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

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Abstract

Financial economists disagree whether the highest degree of financial markets integration had been achieved before World War I, under the Gold Standard, or by the late 20th century. For example, in a series of recent papers, Obstfeld and Taylor investigate empirically the pattern of capital flows over the period from the 1870s till now and provide evidence of a U-shaped trend line in global capital mobility. This paper proposes a systematic methodology to quantify integration and to explore its dynamics utilizing method of principal components. Based on a long series of sovereign bond data for fifteen industrialized economies the paper documents clear evidence of higher financial markets integration at the end of the 20th century compared to the earlier periods. The current trend in integration began after World War II. The overall integration pattern tends to resemble a sloped letter J with a trough as early as the 1920s.

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1 Introduction

Whether world financial markets are well integrated has been of concern for economic historians, financial economists, and macroeconomists for a long time already. Without any doubts high degree of openness in the most of economies by the close of the 20th century renders the closed economy models inappropriate for economic analysis; however, the opposite assumption of full capital mobility still has to be rigorously checked. In particular, the literature has not yet reached an agreement regarding the extent of international integration "now" compared to "then".[1] Researchers often quantify integration by conventional co-movement measure, the coefficient of correlation. I claim that the lack of consensus in the literature is partially caused by the deficiency of this measure for describing dynamics of integration.

This paper is not the first study of historical financial integration. Financial economists explore possibilities for hedging risks by holding internationally diversified asset portfolios. This literature documents benefits of international diversification and implies that globalization makes an investor worse-off since high co-movement of markets decreases diversification opportunities.[2]

Macroeconomists devote themselves to studying financial sector development, international goods and factor flows, growth and convergence.[3] This literature is somewhat inconclusive on the issue of the relative extent of financial integration today and in the past. Bordo, *et al.* (1999) argue that international integration of capital and commodity markets is deeper now than ever before (pre-1914). Mauro, *et al.* (2000) compare yield spreads on sovereign bonds issued by emerging markets in the 1990s with those in the period 1870–1913. They show that the spreads are higher and more volatile now than they were in the pre-World War I period and co-movement of spreads is higher today. Sudden changes in spreads in recent years were associated with global crises whereas country events had a bigger role in the 1870–1913. Goetzmann, *et al.* (2001) study the historical correlations of four major equity markets over 150 years and compare the diversification opportunities during seven sub-periods from 1860 to 2000. According to them

[1] The notions of "now" and "then" were introduced by Mauro *et al.* (2000) who name the 1990s as "now" and period of the 1870-1913 as "then". In this study, by "then" I refer to all the major historical periods between the last decades of 19th century, the time which is called the "golden era" of globalization, and the recent globalization period, the 1990s.

[2] An example of early studies is Levy and Sarnat (1970). A recent paper by Goetzmann, Li and Rouwenhorst (2001) compares the diversification opportunities during seven sub-periods from 1860 to 2000.

[3] Baumol (1986), Taylor and Williamson (1997), O'Rourke and Williamson (1994), O'Rourke, *et al.* (1996), O'Rourke, *et al.* (1994), Williamson (1995, 1996) are among numerous studies of early growth and industrialization. Prasad *et al.* (2003) investigate benefits and costs of recent financial globalization for the emerging markets. Rajan and Zingales (2003) show that the opposition to financial sector development by domestic interest groups is undermined when country is open to trade and capital flows.

the current period is unique and characterized by increased correlation across markets and a greater risk to investors. However, the large number of emerging markets expands investment opportunity set and opens new possibilities for diversification.

Some other studies are more cautious in their conclusions regarding the extent of present integration compared to the past. Early studies by Zevin (1992), Neal (1985, 1990), and Obstfeld (1995) show that historical periods in 18th century, the 1890s, and the 1980s are quite similar with respect to the degree of capital markets integration. A study of historical British capital flows by Clemens and Williamson (2000) claims that both prior World War I and recently integration of capital markets is sufficient to eliminate the influence of international market failures on capital flows. In their comprehensive studies Obstfeld and Taylor (1998, 2002a, 2003) investigate empirically the pattern of capital flows over a long period since the 1870s till now and provide evidence of a *U-shaped* trend line in global capital mobility. One of their main conclusions is that there was a dramatic decline of capital mobility in the inter-war period and a very slow recovery of capital mobility after that. Eichengreen and Bordo (2001) argue that compared with pre-1914 era of financial globalization, economic crises are growing in frequency but they are not more severe. 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 (late 1990s)—the periods, they claim, of high international capital mobility. Bordo and Murshid (2002) study monthly spreads on long–term sovereign bond yields and conclude that financial market shocks were more globalized before 1914 compared to the present.

Authors of these studies draw the conclusions about financial integration today and in the past from "quantity criteria" of the integration, such as the volume of gross and net capital flows, "price criteria," such as deviations from the interest rate parity condition, and sometimes both.[4] Price criteria are the subject of the lion's share of the studies, primarily because of the unavailability until recently of the historical capital flows and stock data and some problems associated with measuring them. Normally, the arguments proceed in the following fashion. The theories related to international integration—such as, for example, international arbitrage theory—are applied to the data. If the theoretical predictions implying high capital mobility are supported by the data the conclusion is drawn that the financial markets are integrated in

[4]Obstfeld and Taylor concentrate on both quantity and price criteria. Their work in this area is summarized in the recent book, Obstfeld and Taylor (2004).

the period under consideration. This approach makes it difficult to directly compare the *extent of integration* in various historical periods and its development over time. What these studies seem to lack is the uniform measure of integration. Such an "integration index" should a) be theory-based and b) transparently and clearly reflect the extent of integration in a particular market.

As a starting point of this paper, I demonstrate that predictions about integration dynamics might be sensitive to how the data is transformed prior to calculation of correlations. I propose a methodology based on the principal component analysis which is sufficiently general to quantify the extent of integration at various markets. Even though this technique is rather old it has not found a widespread application in integration literature due to problems of interpretation. The methodology advocated in this paper is simple to implement but rich enough to describe several aspects of integration. My method summarizes the dynamics of integration in form of a simple "index of integration". In contrast to the previous studies which, at best, estimate the extent of integration over pre-determined time periods, my measure illustrates the continuous evolution of integration over time. In addition, this approach distinguishes between two potential causes of setbacks in markets co-movement: the divergencies of a few countries from the world and simultaneous deviation of a large group of countries. It is important to discriminate between individual country shocks, which are not necessarily the evidence of shutdown of integration, and true "crises" at global markets. I describe how to determine which effect drives the observed integration patterns. These features make my methodology a potentially superior technique compared to conventional correlation coefficient or measures of cross-section variation.

I illustrate the benefits of new methodology in a study of long-run integration in historically most actively traded segment of financial market. Conclusions about the degree of integration are drawn from an analysis of sovereign bond yields for a sample of industrialized economies over 130 years, from 1875 to 2002. The sample includes fifteen industrialized economies whose sovereign debt markets were sufficiently developed to be continuously traded at the major international financial center (London) as early as the late 19th century. Macroeconomic characteristics of these countries have been rather similar; with a few exceptions, there were no major defaults on the government debt across these countries that would create discontinuities in the time series.

Paper shows a remarkable consistency of integration pattern established by the "index of integration" with those brought about by conventional measures of co-movement used in the literature. In addition to comparison of the integration patterns across exogenous "globalization periods" defined in the literature, this paper illustrates dynamics and endogenous changes in integration irrespective of historical political and economic events such as Great Depression, global wars, or international monetary regime change. This, more objective, approach allows to reveal candidate time periods for country- of group-specific shocks to integration. In the end, two complementary "indices of regionalization" show that the "crises" picked up by the "index of integration" may be brought about by two different causes. I explore possibility of overall "disintegration," when some forces impair the co-movement of most countries with the world, and "regional crises," when only a few countries divert from the group. Consequently, the methodology of this paper goes beyond the mechanical application of the method of principal components as observed in the existing literature. The results of calculations have clear economic interpretation which can be further investigated.

The main conclusions of the empirical analysis are the following. First, there is a clear evidence of greater integration at the end of the 20th century than prior to World War I. High financial integration that existed before 1914 had been disrupted by the war, restored in the interwar period but again shattered during the Great Depression of the 1930s and World War II. The current trend line in integration started after the mid-1940s. Second, over the long run the government bond returns of industrialized economies did not drift arbitrarily far apart from those of major financial centers (Great Britain and the United States) and the "world" interest rates. Third, the evidence shows that studies of long run financial integration based on the price criteria should not employ spreads relative to a particular financial center, such as the United States. The better practice is investigating of the spreads relative to the "world" interest rate, immune to the idiosyncratic shocks particular to a single economy. Last, the interpretation of the first principal component as the measure of the unobserved "world" interest, advocated by this paper, has solid theoretical justification and provides additional information about financial markets integration over time, in particular, about the group- versus country-specific shocks to integration.

The rest of the paper is organized as follows. Section 2 establishes basic stylized facts about capital markets integration based on the conventional correlation coefficient analysis. Section 3 develops a methodology to quantify integration at various markets. Then the method is applied to the same data as in Section 2. I describe the resulting integration pattern, compare to the previous results, and offer some extensions to the basic analysis. Section 4 concludes.

2 Financial Integration in the Past and Present: Stylized Facts

2.1 Historical Sovereign Bond Data

The primary object of the study are historical monthly series for the returns on long-term government bonds. The source of data is *Global Financial Database*, 2002 edition. This data is of relatively good quality by historical standards. The database reports all the data as *yields* so they can be compared more easily with each other. For historical periods the yields are calculated by dividing the coupon by the price of bond. More recently national governments started to report the indices of bond yields. The results of this paper will be compared to the findings of the other studies of integration based on this source either.[5] More detailed description of the data is provided in the Data Appendix A of the working paper version.

Following the literature on economic history and other studies of the financial markets over the long run I divide the sample into five exogenous periods defined by the "international monetary arrangements."[6] The sample includes fifteen economies whose macroeconomic characteristics have been rather similar, financial markets were sufficiently developed, and sovereign debt has been continuously traded at the major international financial centers (London and later New York) as early as the late 19th century. All of them are now classified as industrialized economies.[7] With a few exceptions, there were no major defaults on the government debt across these countries that would create discontinuities in the time series.

I investigate *expected* real bond returns calculated as the difference between nominal yield and expected inflation rate $r_{i,\,t} = i_{i,\,t} - \pi^e_{i,\,t}$, where $\pi^e_{i,\,t}$ represents country i inflationary expectations in period t.[8] Inflationary expectations are calculated as the 25-months moving window linear

[5] They are papers by Obstfeld and Taylor, Goetzmann *et al.* (2001), and Bordo and Murshid (2002), among others.

[6] Historical periods of the world capital market integration are defined as follows. Classical gold standard: 1875:01–1913:12, 39 years (468 monthly observations available); Inter-war period: 1919:01–1939:12, 21 (252); Bretton Woods system: 1945:06–1971:07, 27 (314); Recent float: 1971:08–1990:12, 19 (233); Modern globalization: 1991:01–2002:12, 12 (144). I omit the periods associated with 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.

[7] They are Austria, Belgium, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom, and the United States. I also analyze a group of the "core" countries which have the longest series and have most advanced financial markets. These include France, Germany, Italy, United Kingdom, and the United States.

[8] There are several approaches in the literature to modeling inflationary expectations. The most common one is to estimate them as the forecast from the VAR model that includes current and lagged inflation, short interest rates and other "relevant" macroeconomic variables. This approach presumably captures the rational expectations forecast, *i.e.*, forecast based on all the information available to market participants. However, for the purposes of this paper I adopt the simplified proxy of the π^e based on the assumption of the perfect foresight.

filter centered at the current period inflation. By including both lagged and leading terms in the calculation of π^e I try to reflect both adaptive and rational expectations of economic agents in forming their inflationary forecast.[9] Weights to lags and leads of inflation rates are assigned according to the Normal distribution with the center at current observation since agents tend to weigh the distant past or future less. The resulting series are plotted in Figure 1. I will refer to the real yields as "returns" hereinafter.

Table 1 represents the summary statistics for bond returns across exogenous historical periods. The upper panel of the table represents the average return and the corresponding standard deviation for each country over the whole time period. There are three main groups of countries formed by comparison to unweighed average return for the group (equal to 5.76). The first group includes Switzerland, United States, and the Netherlands with returns below average; presumably, they are the countries with the lowest risk. Countries with returns slightly less and equal to the average are in the intermediate group. They are United Kingdom, Belgium, Sweden, Norway, Germany, France, and Japan—the most advanced countries of Western and Northern Europe. The last group including Denmark, Austria, Italy, Spain, and Finland consists of the smaller economies and those of the Southern Europe. Their return is above average and (with exception of Austria) was characterized by higher volatility measured by standard deviation.

The lower panel of Table 1 contains the average values of returns across the five historical periods under consideration and allows to trace the long-term patterns in countries' bond markets. For all the countries the real bond yields remained low and stable throughout the first half of the 20th century. Following the World War II the returns rose continuously reaching double digits in the 1970s–80s, then turned down sharply in the 1990s. Period IV is also exceptional by the higher variability or returns which decreased somewhat by the 1990s but did not reach the low pre-World War II level. The similar pattern is observed in the behavior of cross-section variability of returns. Both unadjusted and mean-adjusted cross-section standard deviations imply the hump-shaped pattern of variability with the top in Periods III – IV and the tendency for convergence in the last period. The general ordering of countries in terms of levels of returns is approximately preserved over time despite some important changes in the individual country

In the analysis of the long-run behavior of the real returns this measure should be sufficient, even for the periods of relatively high inflation (such as post-Bretton Woods era). Gagnon and Unferth (1995) study the common component in the *ex post* real interest rates of nine OECD in the 1977–1993 and show that their results are robust to the calculation of the real interest rates as *ex ante* rates using the fitted value of inflation from the regression of inflation on a constant, lags of inflation, interest rate, and change in exchange rate.

[9] The equality of the leading part of expected future inflation with actual future inflation is based on the assumption of perfect foresight.

risk over time.

2.2 Long-Run Financial Market Efficiency

Prior the analysis of various measures of co-movement, it is essential to explore time series properties of the data. In integrated financial markets the free movement of capital across countries leads to equalization of their interest rates and eliminates the possibility of arbitrage profits.[10] If this were true, the differences of interest rates should not drift arbitrary far from each other over the long run. In technical terms they should follow some pattern distinguishable from the random walk. Hence, the natural way to proceed is to pre-test for unit root. Some of the techniques I use later also require the prior knowledge about this property of the series. I use the generalized-least-squares (GLS) version of the ADF test developed by Elliott, *et al.* (1996). DF-GLS test dominates other tests for unit root when autoregressive parameter is less than, but very close to one—the property one can expect in the financial series.

For all countries in the sample (except for Germany and Switzerland) I cannot reject the hypothesis of the unit root versus the alternative of level of trend stationarity over the whole time period at 5% nominal size. This is consistent with the non-arbitrage condition at international financial markets. In the literature on international financial markets integration it is common to study the returns on stocks and bonds relative to some reference country. Statistical stationarity of the absolute or relative deviations (essentially, this is an excess country risk) would imply the cointegration and long-run convergence of interest rates. I calculate the excess real return versus the average "world" return defined, as the first approximation, as the real return on the equally weighted portfolio containing bonds of all in-sample countries. For the excess returns over the "world" return I are able to reject unit root hypothesis at 5% for 10 countries out of 15. The rejection of unit root for these countries means that real interest rates for those countries do not drift arbitrary far apart form the "world" interest rate. This signifies the presence of real bond yield equalization and integration of those countries' economies with the international capital market approximated by the average real yield on the equal-weight portfolio of countries' bonds. To check the robustness of these results I also use the deviations of the bond return from the real return on British Consol and on the U.S. 10-year government bond as it is usually done in the literature and find generally similar results. Working paper version of the paper contains

[10] International arbitrage also eliminates the difference in interest rates due to expected depreciation of the currencies as suggested by uncovered interest rate parity condition. It is a conventional wisdom now that the condition holds in the long run.

full discussion of this analysis. Perron (1990) shows that the existence of the mean shift in a stationary time series biases the usual tests for a unit root toward non-rejection. While over the short-run failure to reject the unit root in bond yield data is quite plausible suggesting the financial market efficiency, at the very long-run horizon such as 130 years it might be the case that the yields are stationary if I allow the existence of one-time break in mean. Therefore, I test for unit root in time series allowing the presence of a structural change in its mean under the alternative hypothesis following the procedure developed by Zivot and Andrews (1992) and Perron and Vogelsang (1992). Combining the evidence of conventional unit root test with the test allowing one intercept change shows that for the majority of countries in sample the bond markets were efficient even over the long-run. However the returns do not drift arbitrary far apart form the "world" return and each other. Returns tend to move together, and individual bond markets remain integrated with the international capital market over the very long-run.

2.3 Analysis Of Historical Correlations

In the previous section I take the "very long run" prospective and analyze the behavior of *individual* returns over the whole time period. In a study of integration the primary questions are whether the countries move together over time and when and why there are periods of breakdown in integration. The simplest way to represent the co-movement is the correlation coefficient. In application to financial markets this measure was used, among others, by Goetzman *et al.* (2001), Obstfeld and Taylor (2002a, 2002b, 2004), Rajan and Zingales (2003) for equity markets, and Mauro *et al.* (2002) for emerging market bonds. I calculate the pairwise unconditional coefficients of correlation for levels of bond returns and spreads across five historical periods described in Section 4 and for the whole time period to check the consistency of integration patterns discovered by these researchers.[11] Then I calculate the simple average of the off-diagonal correlation coefficients for the corresponding period.

There is one argument in favor of working with spreads rather than with levels of the financial series. The unconditional correlation coefficient is only defined for stationary variables. I have shown in the Section 2.2 that over the long run the levels of return are non-stationary, or

[11] I omit the countries which have too many missing observations in the corresponding period. Thus, in Period I I have a sample of 12 countries (no Austria, Finland, and Switzerland), in Period II—13 countries (no Austria and Finland), and in Period III—14 countries (no Finland). Fortunately, I have at least twelve countries in the "smallest" sample. As a robustness check I also build the correlations based on 11–county sample (also excluding Japan) to make sure I have countries of approximately similar level of institutional development for the whole time period.

random walks. In this case the correlation coefficient, which is a measure of linear association between two series, is misleading. As the response to this argument I can claim that I never deal with infinite sample sizes therefore, strictly speaking, the correlation coefficient exists (This is especially true with rolling correlations when the bandwidth is substantially less than the whole sample size). The evidence of stationarity of the spreads relative to the U.S., Great Britain and the "world" for the majority of countries in the sample established in the Section 2.2 suggests a special case of cointegrating relationship (with the cointegrating coefficient equal to one). Due to these considerations I shall interpret the results from correlation coefficient analysis with caution as the approximate long–term trends. The analysis of correlations of the levels of returns and deviations from the various benchmark returns is performed as the preliminary check of integration patterns.

2.3.1 Correlations Of Real Bond Returns

Panel A of Figure 2 represents the average correlation coefficient for the levels of returns calculated across five pre-determined historical periods. The overall long-term pattern is a gradual increase of average correlation (with decline in the 1970s–80s) to the peak in the 1990s. Of course, the averaging of the correlation coefficients masks a lot of information about the correlations between the individual pairs of countries and makes it difficult to uncover some of the countries which were the obvious outliers in a particular historical period.

To decrease the problem of over-aggregation I build the cross-country average rolling correlation, with 156 months (13 years) centered moving window, based on the shorter sample of 11 countries in all periods (presented at Panel B of Figure 2). The average correlation is again the average of the pairwise off-diagonal correlation coefficients across countries calculated for the period of 156 months. By choosing relatively wide bandwidth for the calculation of the correlations I assure enough observations to preserve the time variation across countries. On the other hand I avoid the exogenous choice of the historical periods made in the previous exercise.[12]

[12] Unfortunately because of missing observations in the beginning of the full sample I need to get rid of four countries in sample (they are Austria, Finland, Japan, and Switzerland). Goetzmann *et al.* (2001) use backward looking window with bandwidth of 60 months in their analysis of equity returns over the long run, while Obstfeld and Taylor (2002a) calculate 120 month centered rolling correlations of real sovereign bond yields. I tend to choose the wider band because it is reasonable to believe that it takes time for the group of countries to become disintegrated, even though an individual country can become segmented from the world financial markets quicker. I experimented with the bandwidths of 60, 120, 144, and 180 months found in literature and got similar results for the correlation patterns across time. Normally, the narrower the bandwidth, the more volatile the average correlation—the result of insufficient amount of data to build the correlation. I use the centered window in my calculations.

Solid line in Panel B of Figure 2 represents the 11-country sample and dashed line sample of "core" countries including France, Germany, Italy, United Kingdom, and the United States as a robustness check. The long term pattern of the correlation is similar to one found with average by-period correlations: correlation increases over the long run. There are some significant short-run differences though. The periods of high correlation correspond to the 1880s, World War I, the mid-1920s–late 1930s, and the mid-1960s–1970s. The correlation falls drastically around the beginning of the 20th century. Another noticeable falls coincide in time with European recession in the early 1920s, World War II, early 1960s and global economic crisis of early 1980s. Correlation for the sample of "core" countries has similar pattern with more pronounced spikes and hollows in these periods. Despite these fluctuations in cross-country correlation in shorter periods, the overall pattern tends to have the shape of sloped letter J, with much higher correlation in the last decade of the 20th century than ever before.

The analysis of average correlation and rolling correlations of real yields on sovereign bonds gives us the rough picture of the patterns exhibited by this segment of international financial markets. As the first approximation, I can claim that financial markets moved together relatively closely for a short period of time in the end of the 19th century, then the the co-movement was disrupted in the turn of the centuries. After that the integration of the markets gradually increased over the 20th century and according to this measure reached unprecedentedly high extent in its last decade. Steadily rising correlation coefficient after World War II may be interpreted as the evidence of the growing integration in international financial markets. On the other hand, the Debt Crises and global recession of the early 1980s had dissimilar impact on individual countries, caused setback in the process of globalization, and was characterized by the fall in the correlation. But if the financial markets are affected by some event in the similar fashion the correlation across countries might be high even without substantial integration.[13]

[13] In the working paper version of this paper I describe some historical events related to financial markets integration. World War I is one example of an event when all the European economies were disrupted. Following this logic the increase in correlation during the late 1920s–late 1930s might be the result of the U.S. Great Depression spread over to the Europe—the disruption similar to World War I. There is an evidence however that the economic crises began in Europe earlier—in early 1920s, following the war. Among the possible causes are sharp fall in commodity prices in 1921, German hyperinflation of 1923 and recessions which stroke the countries, such as France and Great Britain, which returned to the Gold Standard at pre-war parity (see Britton (2001), O'Rourke and Williamson (1999)). On the other hand, by the time the U.S. Great Depression stroke the the financial markets functionality was somewhat restored. The main mechanisms, involving interest rates, capital flows and commodity prices were still in working order. In such a case, higher correlation may be interpreted as the evidence of improvement in the international financial architecture during the peaceful inter-war decades when the European economies overcome the destruction caused by World War I. Britton (2001) claims however that it was not enough time to build the confidence and to calm the speculations to be able to restore system like pre-war Gold Standard. Obstfeld and Taylor (2004, p.121) claim that "the period of the maximal interest-rate deviations at mid-century was also the era of minimal quantity [of capital flows] activity".

Since both of these scenarios are possible I need to find additional evidence of the extent of integration among the national capital markets over time.

2.3.2 Correlations of Spreads

Existing literature uses two reference countries in calculating interest spreads, Great Britain and the United States.[14] One of the arguments explicitly mentioned in the literature is importance of a particular country as a financial center and the world economic power. It is true that Great Britain had been an important country in the world since Industrial Revolution till approximately the 1950s when its colonial Empire collapsed. On the other hand, the economic and political power of the United States started to be recognized after World War I and was not questioned by anyone after the World War II.[15] Since the "importance" of any of these two countries was changing over the century the estimates of co-movement based on one of the economies might bear some degree of spuriously. I calculate the average correlations and rolling correlations for the deviations of bond returns for in-sample countries from real return on the U.S. 10-year government bond and real return on British Consol. Figure 3 presents the correlations of spreads versus the U.S. and British returns. It is obvious that the pattern of correlations across five periods is quite different both from each other and from correlations of levels of returns (Panels A and C of Figure 3). Correlations of spreads versus the U.S. stay approximately the same during first four periods within the range of 0.3 and increase to the high of 0.8 in the last period. On the other hand, with deviations from British Consol the correlation grows slowly from 0.4 to 0.7 during the same period and falls to 0.4 in the last decade. This represents the inverted-U shape of the correlations with the peak in Period IV. Building correlations on the smaller sample does not change these patterns much. As before, the rolling correlations reveal shorter-run patterns in correlations masked by the aggregation in average correlations. Panel B of Figure 3 shows the obvious U-shape pattern in the correlation of spreads versus the U.S. with the trough in the 1920–1950 (ignoring the spike during World War II). Again I observe the inverted-U pattern with the peak in the mid-1960s–early 1980s in the correlations of spreads versus Great Britain. Amazingly, the spikes in Panel D of Figure 3 depicting the correlations

[14] Mauro *et al.* (2002) studies the deviations of bond yields from British Consol in the historical sample (1870–1913) and from the U.S. long-term government bonds in the modern sample (1992–2000), while Obstfeld and Taylor choose the U.S. as the reference country in their studies.

[15] One illustration of the importance of the London of international financial center is that before the 1920s very few governments kept government bond yield data—most of the data comes from the London stock exchange. Prior to World War I, very few foreign bonds were traded on the New York Stock Exchange, and its only in the beginning of 1920s foreign governments began to take advantage of the NYSE's liquidity.

of spreads versus Great Britain occur exactly in periods of low correlation of spreads versus the U.S.

The findings in this section lead to an important conclusion. If one believes that the correlation coefficient of returns across countries is one of the appropriate measures of the capital markets integration the use of spreads relative to some particular economy might give a misleading result. This probably because the correlation of excess returns depends heavily on the behavior of an asset of the reference country and reflects that country's domestic policies.

While keeping these two considerations in mind I still find it compelling to study the deviations form some "benchmark". As I claimed before, the more objective measure is the deviation of the individual yield from the return on equally weighted portfolio containing bonds of all in-sample countries. The interpretation of the correlation coefficient in this case is quite different from the previous cases. High correlation between the levels of returns can be interpreted as an evidence of high co-movement of returns across countries, absence of arbitrage opportunities, and hence greater integration of financial markets. In contrast, high correlation between spreads versus the return on equally weighted portfolio implies presence of inefficiencies at the international capital markets because excess returns move in the same direction and arbitrage profits are possible. The average correlation of spreads versus this estimate of the "world" return gradually decreases from about 0.11 in the Period I to 0.08 and then to zero and even turns negative by the Period IV. The absolute value of the coefficients of correlations is much smaller than discovered before. The rolling correlation shows that except for the noticeable spikes in the mid-1870s, around 1905, and during the World War II the average correlation stays close to zero. Consequently, international financial markets became well integrated even in early 20th century. World War II as well as the period before 1905 were characterized by the disruptions in the international capital markets integration. This finding is consistent with the analysis of the correlations of levels. In Figure 2 the period of low correlation is the same period before 1905, and correlation rises steadily from the early 1920s on.

3 "Index of Integration"

3.1 Background

The analysis of the previous section illustrates the changing co-movement pattern of the international financial markets over the long run. Correlations of the bond yields across sample of fifteen countries follow the shape of sloped letter J which might be interpreted as the presence of relatively high integration in the 1875–80 and its steady growth since as early as the mid-1920s (interrupted by the Great Depression and World War II). The deficiency of the the correlations based on the yields in levels is proven by the existence of the large spikes in correlation coefficient in wartime—the effect hardly attributable to increase in integration but rather reflecting common shocks among a group of countries. In line with the literature I explore the correlations of excess return relative to two reference countries: the U.S. and Great Britain. I found the evidence of the U-shaped pattern in correlations of deviations from the United States, the result consistent with the literature. In contrast, correlation of deviations from British Consol exhibit inverted-U pattern. I claim that measuring international integration over the long run based on deviation form the yield of some particular country is not accurate because it lacks objectivity and is largely influenced by policies of the reference country. Apparently we need some alternative to the "conventional" price-based measure of integration. Possible alternative is to use the excess return relative to the portfolio containing bonds of all in-sample countries in equal shares. With this measure I found the correlations close to zero starting from World War I which is consistent with the no-arbitrage condition in international financial markets and their integration. It is hard to use this approach for *quantifying* the integration—a desirable property of an "integration index". Another important deficiency of correlation coefficient as a measure of integration is the possibility of spurious results when the underlying series are non-stationary.

There is a better empirical methodology to describe common features of a set of correlated economic variables. Assume $\{z_i\}_{i=1}^{n}$ is a set of n observed variables. Each of vectors z_i can be described as the linear combination of n common factors f_j and a unique factor u_i, specific to the variable z_i:

$$z_i = \lambda_{i1} f_1 + \lambda_{i2} f_2 + ... + \lambda_{in} f_n + \delta_i u_i, \quad i = 1, ..., n. \tag{1}$$

One of the methods for calculating the factors is the method of principal components. This paper proposes an improved methodology to study the co-movement based on the *principal component analysis* and applies it to the real interest rates in different countries.[16]

The aim of the *principal component analysis* is to describe the variation of a group of variables

[16] An introduction to the the methodology is Rabe-Hesketh and Evitt (2004); one of the early empirical applications is Nellis (1982).

using a set of orthogonal variables each of which represents a special linear combination of the original variables. The method is not based on some specific assumptions about the structure of the variables, such as stationarity, which is an advantage. Principal component analysis transforms the observed data vectors $z_1, z_2, ..., z_n$ to unobserved vector variables $f_1, f_2, ..., f_n$ referred to as *components*. The components are weighted linear combinations of the original variables z_i represented by the matrix system:

$$\mathbf{F_{n\times 1}} = \alpha_{\mathbf{n\times n}}\mathbf{Z_{n\times 1}} \tag{2}$$

where, for example, the first line of the system takes the form $f_1 = \alpha_{11}z_1 + \alpha_{12}z_2 + \ldots + \alpha_{1n}z_n$.

The coefficients of the component f_1, $\alpha_{11}, \alpha_{12}, \ldots, \alpha_{1n}$, are called scoring coefficients or *loadings*. 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 explains maximum of the residual variation after the previous component is removed form the data, and so forth. Therefore, these components capture most of the observed variability in the data. Technically, the coefficients α_{ji} are nothing more than elements of the eigenvectors for the sample covariance matrix of the data $\mathbf{Z}$; the variances of components z_j are the corresponding eigenvalues of $\mathbf{Z}$. In case when the variables z_i have different scales it is advisable to calculate the components from the sample correlation matrix which is analogous to converting all the variables to having zero mean and unit variance prior to calculation. This will avoid putting too much weight to the variables with larger standard deviations.

Principal components can be ranked by the proportion of the total variation in a series they explain. For instance, in the system (2), $\mathbf{a_1}$ is the first eigenvector of the covariance matrix with the largest eigenvalue. In practice one is interested only in the factors which explain more variation than any single variable—the ones with eigenvalues greater than one, the average of all eigenvalues. The other factors are less significant and may be considered the noise.

3.2 Principal Components as a Measure of Returns Comovement: Suggestions For Improvement

The papers on the financial market integration which employ this methodology normally look at the proportion of the total variation in economic series described by the first principal component. The logic goes that the existence of a single variable explaining most of the variation in the data would imply their high co-movement and be an evidence of market integration. The existence of several factors each affecting only a subset of countries in the total would be the evidence of market segmentation. One example of applying factor analysis for studying the interest rate co-movement (or *"covariability"*) is an earlier work Nellis (1982) which compares the financial integration among the major industrialized countries before and after move to the floating exchange rate regime in the early 1970s.[17] In a more recent paper, Mauro *et al.* (2002) calculate the share of variation accounted for by the first principal component in the sovereign bond yield spreads for a group of emerging market countries as one of the measures of yield co-movement. Their result is that this proportion was high in historical period (1877–1913) but is significantly higher in modern period (the 1990s). They interpret this result as the evidence of higher co-movement in spreads and hence integration in the recent period. Bordo and Murshid (2002) uses the principal component analysis of the spreads on long-term sovereign bond yields and a measure of currency crises, together with other techniques, to come to the opposite conclusion that financial market shocks were more globalized before 1914 compared to the present. The latter paper stresses the possibility of the dependence within groups and thus considers the first three principal components. These authors reveal sharp distinctions between advanced and emerging countries in the 1990s and divide sample countries into several groups according to the spreads behavior. The conclusion which might be drawn from their result is that the use of the proportion of variation explained by the first principal component alone might mask important country-specific or group-specific differences which affect the inference about the degree of international financial market integration.[18]

[17] Gagnon and Unferth (1995) calculate the country loadings for the first four principal components over the full time period as an additional measure of co-movement for the real interest rate of nine developed economies over 1977–1993.

[18] The idea that the mechanical interpretation of the first principal component as the measure of the international integration might be incorrect is not new. Nellis (1982, p.346) lists the cases when the researcher should be careful with such interpretation. A high and growing degree of integration among the subset of countries might generate the strong first factor. Therefore, Nellis says, this factor only relates to financial interdependence within that subset of countries and not overall integration. The indicators of such possibilities are: (1) first principal components 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

Taking into account methodological considerations and empirical results form the previous work this paper proposes an improvement of the use and interpretation of the principal component analysis in the study of international financial integration. The following strategy proved to be useful.

1. Perform extraction of components from the data $\{z_i\}_{i=1}^n$ allowing for as many factors as there are series, n. This will give estimates of n eigenvectors containing coefficients $\{\alpha_{ji}\}_{j,i=1}^n$ and corresponding eigenvalues.[19]

2. Count the number of components with eigenvalues greater than one to explore the possibility of a significant market segmentation. In practice, if one studies co-movement of the similar variables across "individuals" (such as countries or regions) there will be a single most important factor with eigenvalue greater than one.

3. Estimate the proportion of the total variation in variables z_i explained by the first principal component f_1 as the dynamic measure of integration ("index of integration") in the full group of countries. This measure may be plotted versus time to provide visual illustration of the time path of integration.

4. To reveal the possible country-specific and group-specific patterns in integration, study the factor loadings associated with the first component, $\{\alpha_{1i}\}_{i=1}^n$. Notice that if the loadings are multiplied by the square root of the corresponding eigenvalue the products will provide estimates of the correlation between an observed variables z_i and unobserved first principal component, which are easier to interpret than eigenvalues.

5. To summarize the role of individual countries calculate the standard deviation of the individual countries' component loadings associated with the 1st principal component and number of countries out of sample with negative loadings ("indices of regionalization").

Before presenting the results corroborating the benefit of such methodology, several other considerations are worth emphasizing.

First consideration involves the decision on the form in which series should be studied—levels of returns or spreads. This affects the interpretation of the results. This task involves the

the residual variation after the first component is accounted for. These contingencies may signify the segmentation in the financial markets. However, Nellis does not study these possibilities in his paper.

[19]One of the ways to extract components from the data is to use STATA's `pca` command.

considerable intellectual effort what probably describes the limited use of this technique in the literature. Theoretically, if majority of countries are integrated into the world financial markets then their interest rates move together with the "world" rate, and hence with each other. This is the implication of a standard non-arbitrage assumption in the absence of restrictions to capital flows. Strictly speaking, there is no such variable as the "world" interest rate. In the previous sections I compared the behavior of individual interest rate with some candidates; they were real returns on British Consol and the U.S. government bond, as well as the return on equal-weight portfolio of all in-sample countries.[20] Obviously, these measures are quite *ad hoc*. In contrast, the first principal component of the real interest rates may naturally be interpreted as the "world" return since this factor captures most variation in individual returns. This proxy reflects the continuously changing individual counties' influence on the world return. For example, when country shuts down its capital markets its domestic financial markets' behavior diverges from the world market. First principal component will immediately capture this disintegration which will show up as the lower loading corresponding to this country. Hence in contrast with studies by Mauro *et al.* (2002) and Bordo and Murshid (2002), who work with bond yield spreads, I propose to investigate the levels of real sovereign bond yields. This interpretation is applicable to other markets which possess price criteria, *i.e.*, for which the notion "world price" can be defined.

Second consideration is related to the time period to estimate the principal components. The estimation should be performed as the moving window over the sub-sample shorter than the sample size. This is an innovation of this paper. All other studies calculate the principal components over the whole period as the general measure of a country co-movement within the group. Or, at best, the estimation is performed over the exogenously defined sub-periods; normally, they reflect the periods before and after some important events in the history of globalization such as collapse of Gold Standard or of Bretton Woods system. Researchers try to relate these events to changes in globalization. The rolling window estimation reveals important dynamics in the integration and country- or group-specific shocks hidden when a single number corresponding to the whole period is reported. Rolling window estimation of the correlation coefficient became a conventional of co-movement in the integration literature.[21] This paper is

[20]Gagnon and Unferth (1995) proxy the "world" interest rate by sample average of real interest rate calculated by panel regression of *ex post* interest rate on constant, country dummies and year dummies (1977–1993). Ford and Laxton (1999) use Gagnon and Unferth (1995) data extended through 1997.

[21]See, for example Obstfeld and Taylor (2002a) or Goetzmann, *et al.* (2001).

first to calculate the principal components in such a way. I study the co-movement during the five exogenously defined historical periods as the robustness check for the comparison with the existing literature.

Third consideration involves sample selection. A high and growing degree of integration among the subset of countries, or simply peculiar characteristics of the group, might generate the strong first factor. That is why Bordo and Murshid (2002) who study the the data for advanced and emerging markets discover sharp group differences in integration patterns. To minimize the possibility of this effect a researcher should concentrate on the evolution of the stable sample of countries with approximately similar institutional and economic characteristics over the long run which represent bulk of the global market hovewer.[22]

Last consideration is related to the previous one and involves the possibility of country- or group-specific effects. Potentially, the "index of integration" may have lower value during some sub-period for two reasons. First, the majority/several countries have low loadings simultaneously; this is an example of true "lack of integration" since some forces impair the co-movement of most countries with the "world". Second, a few countries have *very* low or even negative loadings; this is a "regional crisis" rather than fall in integration since most of the countries move together with the "world" and only a small number diverts from the group. Principal component analysis performed in the way outlined here allows to explore such possibilities. This makes the "index of integration" a superior technique compared to the correlation coefficient or cross-section variation. Examination of the loadings associated with the first principal component is an important check which should supplement the analysis outlined here.

The following section presents the implementation of the methodology for quantifying the integration at the sovereign bonds market over the long-run.

[22]Bordo and Schwartz (1996) classify Austria, Denmark, Italy, Japan, Spain and the U.S. to be emerging countries in pre-World War I period. In this paper the short sample (11 countries) including Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, United Kingdom, and United States over the long-term period of 130 years, instead of comparing two distinct subperiods. Austria, Finland, Japan, and Switzerland were omitted due to lots of missing observations in the beginning of the sample. Obstfeld and Taylor (2004) study similar set of countries and refute the idea that these countries faced different "shocks to technology" over the century. According to them, "technological evolution was not smooth and linear, but [...] it was at least unidirectional, and, absent any other impediments, would have implied an uninterrupted process toward an even tightly connected global marketplace" (p.122). Therefore, I think that all the countries in 11-country sample are characterized by the similar structural/institutional conditions, at least in relation to the financial markets development.

3.3 Quantifying Integration at Sovereign Bond Market

At first I calculate the proportion of total variation in 11 yield series explained by the first principal component during the pre-defined historical periods. This is the approach followed by the studies which employ principal components analysis.[23] The proportion equals to 55% in the Period I (1875:01–1913:12), 58% in the Period II (1919:01–1939:12), 85% in the Period III (1945:06–1971:07), 60% in the Period IV (1971:08–1990:12), and 93% in the Period V (1991:01–2002:12).[24] The estimates are depicted as the small squares in Figure 4 (Panel A). Based on this measure, the co-movement of the 11 in-sample countries' yields increased sharply in the recent globalization period as compared to first two historical periods. The co-movement was also pretty high from the end of World War II till the collapse of Bretton Woods system, and was interrupted by the turbulent 1970s–80s. Still, in historical periods the first principal component accounted for at least 55% of variation in real bond returns, and for 87% on average for the whole period 1880–2002. This measure is broadly consistent with the findings of the historical integration studies but masks the short-run dynamics.

Methodology outlined in the previous section allows to overcome this limitation. I estimate principal components on the set of 11 industrialized countries using 13-year (156 month) centered moving window.[25] The rolling window estimation reveals shorter-run patterns in co-movement masked by the aggregation and is immune to exogenous choice of the time periods. The graph of the total variation in returns explained by the first principal component—the "index of integration"—is presented in the Figure 4 (Panel B). There is a clear evidence of higher integration at the end of the 20th century compared to the earlier periods. The current trend in integration began from as early as the early 1920s and is evident after World War II . The overall integration pattern tends to resemble a sloped letter J with a trough as early as the 1920s. This is the main result of this paper. Obviously, the aggregated estimates of the proportion depicted in Panel A similar to the measures being used in the integration literature masks important short-run differences.

[23]Mauro *et al.* (2002) estimate the proportion explained by the first principal component together with asymptotic standard errors based on the assumption that the data is multivariate normal. They admit that this assumption might be restrictive for financial data therefore their asymptotic results may lead to misleading results. As the preliminary check I tried this estimation on my data. The estimated standard errors are not very big to distort the general trends in the changed proportion of variation attributed to the first principal component over historical periods I study.

[24]Using the 15-country sample the proportion equals to 52% in Period II, 70% in Period III, 51% in Period IV, and 92% in Period V. The missing data for Austria, Finland, Japan, and Switzerland do not allow to perform the estimation in the Period I.

[25]Estimations with bandwidth of 120 and 180 months produced very similar pattern.

To prove that the new measure in fact reflects actual dynamics of the bond market integration and not something else I employ a series of additional checks. They illustrate that the proposed index of integration provides additional insights about capital markets behavior over time.

Lothian (2002) emphasizes the cross country variation of various real interest rate series (calculated as the cross-country standard deviations of 5-year averages) in the study of globalization of financial markets. Higher standard deviations are interpreted by him as interest rate divergence. In the Figure 5 I present the "index of integration" together with cross-country variation in returns.[26] Both measures reflect the existence of certain "waves" of integration over the last 130 years. For this group of countries the real returns tend to converge (1) in the period from the beginning of the 20th century till first years of World War I; (2) from the late 1950s till the early 1970s; and (3) in the recent period starting from approximately 1982.[27] Even if the late 1920s–1930s were characterized by great divergence of returns, the upward trend in integration of financial markets can be traced from as early as the mid-1920s. This trend is the longest in the history. The greatest disruptions to this process coincide with the world economic crisis following Great Depression in the late 1930 together with World War II, as well as series of oil shocks and debt crises in the 1970s–early 1980s. From the start of the 20th century to World War I the cross-country divergence of returns was the lowest in the history; there is only a tendency to reach such low deviation of returns after the mid-1980s. Clearly there is consistency between the two measures of co-movement. Over time, higher cross-section variation of returns is associated with lower proportion explained by the 1st principal component—both imply divergencies in real sovereign bond yields.[28] However, the "index of integration" is an improvement over cross-section standard deviation. In addition to illustrating the degree of integration over time (which is also captured by the latter measure) the index allows to reveal reasons for the observed pattern. Noticeably the recent period is characterized by much higher than before proportion of variation attributed to the single important factor (1st principal component). I conjecture that the period prior to World War I had more country- or group-specific shocks to

[26] Cross-country variation is calculated as the standard deviation of yields across in-sample countries de-scaled by the corresponding cross-section mean. The resulting monthly measure is smoothed by two filters: centered unweighted 156 months (13 years) moving window and with centered 61 month (5 years) Normal filtering. In the latter case the weights to lags and leads are assigned according to Normal distribution with the center at the current observation.

[27] These periods roughly correspond to the exogenous periods I, III, and V defined in Table **??**.

[28] The coefficient of correlation between cross-section variation of returns and proportion explained by the first factor is from -0.54 to -0.63 depending on the smoothing method used for cross-section variation.

integration.[29] Principal component analysis allows to test this statement.

Normally, the lower the proportion in total variation explained by the first component, the greater the number of extracted components with eigenvalues greater than unity. The number of extracted principal components with eigenvalues greater than unity varies from period to period. In 11-country sample across exogenous historical periods this number is three in Period I (1875:01–1913:12), three in Period II (1919:01–1939:12), one in Period III (1945:06–1971:07), two in Period IV (1971:08–1990:12), and one in Period V (1991:01–2002:12). This finding alarms us about the possibility of market segmentation and country-specific shocks in Period I, II, and IV.

To further explore this possibility I calculate the loadings (scoring coefficients) of the individual country returns onto the first principal component over time (they are coefficients α_{1i} in (2)). One can directly compare the loadings of individual countries to each other to learn which countries contribute most to the "world" return represented by the first principal component. Loadings can also be used to calculate correlation of the unobserved "world" interest rate with the country's interest rate (but they are immune to the drawbacks of simple unconditional correlations calculated for non-stationary series). Both loadings and the correlations are essentially the same and differ only by a constant multiplier.[30] Both allow to reveal individual countries whose bond returns seemed to move independently of those in other countries. However, the latter measure is more conventional and easier to interpret. In this part of the paper I am interested in revealing the periods of sudden drops in the country co-movement with the "world". Consequently, in what follows I discuss the correlations of country returns with the first principal component.

Across exogenous historical periods the correlation between country returns and unobserved first principal component are above 85% except for the following cases (value of the correlation is given in brackets): Italy (11%), Spain (−16%), and the U.S. (50%) in Period I; Germany (13%) and Spain (−37%) in Period II; Germany (40%), Norway (50%), and Great Britain (29%) in Period IV. These results show some important individual country divergencies from the world.[31]

[29]This claim would be consistent with the conclusion of Mauro *et al.* (2000) that sudden changes in spreads in recent years were associated with global crises whereas country events had a bigger role in the 1870–1913.

[30]The estimates of the correlation between observed variables z_i and unobserved first principal component f_1 are equal to the product of their loadings $(\alpha_{11} \quad \alpha_{12} \quad \ldots \quad \alpha_{1n})'$ and the square root of corresponding eigenvalue. Therefore, the scoring coefficients are just proportional to the correlation coefficient. In the rest of the paper I study "correlation" calculated in this way.

[31]In such a case Bordo and Murshid (2002) explore the loadings of the second and third 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.

My methodology allows to go beyond reporting loadings over the whole period and study the individual country dynamics relative to the group. I investigate the time patterns of the loadings, close in spirit to what Nellis (1982) does.[32] The dynamics of the correlations are reported in Figure 6. The overall result is that over the long run the correlations of country returns with a single important factor are quite high—all the countries remain pretty integrated with international financial markets. However, there are noticeable periods of time when the individual bond yields moved independently form the "world" real interest rate. Besides the individual country-specific episodes of segmentation, there are some periods when several countries have such disconnection simultaneously. For example, there are clustering of lower loadings for Belgium, Germany, Italy, Spain, and the United States around the 1894–1902; for Belgium, France, Germany, and Spain in the mid-1920s–late 1930s; for Germany and Great Britain in the 1973–early 1980s.

It is possible to construct a measure which adds additional dimension to quantifying the integration compared to the "index of integration". It summarizes country- or group-specific effects as another simple index. Figure 8 illustrates the point. Panel A depicts the familiar "index of integration," *i.e.*, proportion of the variation in bond returns explained by the 1st principal component. According to the index the biggest "disintegration" was observed in the mid-1890s, in the mid-1920s, and prior and during World War II. In Panel B I present two "indices of regionalization": the line is the standard deviation of the individual countries' component loadings associated with the 1st principal component; the bars represent number of countries out of 11 with negative loadings. Both "indices of regionalization" show that the "crises" picked up by the "index of integration" are in fact brought about by very different causes. The turn of the 20th century faced a real "global crisis": countries frequently diverted from the group and their weights in the "world" return varied a lot. In contrast, post-World War I "crises" were caused by some individual divergencies, where at most two countries diverted from the group. Post-Bretton Woods era does not observe even this kind of divergencies. There is a short period of discontinuity in British rates co-movement and some instability in the end of the 1970s. Otherwise integration of capital markets of in-sample countries is remarkable. One shall use a thorough analysis of the historical evidence to find the correspondence between these deviations and the national or international policy changes and shocks.[33] This task is complicated by the

[32] The estimates of the correlations of country returns with the unobserved "world" return are reported in longer version of this paper.

[33] Obstfeld and Taylor (2004) summarize the research offering of one of the potential transmission mechanisms. These authors attribute the patterns in long-run financial market integration to the interplay between domestic policy and external cooperation within "macroeconomic policy trilemma" framework.

fact that policy changes and actual changes in market integration may be disconnected in time as Bekaert, Harvey and Lumsdaine (2002) show in the study of developing countries equity markets in the 1990s. The analysis presented in this paper is not tailored to provide the formal event analysis of such hypotheses. Nevertheless it does provide the evidence on the character of the group behavior over time which is useful in formulating these hypotheses.

4 Conclusion

In this paper I explore why the existing empirical literature studying international financial markets lacks consensus on whether the highest degree of integration had been achieved before World War I or by the late 20th century.

I show that a conventional measure of co-movement, the coefficient of correlation, has a limited applicability as a measure of long-run integration. I suggest a systematic methodology based on the method of principal components to quantify the integration and to explore its dynamics. It seems to eliminate the limitations of conventional approaches. Despite its computational simplicity the suggested methodology is quite general and applicable to other markets which possess "price criteria", i.e., for which the notion "world price" can be defined.

I claim that the first principal component of the real returns in levels may naturally be interpreted as the world return since this component captures most variation in individual series. The proportion of variation in individual returns explained by the first principal component is the "index of integration" advocated in this paper. I introduce an estimation method which displays continuous evolution of integration over time. Within my methodology it is possible to construct a measure which adds another dimension to just quantifying the integration by distinguishing between two potential causes of setbacks in markets co-movement. The divergences of a few countries from the world are not necessarily the evidence of shutdown of integration. In contrast, simultaneous deviation of a large group of countries is a true "crisis" at global markets. It is important to discriminate between these two possibilities since they affect the interpretation of results. I describe how to determine which effect drives the observed integration patterns. These features make my methodology a potentially superior technique compared to conventional correlation coefficient or measures of cross-section variation.

As an empirical application the paper focuses on the behavior of long-term government bond yields for fifteen industrialized economies during 130 years from 1875 to 2002. The data on the yields comes from a comprehensive historical database of financial variables, Global Financial Database. The pattern of integration based on the coefficient of correlation depends on how the data is transformed. Correlations of spreads versus the U.S. bond returns indeed reveal a U-shaped trend of integration over the 20th century—the observation documented by the literature. In contrast, spreads versus British consol exhibit inverted-U pattern of correlations. Choice of another benchmark, such as return on the equally weighted portfolio containing bonds of all in-sample countries is rather ad hoc. I apply my methodology to this data and find clear evidence of greater capital markets integration at the end of the 20th century compared to the previous periods. The current trend in integration began after World War II. I also show that financial integration had been restored during the interwar period but disrupted during the Great Depression of the 1930s and World War II. Instead of having the U-shape overall integration pattern tends to resemble a sloped letter J with the trough as early as the 1920s. The turn of the 20th century is unique. It faced a real global crisis: several countries frequently diverted from the world and their weights in the world return varied a lot. In contrast, post-World War I crises were caused by some individual divergences, where at most two countries diverted from the group.

Although this paper determines the integration pattern over time and reveals some country- and group-specific shocks to integration it does not study the events which might have caused these changes. The search for such explanations has been started in the literature but the conclusions are still very preliminary.[34] The creation of the theory of financial integration and comprehensive empirical work in this direction remains a promising area of research in international macroeconomics and finance.

[34]Obstfeld and Taylor (2004), Rajan and Zingales (2003), among others, stress the importance of political, institutional factors, and changing role of government in economic life as opposed to technological factors in shaping the integration in the 20th century.

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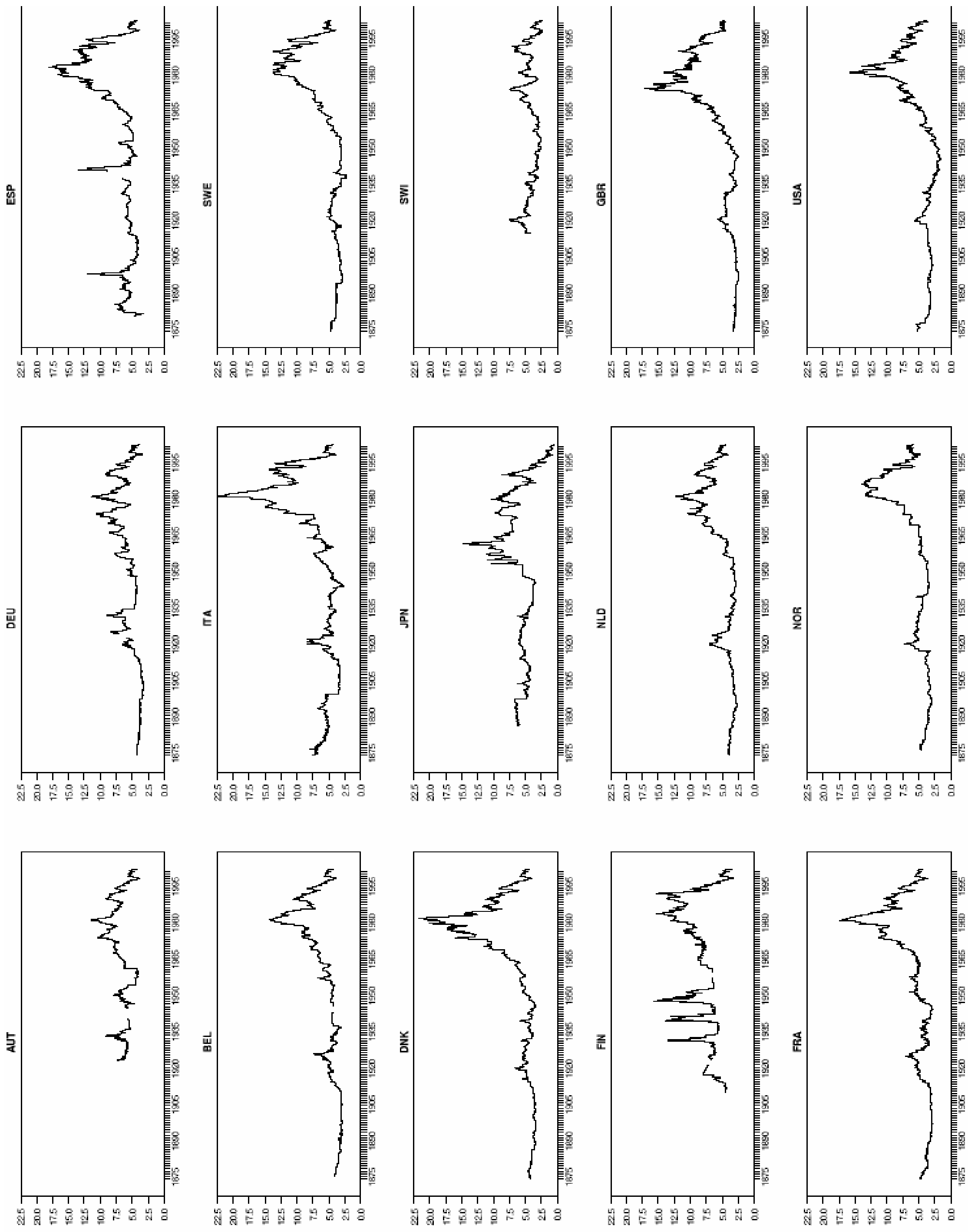
Table 1: Real government bond returns. Descriptive statistics

	Full Time Period 1875:01 – 2002:12	
	Mean	Std. dev.
Austria	6.64	1.45
Belgium	5.33	2.35
Denmark	6.28	3.72
Finland	8.11	2.60
France	5.44	2.81
Germany	5.40	1.76
Italy	6.74	3.57
Japan	5.72	2.11
Netherlands	4.82	2.02
Norway	5.36	2.55
Spain	7.15	3.12
Sweden	5.35	2.81
Switzerland	4.22	1.09
United Kingdom	5.29	3.09
United States	4.59	2.46
Average	*5.76*	*2.50*
σ^r_{CS}	1.77 (1.38)*	
σ^r_{AdjCS}	0.28 (0.24)*	

	Period I 1875:01 – 1913:12		Period II 1919:01 – 1939:12		Period III 1945:06 – 1971:07		Period IV 1971:08 – 1990:12		Period V 1991:01 – 2002:12	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
Austria	–	–	6.16	0.67	6.04	1.19	8.38	1.10	6.19	1.31
Belgium	3.32	0.32	4.63	0.78	5.45	1.07	9.62	2.05	6.42	1.57
Denmark	3.81	0.30	4.86	0.57	6.09	1.86	13.76	3.46	6.70	1.63
Finland	4.50	0.07	6.91	1.49	8.02	1.84	10.92	1.76	7.36	3.30
France	3.37	0.44	4.64	0.84	5.29	0.93	10.99	2.45	6.25	1.53
Germany	3.75	0.28	5.75	1.59	6.02	1.14	7.74	1.48	5.82	1.42
Italy	4.94	1.23	5.24	1.02	5.94	1.28	13.19	3.78	8.49	3.41
Japan	5.39	0.87	5.11	0.72	7.44	2.31	7.08	1.62	2.67	1.74
Netherlands	3.41	0.38	4.35	1.16	4.51	1.52	8.33	1.43	6.29	1.30
Norway	3.62	0.42	5.12	0.55	4.39	0.77	10.08	2.67	6.97	1.51
Spain	5.49	1.25	5.85	0.59	5.89	1.17	12.89	2.42	7.95	2.98
Sweden	3.72	0.47	4.09	0.79	4.59	1.44	10.68	2.03	7.43	2.31
Switzerland	–	–	4.62	0.89	3.49	0.82	4.89	1.00	4.13	1.25
United Kingdom	2.92	0.22	4.11	0.71	5.23	1.84	11.24	1.97	6.98	1.80
United States	3.44	0.56	3.59	0.82	3.67	1.53	9.19	2.28	6.13	1.01
Average	*3.97*	*0.52*	*5.00*	*0.88*	*5.47*	*1.38*	*9.93*	*2.10*	*6.39*	*1.87*
σ^r_{CS}	0.80		1.10		1.52		2.76		1.58	
σ^r_{AdjCS}	0.22		0.23		0.29		0.27		0.25	

Notes: For individual countries the mean and standard deviation represent time statistics for the sub-period. σ^r_{CS} is the cross–section standard deviation, calculated as the average of standard deviation across in-sample countries; σ^r_{AdjCS} is adjusted cross–section standard deviation, where the original countries' standard deviations were divided by the cross–section average yield. In calculation of the cross–section standard deviations I omit Austria, Finland, Japan, and Switzerland in Period I, and Austria in Period II due to missing observations.
* without Austria, Finland, and Switzerland.

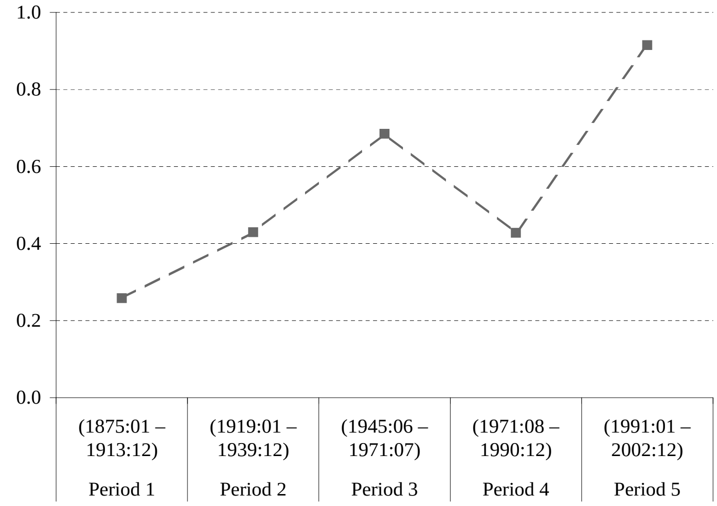
Figure 1: Real returns on government long-term bonds, 1875:01–2002:12



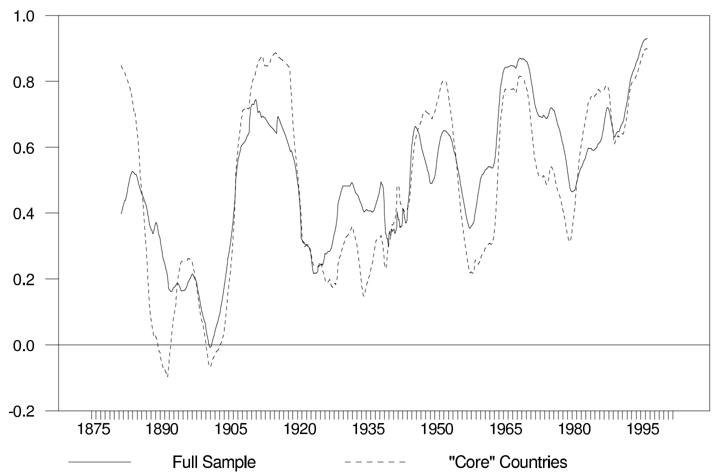
Notes: Historical monthly series for the returns on long-term government bonds issued by industrialized economies. Real yield is calculated from the nominal data using the the 25-months moving window linear filter centered at the current observation to estimate expected inflation. The following abbreviations 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.

Figure 2: Average correlation for the level of real returns on government long-term bonds, 1875:01–2002:12

A. Estimation over historical sub-periods



B. Centered rolling window estimation

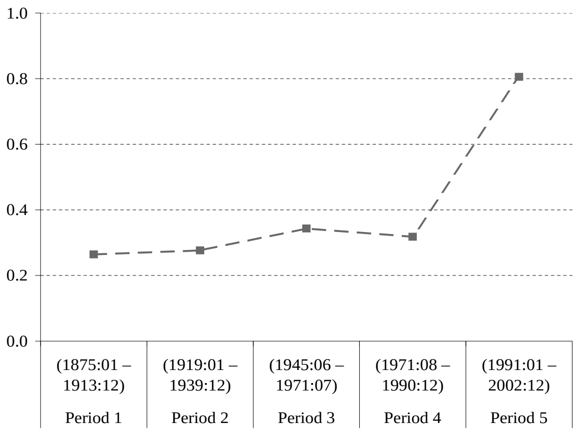


Notes: Panel A: Average correlation is calculated as the arithmetic average of off-diagonal pairwise correlation coefficients of the countries in sample. Correlations are calculated over corresponding sub-samples defined in Section . Sample countries change to make sure there are no missing observations in the middle. In Period 1 I drop Austria, Finland, and Switzerland; in Period 2 - Austria and Finland; in Period 3 - Finland due to lots of missing observations. Period of German hyperinflation in 1925:06-12 is also omitted. Panel B: Estimation by cross-country rolling correlation, 156 months centered moving window. Short sample (11 countries) in all periods includes Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, United Kingdom, and United States. Austria, Finland, Japan, and Switzerland were omitted due to lots of missing observations.

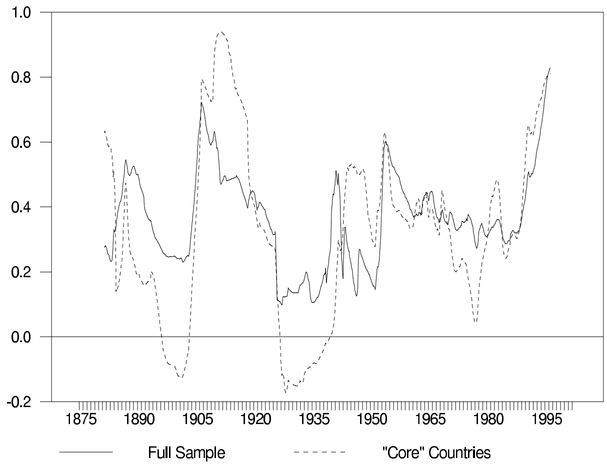
Figure 3: Average correlation for spreads on government long-term bonds (Spreads versus long-term real interest rate of the main financial centers), 1875:01–2002:12

Spreads versus the U.S. 10-year bond return

A. Estimation over historical sub-periods

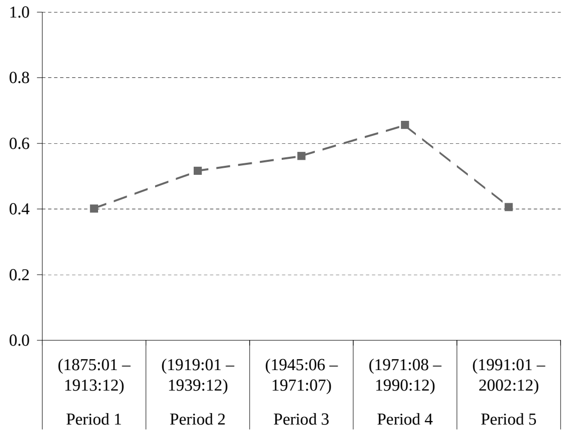


B. Centered rolling window estimation



Spreads versus British Consol

C. Estimation over historical sub-periods

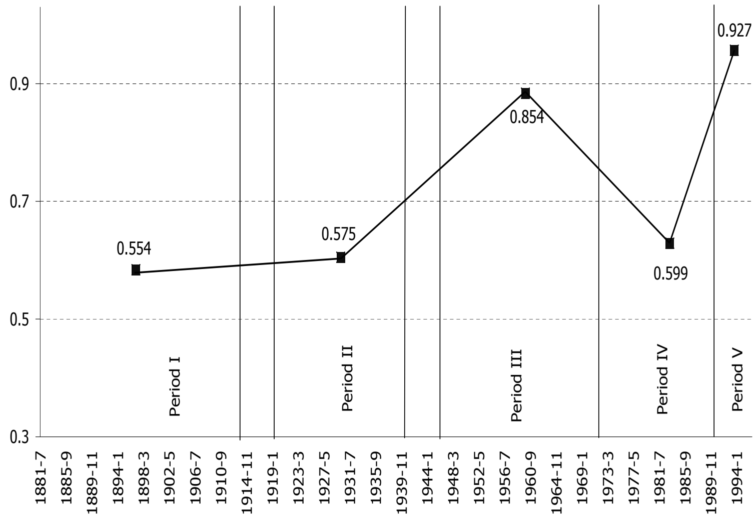


D. Centered rolling window estimation

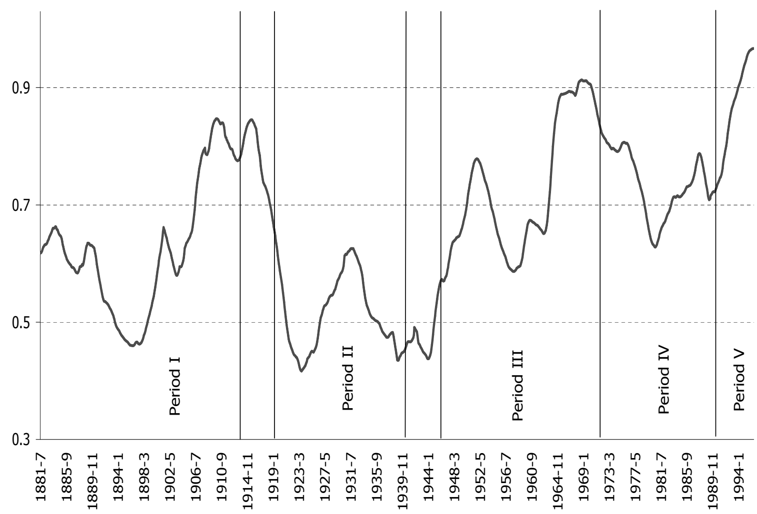
Notes: Average correlation is calculated as the arithmetic average of off-diagonal pairwise correlation coefficients of the countries in sample. Correlations are calculated over corresponding sub-samples defined in Section . Sample countries change to make sure there are no missing observations in the middle. In Period 1 I drop Austria, Finland, and Switzerland; in Period 2 - Austria and Finland; in Period 3 - Finland due to lots of missing observations. Period of German hyperinflation in 1925:06-12 is also omitted. Estimation by cross-country rolling correlation, 156 months centered moving window. Short sample (11 countries) in all periods includes Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, United Kingdom, and United States. Austria, Finland, Japan, and Switzerland were omitted due to lots of missing observations.

Figure 4: Proportion of the variation in bond returns explained by the 1st principal component, 1881–1996

A. Estimation over historical sub-periods

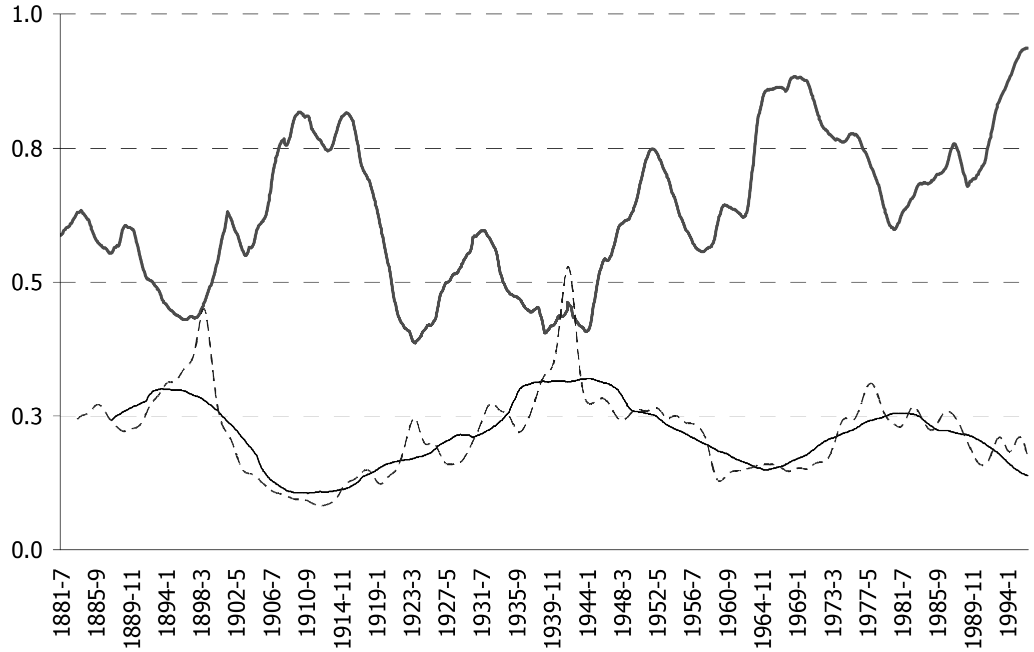


B. Centered rolling window estimation
("Index of Integration")



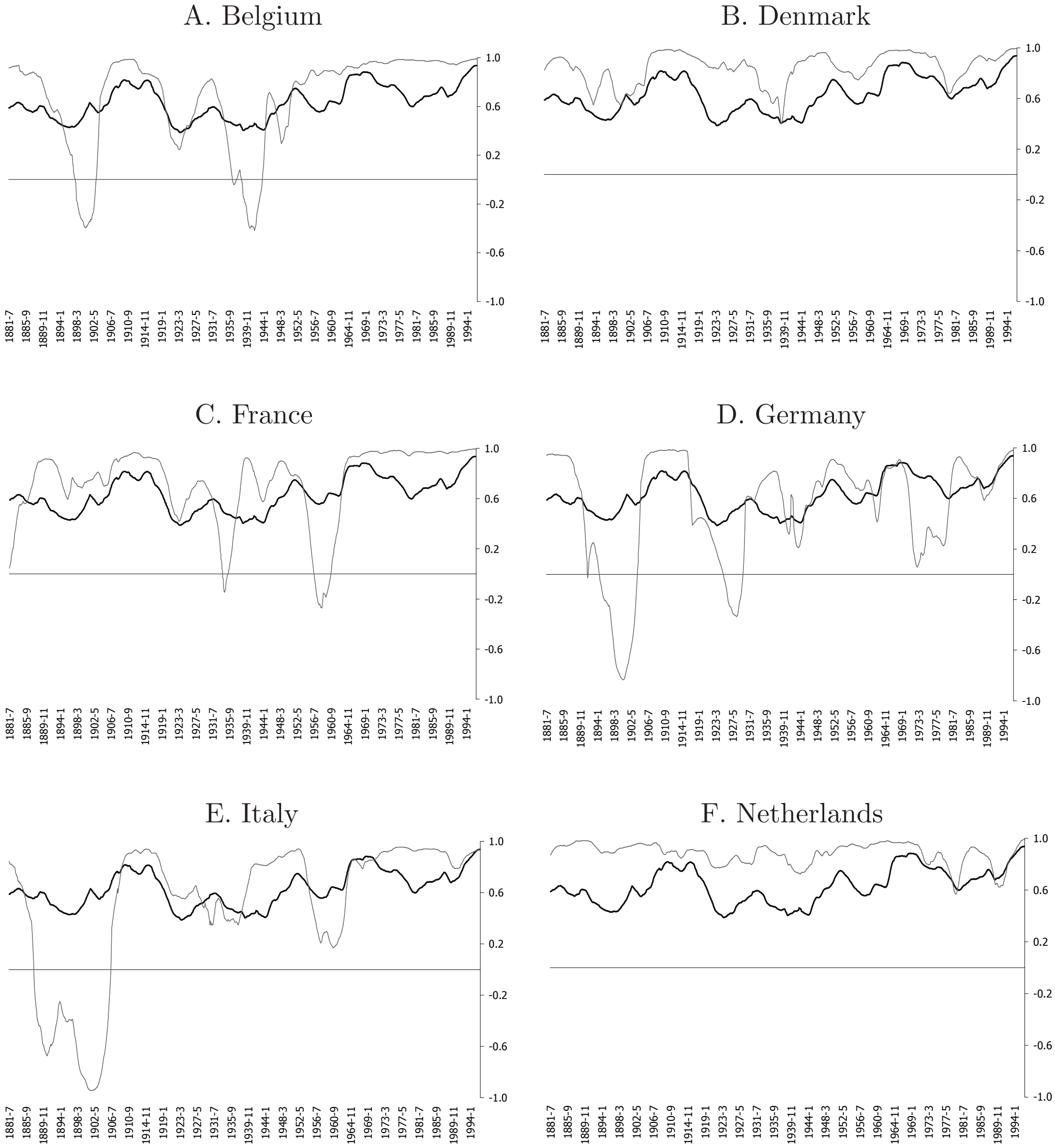
Notes: Estimates of the proportion of variation in bond returns explained by the first principal component. Real government bond returns are in levels. In-sample countries are Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, United Kingdom, and United States. In Panel A: Estimation is performed over the exogenous historical periods. They are Period 1: 1875:01–1913:12; Period 2: 1919:01–1939:12; Period 3: 1945:06–1971:07; Period 4: 1971:08–1990:12 ; Period 5: 1991:01–2002:12. In Panel B, the estimation of the component is performed as the centered rolling window with the bandwidth of 156 months.

Figure 5: Cross-section variation of the bond returns and proportion explained by the 1st principal component



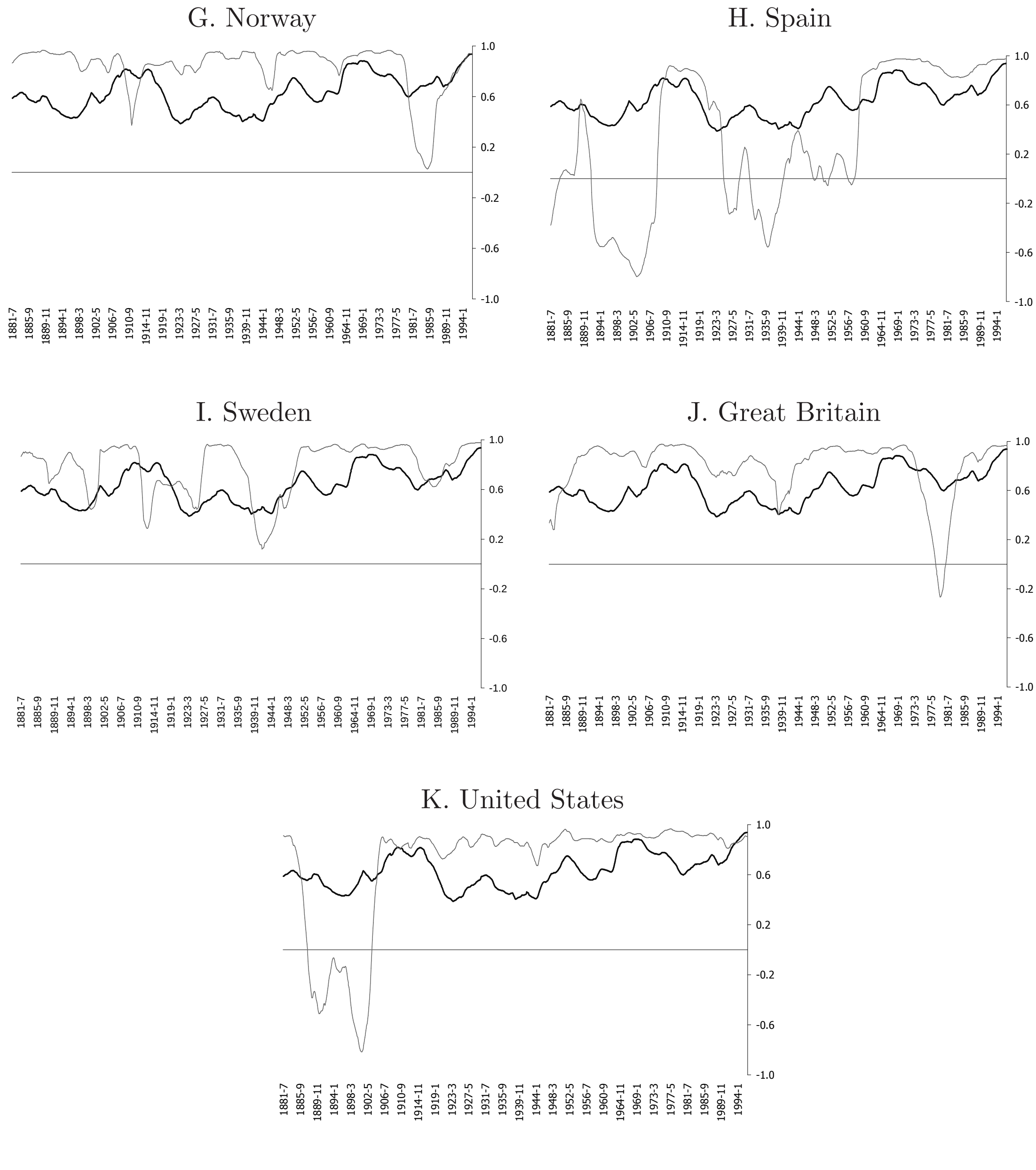
Notes: Thick line is the proportion of variation in bond returns explained by the 1st principal component or "index of integration". Cross-country variation is calculated as the standard deviation of returns across in-sample countries divided by corresponding mean. The measure is smoothed with centered 156 months moving window averaging (thin line); and with 61 month Normal filtering (dashed line) where the weights to lags and leads are assigned according to Normal distribution with the center at current observation.

Figure 6: Instances of disintegration by countries. Correlations of individual returns with the 1st principal component, 1881–1996



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

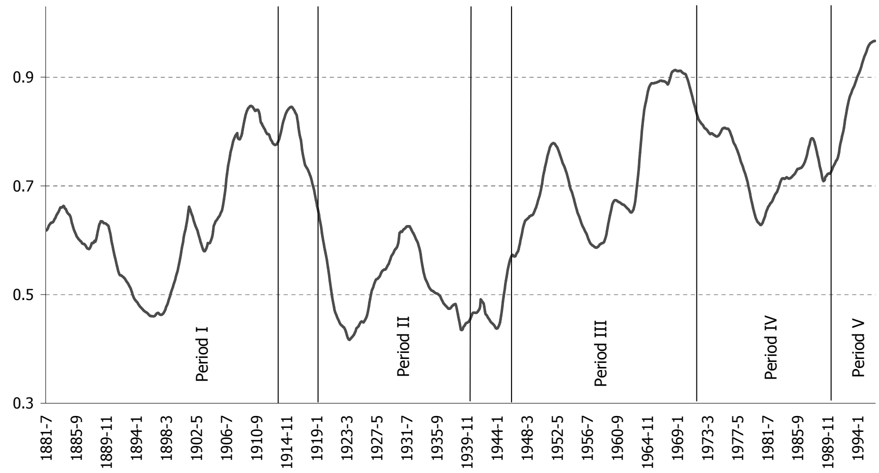
Figure 7: Instances of disintegration by countries. Correlations of individual returns with the 1st principal component, 1881–1996 (contd.)



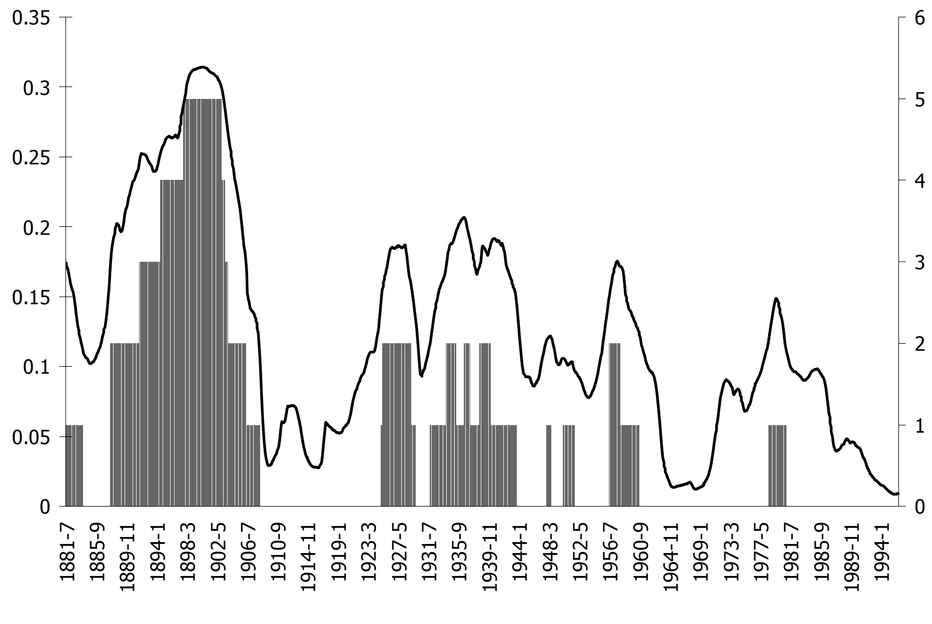
Notes: Correlations of individual returns with the 1st principal component is represented by the thin line, and proportion of total variation in bond returns explained by the 1st principal component ("index of integration") is added to each graph as the thick line. To calculate the estimates of the correlation between an observed returns and unobserved first principal component the loadings need to be multiplied by the square root of the corresponding eigenvalue. 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 8: Country-specific and group shocks to integration, 1881–1996

A. Proportion of the variation in bond returns explained by the 1st principal component ("Index of integration")



B. Variability of the loadings of the bond returns on the 1st principal component ("Index of regionalization")



Notes: Panel A: See notes to the Table 4. Panel B: Thick line is the standard deviation of the individual countries' component loadings associated with the 1st principal component (left scale). Bars represent number of countries out of 11 with negative loadings (right scale). Estimates of the proportion of variation in bond returns explained by the first principal component. Real 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.