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Abstract

The disconnect between rising short and low long interest rates has been a distinctive feature of the 2000s. Both research and policy circles have argued that international forces, such as global monetary policy (e.g. Rogoff, 2006); international business cycles (e.g. Borio and Filardo, 2007); or a global savings glut (e.g Bernanke, 2005) may be responsible. In this paper, we employ recent advances in panel data econometrics to document the disconnect and link it explicitly to the existence of a global latent factor that dominates the long end of the term spread for the recent period; the saving glut story emerges as the most likely contender for the global factor.

Keywords: Short and Long Interest Rates, Financial Globalization, Panel Data, Factor Models

JEL Classification Numbers: E43, F01, F36, G15, C33

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1. Introduction

Prior to the recent global financial crisis, two topics were prominent in policy and academic circles. First, the low levels of long term interest rates despite increasing short rates, the so-called *Greenspan Conundrum*, raised concerns about the possible failure of the monetary policy transmission mechanism in the US, see Greenspan (2005). Second, the large Global Imbalances, and in particular the excessive US external deficit, were the subject of intensive debate given their potential to force a sharp correction on the global economy.

The literature generated by these two issues has either taken a domestic or an international perspective.[1] Recently, the latter has gained momentum. It supports the view that the combination of excessive risk-taking and an international search for yield in a financially integrated global economy may be one of the main explanations for the crisis (see OECD, 2008; King, 2009; Caballero and Krishnamurthy, 2009). This international search for yield may have induced greater co-movement of international returns. According to an interpretation from Bernanke (2005), a more global perspective might warrant a common explanation for both Global Imbalances and the Greenspan Conundrum and help solve the 'puzzling' behavior of interest rates: *"From a narrow U.S. perspective, these [low] long term rates are puzzling; from a global perspective, they may be less so"* (Bernanke, 2005, p.7).

[1] Low long term interest rates have either been linked to domestic sources (like changes in monetary policy regime), or global sources (global monetary policy; see Rogoff, 2005, and Borio and Filardo, 2007). Boivin and Giannoni (2008) highlight a recent change in the US monetary transmission mechanism potentially due to global factors. Explanations for the large US current account deficit have either been considered as "made in the USA" (fiscal imbalances and overpriced equity and/or house prices contributed to low saving rates and external imbalances), or due to a global savings glut (Bernanke, 2005).

Along these lines, Caballero et al. (2008) were the first to propose a formal model that produces a US current account deficit, low interest rates and a shift in global portfolios towards US assets. Empirically, the idea that foreign holdings may drive the low levels of US interest rates, has found support by Craine and Martin (2009) and Warnock and Warnock (2009). However, the interest rate puzzle does not appear to exist only in the US, but also in other industrial countries.

Hence, in this paper, we pursue the global perspective solicited by Bernanke to uncover an economic rationale for the puzzling behavior of long term interest rates. Specifically, we apply recent econometric panel time series methods to investigate the country-specific and international linkages between domestic interest rates at the short and long end of the maturity spectrum, or the term spread. We analyze a sample of eight industrial countries between 1988 and 2006.[2] The international dimension to interest rates has also been investigated by Moon and Perron (2007) and Henriksen et al. (2009). Nevertheless, Henriksen et al. (2009) only highlight co-movements in short term interest rates. And Moon and Perron (2007) report, but do not draw attention to the relatively high correlations at the long end of the yield curve. Another recent paper from Diebold et al. (2008) emphasizes the international dimension of interest rates presenting evidence of a "global yield curve". Here, we go beyond these analyses to provide an economic rationale for co-movements in long rates.

Using the *Uniform Spacings* method of Ng (2006), a methodology that allows an overall assessment of the degree of correlation in the panel, we find that long rates are more correlated internationally than with their domestic short counterpart, especially in

[2] Factor models have also been used recently by *inter alia* Ciccarelli and Mojon (2008), Crucini et al. (2008) and Stock and Watson (2008) to examine linkages in global and regional variables.

the more recent period. Given the pervasive and maturity-dependent nature of correlations between interest rates, we next look for global factors at the opposite ends of the spread, using a Bai and Ng (2004) *Panel Analysis of Non-Stationarity in Idiosyncratic and Common components* (PANIC) methodology. Evidence of a global factor is only supported in the long end of the term spread and from 2000 onwards - when long and short-term interest rates decoupled. The global factor may be linked to the observed break in the relationship between country-specific short and long term rates and to the much discussed failure in the transmission of monetary policy in the first half of the 2000s. In the final stage of our analysis, we attempt to identify the "global end" of the term spread, drawing on alternative explanations proposed in the literature. We find evidence that global savings have been driving the long end of the term spread in recent times.

The rest of the paper is set out as follows. In the next section, we provide a short discussion of the related literature. Section 3 presents the empirical analysis of the domestic and international interest rates co-movements. Section 4 investigates the possible alternative sources of the global factors behind the long end of the term spread, and Section 5 concludes.

2. International Factors and the Term Structure of Interest Rates

Despite an extensive literature, there is neither theoretical nor empirical consensus on the domestic nexus between short and long term interest rates.[3] With widespread economic and financial globalization, an exclusively domestic focus on the term spread may be too restrictive. In this direction, a number of authors have investigated

[3] Prominent papers in this literature include work by Campbell and Shiller (1987), Hall et al. (1992) and Shea (1992). For interesting discussions see also Peersman (2002), Cook and Hahn (1989), Kugler (1988) and Hardouvelis (1994).

international interest rates co-movements with respect to the Uncovered Interest Parity Hypothesis (UIP), the Real Interest Rate Parity Hypothesis, or the relationship between the Expectations Hypothesis of the Term Structure and UIP.[4]

In a different setting, Moon and Perron (2007) use correlation analysis and factor models to investigate interest rate co-movements over a full spectrum of different maturities in Canada and US.[5] Moon and Perron present evidence of considerable within country correlation between interest rates at close maturities (e.g. 3 and 6 months or 7 years and 10 years), and suggest a much lower correlation between interest rates at distant maturities (e.g. 3 months and 10 years) and between international rates of the same maturity across countries (correlation for three month Canadian T-Bills and three month US Treasury is ≈ 40%). However, in their discussion they appear to overlook the evidence of higher international dependence of interest rates at the longer end of maturity spectrum (e.g. ≈ 60% for Canadian and US 10 year interest rates). Yet, this evidence can be interesting with respect to the de-coupling of short and long interest rates observed in recent years. Interest rates co-movements over the maturity spectrum are also analyzed in a different, but related, setting by Diebold et al. (2008). They model the yield curve using international factors for level, slope and curvature[6] and argue for the existence of a global yield curve.

The large co-movements at the long end of the term spread or the existence of a global yield curve can have different alternative explanations. One possible contender is

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[4] See, among the others, Juselius and MacDonald (2004), Chinn and Meredith (2005), Bruggerman and Lutkepohl (2005) and Bekaert et al. (2007), Camarero et al. (2009).

[5] Henriksen et al. (2009) also highlight the high correlation of interest rates across countries, suggesting this is of a higher order than common output fluctuations. Interestingly, they examine the behavior of only short term interest rates.

[6] In addition, see Duffie and Kan (1996) and Dai and Singleton (2000).

the role played by "global monetary policy" as discussed by Rogoff (2006), Borio and Filardo (2007) and Ciccarelli and Mojon (2008).[7] Wu (2006), on the other hand, alludes to the risk dampening effect of greater integration and the greater availability of savings that have translated into the observed low levels of long term bond yields in the US.

In reference to the US, Warnock and Warnock (2009) argue that while domestic monetary policy may have played a part in reducing long term rates during the 1990s, the decreasing trend in long term interest rates in the 2000s is mostly due to foreign capital inflows into US government bonds. Along these lines, Caballero (2006) claims that the shortage of international financial assets, especially in developing countries, and the increasing demand (flight-to-quality) for US assets are the main explanations for low interest rates. Caballero et al. (2008) present a theoretical model in which the US current account deficit, the decline in long run interest rates, and the rise in US assets in global portfolio result in equilibrium in a three regions model, where the rest of the world struggles to generate financial assets from real investment.

In this paper, we proceed along the lines of Moon and Perron (2007) and analyze the co-movement of short and long rates both domestically and internationally. Yet, our work is different in at least two dimensions. First, whereas they stress co-movement across the maturity spectrum, we prefer to focus on the international dimension of the analysis and investigate interest rates for a number of industrial countries. Second, we also apply recent panel factor methodologies to investigate the extent to which international interest rates co-movements can be attributed to latent global factors at the short and/or the long end of the term spread. This methodology allows us to test

[7] Borio and Filardo (2007) call this the globe-centric approach to domestic inflation and argue that "*in a number of cases, global factors appear to have supplanted the role of domestic measures of economic slack*".

Bernanke's suggestion that from a global perspective it is possible to shed light on the Greenspan conundrum. In the final stage, we try to disentangle the global factors behind interest rates co-movements in order to discriminate among competing explanations for the low levels of the long rate observed at the international level before the global crisis.

< TABLE 1 HERE>

3. Term Spread Correlations

3.1 Data

We first investigate co-movement of the two components of the term spread for a sample of eight industrial countries. Monthly data from January 1988 to July 2006 are collected from the *IMF International Financial Statistics* for Canada, Germany, Japan, New Zealand, Sweden, Switzerland, the United Kingdom and the United States. Three Month Treasury Bill Rates are used as Short Run (SR) interest rates, and yields on government debt of 10 year maturity as Long Run (LR) interest rates (percent per annum). See Appendix B for further details. Figures 1 and 2 show an overall decline of both short and long rates from the 1990s onwards. Short rates started moving upwards in most countries from 2003, while long rates were sluggish to

<FIGURE 1 HERE>

<FIGURE 2 HERE>

<TABLE 2 HERE>

respond and often even dropped below the respective short rate. Moreover, short rates seem to display greater cross country variability during the later sample period.[8] In contrast, the long interest rates display a remarkable degree of co-movement and increasingly so towards the end of our sample period. Simple descriptive statistics reported in Table 1 also suggest that long rates are less volatile than short rates for the whole sample (with the notable exception of Japan), a feature recently discussed by Atkeson and Kehoe (2008).

3.2 Uniform Spacings Methodology

Compared to more traditional correlation analysis, the *Uniform Spacings* method developed by Ng (2006) allows us to summarize the overall statistical significance of co-movements of our panel of international interest rates at different maturities. This approach does not examine the sample correlations directly, but instead the probability integral transformation of the ordered correlations (i.e., $\bar{\phi}_j, \forall j = 1 \ldots n$). If the underlying correlations are equal to zero, then the *Uniform Spacings*, $\Delta\bar{\phi}_j = \bar{\phi}_j - \bar{\phi}_{j-1}$, should have particular statistical properties. It is these statistical properties that are tested. The Spacings Variance Ratio (*SVR*) test is used to partition the series of correlations into two subsamples of small and large correlations. We use a standardized *SVR* test, which is asymptotically normally distributed $\sqrt{\eta} SVR(\eta) \rightarrow \mathrm{N}(0, \omega_q^2)$, as follows:

$$svr(\eta) = \frac{\sqrt{\eta} SVR(\eta)}{\sqrt{\omega_q^2}} \tag{1}$$

[8] This behavior can probably be associated with differences in monetary policy stance. The Federal Reserve, for example, applied a particularly activist approach of monetary easing during the early years of the 2000s. The ECB, instead, was accused of greater intransigence in the face of a downturn in Euro Area activity. The UK pursued a middle ground of a stronger concern for monetary credibility and also short run adjustment of the business cycle.

Where η is a subset of $n=N(N-1)/2$ correlations for N time series. The proportion of correlations, which can be classified as Small is $\hat{\theta} \in [0,1]$. If the *svr* test statistic for the subgroup of pairings that have small correlations is significantly different from zero, then these pairings are significantly correlated even though they have relatively small correlations. Given that these correlations are quantitatively smaller than the large correlations, then the subsample Large must also be significantly different from zero. Table 2 presents the proportion of small correlations ($\hat{\theta}$) and the *svr* for both Small and Large subgroup correlations obtained applying Ng (2006). Further, the analysis was repeated over the full period and for two sub-periods, before and after 1999. The *svr* statistic indicates that the subgroup of Small correlations is insignificantly different from zero for all three time periods. The proportion $\hat{\theta}$ is the same for the full and earlier time period (10%) and only slightly larger for the later sample period (14%). Below, we look more carefully at which individual sample correlations change magnitude in the later period. For the moment, the overall evidence is of a large proportion of statistically significant large correlations of interest rates throughout the entire sample period (*svr* statistic for large correlations is greater than the 5% critical value).

<FIGURE 3 HERE>

The nature and degree of pervasiveness of correlation in the data can further be analyzed looking at the degree of correlations heterogeneity. This, according to Ng (2006), can be assessed graphing the transformed ordered correlations ($\bar{\phi}_j$) . Figure 3 provides the q-q plots for transformed ordered correlations over the full period and over two sub-periods, before and after 1999. Under the assumption of correlation homogeneity, the plot should be linear over the 45^o line. The greater the deviation from the 45^o line, the greater the correlation heterogeneity in the data. A strong degree of heterogeneity emerges for both the full sample and the two sub-samples. This result suggests that some interest rates are clearly more correlated than others in our data set.

The groups of Large and Small correlations for the full sample of interest rates are presented in Table A1 for the full sample period and Table A2 for the period post 1999 in Appendix A. A notable result from these sample correlations is the evidence of large international correlations at the long end of the maturity spectrum. Moreover, these correlations increase in the most recent period. For example, in the most recent period, the US long rate is highly correlated with the rates in Germany, New Zealand, UK, Sweden, Switzerland and Canada. The long rates of three European countries (i.e. Germany, Sweden and UK) are correlated above 0.8 for the recent period compared to less than 0.7 for the whole sample period. The German long rate is highly correlated with both the US long rate (0.808) and with the UK (0.873), for the later period.

In contrast, international correlations at the short end of the spread are generally lower and tend to decrease in the 2000s. The rates of New Zealand, Sweden and Japan, for example, are all insignificantly correlated since they are in the subgroup of Small *svr* correlations. The smaller short rate correlations corroborate the view that individual authorities' monetary policy is not associated at the short end of the maturity spectrum.[9]

<TABLE 3 HERE>

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[9] Breedon et al. (1999) suggest that short term interest rates may have a tendency to reflect monetary policy which is typically established domestically based on domestic inflation and output. Chinn and Frankel (2005) present evidence that UIP holds better at long horizons. Bekaert et al. (2007) suggest that this is sample specific. We emphasize that this is due to a greater correlation of long interest rates. Ang and Piazzesi (2003) suggest macro factors affect short run yields. Evans and Marshall (2007) suggest macro factors additionally impact long run yields once we account for interest rate smoothing (over 1959-2000).

Additionally, within country correlations exhibit smaller sizes than many long rates international correlations, and while the latter have increased in the most recent period, the former have decreased. This evidence is confirmed in Table 3, where correlations are reported between short and long run interest rates within countries for the full period and for the two sub-periods before and after 1999. The mean sample correlation of individual country short and long rates has fallen from 0.423 to 0.263 between the earlier and later sub periods. A t-test rejects the null of no change in the mean between the two sub-periods. Consequently there is clearly a decline in the linear association between short and long interest rates within countries.

To sum up, a number of interesting results emerge from the correlation analysis. First, international long rates correlations are higher than short rates correlations. Second, domestic term spread rates correlations are surprisingly low and lower than international long rates correlations. Third, while short term international correlations and within country term spread correlations have decreased over time, long rates international correlations have increased. Fourth, correlation is pervasive in the data, but the degree of pervasiveness is different across both the maturity spectrum and over time.

4. The Global Side of the Term Spread

The pervasive nature of correlation warrants further investigation on the international dimension of the term spread, especially at its longer end and for the more recent period. This issue can be further investigated by means of panel factor methods. In particular, we begin by testing the convergence properties of the interest rates series, using the *Panel Analysis of Non-Stationarity in Idiosyncratic and Common components* (PANIC) methodology due to Bai and Ng (2004) on the pairwise interest rate differentials, where evidence of stationarity can be taken as an indication of convergence.

The Bai and Ng (2004) PANIC methodology endeavors to model nonstationarity in a panel time series (y_{it}) by assessing to what extent nonstationarity is due to a common factor (F_t) and to a idiosyncratic error (ε_{it}). We define this relationship algebraically:

$$y_{it} = c_i + \lambda_i F_t + \varepsilon_{it} \quad (2)$$

Where c_i is a fixed effect and λ_i are factor loadings. The factor is obtained by first differencing the raw data, extracting the principal component from the differenced data and re-cumulating the principal component. Three information criteria can be used to differentiate between the correct number of factors (ICi, $\forall i = 1,2,3$), although Bai and Ng (2002) emphasize a Bayesian Information criteria when there is cross sectional dependency (i.e. IC3 in Table 4). Nonstationarity that is pervasive can be tested by examining whether the common factor is nonstationary. A Fisher type panel unit test is used to examine whether the idiosyncratic component ε_{it} is nonstationary.

<TABLE 4 HERE>

Results in Table 4 seem to confirm the disjoint behavior of the two components of the term spread. There seems to be greater evidence of convergence in the idiosyncratic component of long interest rates differentials, and smaller evidence of stationarity (and convergence) in the idiosyncratic of short rates differentials for the more recent period. For example, we reject the null hypothesis of unit root in long run interest differentials for the idiosyncratic component (test statistic = 5.901) for the most recent period. But we are unable to reject the unit root null (i.e. no convergence) for the idiosyncratic component in short term interest rates differentials for the most recent sample period (test statistic = -1.503). Hence, short rates seem to have become more representative of independent or country specific policies and long rates dominated more and more by an international dimension.

< TABLE 5 HERE>

Finally, we can investigate whether interest rates are indeed dominated by latent common factors. In Table 5, then, we present the results on the PANIC approach run on the short and long interest rates series. Interestingly, the two components of the term spread do seem to behave differently in terms of idiosyncratic and factor nonstationarity. When all interest rates series are pooled together (in rows 3 to 5 in Table 5), the tests indicate nonstationarity in the idiosyncratic for the recent period (test statistic 0.181). This, however, appears to be due to idiosyncratic nonstationarity in the short interest rate, since this is equal to -1.485. Greater evidence of stationarity is found for the idiosyncratic component in the long rates, which instead seem to be dominated by a common factor. Indeed, and most interestingly, IC3 suggests the existence of a common factor only for the long rates and only for the more recent period. Moreover, the share of long interest rates series variance explained by the common factors increases considerably in the recent period from around 45.2% to around 66.9%, suggesting that a single common factor does an excellent job at summarizing recent variation in the data. In contrast, the share of short rate variance explained by the first component goes down from 52.1% to 48.5%.

5. What lies at the global end of the term spread?

In the above analysis, we have gathered substantial evidence of an international dimension, or a “global side”, to the long end of the term spread. Indeed, international correlations in long rates are both higher than short rates correlations and, surprisingly, than within country correlations between short and long rates, or the term spread. Also, the first principal components explain a greater amount of the total variance of long term interest rates than short rates. This evidence is particularly strong during the most recent period, characterized by the puzzling behavior of long interest rates. Indeed, over the most recent period, long run interest rates seem to display convergence properties, and more importantly, seem to be driven by a common factor.

Our results further suggest a disjoint behavior of short and long rates, with the former becoming more dominated by country-specific forces and the latter by international factors. This phenomenon, clearly, indicates that the long rates international dimension is causing a substantial break in the domestic term structures and corroborates Bernanke’s statement that a global perspective should be taken on the recent puzzling behavior of long run interest rates. Along these lines, the natural step forward is, then, to relate some plausible explanations put forward in the literature for the low levels of long interest rates to the common factor identified for the long rates post 1999.

First, however, we can further substantiate the validity of the identified common factor. As discussed by Bai and Ng (2004), we can analyze whether any particular series dominates the factor using ratio of standard deviation, σ(.), of the differenced idiosyncratic component ($\Delta\varepsilon_{it}$) in equation (2) to the ratio of the standard deviation of differenced data (Δy_{it}). If the idiosyncratic component explains most of the variation in each series then $\sigma(\Delta\varepsilon_{it})/\sigma(\Delta y_{it})\rightarrow 1$. This ratio will be small if the common factor explains a substantial proportion of total variation in each series.

<TABLE 6 HERE>

The results presented in Table 6 show how all the series are associated with the first global factor in long run interest rates to a certain extent (apart from Japan). For Germany, New Zealand, Sweden, UK and US over three quarters of the variation in the individual series is explained by the first principal component. This share is smaller for Switzerland, Canada and Japan, but the majority of variation of these series is explained by the first principal component (more than 60% on average). The second component adds less than 15% to the total variation explained by the first principal component.

We take this as further evidence that the first component does a good job at summarizing the commonalities in long term interest rates across countries, especially for the US, Germany and the UK, and the results are not driven by one small and idiosyncratic country.

Then, following an approach similar to the one suggested by Gengenbach et al. (2006), we can apply Johansen (1988) Trace Test Statistic to examine the extent to which the derived nonstationary common factor cointegrates with alternative explanations for the low levels of long interest rates in the 2000s. Specifically, following the discussion in the literature in Section 2, we take under consideration measures of global inflation, global output, and global savings (see Appendix B for a description of these variables).[10] The first, CPI inflation in industrial countries, follows from the suggestion by Rogoff (2006), Borio and Filardo (2007) and Ciccarelli and Mojon (2008) of an international dimension of monetary policy and inflation. The second, industrial production in industrial countries, relates commonalities in the long end of the spread to measures of the international business cycle.[11] The third pursues the savings "glut" explanation of Bernanke (2005), supported by Wu (2006), Craine and Martin (2009) and Warnock and Warnock (2009) for the US only. In order to proxy for global savings we use World International Reserves.

<TABLE 7 HERE>

Firstly, in Table 7 we are unable to reject the null hypothesis of no relationship between CPI inflation in a sample of industrial countries and the first principal component of long run interest rates, since we are unable to reject the null hypothesis that the rank of the VAR is equal to zero according to Johansen (1988) Trace test statistic for our sample period. To the extent that global inflation is mapped by our measure of inflation, we do not think this is the most important determinant of the recent global trend in long term interest rates. To examine the importance of the international business cycle, we examine the relationship between industrial countries' Industrial Production and the first factor in long rates. We are not able to reject the null hypothesis of no cointegrating

[10] Evidence, available upon request, indicates that our four potential explicators are nonstationary.
[11] Indeed, Borio and Filardo (2007) suggest that global excess capacity is increasingly important for a country's domestic inflation. If individual countries interest rates respond in a common way to these shocks there should be a strong relationship between the common component of interest rates and global industrial production.

vector between average industrial production and the first principal component of long interest rates at the 5% significance level.

Finally, we consider the importance of global savings as a variable potentially related to the commonalities in long rates, finding strong evidence of a long run relationship between international reserves and the principal component of long interest rates. Indeed, this evidence survives at the 1% level of statistical significance. These results seem to provide empirical support for the argument from Bernanke (2005) that the global savings glut and the increase in holdings of international reserves by emerging markets may be behind the global factor in the long interest rates of industrial countries and may be a plausible explanation for the the domestic interest rates disconnect observed before the 2008 global financial crisis.

6. Conclusions

The low levels of long interest rates of industrial countries in spite of increasing short rates have been a distinctive feature of the period before the 2008 international crisis. According to Bernanke (2005), a global perspective should be adopted to explain such puzzling behavior. The unraveling of the crisis has not unwound the concerns of the possible failure in the monetary policy transmission mechanisms and has corroborated the view that greater international economic and financial integration and international factors may be responsible for such disconnect. For example, according to some commentators, global monetary policy and global inflation are responsible for the low levels of the long run interest rates. Others have considered this a consequence of increasing business cycle correlation. Yet others, along the line first drawn by Bernanke (2005), have linked low long term interest rates to the global saving glut.

In this paper, we adopt a global perspective to investigate the puzzling behavior of domestic interest rates. We analyze linkages between the short and long ends of the term spread both domestically and internationally for a set of industrial countries between 1988 and 2006. Using the *Uniform Spacings* method suggested by Ng (2006), we are able to obtain a measure of the overall degree of correlation in the data. We find a number of interesting facts. First, there is greater evidence of international correlation at the long end than at the short end of the term spread. Secondly, and surprisingly, long rates are more correlated internationally than domestically with their short rates. Finally, the post 2000 period has witnessed both a decrease in the domestic short to long correlation (the term spread failure) and an increase in the correlations at the long end of the spread. The PANIC method of Bai and Ng (2004) not only confirms the spacings correlations evidence, but further suggests that a (non-stationary) global factor dominates the long end of the spread, but not the short end. We take this as evidence in favor of the global approach to the interest rates conundrum, as suggested by Bernanke.

In the final step of our analysis, we try to discriminate among possible alternative explanations for the "global end" of the term spread. Using an approach similar to Gengenbach et al. (2006), we first extract the principal components in the panel of long term interest rates, and then test if it cointegrates with either measures of global inflation, global output, or global saving. Results allow us to conclude more favorably for the latter hypothesis, providing empirical support for Bernanke's interpretation.

Our work also adds to the rationalization of the *Greenspan Conundrum* from a global perspective highlighting that the domestic disconnect of interests rates is not only a feature of the US but of industrial countries in general. Global factors, and global saving in particular, seems the more likely explanation for the observed disconnect between the short and long ends of the term spread.

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Appendix A. Interest Rate Correlations

Table A1. Interest Rates Correlations: 1988*M*1-2006*M*7

Small Correlations Group			Group of Large Correlations		
Country 1	Country 2	$\hat{p}_j$	Country 1	Country 2	$\hat{p}_j$
Japan^{SR}	Sweden^{LR}	0.003	*Canada^{SR}*	*Canada^{LR}*	*0.340*
<u>Sweden^{SR}</u>	<u>US^{SR}</u>	<u>-0.015</u>	Germany^{SR}	Sweden^{LR}	0.342
Sweden^{SR}	Japan^{LR}	-0.016	Switzerland^{LR}	US^{LR}	0.357
<u>Japan^{SR}</u>	<u>Sweden^{SR}</u>	<u>-0.020</u>	**Sweden^{LR}**	**Switzerland^{LR}**	**0.361**
UK^{SR}	Canada^{LR}	0.026	*Switzerland^{SR}*	*Switzerland^{LR}*	*0.368*
UK^{SR}	US^{LR}	-0.026	**Sweden^{LR}**	**US^{LR}**	**0.372**
<u>New Zealand^{SR}</u>	<u>Sweden^{SR}</u>	<u>0.029</u>	<u>Switzerland^{SR}</u>	<u>UK^{SR}</u>	<u>0.380</u>
Canada^{SR}	Japan^{LR}	0.031	**Switzerland^{LR}**	**UK^{LR}**	**0.383**
Sweden^{SR}	Switzerland^{LR}	0.041	Germany^{SR}	Switzerland^{LR}	0.386
Sweden^{SR}	New Zealand^{LR}	0.071	*Sweden^{SR}*	*Sweden^{LR}*	*0.386*
<u>New Zealand^{SR}</u>	<u>Switzerland^{SR}</u>	<u>0.071</u>	<u>Canada^{SR}</u>	<u>Sweden^{SR}</u>	<u>0.409</u>
Sweden^{SR}	US^{LR}	-0.076	*US^{SR}*	*US^{LR}*	*0.411*
			New Zealand^{LR}	**Sweden^{LR}**	**0.411**
			UK^{SR}	*UK^{LR}*	*0.413*
			<u>Canada^{SR}</u>	<u>US^{SR}</u>	<u>0.420</u>
			Canada^{LR}	**Sweden^{LR}**	**0.428**
			Germany^{LR}	**New Zealand^{LR}**	**0.443**
			New Zealand^{LR}	**UK^{LR}**	**0.447**
			New Zealand^{SR}	*New Zealand^{LR}*	*0.474*
			Canada^{LR}	**Germany^{LR}**	**0.479**
			Canada^{LR}	**UK^{LR}**	**0.489**
			Germany^{SR}	*Germany^{LR}*	*0.497*
			UK^{LR}	**US^{LR}**	**0.508**
			New Zealand^{LR}	**US^{LR}**	**0.516**
			Germany^{LR}	**Switzerland^{LR}**	**0.529**
			Canada^{LR}	**US^{LR}**	**0.544**
			Sweden^{LR}	**UK^{LR}**	**0.576**
			Germany^{LR}	**Sweden^{LR}**	**0.599**
			Germany^{LR}	**US^{LR}**	**0.656**
			Germany^{LR}	**UK^{LR}**	**0.678**

Notes: For presentation purposes, in the Large correlations group we have chosen the cut-off point of $\hat{p}_j$=0.34, where $\hat{p}_j$ are the sample correlations. Domestic term spread correlations are in italics, Long rates correlations are in bold, and Short rates correlations are underlined.

Table A2. Interest Rates Correlations: 1999*M*1-2006*M*7

Group of Small Correlations			Group of Large Correlations		
Country 1	Country 2	$\hat{p}_j$	Country 1	Country 2	$\hat{p}_j$
Switzerland^{SR}	Sweden^{LR}	0.023	<u>UK^{SR}</u>	<u>US^{SR}</u>	<u>0.467</u>
Canada^{SR}	*Canada^{LR}*	*0.030*	Germany^{SR}	UK^{LR}	0.474
New Zealand^{SR}	Japan^{LR}	0.037	Germany^{SR}	Canada^{LR}	0.480
New Zealand^{SR}	Sweden^{LR}	0.040	**Canada^{LR}**	**Sweden^{LR}**	**0.481**
Canada^{SR}	Japan^{LR}	0.043	**Canada^{LR}**	**US^{LR}**	**0.486**
US^{SR}	Sweden^{LR}	0.043	**Sweden^{LR}**	**Switzerland^{LR}**	**0.495**
Japan^{SR}	Canada^{LR}	-0.046	Germany^{SR}	Sweden^{LR}	0.497
Japan^{SR}	*Japan^{LR}*	*0.048*	**New Zealand^{LR}**	**Switzerland^{LR}**	**0.498**
Switzerland^{SR}	Canada^{LR}	0.050	**Canada^{LR}**	**Germany^{LR}**	**0.503**
US^{SR}	UK^{LR}	0.051	**Canada^{LR}**	**UK^{LR}**	**0.503**
US^{SR}	Canada^{LR}	-0.071	**Switzerland^{LR}**	**US^{LR}**	**0.532**
Japan^{SR}	New Zealand^{LR}	-0.071	<u>Canada^{SR}</u>	<u>New Zealand^{SR}</u>	<u>0.539</u>
<u>Japan^{SR}</u>	<u>Sweden^{SR}</u>	<u>0.076</u>	Germany^{SR}	New Zealand^{LR}	0.544
UK^{SR}	Japan^{LR}	0.077	Germany^{SR}	US^{LR}	0.559
<u>Japan^{SR}</u>	<u>New Zealand^{SR}</u>	<u>0.081</u>	<u>New Zealand^{SR}</u>	<u>US^{SR}</u>	<u>0.566</u>
New Zealand^{SR}	UK^{LR}	0.087	**Canada^{LR}**	**Switzerland^{LR}**	**0.585**
UK^{SR}	Canada^{LR}	0.091	**Germany^{LR}**	**Switzerland^{LR}**	**0.586**
			Germany^{SR}	*Germany^{LR}*	*0.591*
			Germany^{LR}	**Switzerland^{LR}**	**0.595**
			<u>Canada^{SR}</u>	<u>US^{SR}</u>	<u>0.661</u>
			Sweden^{LR}	**US^{LR}**	**0.707**
			UK^{LR}	**US^{LR}**	**0.712**
			New Zealand^{LR}	**Sweden^{LR}**	**0.739**
			New Zealand^{LR}	**UK^{LR}**	**0.759**
			New Zealand^{LR}	**US^{LR}**	**0.765**
			Germany^{LR}	**US^{LR}**	**0.808**
			Germany^{LR}	**New Zealand^{LR}**	**0.812**
			Sweden^{LR}	**UK^{LR}**	**0.863**
			Germany^{LR}	**UK^{LR}**	**0.873**
			Germany^{LR}	**Sweden^{LR}**	**0.938**

Notes: For presentation purposes, in the Large correlations group we have chosen the cut-off point of $\hat{p}_j$=0.467 (the top thirty correlations), where $\hat{p}_j$ are the sample correlations. Domestic term spread correlations are in italics, Long rates correlations are in bold, and Short rates correlations are underlined.

Appendix B. Data Definitions and Sources

A. Short Term Interest Rates: Three Month Treasury Bill Rates (1988*M*1-2006*M*7) from IMF *International Financial Statistics* (line 60C..ZF). We have monthly data for Canada, Germany, Japan, New Zealand, Sweden, Switzerland, UK and US.

B. Long Term Interest Rates: Long-term government bond yields (1988*M*1-2006*M*7) from IMF *International Financial Statistics* (line 61…ZF). We use monthly data for Canada, Germany, Japan, New Zealand, Sweden, Switzerland, UK and US.

C. Inflation: Consumer Price Inflation, all items, annual change in inflation. *OECD Main Economic Indicator*. We use an average of Canada, Germany, Japan, Sweden, Switzerland, UK and US monthly data. New Zealand was not available at a monthly frequency.

D. Industrial Production: Industrial countries' industrial production monthly index from IMF *International Financial Statistics* (line 11066..IZF).

E. International Reserves: World total reserves minus Gold (Units: SDRs) (Scale: Millions) (line .1L.SZF), monthly index from IMF *International Financial Statistics*.

Table 1. Summary Statistics for Short and Long Interest Rates

	SHORT RATES		*LONG RATES*	
	Mean	Standard Deviation	Mean	Standard Deviation
Canada	5.694	3.116	7.212	2.054
Germany	4.405	2.100	5.814	1.581
Japan	1.381	1.752	2.915	1.931
New Zealand	7.944	3.077	7.892	2.510
Sweden	6.536	3.916	7.529	3.025
Switzerland	3.177	2.663	4.058	1.332
UK	6.851	3.123	7.117	2.318
US	4.448	1.968	6.192	1.537

Table 2. Spacing Variance Ratio Test Statistics

	$\hat{\theta}$	**Small Correlations**	**Small *svr***	**Large *svr***
1988-2006 (T = 223)	0.100	12 out of 120	0.502	4.834*
1988-1998 (T = 133)	0.100	12 out of 120	0.231	4.634*
1999-2006 (T = 90)	0.142	17 out of 120	-0.410	4.830*

Notes: $\hat{\theta}$ is the proportion of correlations that are small. The standardized Spacings Variance Ratio (*svr*) test statistic and indicates whether correlation is significantly different from zero for a subgroup of correlations. *svr* is distributed as standard normal, therefore the critical value is 1.65 (significant at 5% marked with asterisk). We account for potential serial correlation in the time series by using an AR(1) specification, following Ng (2006). N = 16, therefore there are $n=N(N-1)/2$ = 120 potential correlations.

Table 3. Short and Long Interest Rate Correlations

Interest Rates		1988-2006	1988-1998	1999-2006
US^{LR}	US^{SR}	0.411	0.531	0.231
$Canada^{LR}$	$Canada^{SR}$	0.340	0.383	0.030
$Japan^{LR}$	$Japan^{SR}$	0.213	0.237	0.048
$Germany^{LR}$	$Germany^{SR}$	0.497	0.444	0.591
New $Zealand^{LR}$	New $Zealand^{SR}$	0.474	0.514	0.373
UK^{LR}	UK^{SR}	0.413	0.432	0.391
$Sweden^{LR}$	$Sweden^{SR}$	0.386	0.410	0.273
$Switzerland^{LR}$	$Switzerland^{SR}$	0.368	0.431	0.169
Mean		0.388	0.423	0.263
Standard Deviation		0.09	0.09	0.19
t-test Null of No Change in Mean		(1)	p-value = 0.024*	
		(2)	p-value = 0.028*	

Notes: t-test tests the difference in mean of correlation between long and short interest rates. Test (1) assumes equal variance, test (2) considers different variance. P-values examine whether there is a difference in the average correlation for short and long rates over our two sample periods. Asterisk (*) indicates rejection of the null of no change between the two periods at the 5% level. Superscript SR is short rate while superscript LR is long rate.

Table 4. PANIC Evidence on Interest Rate Pairwise Differences

Long and Short Rates					
Sample	Factor	Idiosyncratic	IC1	IC2	IC3
1988-2006	-1.220, -3.251*, -2.498, -3.124*, -2.459 [0.393,0.136,0.104,0.093,0.050]	4.298*	5	5	5
1988-1998	-1.276, -2.543, -1.947, -2.002, -1.826 [0.432,0.137,0.108,0.077,0.049]	2.315*	5	5	5
1999-2006	-1.832, -1.153, -1.295, -1.487, -2.073 [0.326,0.144,0.096, 0.083,0.059]	2.564*	5	5	5
Long Rates					
Sample	Factor	Idiosyncratic	IC1	IC2	IC3
1988-2006	-3.218*, -1.113, -2.798, -2.427, -1.514 [0.270,0.212,0.170,0.136,0.100]	8.288*	5	5	5
1988-1998	-2.292, -1.528, -2.728, -1.698, -0.940 [0.266,0.229,0.172,0.136,0.103]	5.875*	5	5	5
1999-2006	-2.168, -0.380, -0.792, -2.765, -1.913 [0.418,0.189,0.155,0.108,0.075]	5.901*	5	5	5
Short Rates					
Sample	Factor	Idiosyncratic	IC1	IC2	IC3
1988-2006	-1.041, -3.289*, -2.602, -1.703, -3.023* [0.498,0.176,0.138,0.073,0.053]	6.522*	5	5	5
1988-1998	-1.159, -2.538, -2.023, -0.839, -2.347 [0.526,0.172,0.137,0.067,0.052]	1.510	5	5	5
1999-2006	-1.141, -1.693, -1.383, -2.873, -1.037 [0.251,0.198,0.177,0.135,0.093]	-1.503	5	5	5

Notes: this table examines the stationarity of interest rate differentials using Bai and Ng (2004) PANIC. This applies unit root tests to the factors and panel unit root tests to the idiosyncratic component. Panel data set is 1988*M*1 to 2006*M*6 (*N*=120/28, *T*=223/133/90). IC1, IC2 and IC3 are the number of factor recommended by Bai and Ng (2002) information criteria. Asterisks (*) indicates rejection of the null of unit root at the 5% significance level. Large negative tests statistics reject the unit root null hypothesis for the common factor (less than -2.89). Large positive test statistics reject a unit root null for the idiosyncratic component (greater than 1.64). Eigenvalues in square brackets [.].

Table 5. PANIC Evidence on Interest Rate Levels

Long and Short Rates					
Sample	Factor	Idiosyncratic	IC1	IC2	IC3
1988-2006	-1.258, -1.730, -1.422, -1.659, -3.058* [0.371,0.182,0.093,0.081,0.072]	5.124*	5	5	0
1988-1998	-0.633, -0.917, -1.424, -0.731, -1.844 [0.409,0.170,0.093,0.085,0.060]	5.597*	5	5	0
1999-2006	-1.455, -1.651, -0.749, -1.474, -2.060 [0.418,0.188,0.080,0.056,0.040]	0.181	4	3	1
Long Rates					
Sample	Factor	Idiosyncratic	IC1	IC2	IC3
1988-2006	-1.193,-1.961,-1.958,-1.728,-3.693* [0.488,0.134,0.110,0.088,0.068]	5.994*	5	5	0
1988-1998	-0.098, -2.285, -2.104, -1.524, -3.009* [0.452,0.150,0.127,0.094,0.071]	4.895*	5	5	0
1999-2006	-1.655, -1.350, -0.901, -1.166, -3.087 [0.669,0.107,0.070,0.060,0.043]	3.751*	5	5	1
Short Rates					
Sample	Factor	Idiosyncratic	IC1	IC2	IC3
1988-2006	-1.193, -2.181, -1.977, -1.352, -2.637 [0.489,0.182,0.112,0.100,0.049]	2.513*	5	5	0
1988-1998	-0.681, -1.429, -1.657, -0.801, -1.970 [0.521,0.169,0.109,0.100,0.048]	1.473	5	5	0
1999-2006	-1.503, -0.916, -1.706, -2.737, -1.576 [0.485,0.146,0.107,0.082,0.058]	-1.485	5	5	0

Notes this table examines the stationarity of interest rate levels using Bai and Ng (2004) PANIC. This applies unit root tests to the factors and panel unit root tests to the idiosyncratic component. Panel data set is 1988*M*1 to 2006*M*6 for 8 or 16 interest rates (N=16/8, T=223/133/90). IC1, IC2 and IC3 are the number of factors recommended by Bai and Ng (2002) information criteria. Asterisk (*) indicates rejection of the null of unit root at the 5% significance level. Large negative tests statistics reject the unit root null hypothesis for the common factor (less than -2.89). Large positive test statistics reject a unit root null for the idiosyncratic component (greater than 1.64). Eigenvalues in square brackets [.].

Table 6. Common Factor Importance for Individual Long Rates

Number of Factors	**1**	**2**	**3**	**4**	**5**
Countries					
Canada	0.612	0.259	0.053	0.053	0.025
Germany	0.093	0.081	0.081	0.055	0.053
Japan	0.961	0.652	0.152	0.110	0.003
New Zealand	0.226	0.187	0.161	0.155	0.134
Sweden	0.184	0.162	0.162	0.047	0.046
Switzerland	0.577	0.289	0.278	0.276	0.027
UK	0.199	0.170	0.153	0.103	0.096
US	0.197	0.192	0.188	0.034	0.016
Mean	0.381	0.249	0.154	0.104	0.050

Notes: this table examines the degree to which the first to the fifth factor from Bai and Ng (2004) explains the degree of variation in each of the countries long term interest rates between 1999*M*2 to 2006*M*7. This is the ratio of the standard deviation of the idiosyncratic component to the standard deviation of the original series (i.e. $\sigma(\Delta\varepsilon_{it})/\sigma(\Delta y_{it})$). This ratio tends to one when the common factor explains little of total variation in individual series.

Table 7. Common Determinants of Long Run Interest Rates

Industrial Countries' CPI Inflation		
Ho: r =0	17.52 [0.12]	Lag length = 7
Ho: r =1	1.68 [0.83]	
Industrial Countries' Industrial Production		
Ho: r =0	19.57 [0.06]	Lag length = 12
Ho: r =1	5.31 [0.26]	
World International Reserves		
Ho: r =0	57.68 [0.00]*	Lag length = 2
Ho: r =1	7.96 [0.09]	

Notes: This table contains results for cointegration between factors between 1999*M*1 to 2006*M*6 (N=8, T=90). Asterisk (*) denote rejection of the null of no cointegration at the 5% significance levels. P-values in square brackets [.]. The number of cointegrating vectors in the Johansen (1988) Trace Test is denoted by r. Lag length is determined by the Akaike Information Criteria.

Figure 1. Short Run Interest Rates

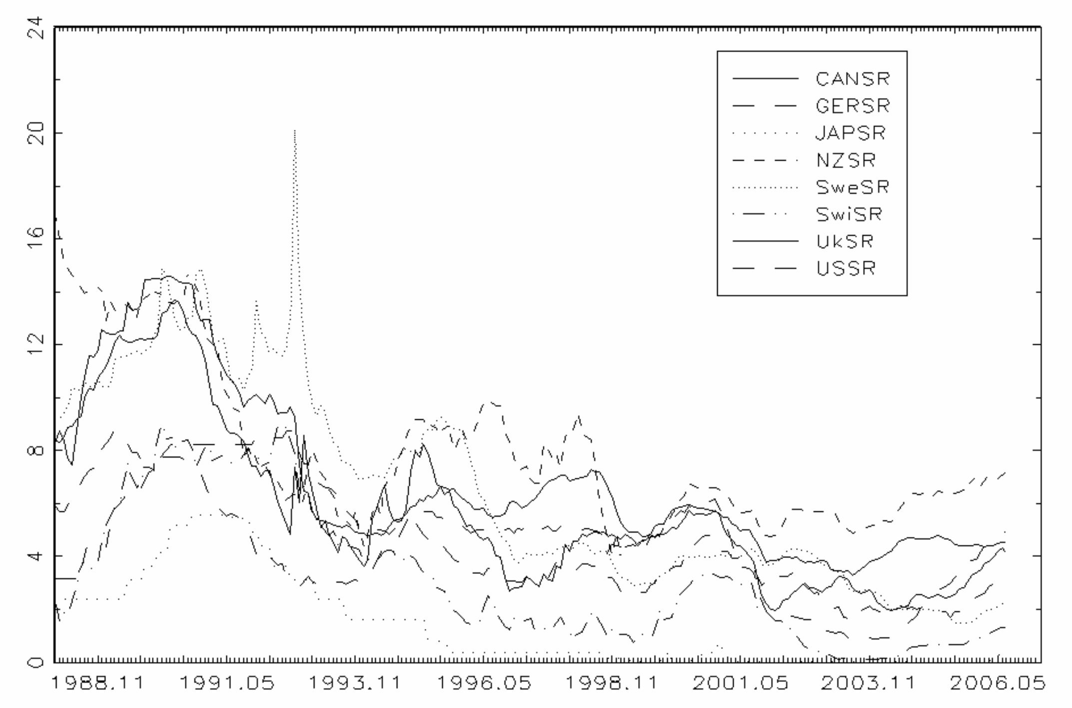

Figure 2. Long Run Interest Rates

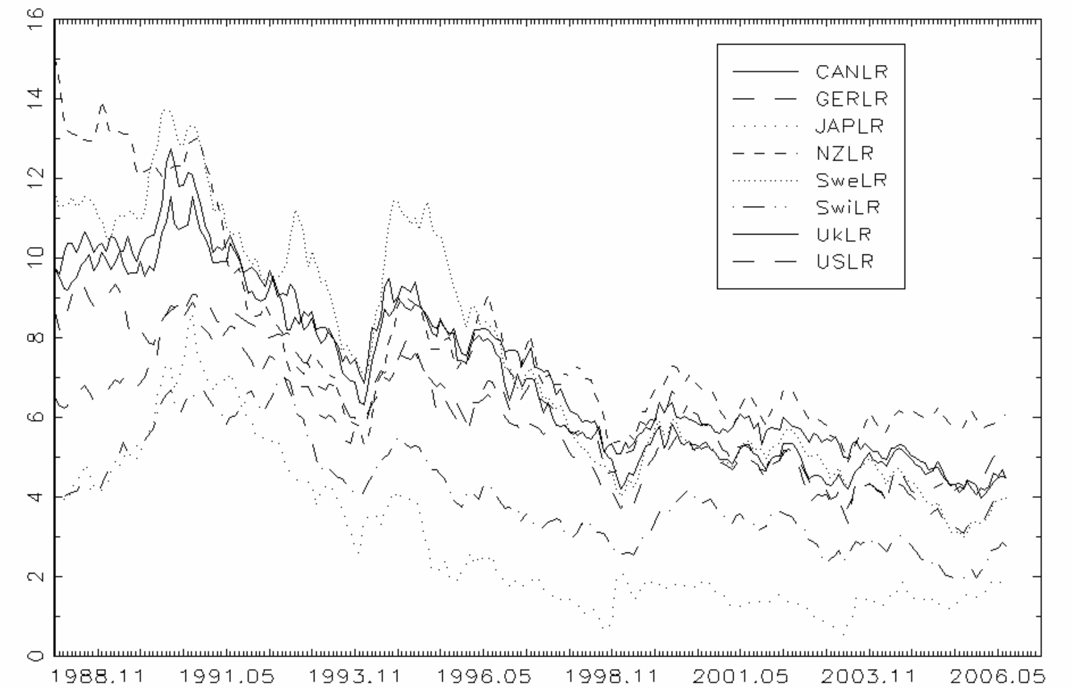

Figure 3. Plot of Transformed Ordered Correlations ($\bar{\phi}_j$)