over 130 years. Integration grew from the late-19th century up to 1914, when World War I broke out. Following this, the trend in integration turned negative and reached a historic low around the time of the Great Depression during the 1930s. There was a partial recovery of international financial linkages in the 1920s; however, it was very short-lived. After World War II, the trend in integration turned positive and continued its upward crawl almost non-interrupted to the present time. Second, despite the common view, it is clear that in the present group of countries integration in sovereign bond market reached the levels comparable to the Gold Standard era as early as the late 1960s, on the verge of the collapse of the Bretton Woods system. Third, the evidence points to a higher financial market integration at the end of the 20th century compared to the earlier periods. The integration thus followed a J-shaped trend with a trough as early as the 1920s, rather than a U-shape, as documented by Obstfeld and Taylor (2004).

[insert Figure 4 here]

To verify whether the graphical evidence for the J-shaped pattern holds true in a statistical sense, I run a regression of the index of integration on linear and quadratic time trend over the

[31] Estimations with the bandwidth of 120 and 180 months produced very similar pattern. In addition, I used the historic bond data from 1880 to 1914 kindly shared by Marc Weidenmier, used in Mitchener and Weidenmier (2009). The resulting pattern of index of integration is very similar and available upon request.

period 1975–2002.[32] I assume the error structure is heteroskedastic and autocorrelated up to 12 months, and also control for the periods of two world wars. Column (1) of Table 2 shows the regression for the monthly index of integration. The coefficients of linear and quadratic trends are highly significant and point to a non-linear trend line. The values of the coefficients imply that the trough in the trend in integration is around Sept. 1928, which is remarkably consistent with the historical evidence pointing at the Great Depression as a "watershed" of financial integration (Obstfeld and Taylor, 2003; 2004). The fact that the minimum in integration corresponds to the late 1920s, closer to the beginning of the sample period used for this estimation, is evidence that the trend line follows a J-shape over the period 1975–2009. Columns (2) and (3) repeat the exercise using quarterly or yearly averages of the monthly data. The results using these "smoothed" series are very similar, with the minima around the time of the Great Depression.

[insert Table 2 here]

6 Toward explaining integration patterns

To prove that my method reflects dynamics of bond market integration and not something else, in particular common shocks, I employ a series of additional checks. The evidence provided so far shows that the recent period is characterized the largest proportion of variation attributed to a single important factor than ever before. Potentially, the index of integration may have a lower value due to country- or group-specific effects. The situation when the majority of countries move in different directions would imply a true "lack of integration" since some forces impair the comovement of most countries. However, if just a few countries drop out of the group, this would be an example of a "regional crisis" since most of the countries would still be moving together with the world and only a small number would diverge. I conjecture that the previous period of high integration, prior to World War I, witnessed many country- or group-specific shocks.[33] Principal component analysis allows for the testing of this conjecture.

[32] Since the index of integration is estimated by a centered moving window of 156 months (13 years), the ends of the periods would use less observations. In the regressions I prefer using the index estimated with all the data. The results over longer period of time, up to 2008:09 are very similar.

[33] This claim would be consistent with the conclusion of Mauro et al. (2002) that sudden changes in spreads in recent years were associated with global crises whereas country events had a bigger role in the 1870–1913.

As discussed in **??**, the PCA normalizes the original series to a variance of one. Normally, the lower proportion of total variation explained by the first component implies the existence of a larger number of components with variances (eigenvalues) greater than one, each of them explaining more variation than any original series. In my sample, the number of principal components with eigenvalues greater than one indeed varies over time. Across exogenous historical periods, this number is two over 1875–mid-1914, three over 1919–1939, one in 1945–1971, two over 1971–1990, and one over 1991–2009 or over 1971–2009. This finding further alarms us about the possibility of market segmentation and country-specific shocks before the two world wars and during the Bretton Woods period.

6.1 Country effects, group divergencies, and index of segmentation

Country loadings on the first principal component, represented by the coefficients α_{1i} (see Section 4), help identify the periods of sudden drops in individual country comovement with the world, or group divergencies. Countries with larger loadings contribute the most to the unobserved world return approximated by the first principal component; low or negative loadings reveal those countries whose bond returns move independently. I investigate time patterns of loadings, close in spirit to study by Nellis (1982) does.[34] Using country loadings on the first principal component, one can recover correlations of the unobserved world return with country returns, which are easier to interpret.[35] The dynamics of the correlations are reported in Figure 5. Overall, the correlations of country bond yields with the world are quite high—all the countries remain relatively integrated into international financial markets. However, there are noticeable periods when the individual bond returns moved independently form the world return. In addition, there are some periods when several countries have such decoupling simultaneously. For example, there are noticeable clustering of lower correlations for Belgium, Germany, Italy, Spain, and the United States from approximately 1894 to 1902; for Belgium,

[34]Bordo and Murshid (2006) explore the loadings of the first and higher-order principal components and use cluster analysis to divide countries into the groups. In this study I am more interested in the analysis of integration of all in-sample countries. Grouping of countries based on some criterion is an important exercise but is of the secondary interest for my study.

[35]As discussed in Joliffe (2002), the estimates of the correlation between observed variables x_i and unobserved first principal component f_1 can be derived from the eigenvalue decomposition of the sample covariance matrix. The correlations are equal to the product of a country loadings $(\alpha_{11} \quad \alpha_{12} \quad \dots \quad \alpha_{1n})'$ and the square root of corresponding eigenvalue. Therefore, the loadings are proportional to the correlation coefficient. In the rest of the paper I study correlations calculated in this way.

France, Germany, and Spain in the mid-1920s–late 1930s; for Germany and Great Britain in 1973–early 1980s; and for Norway and Sweden in the 1980s.

[insert Figure 5 here]

In addition to index of integration, I develop a companion measure that summarizes country- or group-specific effects. I argue that such *index of segmentation* should supplement analysis of markets comovement to give a more complete picture about the dynamics of integration. Figure 6 presents two versions of the index of segmentation. The line is the standard deviation of the individual country loadings associated with the first principal component and the bars represent the number of countries out of 11 (the sample size) with negative loadings. Both indices of segmentation show that the "crises" picked up by the index of integration in various time periods are in fact brought about by very different causes. There was little integration in the entire sample at the turn of the 20th century: all countries frequently diverted from the group and their weights in the world return varied. In contrast, post-World War I "crises" were caused by some individual divergences, where at most two countries diverted from the group. The post-Bretton Woods era does not observe even this kind of divergences. Notably, there is a short period of discontinuity in British rate comovement and some instability at the end of the 1970s. Otherwise, integration of bond markets of in-sample countries is remarkable. In Volosovych (2011), I name a number of global and country events that could have caused the time pattern of integration discovered by indices of integration and segmentation seen in Figures 4–6. Overall, the methodology advocated in this paper matches country events and global crises in financial integration remarkably well.

[insert Figure 6 here]

6.2 Role of global market environment, economic policies, and shocks

I include proxies for market frictions, policies and institutional arrangements into the time-series regression of Table 2 in order to study which factors were associated with the observed pattern of integration more formally. The first variable is a proxy for pro-globalization market environment, measured by the trade openness. The *average trade openness* is defined as average over in-sample countries of exports plus imports over GDP. I supplement the historic trade data on the merchandize trade from Brian Mitchell's International Histological Statistics with the modern data on trade in goods and services by splicing the series from approximately 1960 so that the break is minimized. The second set of variables includes measures of domestic economic policy and macroeconomic fundamentals. I use the cross-sectional *average inflation rate* as a proxy of overall laxity of government policy, such as the degree of commitment to a fixed exchange rate regime or inclination to finance excessive government expenditures. I calculate inflation rate as an ex post year-on-year change in monthly CPI, based on GFD data supplemented by data from the International Historical Statistics volumes and the IMF's International Financial Statistics database starting from 2003. In the regressions I use annual averages of these series to smooth volatility and because earlier price data is often available only at the annual frequency. In addition, to control for fiscal policy, I compute the cross-sectional *average government deficit to GDP* using annual data from Bordo et al. (2001), supplemented with the negative of the overall budget balance from the World Bank's World Development Indicators database in the 1990s and 2000s .[36] For each country in my sample, I construct the monthly binary variable equal to 1 if the country pursued an exchange rate regime other than a free flat in a given time period. I also construct the binary variable equal to 1 for periods of capital controls. Similarly to Bordo (1999), I treat the 'capital controls' broadly to include various restrictions on capital (in/out)flows or foreign currency transactions, foreign exchange controls, and other frictions related to currency convertibility. I use annual dummies from Bordo et al. (2001) and adjust them to the exact months of changes in the regimes and capital controls using qualitative descriptions in this paper, Bordo and Schwartz (1996), Bordo and Rockoff (1996), Eichengreen (1994, 1996), Bordo (1999), and other sources (the details of these adjustments are available from the author). The variable Prevalence of Capital Controls is the fraction of countries with restrictions on capital flows in a given time period. The variable Prevalence of Pegged Exchange Rate Regimes is constructed similarly using monthly exchange rate regime dummies. My third set of variables includes proxies for economic shocks

[36]The series is the Cash surplus/deficit, %GDP. Such flow measure was used by Bordo and Rockoff (1996) and Bordo et al. (1999a) while Flandreau et al. (1998) and Obstfeld and Rogoff (2004) advocate the stock of public debt to GDP as a better measure of overall country solvency. Besides the difficulty to construct a consistent series of debt/GDP ratio over 100+ years, Flandreau and Zúmer (2004) argue that the nominal debt is a poor measure of true indebtedness because the burden depends on the interest rate at which the debt is issued, not on its nominal amount.

such as financial and economic crises or hyperinflation episodes. In order to control for the episodes of *financial crises* I refer to the chronology described in Bordo et al. (2001) and define a binary variable taking the value of 1 in the first and on-going years of banking, currency, or twin crisis, excluding the recovery period. The variable Prevalence of Financial Crises is the fraction of in-sample countries in the crisis state. I also control for *"economic disasters"*, defined by Barro and Ursua (2008) as cumulative declines in consumption by at least 10% and shown to significantly affect the rates of return for stocks, bills, and bonds. Typically, GDP and consumption fall concurrently; however, I prefer using consumption disasters since these might cause more pressure on the government to change policies because of social unrest. The variable Prevalence of Consumption Disasters is the fraction of countries that have experienced extreme declines in consumption during a given time period. I also control for the *hyperination years* including the incidents covering my larger sample of 15 countries: Germany (1923), Italy (1944), Greece (1946), and Japan (1946-47) based to Bordo et al. (2001). Despite being a country phenomenon, hyperinflation could have international effects. Finally, in this group, I include the *average country risk*, computed as the cross-sectional average of individual bond spreads versus the estimated "world" return, to capture all unaccounted country characteristics that may discourage foreign investment and thus negatively affect integration.

Table 3 presents the regressions of the monthly index of integration on the time trend, world war periods, and groups of controls separately. The definitions of the variables imply the following interpretation of results. If a particular explanatory variable is positive significant then this factor may be consistent with market integration or reflect a common shock affecting all or most of the countries, which may be interpreted as evidence of market integration too (see Bordo et al., 2001). Negative significance would be consistent with declines in integration. Column (1) indicates that trade openness was, on average, complementary to financial openness as the literature shows. In fact, the loss of significance of the trend terms indicates that trade openness is quite important. Columns (2)–(6) focus on policies. Columns (2)–(3) indicate that high-inflation and high-government deficit policies generally were associated with a divergence of returns or lower integration; the average inflation and budget deficit have negative coefficients individually and together. In column (5), the addition of the Prevalence of Pegged Exchange Rate Regimes results in the budget deficit variable being insignificant, while the average inflation remains negative significant. Pegged exchange rate regime itself is positive significant in support of the argument that these policies mostly served as a credible commitment device in this group of countries. The last policy variable, the Prevalence of Capital Controls, added in column (6), is negative significant, although at the 10% level only. I do not consider this evidence strong enough to conclude that over the last 100+ years governments have been generally successful in containing capital mobility. It is important to observe that the trends remain significant in the regressions with policy controls. This implies that policy variables have a secondary importance in explaining time variation in integration. The remainder of the table looks at the role of various economic shocks. The majority of crises happened during the turbulent 1920s and post-WWII, which also saw the remarkable hyperinflation spells in central European countries. When included, the hyperinflation years are negative and very significant. Apparently, hyperinflations were detrimental to the overall integration but were not global shocks that would force most of the yields to move together and result in a positive coefficient. Columns (7)–(9) show that financial (banking, currency, or twin) crises have an expected negative sign but are insignificant, whereas the episodes of extreme falls in consumption are significant and associated with lower values of index of integration. Finally, column (10) includes the Average Country Risk, which can be interpreted as a broad proxy for the "unexplained" factors priced into the country yields. As seen, the country risk is significant and negatively correlated with the index, which I interpret as evidence of the overall backlash against integration when the overall (actual or perceived) level of risk rose. Upon inclusion of this control, both explicit measures of crises are negative, as expected, but insignificant. As in the case of policy controls, the measures of economic shocks by themselves are not sufficient to "explain" the J-shape in integration.

[insert Table 3 here]

Table 4 combines these controls in one multiple regression to determine which of them are "preferred" by the data. Column (1) shows that trade openness and the prevalence of pegged exchange rate regimes remain significantly positively correlated with the index of integration while average inflation rate and the measure of overall unexplained country risk have negative significant coefficients. The hyperinflation years saw lower integration while world wars still appear as important global shocks. Capital controls did not seem to tame financial returns from moving together, and financial or macroeconomic crises seem to work their way through the overall country risk. The linear time trend lost it significance while the quadratic trend remains positive and significant.

[insert Table 4 here]

Figure 4 reveals that according to the integration index the sovereign bond markets became quite synchronized by the late Bretton Woods years. One may worry that in that quiescent era, there weren't many shocks and the integration looks high because the yields of all or most countries had little variance, while in fact most markets remained segmented. To address such concern, I would like to point out that according to the descriptive statistics of the return data the entire Bretton Woods period was not exceptional (compared to, for example, the Gold Standard) in terms of low volatility of interest rates (see Table 1). Furthermore, as seen in Figure 4 the relatively high level of integration is observed only in late 1960s, close or on the verge of the collapse of the Bretton Woods system, which fell precisely because governments were unable or unwilling to tame trade flows and associated with them flows of capital. Nevertheless, in column (2) of Table 3 I include the Bretton Woods Period dummy (taking the value of 1 in the period 1945:06–1971:07, and 0 otherwise, using the timing from Bordo and Schwartz, 1999) to control for the characteristics of the period that my other controls might have missed. The Bretton Woods dummy appears positive significant implying high comovement of returns during this period. Not surprisingly, the inclusion of the dummy eliminates the significance of the variable Prevalence of Pegged Exchange Rate Regimes because the majority of such regimes was observed exactly during the Bretton Woods era of fixed exchange rate regime centered around the U.S. dollar. The fiscal policy variable becomes weak negative significant, which is what we would expect in theory. Finally, the coefficient to the unexplained Country Risk remains significant but falls on absolute value, which implies that that variable partially captured the phenomenon of Bretton Woods. The significance of other variables were not affected. Most importantly, the U-shape long-run pattern of integration survives and gains in statistical significance.

One might argue that 6-lags (half-year) order assumed for the error structure might be too short to account for autocorrelation and to produce consistent standard errors. In column (3), I allow for 12 lags (one year) in errors in specification of column (1) with similar results except that now the trend terms and world war dummies are insignificant at conventional levels. This result is intuitive since usually there is a great deal of persistence in monthly financial data. The inspection of Figure 4 reveals some short-term volatility in the index of integration and the same could be true in the monthly explanatory variables. Even so, short-term noise in the dependent variable would end-up in the error term and would not bias the coefficient estimates. It is also unlikely that the noise would affect the regression results given the long-run horizon. Still, in the remainder of the table I smooth the data by taking quarterly and annual averages of the monthly series and preserve one year-long lag structure in the Newey-West errors. The results in the remainder of the table match the results of monthly data well. The significance of the coefficients with annual averages decreases, especially for trade, perhaps due to over-smoothing or a smaller sample size.

6.3 Discussion and implications

The evidence from the multiple regression analysis shows that both policy variables and global environment factors are correlated with broad long-term integration trends. I must stress that the evidence in these regressions should not be interpreted as causal. It is possible that governments would respond to changes in integration with certain policies. As such, establishing a causal relationship is an important but difficult task because of simultaneity in the degree of integration, policies, institutional changes, market frictions, shocks, and so on. In addition, my measure of integration does not tell what parties, private or public, dominated the sovereign debt markets in a particular time period. For example, it is possible that a relatively high degree of integration in the late 1960s was due to the lending/borrowing by governments instead of by private parties, while the anecdotal evidence points on the growing role of the private sector (see Eichengreen, 1996; Krugman and Obstfeld, 2009; and footnote 8). The task of this paper was more modest and included a search for broad patterns of integration that are common across countries and over a very long period. Uncovering explicable factors that are correlated with the degree of integration could point to policies and local or global institutional arrangements that are conducive to financial globalization.

It is important to remember that the UIP condition with risk is one but not the only criterion of integration. The UIP is an appropriate theoretical benchmark for exploring financial markets integration from the prospective of investors in financial assets or financial arbitrageurs. In contrast, a domestic investor speculating in foreign goods or simply considering returns in her own country focuses on real rather than nominal returns. As the result of *real* arbitrage, the Real Interest Parity condition would hold by which the expected real interest rate differential is zero or possibly constant. Obstfeld and Taylor (2003, 2004) also note that real long-term bond returns are most directly related to the costs of capital investments and the expected marginal return on investment. Convergence of real interest rates is thus a broad measure of financial integration because in integrated economies we would observe convergence of the real rates of return on both physical assets and financial assets. A study of integration in markets for real assets should then be motivated by the real arbitrage considerations, and the integration could be measured by the comovement of real interest rates within the PCA framework I advocate here. In a working paper version of this paper I computed the expected real returns and established the similar pattern of integration based on real and nominal returns, except for some short-run differences, particularly in the 1950s (see Volosovych, 2011).

Overall, the historic data shows that when inflation rates were relatively low, fiscal policy was prudent, and countries adopted some form of pegged exchange rate arrangement, integration was higher. When the world was open to trade, finance generally followed (or went hand in hand). This evidence should not be interpreted literally as, for example, the case for the fixed exchange rate regimes in order to promote integration. Rather, the low inflation, international monetary arrangements based on certain rules, and openness to trade seem to signal the commitment of countries to good economic policies and global cooperation in general. The fact that the pattern of integration resembles a J-shape in combination with the finding that these particular policies have the strongest correlation with the integration index indirectly show that such policies were likely to have caused the upward trend in integration we have experienced since the 1930s. The significance of the war and hyperinflation stresses the importance of accounting for global and large country shocks in measuring integration. Finally, the results show that there remains an unexplained variation in integration, captured by the average level of country risk. Further research might shed light on additional explanations of financial integration patterns.

7 Conclusion

I propose a systematic methodology based on the method of principal components to quantify economic integration, explore its dynamics, and capture the episodes of market segmentation. This method overcomes the limitations of conventional approaches. Despite its computational simplicity, the suggested methodology is quite general and applicable to a variety of markets.

I explore why the existing empirical literature, which relies on comovement of economic variables, lacks consensus on whether the highest degree of integration was achieved before World War I under the Gold Standard or by the late 20th century. I argue that a conventional measure of *comovement*, the coefficient of correlation, has limited applicability as a measure of economic *integration*. Based on the suggested methodology I find clear evidence of higher financial integration at the end of the 20th century compared to the earlier periods.

Time-series regressions show that both policy variables (average inflation, average government deficit, and the fixed exchange-rate regime during Bretton Woods) and the global market environment (approximated by the average trade openness) played a role in explaining the time variation in the index of integration. I also find that "unexplained" changes in overall level of country risk are also empirically important, which warrants further research on the factors behind the unexplained country risk.

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Table 1: Historic bond data. Descriptive statistics

	Full Period 1875:01–2008:09		Gold Standard 1875:01–1914:07		Inter-War 1919:01–1939:08		Bretton Woods 1945:06–1971:07		Modern Float 1971:08–1990:12		Globalization 1991:01–2008:09		Post-Bretton Woods 1971:08–2008:09	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
Austria	6.0	1.7	4.6	1.0	6.6	0.9	6.1	1.2	8.4	1.1	5.5	1.5	7.0	1.9
Belgium	5.3	2.4	3.3	0.3	4.6	0.8	5.4	1.1	9.6	2.0	5.7	1.7	7.8	2.7
Denmark	6.3	3.8	3.8	0.3	4.9	0.6	6.1	1.9	13.9	3.6	5.9	1.8	10.0	4.9
Finland[a]	7.9	2.8	4.5	0.1	6.9	1.5	8.0	1.8	10.9	1.8	6.1	3.3	8.6	3.5
France	5.5	2.8	3.4	0.4	4.7	0.9	5.3	0.9	11.0	2.5	5.5	1.7	8.4	3.5
Germany	5.4	1.8	3.8	0.3	5.9	1.8	6.0	1.1	7.7	1.5	5.2	1.5	6.5	2.0
Italy	6.6	3.7	4.5	0.7	4.8	0.4	5.9	1.3	13.4	3.8	7.2	3.5	10.4	4.8
Japan	5.7	2.2	5.7	0.9	5.1	0.7	7.5	2.3	7.1	1.6	2.2	1.6	4.7	2.9
Netherlands	4.9	2.0	3.4	0.4	4.4	1.2	4.5	1.5	8.3	1.5	5.4	1.5	6.9	2.1
Norway	5.4	2.7	3.8	0.5	5.3	0.8	4.0	1.2	10.3	2.8	6.2	1.8	8.3	3.1
Spain	7.7	4.3	7.7	5.6	5.8	0.5	5.9	1.2	12.9	2.4	6.7	3.1	9.9	4.2
Sweden	5.4	2.8	3.7	0.5	4.1	0.8	4.6	1.4	10.7	2.0	6.4	2.5	8.6	3.1
Switzerland[a]	4.1	1.2	–	.	4.6	0.9	3.5	0.8	4.9	1.0	3.6	1.3	4.3	1.3
United Kingdom	5.4	3.1	2.9	0.2	4.1	0.7	5.2	1.8	11.3	2.0	6.2	1.9	8.9	3.2
United States	4.7	2.4	3.4	0.6	3.6	0.8	3.7	1.5	9.2	2.3	5.5	1.2	7.5	2.6
All countries	5.8	3.0	4.2	2.0	5.0	1.3	5.4	1.9	10.0	3.3	5.5	2.4	7.9	3.6
Number of months	1,483		475		248		314		233		213		446	
Average σ_{CS}	2.14 (2.06)*		2.03		1.30		1.91		3.27		2.43		2.87	
Average CV_{CS}	0.39 (0.37)*		0.49		0.26		0.35		0.33		0.44		0.38	

Notes: For individual countries the mean and standard deviation represent the time statistics for the sub-period. World War periods (1914:08-1918m11 and 1939:09-1945:08) are excluded. [a]Data for Finland starts from 1910:09; data for Switzerland starts from 1915:02. Average σ_{CS} is the time average of the cross-sectional standard deviation across in-sample countries. Average CV_{CS} is the time average of the cross-sectional standard deviation divided by the cross-sectional mean across in-sample countries. * without Finland, and Switzerland with missing data in Gold Standard period.

Table 2: Trend in bond markets integration. Time-series regressions, 1875–2002

	(1)	(2)	(3)
	Dependent variable: Index of Integration		
Type of data	Monthly	Quarterly	Yearly
Time Trend	–.636***	–1.91***	–7.65***
	(.081)	(.263)	(1.86)
Time Trend^2	.493***	4.43***	70.50***
	(.049)	(.477)	(13.20)
World Wars	.013	.013	.014
	(.057)	(.062)	(.106)
Observations	1,526	509	128
Lags Included	12	4	1
F-stat	48.52	42.33	13.61

Notes: Newey-West standard errors in parentheses. *** , **, *, and † denote significance at 1%, 5%, 10% and 15% levels. The error structure is assumed to be heteroskedastic and autocorrelated up to the lag order shown in the table. Index of Integration is the estimate of the proportion of variation in the group of 11 bond returns explained by the first principal component. The estimation of the component is performed as the centered rolling window with the bandwidth of 156 months. Time period is for monthly regression is 1875:01–2002:02 and chosen to always have 156 month of data to estimate the dependent variable. In-sample countries are Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, United Kingdom, and United States. The estimation of the component is performed as the centered rolling window with the bandwidth of 156 months. World Wars is the indicator variable taking the value of one in 1914:08–1918:11 and 1939:09–1945:08 and zero otherwise. Quarterly and yearly data uses the corresponding averages of the monthly data. See Section 6 for the detailed explanation of the variables.

Table 3: Determinants of bond markets integration. Time-series regressions with groups of controls, 1875–2002

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Dependent variable: Index of Integration									
Groups of Controls	Global Market Environment	Policies					Economic Shocks			
Time Trend	–.155 (.161)	–.586*** (.083)	–.588*** (.082)	–.571*** (.082)	–.610*** (.079)	–.487*** (.129)	–.566*** (.085)	–.487*** (.096)	–.487*** (.096)	–.382*** (.091)
Time Trend^2	.136 (.110)	.461*** (.050)	.468*** (.049)	.457*** (.049)	.522*** (.049)	.470*** (.070)	.450*** (.051)	.385*** (.062)	.385*** (.063)	.303*** (.061)
Average Trade Openness	.463*** (.113)									
Average Annual Inflation Rate		–.029*** (.003)		–.025*** (.003)	–.012*** (.003)	–.013*** (.004)				
Average Government Deficit			–.870** (.346)	–.800** (.339)	.391 (.411)	.390 (.410)				
Prevalence of Pegged Exchange Rate Regimes					.167*** (.034)	.184*** (.035)				
Prevalence of Capital Controls						–.061* (.036)				
Hyperinflation Years							–.122*** (.024)	–.117*** (.027)	–.117*** (.027)	–.160*** (.039)
Prevalence of Financial Crises							–.019 (.056)		.000 (.056)	–.015 (.051)
Prevalence of Consumption Disasters								–.162* (.092)	–.162* (.093)	–.110 (.080)
Average Country Risk										–.257*** (.057)
World Wars	.022 (.029)	.012 (.043)	.116* (.060)	.108* (.060)	.068 (.055)	.096* (.056)	.015 (.042)	.099^{+} (.062)	.099^{+} (.063)	.073 (.052)
Observations	1416	1416	1416	1416	1416	1416	1416	1416	1416	1416
Lags Included	6	6	6	6	6	6	6	6	6	6
F-stat	47.85	166.72	41.94	147.21	130.33	114.56	50.67	42.09	35.62	24.68

Notes: Regressions are estimated using monthly data. Newey-West standard errors in parentheses. *** , **, *, and † denote significance at 1%, 5%, 10% and 15% levels. The error structure is assumed to be heteroskedastic and autocorrelated up to the lag order shown in the table. Index of Integration is the estimate of the proportion of variation in the group of 11 bond returns explained by the first principal component. The estimation of the component is performed as the centered rolling window with the bandwidth of 156 months. Time period is chosen to always have 156 month of data to estimate the dependent variable. In-sample countries are Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, United Kingdom, and United States. The estimation of the component is performed as the centered rolling window with the bandwidth of 156 months. Average Country Risk is the average across in-sample countries of the bond spread versus the estimate "world" return. The "world" return is the first principal component of country bond returns. "Prevalence of X" denotes a fraction of countries where X occurs in a given time period. See Section 6 for detailed definitions of the variables. Quarterly and yearly data uses the corresponding averages of the monthly data.

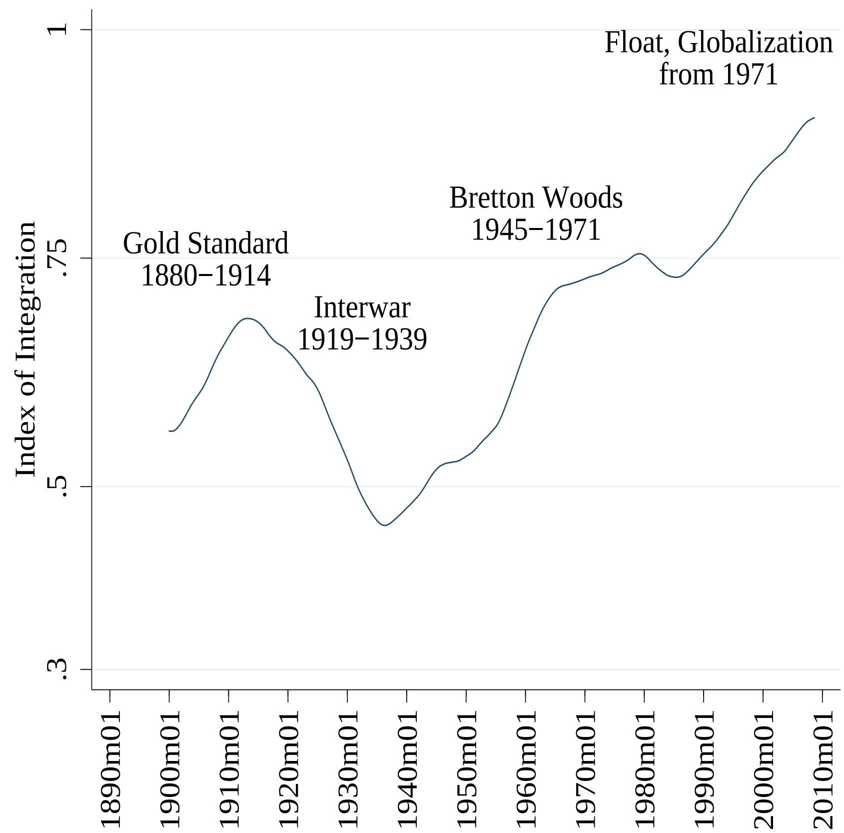
Table 4: Determinants of bond markets integration. Time-series regressions, 1875–2002

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: Index of Integration						
Type of data	Monthly			Quarterly		Yearly	
Time Trend	–.237	–.266*	–.237	–.702	–.772^{+}	–2.69	–2.89
	(.152)	(.151)	(.204)	(.520)	(.516)	(3.41)	(3.40)
Time Trend^2	.215**	.190*	.215	1.919*	1.666^{+}	29.84	24.42
	(.104)	(.099)	(.140)	(1.067)	(1.017)	(27.84)	(26.53)
Average Trade Openness	.326***	.456***	.326**	.318**	.452***	.278	.427*
	(.122)	(.118)	(.163)	(.139)	(.136)	(.227)	(.222)
Average Annual Inflation Rate	–.020***	–.025***	–.020**	–.021***	–.026***	–.025*	–.032***
	(.007)	(.007)	(.009)	(.008)	(.007)	(.013)	(.012)
Average Government Deficit	–.024	–.533^{+}	–.024	–.084	–.649*	–.365	–1.144^{+}
	(.346)	(.333)	(.434)	(.403)	(.391)	(.702)	(.739)
Prevalence of Pegged Exchange Rate Regimes	.147***	–.000	.147***	.146***	–.001	.136**	–.037
	(.031)	(.042)	(.040)	(.035)	(.048)	(.058)	(.081)
Prevalence of Capital Controls	.037	–.068^{+}	.037	.035	–.069	.025	–.097
	(.034)	(.043)	(.045)	(.039)	(.049)	(.065)	(.080)
Hyperinflation Years	–.064***	–.076***	–.064**	–.063**	–.071***	–.058	–.061^{+}
	(.024)	(.023)	(.028)	(.027)	(.026)	(.042)	(.038)
Prevalence of Financial Crises	.046	.062^{+}	.046	.047	.065^{+}	.051	.057
	(.044)	(.038)	(.054)	(.049)	(.042)	(.068)	(.059)
Prevalence of Consumption Disasters	.023	.025	.023	.014	.019	–.026	–.023
	(.064)	(.064)	(.083)	(.075)	(.075)	(.122)	(.125)
Average Country Risk	–.234***	–.199***	–.234***	–.239***	–.207***	–.270**	–.234*
	(.061)	(.061)	(.081)	(.071)	(.070)	(.119)	(.118)
World Wars	.096**	.164***	.096	.110*	.181***	.174	.268**
	(.049)	(.047)	(.060)	(.060)	(.058)	(.119)	(.118)
Bretton Woods Period		.171***			.168***		.187***
		(.039)			(.045)		(.071)
Observations	1416	1416	1416	472	472	118	118
Lags Included	6	6	12	2	2	1	1
F-stat	44.23	58.20	39.60	38.08	48.12	30.07	28.51

Notes: Newey-West standard errors in parentheses. *** , **, *, and † denote significance at 1%, 5%, 10% and 15% levels. The error structure is assumed to be heteroskedastic and autocorrelated up to the lag order shown in the table. Index of Integration is the estimate of the proportion of variation in the group of 11 bond returns explained by the first principal component. The estimation of the component is performed as the centered rolling window with the bandwidth of 156 months. Time period is chosen to always have 156 month of data to estimate the dependent variable. In-sample countries are Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, United Kingdom, and United States. The estimation of the component is performed as the centered rolling window with the bandwidth of 156 months. Average Country Risk is the average across in-sample countries of the bond spread versus the estimate "world" return. The "world" return is the first principal component of country bond returns. "Prevalence of X" denotes a fraction of countries where X occurs in a given time period. "Bretton Woods Period" is the binary variable taking the value of 1 in the period 1945:06–1971:07, and 0 otherwise. See Section 6 for detailed definitions of the variables. Quarterly and yearly data uses the corresponding averages of the monthly data.

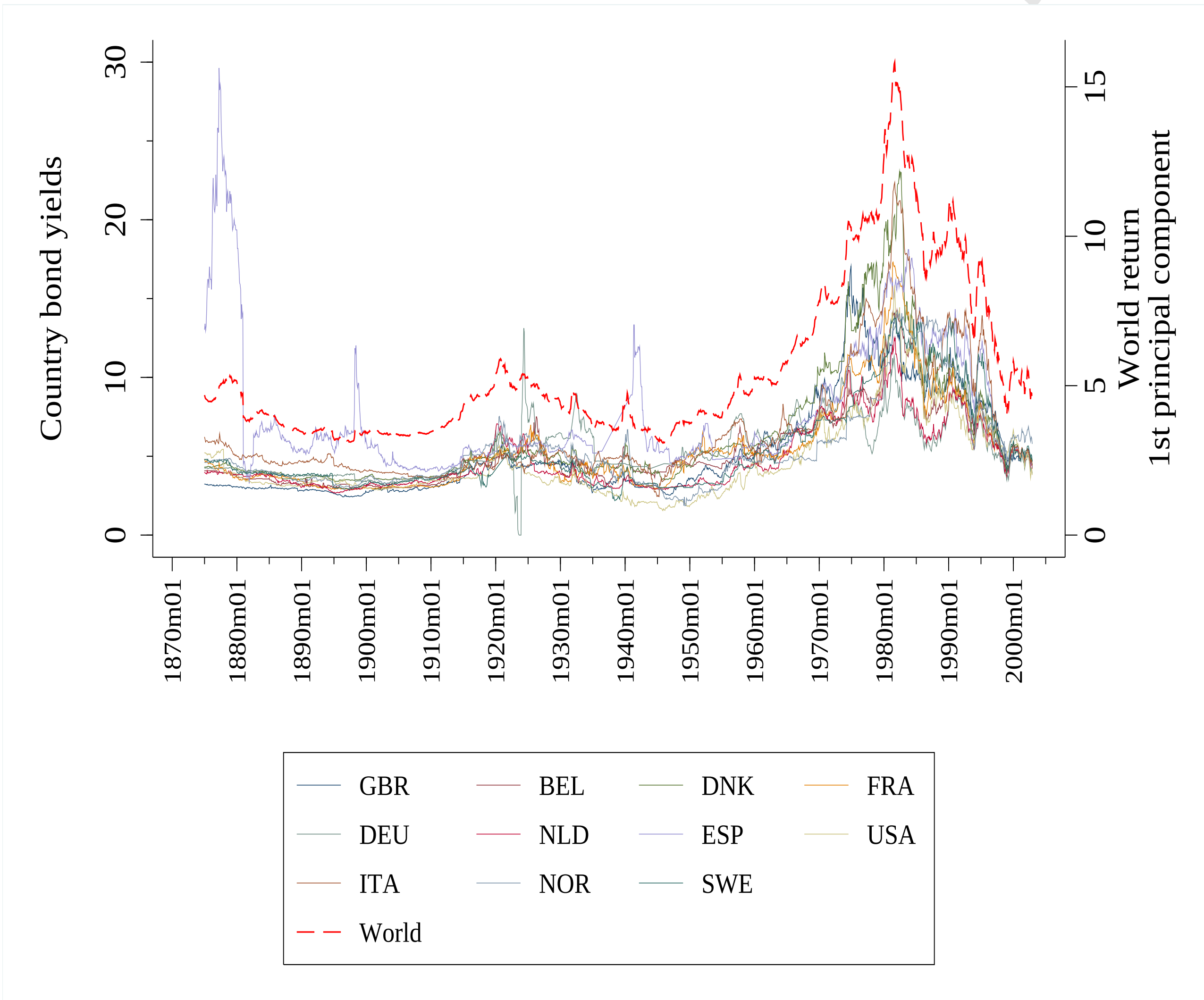
Figure 1: Long-run trend in bond market integration, 1900–2008

Proportion of variation in bond returns explained by the 1st principal component (smoothed series)



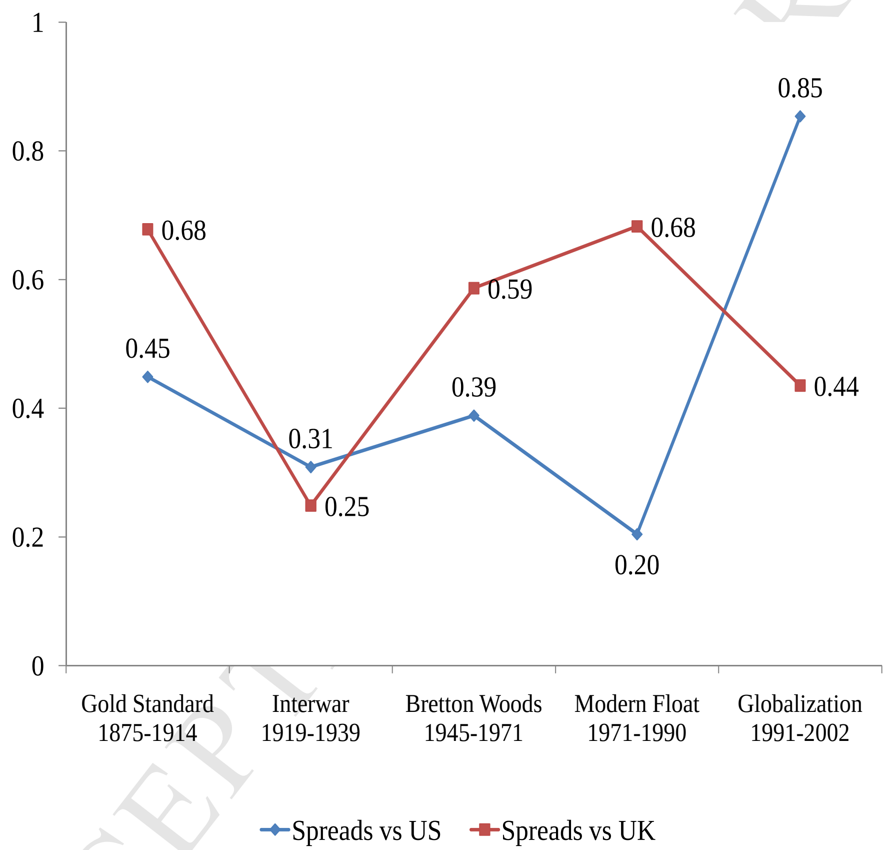
Notes: Estimates of the proportion of variation in bond returns explained by the first principal component smoothed using the uniformly weighted moving average smoother. Government bond returns are in levels. In-sample countries are Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, United Kingdom, and United States. The estimation of the component is performed as the centered rolling window with the bandwidth of 156 months.

Figure 2: Yields on sovereign long-term bonds and the estimated “world” return, 1875–2002



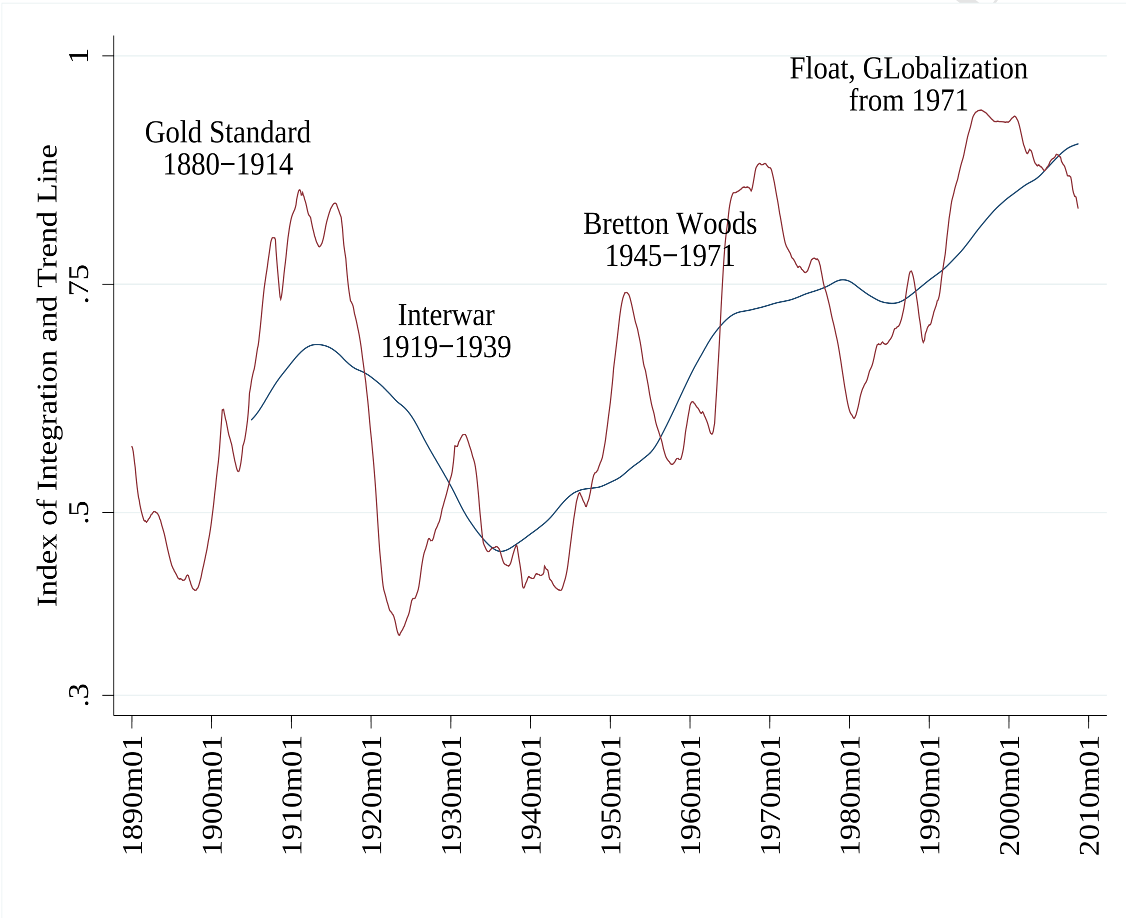
Notes:
The graph depicts historical monthly series for the yields on long-term government bonds issued by industrialized economies (thin solid lines, left axis) and the estimated “world” return (thick dashed line, right axis). The following abbreviations for the country names are used at the graph: AUT for Austria, BEL for Belgium, DNK for Denmark, FIN for Finland, FRA for France, DEU for Germany, ITA for Italy, JPN for Japan, NLD for the Netherlands, NOR for Norway, ESP for Spain, SWE for Sweden, SWI for Switzerland, GBR for United Kingdom, and USA for the United States. World is the estimate of the first principal component using all countries (the “world” return). The estimation of the component is performed as the centered rolling window with the bandwidth of 156 months.

Figure 3: Long-run trends in bond market correlations, 1875–2002
Average correlation for bond spreads versus U.S. and Great Britain
Estimation over historical sub-periods



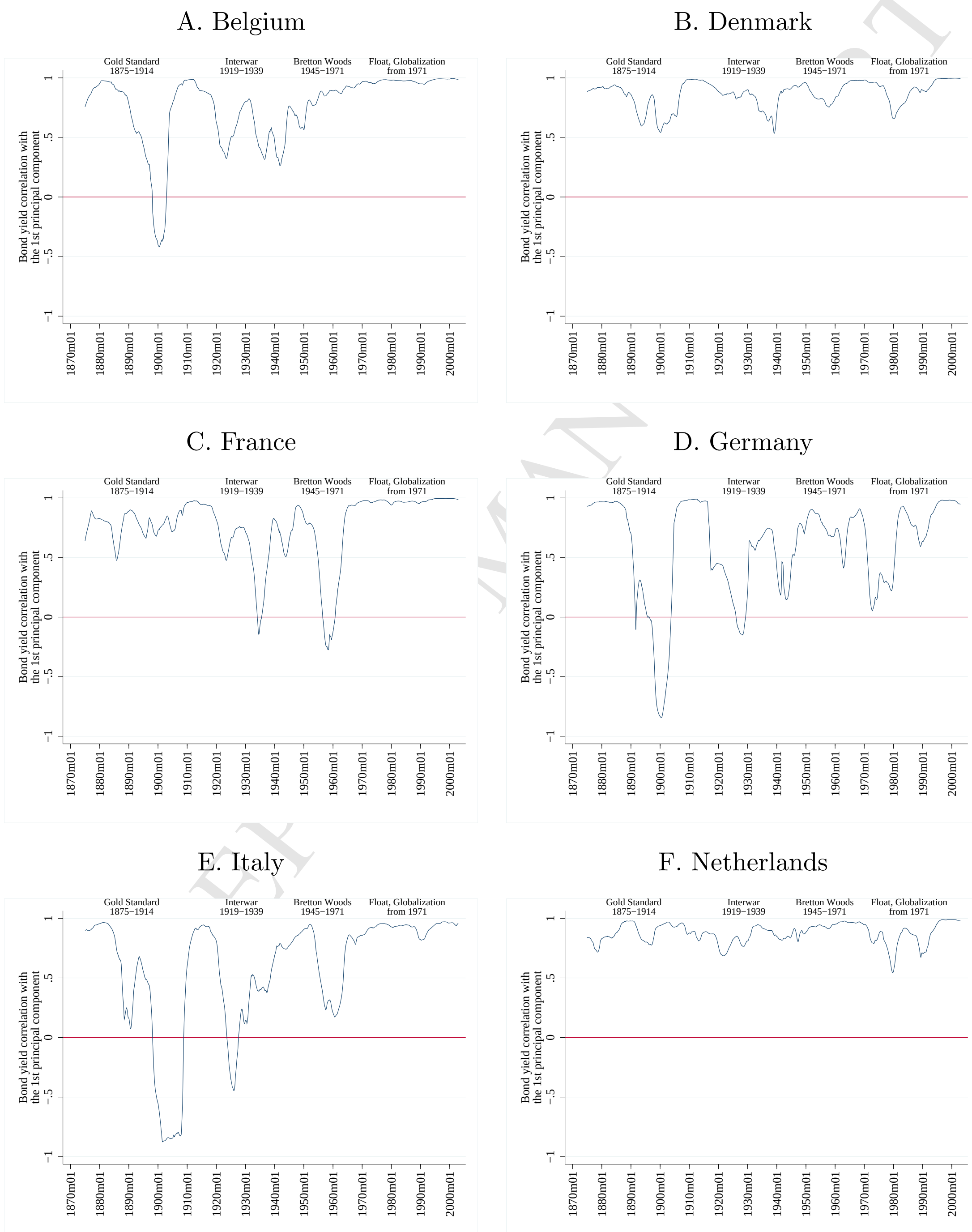
Notes: Average correlation is calculated as the arithmetic average of off-diagonal pairwise correlation coefficients of individual country bond spreads versus the U.S. 10-year bond and British Consol. The correlations are calculated using monthly data over historic sub-periods defined in Section 5.1. Country sample includes countries used in the empirical analysis; they are: Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, and Sweden. Austria, Finland, Japan, and Switzerland were omitted due to lots of missing observations before 1919.

Figure 4: **Index of integration in bond markets and its long-run trend, 1875–2008**
Proportion of variation in bond returns explained by the 1st principal component



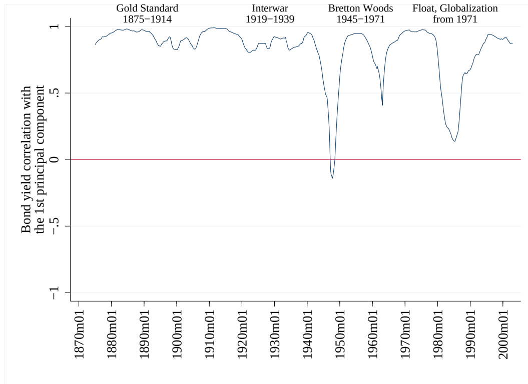
Notes: Index of integration (thin red line) is the proportion of variation in bond returns explained by the first principal component. The trend line (thick blue line) is the smoothed estimate of the Index of integration using the uniformly weighted moving average smoother. Government bond returns are in levels. In-sample countries are Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, United Kingdom, and United States. The estimation of the component is performed as the centered rolling window with the bandwidth of 156 months.

Figure 5: Country-specific effects. The correlations of individual returns with the 1st principal component, 1875–2002

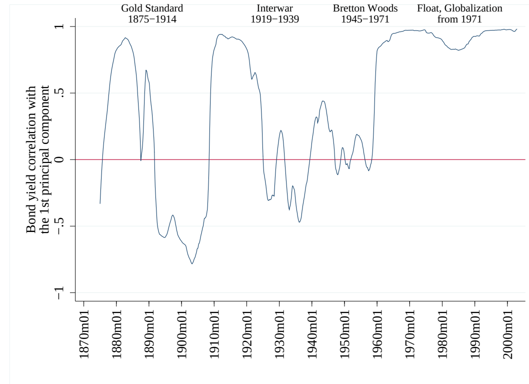


Notes: For detailed notes see the continuation of this figure on the following page.

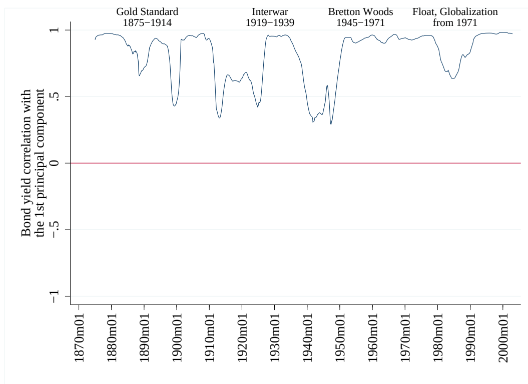
G. Norway



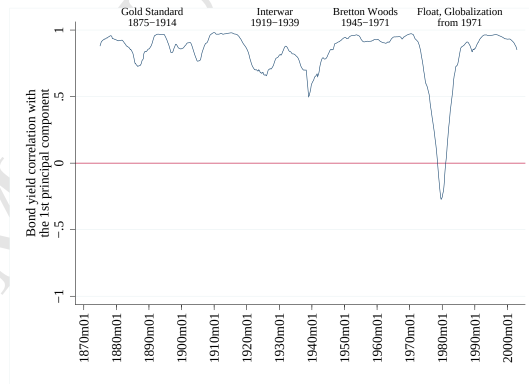
H. Spain



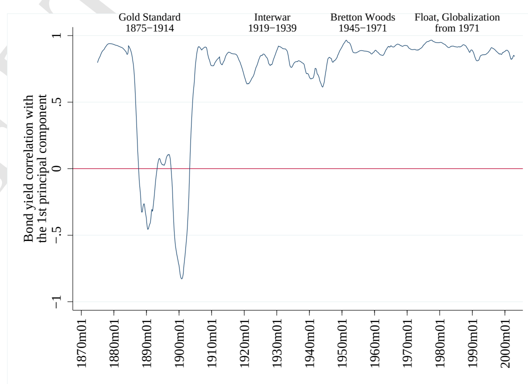
I. Sweden



J. Great Britain



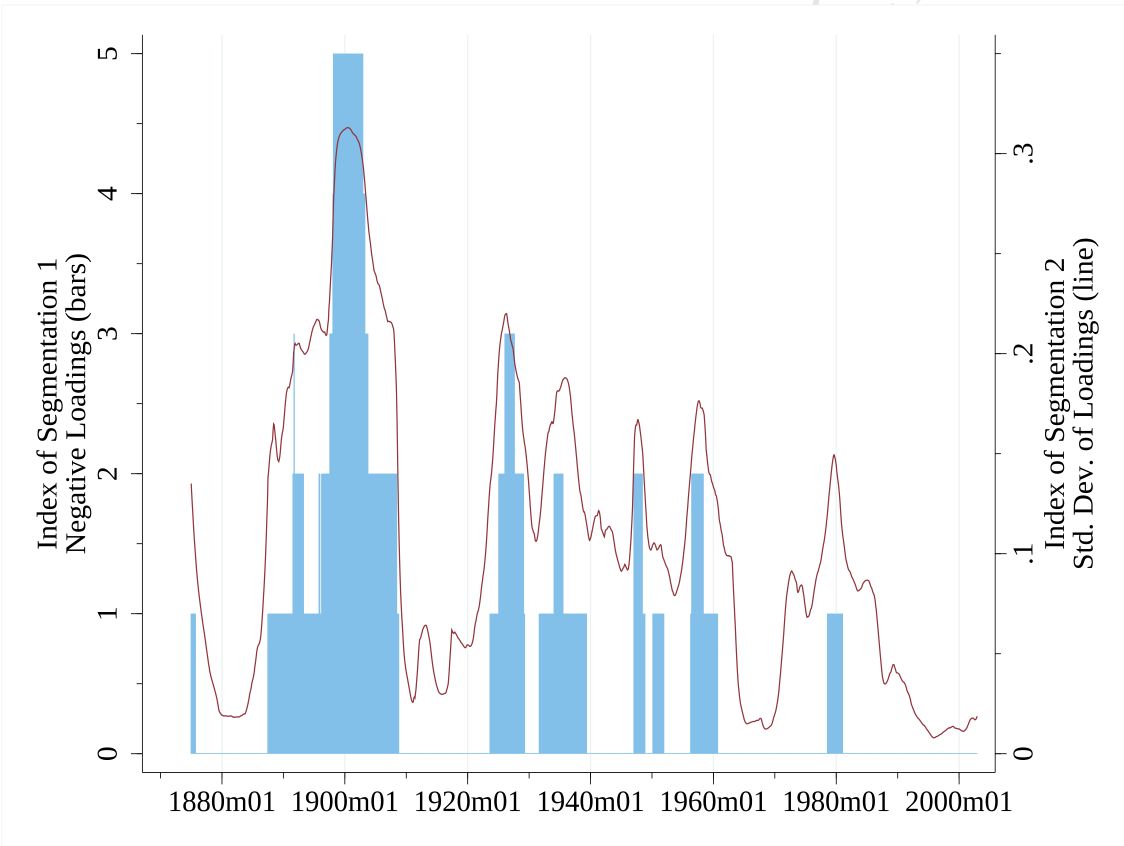
K. United States



Notes: Correlations of individual returns with the 1st principal component. The correlation between an observed returns and unobserved first principal component is computed as explained in Section **??**. The extraction of the 1st principal component is performed for the sample of 11 countries using centered moving window time sub-sample with 156 months bandwidth. In-sample countries are Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, United Kingdom, and United States.

Figure 6: Segmentation in bond markets, 1875–2002

Variability of the loadings of the bond returns
on the 1st principal component (Indices of segmentation)



Notes: The line is the standard deviation of the individual countries' component loadings associated with the 1st principal component (right scale). Bars represent number of countries out of 11 with negative loadings (left scale). The extraction of the 1st principal component is performed for the sample of 11 countries using centered moving window time sub-sample with 156 months bandwidth. In-sample countries are Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, United Kingdom, and United States.

Letter to the Editor of Journal of International Money and Finance,
Prof. James R. Lothian

Re: Ms. Ref. No. JIMF-D-07-00027 (Second Revision)

Title: Measuring Financial Market Integration Over the Long Run: Is there a U-shape?

Dear Professor Lothian:

Thank you very much for your decision to provisionally accept my paper with the reference number JIMF-D-07-00027 for publication at the JIMF. In this version of the manuscript I implemented the following.

1. I incorporated the changes you suggested with respect to JIMF styling and the placement of the acknowledgements

2. I tried to make paper somewhat shorter and further streamlined it (also the comment of the Referee No.1). In particular, I eliminated all the appendices from the manuscript, referring the reader to the long working paper version available online at the Tinbergen Institute WP series.

3. I chose to add some technical details on the method of principal components into the methodology Section 4.2 (since the corresponding appendix is gone), while a short non-technical explanation is left in the Introduction. This did not increase the length of the paper.

4. I placed the discussion of the theoretical literature behind my conditional regressions (the conditioning variables) in the Conceptual Issues Section 3. This part of the literature review is placed now immediately where I first mention that I verify how the comovement of returns changed over time, *conditional* on time-varying determinants of risk premia. I think this improves the flow of the paper.

5. I duly addressed very useful further comments of the Referee No.2. While I was awaiting the rely on the first revision of this paper I started two extensions of this current project.

Interestingly, the two comments I received from the Referee (the integration in financial markets vs. markets for real assets/capital goods; and possible use of higher-order components to help understand the integration patterns) point into the same direction. I attach a letter to the Referee with my detailed replies to his/her queries and explain the extent to which I choose to incorporate these points to the second revision. Briefly, I offer some insights about my current findings on these issues in that letter. But in the current manuscript, I follow your advice and I refer the reader to the longer working paper version. Still, I think the issues raised by the Referee are extremely important and I mention them in the appropriate places of the text (Conceptual Issues, Discussion, etc.).

In conclusion, I would like to thank you and the referees for the contribution to my research. The second round was a very useful experience for me, and the paper further improved as the result. I hope you would share my optimism and remain

Sincerely yours, June 26, 2011

Vadym Volosovych

Assistant Professor of Finance, Erasmus University Rotterdam

Letter to the Referee 2 of the Ms. Ref. No. JIMF-D-07-00027

Title: Measuring Financial Market Integration Over the Long Run: Is there a U-shape?

I appreciate the Referee 2's thorough review of my revised paper and his/her further comments. In this letter, I offer a more detailed replies to the Referee's queries and explain the extent to which I choose to incorporate these points to the second revision.

Specific comments

Comment 1: First, I think the appendix Table E-1 evidence deserves a mention: when we use real rates the picture changes and the "puzzling" high integration in the Bretton Woods era seems to go away a bit.

I follow the advice of the Referee 2 from the first round and take a prospective of an international investor in financial markets and use the the no-arbitrage UIP condition as a benchmark. This approach, according to the the Referee, is more appropriate for a study of financial integration. I agree with such assessment.

The theoretical argument is as follows. As a result of international *financial* arbitrage by the exchange (or currency) risk-neutral investors, similar financial assets in different locations have the same expected rate of return regardless of exposure to the exchange risk. Standard no-arbitrage theory in finance furhter predicts that, when market frictions are negligible, free international capital flows result in the Uncovered Interest Parity condition. In contrast, a domestic investor speculating in foreign goods or simply considering returns in her own country focuses on real rather than nominal returns. As the result of *real* arbitrage, the Real Interest Parity condition would hold by which the expected real interest rate differential is zero or possibly constant. Obstfeld and Taylor (2003, 2004) also note that real long-term bond returns are most directly related to the costs of capital investments and the expected marginal return on investment. Convergence of real interest rates is thus a broad measure of financial integration because in an integrated economy we would observe convergence of the real rates of return on both physical assets and financial assets. Lothian (2002) points to another complication explaining that ex ante real rates converge if either UIP and PPP both hold perfectly, or deviations from the two conditions completely offset one another (if they are due to a common cause, such as errors in forecasts of exchange rate). Having computed the expected real returns I established (in the appendix Appendix E of the first revision) the similar pattern of integration based on real and nominal returns, except for some short-run differences, particularly in the 1950s.

I am sympathetic to the Referee's interest in my findings and, following the Referee's Comment 1, explicitly mention in the Introduction whose prospective I take in this paper. In the Discussion section of the second revision I remind the reader that the UIP condition with risk is one but not the only criterion of integration. A study of integration in markets for real assets should then be motivated by the real arbitrage considerations, and the integration could be measured by the comovement of real interest rates within the PCA framework I advocate. I also mention some evidence on the integration of markets for real assets from the Appendix E from the previous revision, which is now available as a longer working paper version. Given the request of the other Referee and the Editor to further shorten and streamline the paper, I think it is prudent not to add much further information on comovement of the real rates and integration of markets for capital investments (the real arbitrage). I am working on extending the analysis in Appendix E of the first revision to become a companion paper with the focus on possible differences when we use nominal versus real returns within the method of principal components.

Comment 2: ...suppose the first principal component really WAS the same at all times, and really DID capture integration, but that a 2nd component (due to some other idiosyncratic shocks to, eg fear/uncertainty/growth,...) was present. Now if the variance of the 2nd component goes DOWN, the % explained by the first will go UP by construction. I suspect this also helps explain the Bretton Woods puzzle. In that quiescent era, there weren't many shocks (eg financial repressions, steady growth, government macromanagement etc). Thus no wonder there isn't much role for any other shock other than the global bond yield. But does it tell us that integration was high, or just that yields had little variance? I wonder. I think these caveats should be included, and better still something should be down about the second point above, if possible (this was another way making my "heteroskedasticity" argument from round 1.

I am very sympathetic to the Referee's continued interest in the subtleties of the principal component analysis (PCA). Here the Referee warns us again that high comovement of returns is not necessarily a synonym of high integration. The Referee conjectures that during the Bretton Woods there were not many shocks and (or as the result) the yields had little variance *for all/most countries at the same time*. Consequently, there is a lot of commonality in yields which is captured by the 1st component. This is reminiscent to the warning of Obstfeld and Taylor (2004), which I mention in the paper, that two completely closed economies whose interest rates are the same by chance (or due to similar endowments or policies) may look "highly integrated." My response to Obstfeld and Taylor was to argue that over the very long, such as 100+ years, run such "coincidence" is not likely.

However it might be possible over the shorter interval, maybe a decade of the 1960s, as Referee argues. To address such concern, I would like to point out that according to the descriptive statistics of the return data presented in Table 1 of the manuscript the Bretton Woods period was not exceptional (compared to, for example, the Gold Standard) in terms of low volatility of interest rates, measured by average standard deviation of returns, average cross-sectional standard deviation, or the coefficient of variation. Furthermore, the relatively high level of integration is observed only in the late 1960s, close or on the verge of the collapse of the Bretton Woods system which fell precisely because governments were unable or unwilling to tame trade flows and associated with them flows of capital. I appeal to the evidence by Eichengreen (1996) and Krugman and Obstfeld (2009) on the matter, which I also cite.

To further address the Referee's comment about what is going on in 1960s one can proceed in two ways.

1. Follow the invitation of the Referee and explore the higher-order components. Then, we would like to find the interpretation of the 2nd component, and try to relate it to some shocks, policies, etc., in the attempt to rationalize the "unusually high" integration in the 1960s. Could 2nd component, for example, capture the low variance of yields in that period due to absence of shocks?

2. Admit that the 1960s are "different" in some respect and try to explore if the pattern of the 1st component changes in the regression framework of Section 6 when we control for the key features of the Bretton Woods arrangement.

In the current manuscript, I am more inclined to pursue the strategy No. 2. The reason is the great difficulty to convincingly find the compelling interpretation of the higher order components explaining the relatively low proportion of overall variation in similar economic series. This is the reason the macro and international finance literature did not extensively employ the method of principal components. The most prominent recent papers on integration touching upon the PCA method, most notably Mauro et al. (2002) and Bordo and Murshid (2006), hardly provide any interpretation to the principal components. I try improve on this void by providing evidence for the interpretation of 1st component in interest rate data (the first component is the unobserved "world rate"). As I argue in this paper, the first component has a clear theory-based interpretation consistent with the standard no-arbitrage theory. The empirical result shows a single component with larger variance captures the dynamics that is informative of the extent of market integration. In addition, in my paper I develop two "indices of segmentation" (based on individual countries' loadings on the 1st component) and explore dynamic correlations of individual returns with this "world return." These additional tests, presented in Section 6.1, explore country- or group-specific shocks in the way which does not require higher-order components.

Nevertheless, I decided to pursue the route of the higher-order components in a separate paper, duly noting the possibility of such approach in the second revision of the current manuscript. In this note, I would like to offer the results of some preliminary explorations regarding the 2nd component, paying particular attention to the Bretton Woods period.

I. Let me first clarify that it is not necessarily the case that "if the variance of the 2nd component goes DOWN, the % explained by the first will go UP by construction"—the other (3rd, 4th) component's proportion may change. In the PCA, if the proportion of total variation explained by a higher-order principal component goes up, the proportion due to the lower order components *combined* should go down by construction. This is because the components are orthogonal to each other, and each subsequent component explains (a part of) the residual variation in the original series. To verify this intuition, I extracted first 3 components in my bond return series, and computed the dynamic proportion explained by each one. Figure 1 of this note presents the result. There are several moments to note.

1. The proportion of common variation in returns explained by the 2nd component never gets larger than 0.2, and for the 3rd component—than 0.1. The proportion due to 3rd component is fairly small to be considered informative. The 2nd component arguably bears some information.

2. The proportion due to the 2nd component is fairly flat in 1960s–1970s. As I argue above, the drastic upward trend in the 1st component (my index of integration) must be associated with the fall in the proportion due to *all higher-order components combined*.

II. Next and similarly to the approach in Section 6.1, I compute the country loadings on the 2nd principal component, and recover correlations of the 2nd component with country returns. Explorations of these loadings may help form hypotheses about the meaning of this component. The dynamics of the correlations are reported in Figure 2 of this note, the Bretton Woods period is the shaded areas on each graph. We observe the following

1. Overall, the correlations of individual returns with the 2nd component are very noisy compared to the correlations with the 1st component (see Figure 5 in the manuscript). Therefore, it is hard to assign the 2nd component to a single or group of countries (country or group effects) or to some particular monetary arrangement (specific policy or shocks during the Bretton Woods, for example).

2. If the Bretton Woods saw the "coincidentally" calm interest rates in all countries we would not see high loadings on 2nd component for most countries. While we observe some clustering

of high loadings 1960s for France, Germany, and Italy; or in the late 1940 for Norway, Sweden and Spain it is hard to generalize from these patterns.

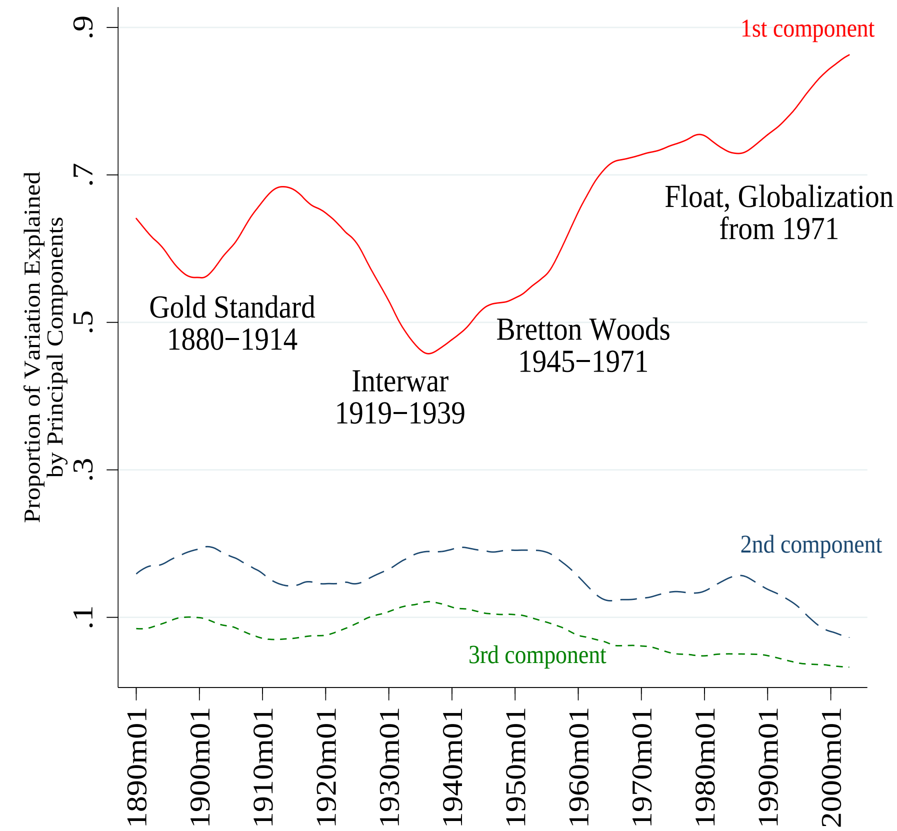
The evidence so far does not seem to suggest that the high value of the index of integration in the late Bretton Woods was coincidental due few shocks or the most yields having little variance. Unfortunately, the 2nd component does not seem to help to explore this argument further, mostly because it is hard to find the interpretation of this component. I will devote a separate paper to this issue.

For this reason, in the second revision I chose to focus on the Strategy No. 2 and control for the unobserved characteristics of the Bretton Woods period in the regression framework. Specifically, I include the Bretton Woods period dummy (taking the value of 1 in the period 1945:06–1971:07, and 0 otherwise, using the timing from Bordo and Schwartz, 1999) in the multiple regressions as in Table 4 of the 1st revision. I think the results became even more informative with this addition, and I must reiterate my gratitude to the Referee for his/her comments. These issues are duly noted and discussed in Section 6.2 of the current version.

I reproduce a part of this table here for monthly data as Table 1. The key finding is high comovement of returns during the Bretton Woods period, as indicated by positive significance of the dummy. With Bretton Woods dummy, the coefficient to the unexplained Country Risk falls on absolute value, which implies that that variable partially captured the phenomenon of Bretton Woods. The other new result worth mentioning is weak negative significance of the fiscal policy variable, which is what we would expect in theory. Not surprisingly, the inclusion of the dummy eliminates the significance of the variable Prevalence of Pegged Exchange Rate Regimes because the majority of such regimes was observed exactly during the Bretton Woods era of fixed exchange rate regime centered around the U.S. dollar. The significance of other variables were not affected. Most importantly, the U-shape long-run pattern of integration survives conditional on all the controls, including the Bretton Woods period dummy. If anything, it gains in the statistical significance.

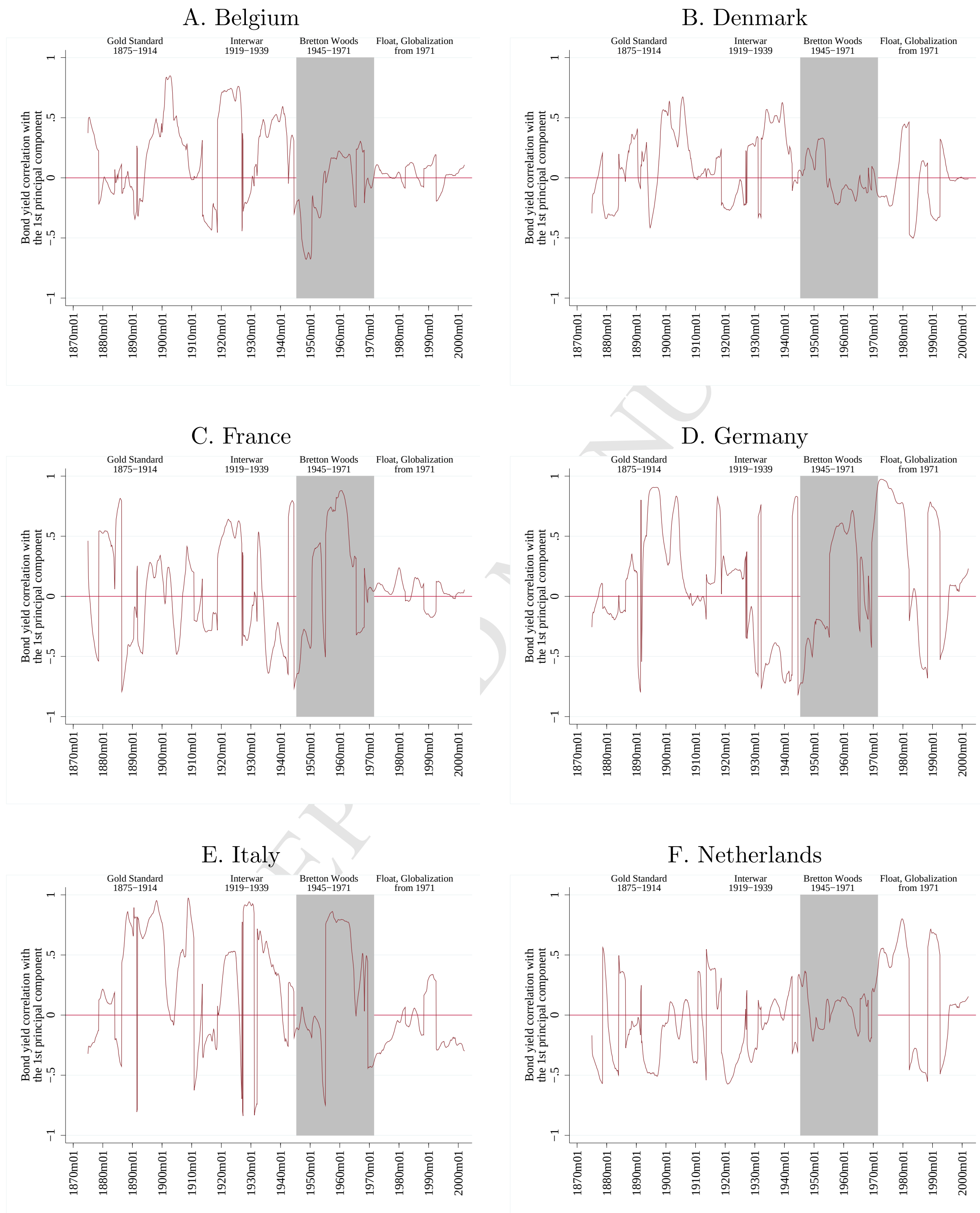
Figure 1:

Proportion of variation in bond returns explained by the 1st, 2nd and 3rd principal components (smoothed series)



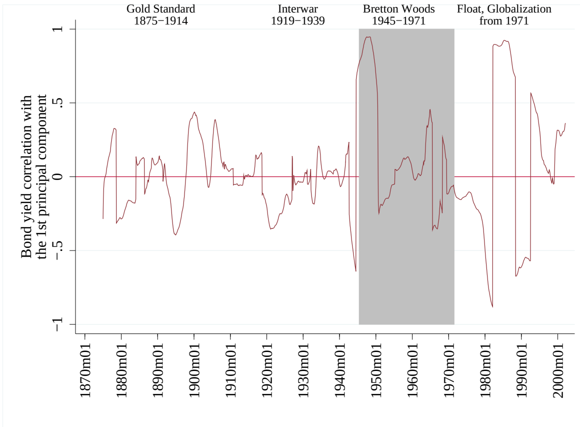
Notes: Estimates of the proportion of variation in bond returns explained by the 1st, 2nd and 3rd principal component smoothed using the uniformly weighted moving average smoother. Government bond returns are in levels. In-sample countries are Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, United Kingdom, and United States. The estimation of the component is performed as the centered rolling window with the bandwidth of 156 months.

Figure 2: Country-specific effects. The correlations of individual returns with the 2nd principal component, 1875–2002

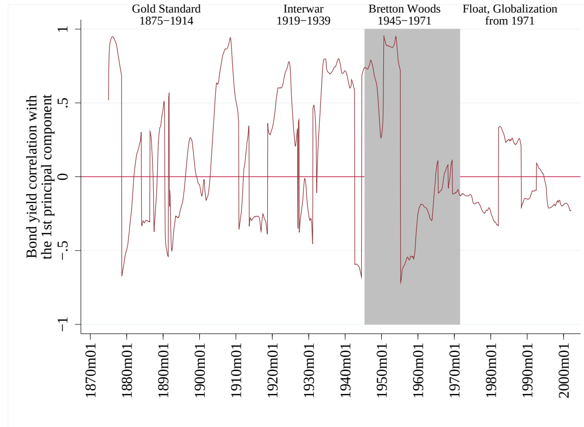


Notes: For detailed notes see the continuation of this figure on the following page.

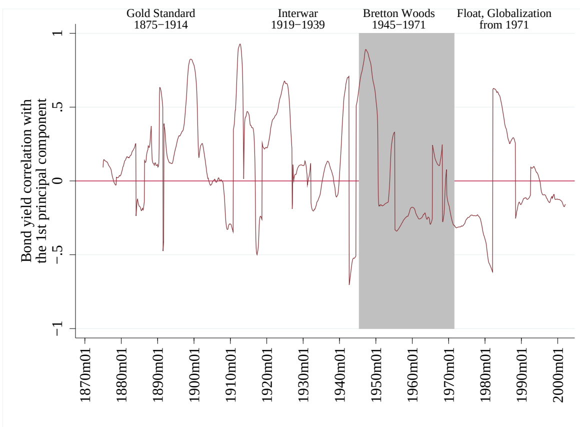
G. Norway



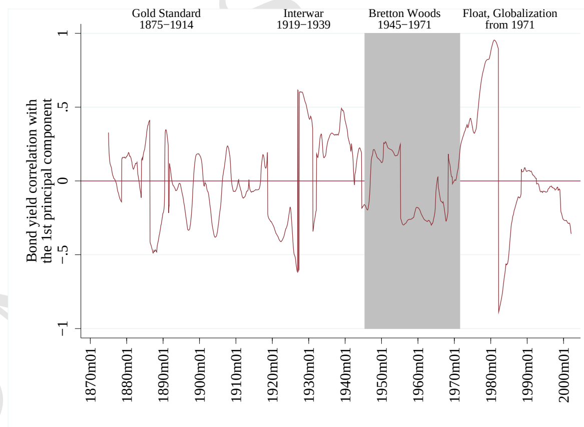
H. Spain



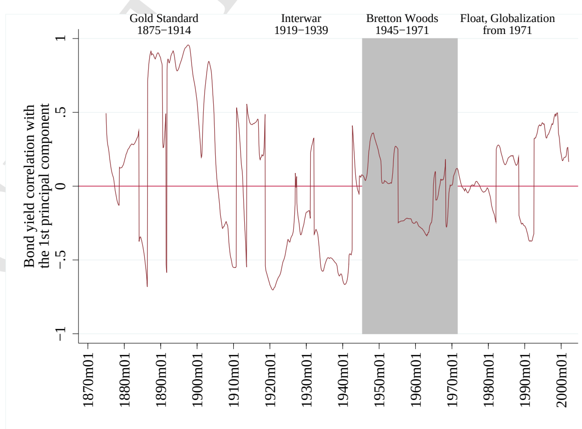
I. Sweden



J. Great Britain



K. United States



Notes: Correlations of individual returns with the 2nd principal component. The correlation between an observed returns and unobserved first principal component is computed as explained in Section **??**. The extraction of the 1st principal component is performed for the sample of 11 countries using centered moving window time sub-sample with 156 months bandwidth. In-sample countries are Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, United Kingdom, and United States.

Table 1: Determinants of bond markets integration. Time-series regressions, 1875–2002

	(1)	(2)
	Dependent variable: Index of Integration	
Type of data	Monthly	
Time Trend	–.237^{+}	–.266*
	(.152)	(.151)
Time Trend^2	.215**	.190*
	(.104)	(.099)
Average Trade Openness	.326***	.456***
	(.122)	(.118)
Average Annual Inflation Rate	–.020***	–.025***
	(.007)	(.007)
Average Government Deficit	–.024	–.533^{+}
	(.346)	(.333)
Prevalence of Pegged Exchange Rate Regimes	.147***	–.000
	(.031)	(.042)
Prevalence of Capital Controls	.037	–.068^{+}
	(.034)	(.043)
Hyperinflation Years	–.064***	–.076***
	(.024)	(.023)
Prevalence of Financial Crises	.046	.062^{+}
	(.044)	(.038)
Prevalence of Consumption Disasters	.023	.025
	(.064)	(.064)
Average Country Risk	–.234***	–.199***
	(.061)	(.061)
World Wars	.096**	.164***
	(.049)	(.047)
Bretton Woods Period		.171***
		(.039)
Observations	1416	1416
Lags Included	6	6
F-stat	44.23	58.20

Notes: Newey-West standard errors in parentheses. *** , **, *, and † denote significance at 1%, 5%, 10% and 15% levels. The error structure is assumed to be heteroskedastic and autocorrelated up to the lag order shown in the table. Index of Integration is the estimate of the proportion of variation in the group of 11 bond returns explained by the first principal component. The estimation of the component is performed as the centered rolling window with the bandwidth of 156 months. Time period is chosen to always have 156 month of data to estimate the dependent variable. In-sample countries are Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, United Kingdom, and United States. The estimation of the component is performed as the centered rolling window with the bandwidth of 156 months. Average Country Risk is the average across in-sample countries of the bond spread versus the estimate "world" return. The "world" return is the first principal component of country bond returns. "Prevalence of X" denotes a fraction of countries where X occurs in a given time period. "Bretton Woods Period" is the binary variable taking the value of 1 in the period 1945:06–1971:07, and 0 otherwise. See Data Appendix for detailed definitions of the variables. Quarterly and yearly data uses the corresponding averages of the monthly data.