Available online at www.sciencedirect.com
SCIENCE DIRECT
Journal of International Money and Finance
23 (2004) 71–97
Journal of International Money and Finance
www.elsevier.com/locate/econbase

Expected returns, risk and the integration of international bond markets

David G. Barr[a], Richard Priestley[b,*]

[a] The Management School, Imperial College, London SW7 2PG, UK
[b] Department of Financial Economics, Norwegian School of Management, Elias Smith vei 15, N-1301 Sandvika, Norway

Abstract

In this paper we model expected risks and returns on government bonds, allowing for partial integration of national and world bond markets. Using a conditional asset pricing model that permits variation in the price of, and exposure to, risk, we find strong evidence that national markets are only partially integrated into world markets. Around one quarter of total expected excess returns is related to local market risk; the remainder being due to world bond market risk. A range of parameter stability tests rejects the hypothesis of time-variation in the level of integration.

JEL classification: G12; G15

Keywords: Partial integration; Expected returns; Conditional asset pricing; Bond markets

1. Introduction

It is generally accepted that returns on tradable assets are predictable, and that a significant source of this predictability is the time-varying compensation that investors require for accepting a risky payoff. A related issue for assets that are traded internationally is the extent to which this compensation is driven by world, rather than domestic, factors i.e. the extent to which the domestic market is integrated into world markets. Several papers have investigated this issue, most of which focus on equity markets. In this paper we ask what can be learned from bond markets.

* Corresponding author. Tel.: +47-67-55-71-04; fax: +47-67-55-76-75.
E-mail address: richard.priestley@bi.no (R. Priestley).

0261-5606/$ - see front matter
doi:10.1016/j.jimonfin.2003.10.005

Econometric models describing this predictability typically fall into either or both of two groups. The first employs "information variables" which, since they are jointly determined with asset prices, contain information about expected returns. The second uses explicit asset pricing models (APMs) to relate expected returns to measures of investor preferences, factor risks and asset specific factor loadings, or betas. Various instruments are used to capture changes in risk aversion, and to proxy the factors (Ferson and Harvey, 1991; Harvey et al., 1994), while ARCH processes are commonly used to model changes in asset betas (see Bollerslev et al., 1988). The challenge for the asset pricing models is to account for the predictability that is evident from the information-variable models.

One way forward is to assume that markets are fully integrated, and to test the restrictions generated by APMs: a rejection being interpreted as a rejection of the joint hypothesis of full integration and the APM (Dumas and Solnik, 1995). This integration assumption reflects a fundamental difficulty in international asset pricing however: while the information-variable approach embraces the possibility of partial integration without difficulty, current APMs can accommodate only the two extremes of integration or segmentation, and both of these will be rejected if markets are only partially integrated. Some combination of the polar models is required in order to deal with partially integrated markets. Errunza and Losq (1985), and Errunza et al. (1992) divide the available assets into those that are traded internationally, and those that trade only domestically. More-recent work, such as Bekaert and Harvey (1995, 1997) combines the polar models, and allows the level of integration to change over time.

Although most international-market studies have focused on equities, bonds do appear in several investigations, but rarely as the main focus. Exceptions are Ilmanen (1995, 1996), who finds evidence of predictability that is just as compelling as that for equity markets, Harvey et al. (1994), who find that the factors driving bond returns are the same as those driving equity returns, and Jorion (1992)[1]. Bollerslev et al. (1988) find a significant role for government bonds and bills, alongside equities, in a 3-asset conditional CAPM for the US, and Giovannini and Jorion (1989) include bonds in the world market portfolio.

There are many possible impediments to complete integration (see Jorion, 1992 for a wide-ranging discussion). These include legal restrictions, imperfect information, asymmetric treatment of withholding taxes and associated credits (Solnik, 2000), home bias, where investors fail to optimse over a worldwide portfolio even in the absence of institutional impediments to capital flows (Stulz, 1999) and local market conventions. For example, the timing of UK auctions of government stock was set on an ad-hoc basis during our sample; an arrangement that was designed to minimise funding costs, but which also reduced price volatility and risk. In Japan, the market for medium-term bonds tends to be less liquid than in other

[1] Jorion (1992) is actually a study of eurocurrency markets but we view these as being similar to short-maturity bonds.

countries as domestic investors tend to buy-and-hold, rather than trade actively (see Fabozzi, 1996).

It seems reasonable to expect bond markets to be more closely integrated than equity markets, largely because differences between bonds in different countries are small. Nevertheless there are reasons to believe that they might not be fully integrated. Home bias, for example, may influence bond investors, as the information requirements associated with local monetary and fiscal policies, expected inflation, and the behaviour of local investors may lead overseas investors to stay home. Similarly, institutions with liabilities denominated in domestic currency may prefer to hedge these with domestic bonds. One aspect of segregation is immediately apparent: the biggest players in the market, the issuers themselves, only rarely issue debt in foreign currency. This reflects both international protocol and the fact that the issuers' liabilities, and tax flows, are predominantly denominated in domestic currency.

The economic costs and benefits of bond-market integration are likely to be significant. In particular, the ability and willingness of investors to diversify internationally should lead to a reduction in the cost of fiscal deficit funding worldwide, just as equity market diversification may reduce the world cost of capital (Stulz, 1999).

In this paper we use a version of Bekaert and Harvey's (1995) CAPM-based model to investigate the level of integration in five of the major world bond markets. We allow for time-varying prices of risk, time-varying exposure to risk, and test for variation in the level of integration itself.

The rest of the paper is organized as follows. Section 2 presents the asset pricing equations and the econometric methods used to estimate them. Section 3 discusses the data and its sources, while Section 4 presents our central, and preferred, results. The robustness of these results is tested against alternative versions of the model in Section 5. The final section concludes and suggests avenues for further research.

2. Methodology

2.1. Prediction equations

We assume that excess returns (r) for country i are linearly related to world and local information variables as follows:

$$r_{i,t} = a_i + b_i^{\mathrm{W}} Z_{t-1}^{\mathrm{W}} + b_i^{\mathrm{L}} Z_{i,t-1}^{\mathrm{L}} + \varepsilon_{i,t} \quad (1)$$

where Z^{W} represents world variables, Z_i^{L} represents local variables for country i, and $\varepsilon_{i,t}$ is an error term.

This equation is consistent with a wide range of asset pricing models, and with any level of integration. If a market is fully integrated the local variables should be absent from Eq. (1). Similarly, if it is completely segmented, the world variables should be absent.

Our strategy is to place APM-based structures on the prediction relationships, and to check their admissibility by testing for orthogonality between the regressors and residuals of the restricted equations (see Bekaert and Harvey, 1995; Ilmanen, 1995).

2.2. The asset pricing model

Many asset pricing theories can account for the presence of explanatory variables in markets that are fully integrated; all single-market CAPM, ICAPM and APT models fall loosely into this category. A number of papers have developed APMs to explain the presence of both world and local variables in Eq. (1). In this paper we adopt the CAPM-based model of Bekaert and Harvey (1995) and assume that returns in country i are generated by the following version of the conditional international CAPM:

$$r_{i,t} = (\theta_i \lambda_{b,t-1} \mathrm{cov}_{t-1}(r_{b,t}, r_{i,t})) + ((1-\theta_i)\lambda_{i,t-1} \mathrm{var}_{t-1}(r_{i,t})) + e_{i,t} \tag{2}$$

where θ_i is interpreted as a measure of the degree of integration. We assume initially that θ_i is constant over time, and test this restriction subsequently. We do not constrain the level of integration to lie in the interval [0,1][2].

The return on the world portfolio is modeled similarly as:

$$r_{b,t} = \lambda_{b,t-1} \mathrm{var}(r_{b,t}) + e_{b,t} \tag{3}$$

$\mathbf{e}_t = [e_{i,t},\ e_{b,t}] | \mathbf{X}_{t-1} \sim N(0, \mathbf{H}_t)$ is the vector of error terms and $\mathbf{H}_t$ is the conditional variance–covariance matrix of excess returns. When markets are completely integrated the coefficient θ takes the value 1, and the variance term in Eq. (2) is reduced to zero. We limit the evolution of the conditional second moments of excess returns to a GARCH(1,1) process (see Baba et al., 1989) i.e.

$$\mathbf{H}_t = \mathbf{C}'\mathbf{C} + \mathbf{A}'\xi_{t-1}\xi'_{t-1}\mathbf{A} + \mathbf{B}'\mathbf{H}_{t-1}\mathbf{B} \tag{4}$$

where $\mathbf{C}$ is a $(N \times N)$ symmetric matrix and $\mathbf{A}$ and $\mathbf{B}$ are $(N \times N)$ matrices of constant coefficients, and place restrictions on $\mathbf{H}_t$ in order to ease computations. Following Bollerslev et al. (1988) and De Santis and Gerard (1997, 1998) (among others), we assume (i) that the variances depend only on lagged squared errors and lagged conditional variances, and (ii) that the covariances depend only upon cross-products of lagged errors and lagged conditional covariances. That is, we restrict the matrices $\mathbf{A}$ and $\mathbf{B}$ to be diagonal.[3]

The final step is to specify a process for the evolution of the prices of risk. Many papers report that this can be captured by a set of information variables (see, for example, Campbell, 1987; Harvey, 1991; Ferson and Harvey, 1993; Bekaert and

[2] With 3 minor exceptions; see Table 7b.

[3] De Santis and Gerard (1997) find strong support for this restriction.

Harvey, 1995; De Santis and Gerard, 1997, 1998). Consequently, we let:

$$\lambda_{b,t-1} = \exp(\kappa_{\mathrm{W}}' \mathbf{Z}_{t-1}^{\mathrm{W}}) \tag{5}$$

$$\lambda_{i,t-1} = \exp(\delta_i' \mathbf{Z}_{i,t-1}^{\mathrm{L}}) \tag{6}$$

The functional form of $\lambda_{b,t-1}$ and $\lambda_{i,t-1}$ ensures that the prices of risk $\lambda_{b,t-1}$ and $\lambda_{i,t-1}$ are positive (see Merton, 1980). Asset pricing theory provides no guide as to what the instruments in these equations should be: we chose to use the variables that appear in the prediction equations.

3. Data

3.1. Bond returns

Our sample consists of data from the US, UK, Japan, Germany and Canada. We use J.P. Morgan Government Bond Return Indices, which are based on weighted portfolios of liquid bonds. For the world bond market, we use Salomon Brothers World Weighted Index. Excess returns are calculated relative to the appropriate 1-month Euro-deposit rate quoted in London.[4] Our central results are based on returns measured in domestic-currency units, which we interpret as arising from currency-hedged investments, but we also review the predictability of common-currency returns.

Panel A of Table 1 reports summary statistics for local-currency excess returns over the period January 1986 to June 1996. The mean excess return, in percent per month, ranges from 0.08% in Germany, to 0.22% for the world portfolio. With the exception of the UK and Germany, the means and standard deviations are very similar; the average mean excess return is around 0.15% per month with a standard deviation around 1.5%. In contrast, the UK has a standard deviation of over 2% and a mean excess return of 0.13%. A similar picture emerges for Germany which, while having a lower mean excess return, has a relatively high standard deviation. The world bond market dominates all of the local markets in terms of the level of return given the level of risk[5]. Unlike the stylized results for stock returns, the excess bond returns appear to be normally distributed.

These patterns in the excess returns are reflected in both the autocorrelation coefficients and the correlations across countries. The highest cross-country correlation is between Canada and the US, which have similar summary statistics, and show no evidence of first order autocorrelation. The UK and Germany, which were linked more or less formally by the European Exchange Rate Mechanism in our sample period, have the second highest inter-country correlation, and both

[4] Euro-deposit rates are used as a proxy for the risk free rate due to the lack of a liquid Treasury bill market in some of the countries. Ilmanen (1995) reports that this choice makes little difference to his results. The excess return on the world index is calculated with reference to the rate on $US deposits.

[5] The variation in the return-variance ratios may be due to different average maturities in the various bond portfolios.

Table 1
Summary statistics

	World	US	UK	Japan	Germany	Canada
Panel A: excess bond returns (per cent per month)						
Mean	0.2187	0.2016	0.1320	0.1966	0.0761	0.2111
S.D.	1.1533	1.3843	2.1479	1.4820	1.1403	1.8709
Max	3.4003	3.7075	6.3541	4.2444	2.1590	5.4063
Min	−2.4769	−2.9944	−7.3622	−4.2418	−3.9375	−4.9432
ρ_1	0.2122***	0.1345	0.1828***	0.1632**	0.1684***	0.0700
Normality	0.6322	0.1430	2.033	2.205	5.257	0.5200
	(0.73)	(0.93)	(0.36)	(0.33)	(0.07)	(0.77)
Correlation matrix						
World	1.0000					
US	0.8905	1.0000				
UK	0.6883	0.4419	1.0000			
Japan	0.6501	0.3842	0.4125	1.0000		
Germany	0.7083	0.4801	0.6325	0.4992	1.0000	
Canada	0.7541	0.7415	0.5260	0.3884	0.4487	1.0000

	WB	WS	WBSP	WGEYR
Panel B: world instruments				
Mean	0.2187	0.6397	0.0962	0.4354
S.D.	1.1533	4.1912	0.1173	0.0687
Max	3.4003	17.9130	0.3231	0.6058
Min	−2.4769	−16.6709	−0.1511	0.3061
ρ_1	0.2122***	0.0231	0.9580***	0.9866**
Normality	0.6322	23.75	3.0490	4.541
	(0.73)	(0.00)	(0.22)	(0.10)
Correlation matrix				
WB	1.0000			
WS	0.3129	1.0000		
WBSP	0.0194	−0.0100	1.0000	
WGEYR	−0.2241	−0.1448	−0.4780	1.0000

Notes: The sample is 1986:01 to 1996:06, monthly. Excess returns are end-month bond returns in local currency net of the start-of-month, 1 month euro-deposit rate. Bond returns for individual countries are from J.P. Morgan bond return indices. The return for the world bond index is from Salomon Brothers. WB is the world excess bond return, WS is the excess return on the world stock market, WBSP is the spread between the yield on long term world bonds and the 1 month US euro dollar rate, WGEYR is the spread between the world stock market dividend yield and the world long term bond market yield. ρ_1 is the first order autocorrelation coefficient. Normality (distributed $\chi^2(2)$) is the Bera-Jarque test for normality of the variable, probability values in parentheses. ** indicates statistical significance at 5%, and * at 10%. The evident non-normality of WS is due largely to excess kurtosis. Summary statistics for the local instruments are similar to those of the global instruments. Corresponding tables for the local instruments are available on request. *** indicates statistically significant at the 1% level.

exhibit evidence of significant first order autocorrelation. All the local excess returns are fairly highly correlated with the world excess return, the cross sectional average correlation is 0.74, providing weak evidence of integration. The US–world return correlation is the largest in the sample, reflecting the relatively large proportion US bonds in the world portfolio.

3.2. Information variables

We use the set of information variables that has become common-place in studies of both equities and bonds.[6] Fama and French (1988) and Keim and Stambaugh (1986), for example, document the presence of common predictability in both US stock and bond markets. This suggests that instruments found to be useful in predicting stock market returns may also be useful in predicting bond market returns (see Ilmanen, 1995).

The local instruments for our study are: the spread between long-bond yields and stock dividend yields; stock market excess returns; the spread between long yields and short rates; lagged bond returns, and a constant. The world instruments are constructed analogously.[7]

Summary statistics for the world instruments are presented in panel B of Table 1. As would be expected given the difference in standard deviations, the stock market excess return exceeds that of the bond market. The yield spread between the long bond and the short rate is positive on average, as is the equity-bond yield spread.

4. Empirical results

We first establish that the information variables contain information about returns. We then incorporate these variables in a variety of APMs. We start with our preferred model, which allows for time variation in both the price of risk, and in the domestic markets' exposures to risk, and then present a number of alternatives, first restricting the prices of risk to be constant, then imposing complete integration of all markets. Finally, we examine the effects of adding stocks to the world portfolio.

4.1. Predictability of returns

We investigate the extent and sources of predictability in local bond markets by estimating Eq. (1) and testing the separate hypotheses that the coefficients associated with the local and world variables are zero, then the hypothesis that the coefficients are jointly zero. The results are reported in Table 2.

The R^2s range from 10% in the US to 20% in Germany, indicating a considerable degree of predictability. For all countries we reject the null hypothesis that

[6] So we have to confess to data snooping. Our defence is that our stability tests do not reject these relationships, the chosen variables appear to work well in all of the countries in our sample, and that this set has become so well snooped that results based on it are of conditional interest regardless of the associated risk of bias.

[7] Bond yields for stock-bond spreads are based on the J.P. Morgan bond indices we use to calculate excess returns. The yield curve spread is based on a representative long bond. Stock market returns and dividend yields are based on Datastream total market indices. All data are collected from Datastream International.

Table 2
Local currency returns. Predicting local excess-returns using local and world instruments

	US	UK	Japan	Germany	Canada
World and local instruments					
R^2	10.15	16.42	15.63	19.72	18.43
Supremum LR	24.44	24.91	15.36	17.50	22.4
Exp-av LR	9.24	9.99	5.37	4.99	8.75
F-test exclude local	1.575	3.411	1.827	2.754	4.227
	(0.17)	(0.01)	(0.12)	(0.02)	(0.00)
F-test exclude world	1.097	3.591	2.225	2.824	4.709
	(0.36)	(0.01)	(0.05)	(0.03)	(0.00)
F-test exclude both	1.814	2.589	2.527	3.246	3.136
	(0.07)	(0.01)	(0.01)	(0.00)	(0.00)
Local instruments only					
R^2	7.15	14.06	10.74	10.37	6.78
Supremum LR	7.17	7.93	11.56	7.84	10.36
Exp-av LR	1.96	2.26	3.18	1.94	2.78
F-test exclude local	2.408	4.054	3.397	2.884	2.114
	(0.04)	(0.00)	(0.01)	(0.02)	(0.07)
World instruments only					
R^2	6.26	5.98	11.66	11.57	5.00
Supremum LR	7.49	7.83	9.99	12.89	12.51
Exp-av LR	2.41	1.78	2.92	3.19	4.34
F-test exclude local	2.379	1.645	3.264	3.378	1.671
	(0.04)	(0.15)	(0.01)	(0.01)	(0.15)

Notes: The table reports OLS results for the following equation:

$$\mathbf{r}_{it} = a + \mathbf{b}_i^{\mathrm{L}}\mathbf{Z}_{i,t-1}^{\mathrm{L}} + \mathbf{b}_i^{\mathrm{W}}\mathbf{Z}_{t-1}^{\mathrm{W}} + it$$

where $\mathbf{r}_{it}$ is a vector of local bond excess returns, a is a constant, $\mathbf{b}_i^{\mathrm{L}}$ is a vector of estimated coefficients associated with the local instruments, $\mathbf{Z}_{i,t-1}^{\mathrm{L}}$ is a vector of local instrumental variables specific to country i, $\mathbf{Z}_{t-1}^{\mathrm{W}}$ is a vector of local instrumental variables and $\mathbf{e}_{it}$ is a vector of residuals. The world instruments are: the spread between the yield on a portfolio of world long term government bonds and the 1 month US euro-deposit rate; the first lag of the world bond market return; the first lag of the world stock market return, and the yield on long term government bonds minus the yield on the equity market. The local instruments are: the spread between the yield on long term government bonds and the 1 month euro-deposit rate; the first lag of the local bond market return; the first lag of the local stock market return, and the yield on long term government bonds minus the yield on the equity market. Supremum LR (see Andrews (1993)) and Exp LR (see Andrews and Ploberger (1994)) are sequential Chow tests for the presence of a single break in any of the coefficients. The supremum test (10%, 5%, 1%) critical values for the local and world regression are (23.15, 25.47, 30.52), and for the remaining 2 are (16.20, 18.35, 22.49). Equivalent figures for the exponential test are (12.71, 14.16, 17.30) and (7.76, 9.01, 11.32). Parameters for the tests are: 15% trimming; 9 and 5 variables tested, and $c = 0$ for the exponential test. The F-test is a test of the restriction that the coefficients on the indicated regressors and jointly zero; probability values are in parentheses.

both sets of instruments can be excluded[8]. For Japan we cannot reject the hypothesis that the local instruments should be omitted, conditional on the world instruments being included. For the US we can reject each set of instruments conditional on the other remaining.

We also report estimated equations for local returns based on the world and local subsets of instruments separately. The evidence indicates clear patterns of predictability in all the local bond markets using local instruments. The R^2s range from 8% in Canada to 14% in the UK. The local instruments in Germany, Japan, the UK and the US are jointly significant at conventional levels while the Canadian instruments are significant at the 7% level. The R^2s of the world models are generally lower (5–12%), although for Japan and Germany alone the world instruments appear to have greater explanatory power than the locals, which suggests that the level of integration may be higher for these countries. The F-tests reveal that the instruments are jointly significant at 5% in Germany, Japan and the US, and at 15% in the UK and Canada. On the basis of the supremum and exponential sequential Chow tests of Andrews (1993) and Andrews and Ploberger (1994) the coefficients of all of the equations appear to be stable.

Overall, the regression R^2s range from 5% to 20% and the models appear to be well specified, with little evidence of parameter instability. These results, which demonstrate that small sets of local and world instruments are able to predict local bond returns in all markets, are consistent with the presence of time-variation in expected returns, and with incomplete integration.

The predictability of international stock returns is usually analysed in terms of US dollars. The predictability of bond returns, however, is more usually analysed using local-currency returns since the volatility of exchange rates greatly exceeds that of interest rates (see Dumas and Solnik, 1995; Chan et al., 1992), and analysing the predictability of dollar-adjusted bond returns may produce more evidence on the predictability of exchange rates than of bond returns. Table 3 reports levels of predictability for returns denominated in US dollars, relative to the US short rate. Despite the currency element, the results are very similar to those for local returns. Overall the local currency equations predict excess returns marginally better, and the exclusion tests are more sharply defined. We choose to model local currency returns, and interpret the competing assets as currency hedged investments.

4.2. Time-varying price of risk, time-varying exposure to risk

We estimate the system of Eqs. (1)–(3) for each of the local bond markets, and for the world bond market, in two steps.[9] We first estimate the world equation,

[8] The weakest rejection being for the US, for which the probability value is 7%.

[9] Ideally we should estimate the system of six equation (5 countries and 1 world equation) jointly. This would lead to a gain in efficiency over our two-step estimator. Such one-step procedures have been followed in models that assume complete integration (see, for example, De Santis and Gerard, 1997, 1998). In models that have both local and global instruments in the mean equations however, joint estimation becomes increasingly difficult due to the number of parameters to be estimated.

Table 3
Common currency (USD) returns. Predicting local excess-returns using local and world instruments

	US	UK	Japan	Germany	Canada
World and local instruments					
R^2	10.15	10.45	15.98	16.01	18.65
Supremum LR	24.44	22.63	23.94	16.53	14.03
Exp-av LR	9.24	8.62	8.34	5.40	4.25
F-test exclude local	1.575	1.91	1.53	2.35	4.33
	(0.17)	(0.11)	(0.20)	(0.06)	(0.00)
F-test exclude world	1.097	1.56	3.41	1.96	4.70
	(0.36)	(0.18)	(0.01)	(0.09)	(0.00)
F-test exclude both	1.81	1.76	2.74	2.73	3.39
	(0.07)	(0.08)	(0.01)	(0.01)	(0.00)
Local instruments only					
R^2	7.15	7.40	4.57	9.92	5.93
Supremum LR	7.17	11.80	14.36	8.85	9.66
Exp-av LR	1.96	2.95	4.76	1.96	1.99
F-test exclude local	2.408	2.38	1.66	3.11	2.21
	(0.04)	(0.04)	(0.15)	(0.01)	(0.06)
World instruments only					
R^2	6.26	4.57	11.54	9.21	6.52
Supremum LR	7.49	11.08	12.75	10.79	8.87
Exp-av LR	2.41	2.73	3.36	2.47	2.64
F-test exclude local	2.379	1.60	3.64	2.90	2.38
	(0.04)	(0.17)	(0.00)	(0.02)	(0.04)

Notes: See notes to Table 2.

and then impose the results on the individual countries in 5 bivariate regressions. In particular, we restrict the estimates of the world bond market price of risk, λ_b, and of the coefficients in the conditional variance of the world market variance, to be the same for all countries.

The results are presented in Table 4, the second row of which indicates that several of the world instruments appear to be important in explaining the world price of risk. The implied expected excess returns for the world portfolio are plotted in Fig. 1. Their magnitude seems plausible overall[10] as does their general evolution. Fig. 1 also reveals a jump in the expected excess return in the month after the October 1987 stock market crash. Despite falls in the subsequent few months it remained high into early 1988. This may reflect uncertainties about the impact of the crash on the real economy, and about the response of monetary and fiscal policy, both of which would have added to uncertainty about bond market conditions. The expected excess return follows an upward trend from 1990 to a turning point in 1993. This pattern is probably a consequence of the recession of the early 1990s,

[10] The average of the expected excess returns is 3.5%; that of the actual excess returns is 2.6%.

Table 4
Partially integrated bond markets: time-varying price of risk, time-varying exposure to risk. Model estimates

		κ_0	κ_1	κ_2	κ_3	κ_4	c	a	b			SupLR	ExpLR
World	–	0.669**	49.555***	1.383	4.085***	4.716***	0.006***	0.116	0.794***				
	–	(0.24)	(13.28)	(4.28)	(0.62)	(1.68)	(6.4E−4)	(0.10)	(0.03)				
	θ_i	δ_0	δ_1	δ_2	δ_3	δ_4	c_{11}	c_{12}	c_{22}	a	b		
US	0.623***	−9.004***	−17.147***	29.345***	−75.508***	−33.749***	0.003***	0.006***	0.006***	0.165*	0.810***	4.52	2.26
	(0.11)	(0.24)	(4.55)	(0.68)	(16.61)	(3.32)	(8.3E−5)	(5.1E−4)	(2.4E−4)	(0.09)	(0.04)		
UK	0.495***	−5.680	331.22***	−326.87***	289.27***	6037.50***	0.003	0.005***	0.006***	0.162	0.937***	1.47	0.04
	(0.09)	(7.36)	(93.65)	(75.09)	(108.73)	(1795.8)	(3.8E−3)	(1.6E−3)	(3.4E−4)	(0.13)	(0.07)		
Japan	0.903***	−2.466***	−36.172***	4.179***	4.931	33.591***	0.008***	0.009***	0.006***	0.093	0.463***	2.18	0.17
	(0.03)	(0.26)	(2.68)	(0.84)	(16.81)	(1.81)	(8.2E−4)	(7.9E−4)	(3.9E−4)	(0.21)	(0.09)		
Germany	0.868***	−31.421***	−97.915***	−76.258***	−83.949	239.38***	0.003*	0.009***	0.006***	0.339***	0.256***	2.07	0.05
	(0.12)	(0.74)	(3.56)	(1.81)	(90.49)	(3.89)	(1.3E−3)	(5.8E−4)	(3.1E−3)	(0.06)	(0.09)		
Canada	0.641***	−22.681***	21.023**	40.141***	104.29***	15.735***	0.006***	0.008***	0.006***	0.283***	0.776***	3.94	0.65
	(0.17)	(9.11)	(10.16)	(13.53)	(35.55)	(5.11)	(8.7E−4)	(1.3E−3)	(2.8E−4)	(0.06)	(0.07)		

Notes: This table reports results from estimating the world bond market price of risk as a function of a set of instruments. Estimates from this model are then imposed on domestic–world bilateral models for each country. The estimation is undertaken in two steps: first, the world bond market price of risk and the equation for the conditional volatility are estimated. κ is the vector of estimated coefficients in the mean world bond market equation. The associated variables are: κ_0, a constant, κ_1, the excess return on the world stock market, κ_2, the world stock market dividend yield minus the long term world bond yield, κ_3, the excess return on the world bond market, and κ_4, the spread between the long term world bond market yield and the 1 month US euro-dollar rate. c, a and b are the constant and the coefficients on the lagged squared errors and past conditional variance respectively in the conditional-volatility equation. Second, these estimates are imposed on domestic–world bilateral models for each country. θ_i is the estimated level of integration, δ_i is the vector of estimated coefficients for the local price of risk. Their associated variables are: δ_0, a constant, δ_1, the excess return on the local stock market, δ_2, the local stock market dividend yield minus the long term local bond yield, δ_3, the excess return on the local bond market and δ_4, the spread between the long term local bond market yield and the 1 month local euro-dollar rate. c_{11}, c_{12}, and c_{22} are estimates of the constants in the conditional variance–covariance equations and a, b are the coefficients on the lagged square errors and past conditional variance. SupLR and ExpLR are supremum and exponential tests for instability in the level of integration: (10%, 5%, 1%) critical values are (7.17,8.85,12.35) and (2.16,2.88, 4.72) respectively.

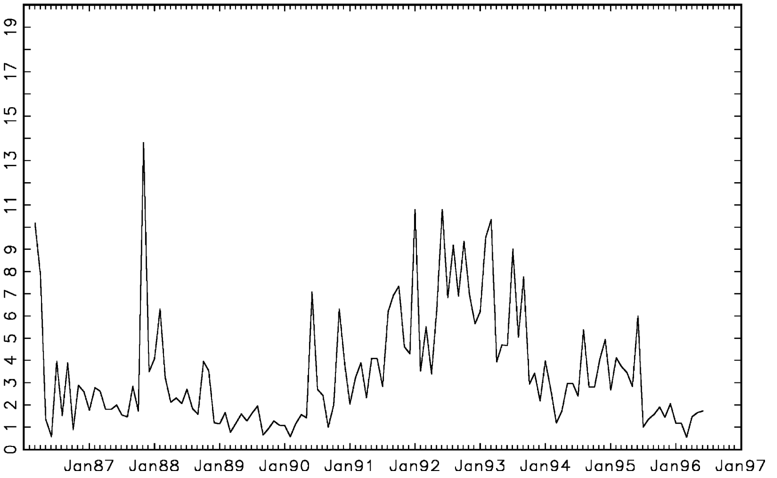

Fig. 1. Implied world bond market expected excess return (% p.a.).

which led investors to demand higher risk premia, and of the subsequent recovery, during which expected returns fell towards pre-recession levels.

In all countries the estimated integration weight is greater than zero and less than 1, suggesting partial integration. The weights range from 0.5 in the UK, to 0.9 in Japan. The estimates of the δs in panel A show that in all countries some of the local instruments are important in forecasting the local price of risk. Thus panel A appears to reflect two observations that lead to the conclusion that markets are only partially integrated; estimates of integration weights less than one, and statistically significant local instruments in the prediction of local prices of risk. The integration coefficient for Japan is larger than the rest, with Germany a close second. The relative US and Japanese weights are interesting for two reasons. First, they reflect the results obtained from the prediction equations i.e. Japan seems to be more exposed than the US to world influences, and second, although the US may be integrated it may be large enough to be immune to world influences i.e. the US may matter for world markets, but world markets may not matter as much for the US. This is a similar finding to those of Campbell and Hamao (1992). It is not surprising that the UK should be less integrated than the others: a sequence of large public sector surpluses in the 1980s greatly reduced the volume of debt outstanding, with consequent effects on liquidity. Anecdotal evidence supports this: a number of fund managers at the time describing the UK as a country without a serious bond market[11]. The coefficients in the conditional variances and covariances indicate time-varying risk exposures.

Residual-diagnostics and tests of the model are reported in Table 5. The R^2s are considerably higher than those in studies of stock markets[12], ranging from 8% for

[11] The absence of a repo market also contributed to this view.

[12] See, for example, Harvey (1991) and De Santis and Gerard (1997).

Table 5
Partially integrated bond markets: time-varying price of risk, time-varying exposure to risk. Further diagnostics

Test d.f.	R^2	Normal 2	Hetero-ske-dastic 12	Auto-corre-lation 12	Engle–Ng 3	λ = constant	λ = zero	Resid ⊥ instr		GARCH roots	
								World	Local	Sum	LR(1)
World	11.807	0.133	1.625	4.482	4.938	64.83	70.74	6.143			
		(0.46)	(0.30)	(0.48)	(0.02)	(0.00)	(0.00)	(0.74)	(0.87)		
US	8.813	0.558	14.030	10.534	9.413	3055.0	4279.7	2.731	1.769	0.975	12.88
		(0.94)	(0.99)	(0.97)	(0.18)	(0.00)	(0.00)	(0.29)			
UK	14.658	4.208	9.322	11.449	3.763	22.92	136.61	3.164	17.93	1.099	0.83
		(0.12)	(0.67)	(0.49)	(0.29)	(0.00)	(0.00)	(0.67)	(0.00)		
Japan	14.285	0.952	11.706	4.671	4.654	790.78	791.61	6.486	7.251	0.556	0.51
		(0.62)	(0.47)	(0.97)	(0.20)	(0.00)	(0.00)	(0.26)	(0.20)		
Germany	8.416	4.166	5.061	8.128	1.397	67.08	93.63	6.851	7.746	0.595	9.60
		(0.12)	(0.96)	(0.78)	(0.71)	(0.00)	(0.00)	(0.23)	(0.17)		
Canada	7.323	1.348	12.061	6.445	0.434	12.33	111.75	2.486	2.858	1.066	0.13
		(0.51)	(0.44)	(0.89)	(0.93)	(0.02)	(0.00)	(0.77)	(0.72)		

Notes: Residual analysis and tests of the model of Table 4. R^2 is the fraction of total variation in excess returns explained by the model. The tests are for normality of the residuals (Bera-Jarque); 12th-order serial correlation of the squared standardised residuals; 12th-order serial correlation of the standardized residuals; asymmetries in the conditional variance (Engle and Ng (1993) joint test); market prices of risk equal to a constant, and to zero (Wald tests), and orthogonality of the residuals with respect to the world and local instruments. Asymptotic standard errors in parenthesis, and probability values in square brackets.

the Germany to 15% for the UK, with an average of 11%. The tests indicate that the residuals are normally distributed, serially uncorrelated and homoscedastic. There is no evidence (except in the case of the US) of asymmetries in the conditional variance.

Table 5 also reports tests for constant, and zero, prices of risk for the world market, and for each domestic market. In all cases we reject these hypotheses in favour of a time-varying positive price of risk. The regressions of the models' residuals on the information variables tests reject orthogonality in only 1 case—the local instruments for the UK's residuals. The final two columns report the sum of the lag coefficients in the GARCH equations, and a likelihood ratio test (distributed $\chi^2(1)$) of this sum against unity. The results indicate that in the two cases in which the sum marginally exceeds one, the likelihood function is locally very flat, and that the estimates could have been generated by a model in which the true sum lies well below unity. We conclude that we cannot reject the hypothesis that the GARCH process is stable for all countries.

4.3. Changing levels of integration

Bekaert and Harvey (1995, 1997) find evidence of changing levels of integration in several emerging equity markets. They interpret the "level of integration" parameter (θ) as the probability that the market will be either completely integrated or completely segregated throughout the investment horizon. Such regime-switching may characterize the major changes in emerging markets, where discrete regulatory changes that liberalise the domestic economy may arise. For the major bond markets however, significant and discrete regime shifts are less likely to occur, with the result that this interpretation has less relevance for our sample. Nevertheless, changing levels of integration cannot be ruled out a priori, and we look for this in several ways. Although the results in Table 2 fail to suggest any instability in the parameters of the prediction equations, this is an indiscriminate test against variations in integration since such parameter instability could be caused, or even masked, by factors other than the level of integration. Thus we also report 3 tests focused specifically on the integration coefficients: first, we use the sequential Chow tests of Andrews (1993) and Andrews and Ploberger (1994) (see Garcia and Ghysels, 1998 for a similar application of these tests); second, we allow the level of integration to follow a linear trend[13], and third, we condition the level on variables that reflect the pattern of interest rates in world markets[14].

The results are presented in Table 6. None of the trend coefficients is significantly different from zero by the usual criteria. The sequential Chow tests are tests against a single structural break at any time in the sample (in contrast to the standard test in which the break point forms part of the alternative hypothesis).

[13] While a linear trend cannot capture long-term movements in a bounded parameter, it should provide a local approximation to any systematic changes in integration.

[14] Hardouvelis et al. (1999) also use conditioning variables, although their selection is rather different from ours.

Table 6
Market integration and conditioning variables

Variable	US	UK	Japan	Germany	Canada
Trend	0.002	−0.014	0.0002	−0.003	−0.006
	(0.005)	(0.12)	(0.0004)	(0.004)	(0.004)
$\bar{r}_s$	0.365	−0.368	−0.103	−2.110	40.819^{+}
	(0.527)	(0.008)	(0.017)	(0.053)	(0.202)
s.d.(r_s)	0.982	−0.137	−0.075	−0.867	0.117
	(1.270)	(0.001)	(0.004)	(0.008)	(0.001)
$r_{s,i} - \bar{r}_s$	−2.574	0.315	0.095	1.209	819.39^{+}
	(0.893)	(0.003)	(0.008)	(0.013)	(1.102)
$\bar{y}_l$	0.409	−0.044	0.004	−0.618	0.241
	(1.059)	(0.001)	(0.000)	(0.019)	(0.014)
s.d.(y_l)	1.696	0.736	0.204	−0.820	−1.226
	(0.437)	(0.003)	(0.009)	(0.006)	(0.015)
$y_{l,i} - \bar{y}_l$	13.272	4.217	−0.092	4.068	1.200
	(0.456)	(0.023)	(0.007)	(0.019)	(0.016)
$\bar{y}_l - \bar{r}_s$	−5.172	14.05	51.93^{**}	−8.438	−1.360
	(0.692)	(0.043)	(2.28)	(0.047)	(0.025)
s.d.$(y_l - r_s)$	2.450	0.60	0.556	−2.021	-442.577^{**}
	(1.100)	(0.002)	(0.011)	(0.010)	(2.152)
$(y_{l,i} - r_{s,i}) - (\bar{y}_l - \bar{r}_s)$	4.441	54.522	-547.969^{***}	0.550	2462.0^{*+}
	(1.219)	(0.041)	(4.705)	(0.004)	(1.964)

$^{+}$ See the following notes.

Notes: The model of this table is identical to that of Table 6 except that the integration coefficient θ is allowed to depend on one of a range of variables, i.e.

$$\theta_t = \phi_1 + \phi_2 x$$

The variables are: the cross-section mean and standard deviation of the 5 national short rates, 10-year yields, and yield-curve spreads; and the deviation of the local equivalents from their cross-section averages. The reported statistics are the estimate of ϕ_2 and its t-statistic. In the case of Canada unconstrained estimated of the linear relationship generated some values for θ outside the range [0,1] for three of the variables: these are indicated by a superscript $^{+}$. The reported results for these cases have been constrained to prevent this i.e. the integration coefficient is estimated as:

$$\theta_t = \frac{(\phi_1 + \phi_2 x)^2}{1 + (\phi_1 + \phi_2 x)^2}$$

The freely estimated values of ϕ_2 were: 313.391 (2.877), 231.925 (1.396), 460.99 (2.082). *** denotes statistically significant at the 1% level, ** at the 5% level and * at the 10% level. The 25% critical value t-statistic is 0.677. Asymptotic t-statistics in parentheses.

Asymptotic critical values of the test are provided in Andrews, and Andrews and Ploberger op cit and are presented in the notes of Table 6. None of the tests rejects the hypothesis of stability at 5%, and only the exponential test for the US does so at 10%. Thus these test too suggest stability in the level of integration.

A disadvantage of the sequential Chow tests, however, is that their power against two or more breaks in the sample is unknown i.e. they were not designed to deal with the multiple breaks that could be generated if the integration level were dependent on some other variable[15]. An exhaustive test against this form of instability is impossible but we consider a limited range of conditioning variables that reflect general conditions in world bond markets. We consider first the stance of monetary and exchange rate policy as measured by the cross-section of short-term interest rates: for each market we allow the level of integration to depend upon (individually) the average of world short rates, the standard deviation of short rates, and the deviation of each country's short rate from the world average. Second, we consider the long-term inflation outlook: we proxy expected inflation using long yields[16], and use the same three constructions as for short rates. Finally, we combine the two and test for any dependence of integration on the slope of the yield curve. The cross-sectional averages are intended to capture general interest rate conditions: for example, when rates and, by implication, their volatility are high, investors may prefer to invest locally. This effect may also be reflected by the cross-sectional standard deviation. The local–world deviation is a measure of the extent to which one country is out of line with the others: if investors prefer to avoid outlier markets, this too may reduce the level of integration.

The results in Table 6 indicate that there is no such instability in the cases of the US, UK and Germany. Integration of the Canadian market appears to depend on the slope of the yield curve: a greater cross-sectional standard deviation reducing the level of integration. Japanese integration also seems to be related to the yield curve, with the level increasing as the slope of the world curve becomes more positive, and declining as the gap between the Japanese and world slopes increases. Although these are isolated results they suggest that our choice of variables has some relevance to the level of integration. The result for Canada is intuitively plausible. It also seems reasonable that the Japanese market may become less integrated when 'world' inflation is expected to rise relative to that in Japan.

5. Alternative specifications of the asset pricing model

The model of the previous section reveals some interesting features of international bond markets, but two further restrictions are of interest in the context of previous research: a constant price of risk, and a completely integrated world market. In this section we examine the empirical significance of these restrictions. Finally, Roll's (1977) critique applies to our model as it does to many others. We have assumed implicitly that there is sufficient separability between stocks and bonds in investors' portfolios for a bonds-only model to be useful.[17] The final

[15] They would not have power against the hypothesis of Bekaert and Harvey (1995), for example.

[16] Campbell and Ammer (1993) and Barr and Pesaran (1997) find that about 90% of the variation in long yields is due to revisions to expected inflation.

[17] This assumption is routine for stocks-only models.

specification offers an indication of the significance of this assumption for our results by adding stocks to the world portfolio.

5.1. Constant price of risk, time-varying exposures to risk

Results for a constant price of risk model are reported in Table 7. The estimated world price of risk is 9.6, but is not statistically different from zero. The estimates for the conditional variance equation indicate some variation the level of risk worldwide. The local market prices of risk are also poorly estimated: only in the case of Germany is the estimate significantly different from zero, and in two cases the estimates are negative, although not significantly so. The lack of precision in these estimates is consistent with coefficients that are changing over time. The levels of risk in local markets appear to be time-varying.

All of the markets appear to be integrated to some extent, although here too the estimates are statistically imprecise with the estimated weight being significantly different from zero in only two cases.

While the diagnostic tests, in Table 7 panel B, do not suggest any misspecification problems, the residual–instrument–orthogonality tests, indicate that the restrictions in this model are too severe. The world residuals are not orthogonal to Z^{W}, and, of the individual countries' residuals, 5 out of 10 orthogonality tests reject at the 1% level. This provides strong evidence against the restrictions of the estimated model as a whole, and indicates that the ability of the information variables to predict returns does not appear to derive exclusively from their ability to predict changes in the ARCH-based exposures to risk.

5.2. A model of complete integration

We interpreted the inability of the local instruments to predict the local residuals from our preferred model as evidence that their influence is adequately captured by allowing them to influence the local prices of, and exposures to, risk. An alternative explanation for the orthogonality results is simply that the local instruments make no marginal contribution to the model at all, and that their presence is due to their correlation with the world instruments, combined with potential small-sample inefficiencies of the estimation.

To assess this we estimate a version of the model that assumes complete integration. The estimation process involves two steps as before. We use the estimates from the world equation in Table 4 and impose these on the 5 world–domestic equations:

$$r_{i,t} = \hat{\lambda}_{b,t-1}\mathrm{c\hat{o}v}_{t-1}(r_{b,t}, r_{i,t}) + e_{us,t} \tag{7}$$

$$r_{b,t} = \hat{\lambda}_{b,t-1}\mathrm{v\hat{a}r}_{t-1}(r_{b,t}) + e_{b,t} \tag{8}$$

where $\hat{x}$ denotes a prior estimate of x. We estimate the variance–covariance matrix as in Eq. (4). If this single-factor version of the model is correct, and local markets

Table 7
Partially integrated bond markets: constant price of risk, time-varying exposure to risk

		λ_b	c	a	b		
Panel A: Model Estimates							
World	–	9.597	0.009***	0.246*	0.478***		
	–	(7.87)	(9.7E−4)	(0.13)	(0.09)		
	θ_i	λ_i	c_{11}	c_{12}	c_{22}	a	b
US	0.307	4.188	0.003***	0.009***	0.009***	0.323***	0.647***
	(0.68)	(4.19)	(2.9E−4)	(5.6E−4)	(3.9E−4)	(0.04)	(0.01)
UK	0.876***	−20.981	0.008***	0.009***	0.007***	0.301***	0.757***
	(0.12)	(24.71)	(1.14E−3)	(8.1E−4)	(3.6E−4)	(0.11)	(0.03)
Japan	0.913	14.132	0.006*	0.007***	0.009***	0.245	0.766***
	(0.65)	(14.81)	(3.6E−3)	(1.3E−3)	(6.0E−4)	(0.16)	(0.19)
Germany	0.597	16.031**	0.006E−4***	0.008***	0.009***	0.113	0.485***
	(0.24)	(7.97)	(4.1E−4)	(7.8E−4)	(6.3E−4)	(0.10)	(0.06)
Canada	0.852***	−5.415	0.005***	0.009***	0.009***	0.406***	0.734***
	(0.24)	(17.11)	(7.0E−4)	(7.1E−4)	(4.1E−4)	(0.03)	(0.02)
Test	R^2	Normal	Hetero-skedastic	Auto-correlation	Engle–Ng	Resid ⊥ instr	
d.f.		2	12	12	3	World	Local
Panel B: residual-analysis							
World	5.175	1.347	6.662	10.096	2.290	19.874	
		[0.23]	[0.88]	[0.61]	[0.51]	[0.00]	
US	5.111	0.244	8.581	9.455	3.171	7.038	5.648
		[0.89]	[0.74]	[0.66]	[0.37]	[0.22]	[0.34]
UK	9.352	3.230	11.921	10.442	1.432	7.467	26.208
		[0.20]	[0.45]	[0.58]	[0.69]	[0.19]	[0.00]
Japan	1.293	2.825	11.771	4.283	3.473	18.969	17.130
		[0.24]	[0.46]	[0.97]	[0.32]	[0.00]	[0.00]

Germany	2.447	5.334	12.712	8.032	2.566	17.461	18.422
		[0.07]	[0.39]	[0.78]	[0.46]	[0.00]	[0.00]
Canada	1.626	0.427	11.799	16.305	3.063	4.633	5.148
		[0.81]	[0.46]	[0.18]	[0.38]	[0.46]	[0.40]

Notes: Panel A reports results for the constant price of risk world bond market. The estimation is undertaken in two steps: first, the world bond market price of risk (λ_b) and the conditional volatility equation are estimated. (c, a and b are the constant and the coefficients on the lagged squared errors and past conditional variance respectively in this equation). Second, these estimates are imposed on domestic–world bilateral models for each country. θ_i is the estimated level of integration, λ_i is the estimate of the local price of risk, c_{11}, c_{12}, and c_{22} are estimates of the constants in the conditional variance–covariance equations and a and b the coefficients on the lagged squared errors and past conditional variance.

Panel B reports residual analysis and tests of the model. R^2 is the fraction of total variation in excess returns explained by the model. The tests are for: normality of the residuals (Bera-Jarque); 12th-order serial correlation of the squared standardised residuals; 12th-order serial correlation of the standardised residuals; asymmetries in the conditional variance (Engle–Ng joint test), and orthogonality of the residuals with respect to the world and local instruments. *** denotes statistically significant at the 1% level, ** at the 5% level and * at the 10% level. Asymptotic standard errors in parenthesis, and probability values in square brackets.

Table 8
Fully integrated model. Time-varying price of risk, time-varying exposure to risk. Diagnostic tests

Test d.f.	R^2	Normal 2	Hetero-skedastic 12	Auto-correlation 12	Engle–Ng 3	Resid ⊥ instr	
						World	Local
US	7.519	0.137	8.945	5.986	5.718	4.686	3.845
		[0.93]	[0.71]	[0.92]	[0.13]	[0.46]	[0.57]
UK	12.014	3.789	10.014	6.497	2.452	4.267	19.19
		[0.15]	[0.61]	[0.89]	[0.48]	[0.51]	[0.00]
Japan	4.447	2.375	9.951	4.301	3.350	8.922	14.34
		[0.30]	[0.62]	[0.97]	[0.34]	[0.11]	[0.01]
Germany	7.521	4.528	10.331	7.906	0.723	9.549	14.16
		[0.10]	[0.58]	[0.79]	[0.87]	[0.09]	[0.01]
Canada	3.946	3.323	13.914	8.785	0.986	1.535	5.324
		[0.19]	[0.31]	[0.72]	[0.81]	[0.91]	[0.38]

Notes: The model estimated is as in Table 4 with the restriction of complete segmentation imposed ($\theta_i = 1$). The table reports analysis and tests of the model. R^2 is the fraction of total variation in excess returns explained by the model. The tests are for: normality of the residuals (Bera-Jarque); 12th-order serial correlation of the squared standardised residuals; 12th-order serial correlation of the standardised residuals; asymmetries in the conditional variance (Engle–Ng joint test), and orthogonality of the residuals with respect to the world and local instruments. Probability values in square brackets.

are completely integrated into world markets, the residuals from the local markets should be orthogonal to the local instruments.

The results are reported in Table 8[18]. The average R^2 for the 5 bond markets falls to 7%; almost a third less than the average for the partially integrated model. Furthermore, three of the local markets now fail the residual orthogonality test with respect to the local instruments. The weaker performance of the fully integrated model, and the increase in number of rejections of orthogonality, reinforce the previous conclusion that even in bond markets it is important to allow for partial integration.

5.3. Adding stocks to the world-market portfolio

As Roll (1977) emphasizes, the market portfolio should contain all assets. In tests of the CAPM using stock market data, a stock index is typically chosen as a proxy for the market portfolio. When the risk and returns of bonds are the object of the model, however, Ilmanen (1995) shows that a version of the CAPM with a stock portfolio proxying the market portfolio performs poorly. Ilmanen's interpretation of this is that bond markets are either segmented from stock markets, (and, therefore, that a stock market portfolio is inappropriate), or that bond markets are driven by a multifactor model in which bonds have zero sensitivity to the stock

[18] Results for the parameter estimates of the mean and variance equations are not reported but are available on request.

market portfolio, and significant sensitivity to the bond portfolio due to its ability to capture interest rate risk.

It can also be argued that the application of APMs based on the solution to the portfolio-allocation problem (such as the CAPM) to the determination of bond returns is inappropriate if government bonds are not regarded as net wealth. Ricardian equivalence and the absence of all market frictions is a strong assumption however, the testing of which is beyond the scope of this paper[19]. Our results can be interpreted as an investigation into the existence and nature of any empirical regularities that are consistent with the assumption that bonds represent net wealth to some degree, and that there is some segmentation between stock and bond markets. Our results add to those of Ilmanen (1995) who concludes that "…expected excess returns are highly correlated across international bond markets and less highly correlated between the world stock and bond markets." In this context, the aim of the present paper is to investigate the nature of these correlations across international bond markets.

In this section we depart from this assumption and reassess the empirical model using a world portfolio which includes both stocks and bonds. We use the world stock market total return index provided by Datastream. Since Salomon Brothers do not provide a market value for their world bond portfolio, we examine the aggregated market values of J.P. Morgan's country portfolios. These sources give the stock market an average weight of 73% (s.d. 2.5%) in the composite world portfolio. This seems to underweight the true market value of bonds. Merrill Lynch report that at the end of 1997 the market value of outstanding bonds was \$24.1345 trillion. Morgan Stanley estimate the market value of equity in the world to be \$23.136 trillion in 1998. In the absence of a time series of the market value of the bond market, we assume first that the market portfolio is equally weighted between stock and bonds. We can capture some of the relative movement in the sizes of the two asset stocks, however, by using the ex post returns to measure capital gains. While this approach cannot reflect the impact of new issues, redemptions, and dividend payments that are not reinvested, it is likely to pick up a substantial part of the variability in the relative size of the two markets.[20]

We focus on the model that allows both the price and quantity of risk to vary and report only a selection of the results.[21] We use the same set of instruments as for the bond model.

Tables 9 and 10 report the diagnostic tests of the models for the equal-weight, and variable-weight stock-bond portfolios respectively.[22] The results for the two weighting approaches are broadly similar, the main exception being the UK, for which the variable-weight portfolio performs significantly better in terms of

[19] See Giovannini and Jorion (1989) and Stulz (1987) for further discussion of this issue.

[20] We use a terminal condition for the construction of the weight series that imposes equal weights at the end of our sample, to reflect the Merrill Lynch figures.

[21] The full set is available on request.

[22] While the market portfolio is an average of both stock and bonds, the local market risk factor remains the local bond market only.

Table 9
Partially integrated bond markets: equal-weighted stock and bond market portfolio

	θ_i	R^2	$N\ \chi^2(2)$	$H\ \chi^2(12)$	S.C. $\chi^2(12)$	EN $\chi^2(3)$	$\lambda =$ constant	$\lambda = 0$	Resid $\perp$ instr	
									World	Local
World	–	7.71	2.57	11.05	19.29	2.90	93.29	402.13	4.910	
			(0.27)	(0.52)	(0.08)	(0.00)	(0.00)	(0.00)	(0.42)	
US	0.81***	8.71	1.060	6.63	9.98	4.09	2706.2	3475.3	5.211	2.127
	(0.05)		(0.58)	(0.88)	(0.61)	(0.00)	(0.00)	(0.00)	(0.39)	(0.83)
UK	0.72	1.72	3.25	13.11	4.05	0.45	34.53	78.07	7.406	24.254
	(0.74)		(0.19)	(0.36)	(0.98)	(0.29)	(0.00)	(0.00)	(0.19)	(0.00)
Japan	0.96***	9.90	1.36	12.11	3.76	2.56	2675.41	2675.97	14.844	11.790
	(0.02)		(0.51)	(0.44)	(0.98)	(0.00)	(0.00)	(0.00)	(0.01)	(0.04)
Germany	0.93***	7.35	4.31	7.49	7.52	0.37	86.73	87.30	5.50	4.84
	(0.03)		(0.12)	(0.82)	(0.82)	(0.00)	(0.00)	(0.00)	(0.36)	(0.44)
Canada	0.40***	0.97	1.35	12.29	2.05	2.59	12.33	111.75	9.91	4.62
	(0.08)		(0.51)	(0.42)	(0.99)	(0.00)	(0.02)	(0.00)	(0.08)	(0.46)

Notes: The sample is 1986:01 to 1996:06. The model estimated is the same as in Table 6 with the exception that the world market portfolio is an equally weighted portfolio of the world stock and world bond market portfolio. Panel A reports residual analysis and tests of the model. R^2 is the fraction of total variation in excess returns explained by the model. The tests are for: normality of the residuals (Bera-Jarque); 12th order serial correlation of the squared standardised residuals; 12th-order serial correlation of the standardised residuals; asymmetries in the conditional variance (Engle–Ng joint test); market prices of risk equal to a constant, and to zero (Wald tests), and orthogonality of the residuals with respect to the world and local instruments. *** denotes statistically significant at the 1% level, ** at the 5% level and * at the 10% level. Asymptotic standard errors in square brackets, and probability values in parentheses.

Table 10
Partially integrated bond markets: return-weighted stock and bond market portfolio. Time-verifying price of risk, time-varying quantities of risk

	θ_i	R^2	$N\ \chi^2(12)$	$H\ \chi^2(12)$	S.C. $\chi^2(12)$	EN $\chi^2(3)$	$\lambda =$ constant	$\lambda = 0$	Resid $\perp$ instr	
									World	Local
World	–	6.91	2.79	11.40	20.32	3.12	77.52	324.84	4.45	
			(0.25)	(0.49)	(0.06)	(0.00)	(0.00)	(0.00)	(0.49)	
US	0.77***	8.71	1.58	6.71	9.91	3.54	4278.3	3333.5	5.83	2.44
	(0.05)		(0.45)	(0.88)	(0.62)	(0.00)	(0.00)	(0.00)	(0.32)	(0.78)
UK	0.70***	9.46	4.63	7.93	7.67	0.95	13598.3	5562.9	11.35	12.92
	(0.10)		(0.10)	(0.79)	(0.81)	(0.26)	(0.00)	(0.00)	(0.04)	(0.02)
Japan	0.95***	9.59	2.43	12.59	4.78	6.12	1868.3	1810.6	15.69	12.93
	(0.01)		(0.30)	(0.40)	(0.97)	(0.00)	(0.00)	(0.00)	(0.01)	(0.02)
Germany	0.99***	7.23	1.82	7.54	7.14	0.67	18.46	17.41	4.89	4.59
	(0.01)		(0.40)	(0.82)	(0.85)	(0.00)	(0.00)	(0.00)	(0.43)	(0.47)
Canada	0.43***	0.58	1.91	12.08	2.80	2.95	6045.5	4563.1	8.24	4.29
	(0.07)		(0.39)	(0.44)	(0.10)	(0.00)	(0.00)	(0.00)	(0.14)	(0.51)

Notes: The estimated model is the same as in Table 9 with the exception that the world market portfolio is a weighted portfolio of the world stock and world bond market portfolio with varying weights, as described in the text. The tests are as described in the notes to Table 9.

explanatory power, and has a more precise estimate of the level of integration. In comparison with the results in Table 4 (for the corresponding bonds-only model), the values for R^2 are substantially lower i.e. the stock-bond portfolio return contains less explanatory information for local bond returns than does the bond portfolio alone. There are rejections of the orthogonality tests in Japan for both the local and global instruments, the UK for the local instruments, and Canada for the global instruments. The pure-bond model appears to perform rather better than the combined bond-stock model, but we cannot measure the difference between the two statistically.[23]

The integration weights now represent the extent to which domestic bond markets are integrated into the world stock and bond markets. The estimates reveal broadly the same story as the pure-bond model, with the Japanese and German markets having the greatest integration. The US estimate is higher, while that of Canada is lower.

Overall, the predictive performance of this model is substantially weaker than that of the bonds-only version, a result that clearly echoes those of Ilmanen (1995), and suggests that the stock and bond markets are not perfectly integrated themselves. This has important implications for the modeling of expected returns on different assets using a CAPM framework. The choice of assets to include in the market portfolio is important and this in itself warrants some attention in future research.

6. Summary and conclusions

In this paper we have shown that the widely accepted ability of certain information variables to predict excess returns on government bonds can be explained by an asset pricing model in which the market prices of risk depend on the information variables, and in which the quantities of risk are driven by ARCH processes. The model indicates the presence of both domestic and world risk factors.

The average contribution of world factors to domestic returns across our 5 countries is only 70%. This level seems surprisingly low in view of the absence of impediments to cross-country investment, and of the near homogeneity of bonds across countries. This estimate implies that the full benefits of international diversification have not been realised in government bond markets, that the world price of bond risk is higher than it need be, and that governments are currently paying too high a rate for their deficit funding. Furthermore, it suggests that bond markets may not be exerting as much anti-inflation discipline as they could if the markets were fully integrated. These observations may, of course, be linked: governments may be willing to continue to pay unnecessarily high funding costs in order to escape the discipline that would be exerted by a fully integrated world bond market. We reject the

[23] Ideally the model should be estimated with all four factors (domestic and world stock and bond excess returns appearing separately). This however, would increase the number of estimated parameters prohibitively.

hypothesis that the extent of international integration of the major bond markets changed during our sample period.

Our results suggest several avenues for further research. First, the theoretical foundations of the Bekaert and Harvey (1995) pricing model used here could be addressed. Our results, and those of Bekaert and Harvey themselves, suggest that resolving this issue is worthwhile. Second, we have considered only a few determinants of time-variation in integration, but there may be others, particularly where the major markets are not involved. Third, we have only scratched the surface of the question of integration across stock and bond markets. Considerably more examination of this issue is warranted, both from the perspective of pricing models, and at the more fundamental level of investor behaviour and practical portfolio management.[24] Fourth, by limiting ourselves to information variables, we have not addressed the fundamental risk factors influencing expected returns domestically and internationally. Fifth, we have speculated about a possible link between integration, funding costs and anti-inflation discipline. There is clearly more work to be done here, both with small macroeconomic models, and by incorporating inflation data into the empirical analysis, along with an examination of the impact and behaviour of inflation-indexed bonds in the UK and the US.

Several of these areas for further research have been left open because the computational demands of investigating them are substantial. With developments in computer technology and estimation techniques it is not unreasonable to expect that in due course a fully specified model embracing many or all of these areas should be feasible.

Acknowledgements

We should like to thank two anonymous referees for comments on earlier drafts which greatly improved the paper. Any remaining errors or omissions are our responsibility.

References

Andrews, D.W.K., 1993. Tests for parameter instability and structural change with unknown change point. Econometrica 61, 821–856.

Andrews, D.W.K., Ploberger, W., 1994. Optimal tests when a nuisance parameter is present only under the alternative. Econometrica 60, 953–966.

Baba, Y., Engle, R.F., Kraft, D.F., Kronner, K.F., 1989. Multivariate simultaneous generalized ARCH, working paper. University of California, San Diego, California.

[24] One of the authors of this paper spent some years as a bond-portfolio manager, turning over a total of about $15bn, but never bought an equity. Such specialization is, of course, typical of most fund managers.

Barr, D.G., Pesaran, B., 1997. An assessment of the relative importance of real interest rates, inflation, and term premiums in determining the prices of real and nominal UK bonds. Review of Economics and Statistics 79, 362–366.

Bekaert, G., Harvey, C.R., 1995. Time-varying world market integration. Journal of Finance 50, 403.

Bekaert, G., Harvey, C.R., 1997. Emerging equity markert volatility. Journal of Financial Economics 43, 29–77.

Bollerslev, T., Engle, R.F., Wooldridge, J.M., 1988. A capital asset pricing model with time-varying covariances. Journal of Political Economy 96, 116–131.

Campbell, J.Y., 1987. Stock returns and the term structure. Journal of Financial Economics 18, 373–399.

Campbell, J.Y., Ammer, J.H., 1993. What moves the stock and bond markets? A variance decomposition for long-term asset returns. Journal of Finance 68, 3–68.

Campbell, J.Y., Hamao, Y., 1992. Predictable stock returns in the United States and Japan: a Study of long-term capital market integration. Journal of Finance 47, 43–69.

Chan, K.C., Angrew Karolyi, G., Stulz, R.M., 1992. Global financial markets and the risk premium on U.S. equity. Journal of Financial Economics 32, 137–167.

De Santis, G., Gerard, B., 1997. International asset pricing and portfolio diversification with time-varying risk. Journal of Finance 52, 1881–1912.

De Santis, G., Gerard, B., 1998. How big is the premium for currency risk? Journal of Financial Economics 49, 375–412.

Dumas, B., Solnik, B., 1995. The world price of foreign exchange risk. Journal of Finance 50, 445–479.

Engle, R.F., Ng, V., 1993. Measuring and testing the impact of news on volatility. Journal of Finance 48, 1749–1778.

Errunza, V., Losq, E., 1985. International asset pricing under mild segmentation: theory and tests. Journal of Finance 40, 105–124.

Errunza, V., Losq, E., Padmanahan, P., 1992. Tests of integration, mild segmentation and segmentation hypotheses. Journal of Banking and Finance 16, 949–972.

Fabozzi, F.J., 1996. Bond Markets: Analysis and Strategies, 3rd ed.

Fama, E.F., French, K.R., 1988. Dividend yields and expected stock returns. Journal of Financial Economics 22, 3–25.

Ferson, W.E., Harvey, C.R., 1991. The variation of economic risk premiums. Journal of Political Economy 99 (21), 385–415.

Ferson, W.E., Harvey, C.R., 1993. The risk and predictability of international equity returns. Review of Financial Studies 6, 527–566.

Garcia, R., Ghysels, E., 1998. Structural change and asset pricing in emerging markets. Journal of International Money and Finance 17, 455–473.

Giovannini, A., Jorion, P., 1989. The time variation of risk and return in the foreign exchange and stock markets. Journal of Finance 44, 307–325.

Hardouvelis, G., Malliaropoulos, D., Priestley, R., 1999. EMU and European stock market integration. Centre for Economic Policy Research, DP 2124, April 1999.

Harvey, C.R., 1991. The world price of covariance risk. Journal of Finance 46, 111–157.

Harvey, C.R., Solnik, B., Zhou, G., 1994. What determines expected international asset returns?, NBER WP 4660.

Ilmanen, A., 1996. When do bond markets reward investors for interest rate risk? Journal of Portfolio Management Winter.

Ilmanen, A., 1995. Time-varying expected returns in international bond markets. Journal of Finance 50, 481–506.

Jorion, P., 1992. Term premiums and the integration of the Eurocurency markets. Journal of International Money and Finance 11, 17–39.

Keim, D.B., Stambaugh, R.F., 1986. Predicting returns in the stock and bond markets. Journal of Financial Economics 17, 357–390.

Merton, R.C., 1980. On estimating the expected return on the market: an exploratory investigation. Journal of Financial Economics 8, 323–361.

Roll, R., 1977. A critique of the asset pricing theory's tests: Part 1. Journal of Financial Economics 4, 129–176.

Solnik, B., 2000. International Investments, 4th ed . Addison Wesley Longman.

Stulz, R.M., 1987. An equilibrium model of exchange rate determination and asset pricing with non-traded goods and imperfect information. Journal of Political Economy 95, 1024–1040.

Stulz, R.M., 1999. Globalization of equity markets and the cost of capital. NBER WP 7021.