A Global Stock and Bond Model

Lucie Chaumeton, Gregory Connor, and Ross Curds

Six fundamental risk factors (four for stocks and two for bonds) explain most of the common volatility of individual stocks and bonds worldwide. Some of the risk factors have a strong international component, and others are more purely national. The cross-national component of the risk factors tends to be stronger within the European Union than worldwide. The model proposed in this article can be used for integration of worldwide asset selection and asset allocation decisions.

Factor models are now widely used to support asset selection decisions. Global asset allocation, the allocation between stocks versus bonds and among nations, usually relies instead on correlation analysis of international equity and bond indexes. It would be preferable to have a single integrated framework for both asset selection and asset allocation. This framework would require a factor model applicable at an asset or country level, as well as at a global level, that covers both stocks and bonds.

We propose a simple and intuitive factor model of international stocks and bonds. It is built on six factors inspired by well-accepted research ideas: market, size, value, and duration factors for stocks, and yield curve shift and twist factors for bonds. Because this model is estimated using asset-level data, it can be used to analyze each asset's sources of risk. Because it is estimated in a global framework, it can also be used for global asset allocation purposes.

The estimates from our model allowed us to draw a number of conclusions about the sources of risk on worldwide stock and bond markets. We found that the global component of the factor model is stronger in bond markets than in stock markets and stronger in the European Union (EU) than worldwide. Two of the risk factors, the market factor for stocks and the shift factor for bonds, have strong global components, as well as nation-specific components. The other four risk factors are mostly nation specific. We also examined the relationships between the factor risks, both within national markets and on a global level.

DATA

Our data consist of monthly returns and fundamental descriptors for individual stocks and bonds from 13 countries: Australia, Belgium, Canada, Denmark, France, Germany, Italy, Japan, the Netherlands, Spain, Sweden, the United Kingdom, and the United States. The data cover 112 months, from February 1986 to May 1995. The number of stocks and bonds differs among months; in an average month, the worldwide sample consists of 487 bonds and 2,000 stocks.

The equity data consist of return series, market capitalizations, dividend yields, and book-to-price ratios each month for each stock. The bond data consist of return series and a standardized description of the cash flows of each bond. Our bond database provides, for each bond, an allocation of all future cash flows into fixed-date vertexes 0, 1, 2, 3, 4, 5, 7, 10, 20, and 30 years in the future. The cash flow allocation assumes that cash flows occur only on vertex dates. Cash flows occurring between vertexes are allocated proportionately to each vertex to preserve the bond's duration and present value.[1]

The returns for stocks and bonds are both expressed in local currencies and in excess of local one-month risk-free returns. In addition, we calculated for each country the end-of-month exchange rates relative to the U.S. dollar. We used these rates to calculate the full set of cross-rates (e.g., the yen/pound exchange rate equals the ratio of the yen/dollar exchange rate to the pound/dollar exchange rate) over the same 112-month period (February 1986 to May 1995).

SIX FUNDAMENTAL FACTORS

Our factor model is designed to be simple, intuitive, statistically accurate, and reliable. None of the factors used in our model is entirely new; to select them, we relied on a whole range of findings from 20 years of factor modeling research in the academic and practitioner literature. For all factors, we used theoretically defined measures of factor exposure, rather than estimating the exposures by time-series analysis.

The two bond market factors are standard (see Kahn 1995). We defined the shift exposure of a

Lucie Chaumeton is a research consultant and Ross Curds a senior research consultant at BARRA International. Gregory Connor is director of research, Europe, at BARRA International and a visiting fellow at the University of London School of Economics.

given bond as the percentage increase in its price, given a constant percentage decline in all yields. As is well known, this amount is equal to the modified duration of the bond. Let $B_{i,t}$ be the price of bond i at time t, $C_{i,t+s}$ be the cash flow of bond i at time $t + s$, and $y_{t,s}$ be the yield on an s-period pure discount bond at time t. Consider a constant percentage decrease in all yields in response to a random shock, dx, so that $dy_{t,s}/dx = -(1 + y_{t,s})$ for all s. The shift exposure of a given bond is its percentage price sensitivity to this parallel shift in yields; that is,

$$\text{SHIFT}_{i,t} = \left(\frac{dB_{i,t}}{dx}\right)\left(\frac{1}{B_{i,t}}\right).$$

Applying the modified version of the well-known results of Macaulay (1938) gives

$$\text{SHIFT}_{i,t} = \left(\frac{1}{B_{i,t}}\right)\sum_{s=1}^{T} s(1 + y_{t,s})^{-s} C_{i,t+s},$$

so that shift exposure is equal to the value-weighted time to maturity of the bond, or modified duration.[2]

Our second bond factor, twist, measures bond price responses to changes in the slope of the yield curve. We predefined a midpoint of the term structure, called *mid* (in our empirical work, we set *mid* equal to four years). We defined a shock to the term structure that causes yields longer than *mid* to increase and yields shorter than *mid* to decrease; the size of the change is proportional to the time difference from *mid*; that is,

$$\frac{dy_{t,s}}{dz} = (1 + y_{t,s})(s - mid).$$

We defined the twist exposure of a bond as the percentage price response to this rotational shock to yields:

$$\text{TWIST}_{i,t} = \left(\frac{dB_{i,t}}{dz}\right)\left(\frac{1}{B_{i,t}}\right).$$

Applying calculus to the present value formula for the price of a bond gives the following explicit formula for TWIST:

$$\text{TWIST}_{i,t} = \left(\frac{1}{B_{i,t}}\right)\sum_{s=1}^{T}(mid - s)s(1 + y_{t,s})^{-s} C_{i,t+s}.$$

The strongest factor in stock market returns is the tendency for all stocks in a given country to move together, the so-called market factor. Historically, exposure to this factor has been measured by market beta, usually estimated by time-series regression of each asset's return against a national equity index. We followed some recent research in replacing estimated market beta with a unit exposure to the market factor for every stock. This approach is the same as imposing the prior assumption that every stock has a market beta of 1.[3]

A large number of empirical studies have established the importance of size and value as factors in stock returns (see Sharpe 1992; Capaul, Rowley, and Sharpe 1993; and Fama and French 1993). We defined average capitalization as the value-weighted average of the market capitalizations of all the firms in a country for a given month. We defined the size exposure of a stock in a given month as the logarithm of its market capitalization divided by average capitalization.

Dividing by the average capitalization of each country-month has two advantages. First, it adjusts for the tendency of average firm size to increase through time because of inflation and real growth. Second, it normalizes size exposure within each country, so that even a very small country has some "large" firms. This adjustment has the disadvantage that size exposure is a country-relative quantity that needs to be interpreted carefully in our global model. In our model, a global investor may hold a "large" stock in Belgium that is smaller than a "small" stock in Germany.

We defined a stock's value exposure using its book-to-price ratio. We adjusted for differences in accounting standards across countries by dividing each company's book-to-price ratio by the capitalization-weighted average of book-to-price ratios for all stocks in the same country for all months in the sample period. We used each country's long-run average book-to-price ratio; we did not adjust for any time series variation in book-to-price ratios within each country.

Following earlier work, we defined stock duration as the reciprocal of the stock's dividend yield (see Bernstein and Tew 1991). Treating an equity as a perpetuity with constant dividend growth, the reciprocal of dividend yield gives the value-weighted average maturity of the cash flows to the share, which is the original definition of duration for bonds. Note that stock duration does not measure sensitivity to parallel shifts in interest rates. Stock duration is value-weighted average maturity, but it is not equal to interest rate sensitivity. We added 1 percent to each stock's stated dividend yield to adjust for nondividend cash flows (such as corporate stock repurchases and cash-financed mergers).

Table 1 lists for each country the average number of stocks and bonds across the 112-month sample and the mean and standard deviation of each of the six factor exposures except market exposure (because market exposure is a 0/1 dummy, these

Table 1. Risk Exposures

Country	Number of Stocks	Number of Bonds	Size		Value		Stock Duration		Shift		Twist	
			Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Australia	67.96	17.45	–1.700	1.155	1.327	1.269	29.433	25.192	3.730	1.577	–0.259	1.688
Belgium	46.21	18.29	–0.789	0.778	0.752	0.833	22.676	13.812	3.816	1.339	–0.190	1.433
Canada	95.26	42.51	–1.764	1.181	1.388	1.488	41.019	29.005	4.086	2.179	–0.608	2.304
Denmark	32.76	25.81	–1.045	0.979	1.396	1.155	47.859	23.692	2.460	1.751	0.965	1.691
France	105.49	26.67	–1.413	1.046	0.948	1.572	32.197	20.487	4.330	2.436	–0.716	2.621
Germany	59.91	73.93	–1.698	1.140	0.835	1.380	39.066	21.186	3.969	1.330	–0.314	1.381
Italy	70.28	36.54	–1.789	1.099	0.875	1.118	34.410	21.274	2.965	1.026	0.753	1.156
Japan	458.54	53.25	–1.954	1.063	1.169	0.616	60.919	14.186	5.244	2.022	–1.620	2.095
The Netherlands	31.57	38.96	–2.705	1.243	1.159	0.780	32.088	21.491	4.001	1.446	–0.414	1.410
Spain	36.44	12.15	–1.602	1.164	1.206	1.133	36.669	27.604	2.698	1.456	0.900	1.389
Sweden	26.03	7.00	–0.627	0.765	0.882	1.082	36.344	14.820	4.082	3.317	–0.215	2.451
United Kingdom	217.84	34.68	–2.087	1.181	1.240	1.593	24.206	12.414	5.164	2.392	–1.708	2.540
United States	511.22	159.10	–1.946	1.106	0.926	1.084	39.202	27.020	4.261	2.994	–0.790	3.144

Note: The first two columns show the average number of stocks and bonds for each country across all months in the sample. The remaining columns show, across all months and all securities (either stocks or bonds), the means and standard deviations of the factor exposures (three for stocks and two for bonds) within each country. The market factor exposure is a 0/1 dummy, so the statistics are not shown (for each country, the market factor has a mean of 1 and a standard deviation of 0).

sample statistics are not meaningful for it). Recall that the value and size exposures are standardized within each country but stock duration exposures are not. Standardizing stock duration within each country has some justification. Note in particular the long average duration of Japanese stocks. In our model, an investor choosing to hold Japanese stocks is also choosing to hold long-duration stocks. We believe that maintaining this feature of the model was better than eliminating it by standardizing stock duration within each country. The shift and twist exposures do not need to be standardized.

RELATIVE IMPORTANCE OF NATIONAL AND GLOBAL FACTORS

We estimated two forms of the factor model: a global model, which has a single set of factor returns across all countries, and a nation-specific model, in which the factor returns are allowed to differ among countries. Table 2 shows the explanatory power of the global model, the nation-specific model, and individually for each of the nations within the nation-specific model. See the appendix for more details on the estimation of factor returns and on the calculation of explanatory power.

On the worldwide sample, our global factors explain 21 percent of stock volatility and 60 percent of bond volatility, an impressive result for such a simple and intuitive model. Allowing factor returns to differ across nations explains an additional 13 percent of stock volatility and 35 percent of bond volatility. A large component of both stock and bond returns is therefore explained by global influences; in the case of bonds, the explanatory power of the global factors is almost two-thirds of that achieved with nation-specific factors.

The models are shown with two estimation universes. The first uses a worldwide sample; the second is restricted to the eight EU countries in our sample.[4] Global influences in this subsample are expected to be higher if the EU is more economically integrated than the world at large. The explanatory power of the global model is indeed higher within the EU than in the whole sample: 26 percent versus 21 percent for stocks and 70 percent versus 60 percent for bonds. Although global factors have more influence within the EU than worldwide, allowing nation-specific factors produces a smaller increase in explanatory power: 7 percent for stocks and 23 percent for bonds. Both the larger global component and the smaller increase from allowing nation-specific factors indicate that the EU is more integrated than the world generally.

The marginal explanatory power of each factor is measured in two ways. Table 3 presents the explanatory power of each factor used alone and the increase in explanatory power resulting from adding a factor to a model that already includes all the other factors.[5] Both measures of marginal explanatory power point to the market factor and shift factor as the main sources of risk for stocks and bonds, respectively. Used alone, the market factor explains 18 percent of stock returns globally and 37 percent nationally, on average. Used alone, the shift factor explains 91 percent of bond returns nationally, on average, and 59 percent globally.

Table 2. Explanatory Power of Global and Nation-Specific Models

	Stocks		Bonds	
Sample	Coefficient	Number of Months	Coefficient	Number of Months
Global				
Worldwide	0.214	112	0.603	112
European Union only	0.261	112	0.695	112
Nation specific				
Worldwide	0.347	112	0.957	112
European Union only	0.332	112	0.923	112
Australia	0.384	112	0.971	85
Belgium	0.505	112	0.946	56
Canada	0.186	61	0.976	108
Denmark	0.375	112	0.954	99
France	0.419	112	0.960	92
Germany	0.490	112	0.942	88
Italy	0.542	112	0.916	39
Japan	0.448	112	0.942	98
The Netherlands	0.494	112	0.948	102
Spain	0.428	112	0.830	56
Sweden	0.520	112	NA	2
United Kingdom	0.406	112	0.898	91
United States	0.305	112	0.980	112

NA = not available.

Table 3. Marginal Explanatory Power of Each Factor Used Alone and Added to Model Using All Other Factors

Model	Market	Size	Value	Stock Duration	Shift	Twist
			Factors Used Alone			
Global	0.184	0.143	0.073	0.153	0.586	0.308
Nation specific						
Australia	0.314	0.181	0.183	0.125	0.939	0.202
Belgium	0.452	0.260	0.141	0.388	0.924	0.272
Canada	0.116	0.119	0.093	0.104	0.943	0.379
Denmark	0.293	0.166	0.207	0.262	0.929	0.094
France	0.383	0.255	0.169	0.311	0.926	0.460
Germany	0.455	0.322	0.164	0.392	0.916	0.339
Italy	0.511	0.385	0.200	0.365	0.899	−0.035
Japan	0.402	0.351	0.325	0.381	0.931	0.668
The Netherlands	0.425	0.398	0.326	0.360	0.927	0.368
Spain	0.371	0.308	0.187	0.281	0.815	−0.093
Sweden	0.420	0.239	0.214	0.295	NA	NA
United Kingdom	0.370	0.321	0.160	0.280	0.864	0.561
United States	0.275	0.236	0.112	0.222	0.956	0.520
Average	0.368	0.272	0.191	0.290	0.914	0.311
			Factors Added to Model			
Global	0.028	0.006	0.005	0.015	0.294	0.016
Nation specific						
Australia	0.065	0.017	0.027	0.016	0.769	0.032
Belgium	0.077	0.017	0.001	0.030	0.674	0.022
Canada	0.022	0.018	0.023	0.009	0.597	0.032
Denmark	0.043	0.014	0.035	0.022	0.860	0.024
France	0.056	0.009	0.011	0.011	0.500	0.034
Germany	0.049	0.013	0.008	0.012	0.604	0.027
Italy	0.052	0.016	0.007	0.009	0.951	0.017
Japan	0.016	0.031	0.006	0.004	0.374	0.011
The Netherlands	0.036	0.020	0.024	0.015	0.580	0.021
Spain	0.065	0.020	0.022	0.009	0.923	0.015
Sweden	0.084	0.013	0.025	0.033	NA	NA
United Kingdom	0.038	0.016	0.009	0.005	0.337	0.034
United States	0.034	0.007	0.005	0.012	0.460	0.024
Average	0.049	0.016	0.016	0.014	0.627	0.024

NA = not available.

The stock duration and size factors have roughly equal importance for stock returns. Value is the weakest factor, explaining only 7 percent of stock returns globally and 19 percent nationally, on average, when used alone.

RELATIONSHIPS BETWEEN THE FACTORS

The correlations between the factors provide an indication of the links between the types of pervasive risk. Table 4 shows these correlations for the global factors, and Table 5 shows the average correlations for nation-specific factors. In both tables, the correlations that are significantly different from zero with 95 percent confidence are marked with an asterisk.[6]

We observed a negative correlation between the market factor and value factor in stocks both globally and nationally. This negative correlation means that a value portfolio that is hedged against the other factor exposures will outperform when the market falls. The value factor and stock duration factor are positively correlated on a global level; the correlation is also positive on a national level but is not statistically significant. The market and stock duration factors are negatively correlated both nationally and globally.

The correlation between the two bond market factors is not economically meaningful because it is dependent on the "midpoint" of the term structure defining the twist exposures. To fit the factor model best, the midpoint should be chosen so that this correlation is not too large in magnitude. A too-low value for the midpoint induces negative correlation between the shift and twist factors; a too-high value induces positive correlation. Because the global correlation is slightly negative and the average national

Table 4. Correlations of the Global Model Factor Returns

Factor	Market	Size	Value	Stock Duration	Shift	Twist
Market	1.000	0.097	–0.274*	–0.196	0.350	0.014
Size		1.000	–0.286	0.119	0.079	–0.093
Value			1.000	0.223*	–0.259*	0.006
Stock duration				1.000	–0.064	–0.134
Shift					1.000	–0.111
Twist						1.000

*Significant at the 5 percent level.

Table 5. Averages across Countries of the Correlations of the Factor Returns in the Nation-Specific Model

Factor	Market	Size	Value	Stock Duration	Shift	Twist
Market	1.000	0.190*	–0.355*	–0.253*	0.408*	–0.043
Size		1.000	–0.079	0.027	0.058	–0.040
Value			1.000	0.179	0.038	0.038
Stock duration				1.000	–0.020	–0.024
Shift					1.000	0.055
Twist						1.000

*Significant at the 5 percent level.

correlation is slightly positive, the choice of four years as the midpoint seems appropriate.

Lastly, we considered the correlations between the stock market factors and the bond market factors. These correlations reflect interactions between two asset classes that are usually analyzed separately. As expected, we found that the market factor in stocks has a strong positive correlation with the shift factor in bonds. This comovement is observed homogeneously at both national and global levels. Bond and stock markets tend to move together, and this interaction is captured by the correlation between their dominant risk factors.

It is revealing that the bond market shift factor and the stock market duration factor have a slight *negative* correlation, showing that theoretically defined stock duration has no useful relationship to interest rate sensitivity. For bonds, interest rate sensitivity and duration (value-weighted time to maturity) are empirically very close substitutes; for stocks, they are not.

WORLDWIDE INTEGRATION OF SECURITY MARKET RISK

The results in Table 2 indicate a large global component to stock and bond market returns. They also reveal that the level of international integration is stronger across bond markets than across stock markets and stronger within the EU than worldwide. An examination of the cross-country correlations of the factors from the nation-specific model allowed us to refine this analysis. If a particular factor is mostly "global" in nature, then these cross-country correlations, shown in Tables 6 and 7, should be high.

Table 6 shows the average of the cross-country correlations for each factor and the percentage of these correlations that are positive. The market and shift factors have the highest average cross-national correlations at about 31 percent and 49 percent, respectively. All correlations between market factors are positive. For the shift factor, 92 percent of the correlations worldwide and 100 percent within the EU are positive.

Table 6. Average Correlation of Each Factor across Countries in the Nation-Specific Model

	Worldwide Sample		European-Union-Only Sample	
Factor	Average Correlation	Percentage Positive Correlations	Average Correlation	Percentage Positive Correlations
Market	0.306*	100.0	0.378*	100.0
Size	0.086	76.9	0.112	78.6
Value	0.007	55.1	–0.012	42.9
Stock duration	0.016	53.8	0.017	60.7
Shift	0.485*	92.3	0.599*	100.0
Twist	0.238*	78.2	0.309*	100.0

*Significant at the 5 percent level.

Table 7. Correlations of Each Country's Factors with Those from Germany, Japan, and the United States

Factor	Australia	Belgium	Canada	Denmark	France	Germany	Italy	Japan	The Netherlands	Spain	Sweden	United Kingdom	United States
Market													
Germany	0.438*	0.378*	0.127	0.378*	0.509*	1.000	0.375*	0.148	0.374*	0.388*	0.177	0.345*	0.288*
Japan	0.061	0.215*	0.335*	0.108	0.309*	0.148	0.312*	1.000	0.136	0.375*	0.220*	0.275*	0.296*
United States	0.332*	0.349*	0.382*	0.265*	0.417*	0.288*	0.285*	0.296*	0.412*	0.345*	0.174	0.635*	1.000
Size													
Germany	0.065	0.078	0.023	0.164	0.256*	1.000	0.056	0.038	0.191*	0.079	0.111	0.203*	0.019
Japan	–0.175	0.211*	0.153	–0.046	0.135	0.038	0.181	1.000	0.160	0.153	–0.040	0.199*	–0.139
United States	0.046	0.039	0.174	–0.154	0.218*	0.019	–0.054	–0.139	0.038	0.120	0.041	0.174	1.000
Value													
Germany	0.129	–0.008	–0.184	–0.022	–0.037	1.000	–0.169	0.043	0.071	–0.072	0.197*	–0.120	–0.112
Japan	–0.020	–0.131	0.087	–0.149	–0.023	0.043	–0.079	1.000	0.037	0.018	0.006	–0.057	0.022
United States	–0.051	0.003	0.281*	0.000	0.263*	–0.112	0.052	0.022	0.230*	0.090	0.024	0.147	1.000
Stock duration													
Germany	0.105	–0.080	–0.098	0.107	0.267*	1.000	0.083	0.131	–0.133	0.150	0.149	0.025	0.149
Japan	0.059	–0.048	0.090	–0.051	–0.112	0.131	0.101	1.000	–0.036	0.000	–0.005	0.151	0.076
United States	0.159	0.028	0.062	–0.075	0.053	0.149	–0.078	0.076	–0.056	–0.021	–0.123	–0.001	1.000
Shift													
Germany	0.387*	0.774*	0.403*	0.583*	0.783*	1.000	0.561*	0.522*	0.960*	0.394*	—	0.625*	0.458*
Japan	0.165	0.527*	0.397*	0.248*	0.418*	0.522*	0.360*	1.000	0.511*	0.129	—	0.497*	0.470*
United States	0.367*	0.289*	0.688*	0.283*	0.397*	0.458*	0.173	0.470*	0.450*	0.116	—	0.441*	1.000
Twist													
Germany	0.155	0.570*	–0.068	0.172	0.515*	1.000	0.186	0.103	0.566*	0.250	—	0.259*	0.048
Japan	0.142	0.062	0.080	0.155	0.317*	0.103	–0.149	1.000	0.133	0.014	—	0.161	0.032
United States	0.408*	–0.053	0.243*	0.082	–0.049	0.047	–0.092	0.032	0.094	–0.146	—	0.197	1.000

*Significant at the 5 percent level.

As shown previously by Capaul, Rowley, and Sharpe (1993), the value factor is very nation specific. The average correlation is very close to zero, and only about half of the correlations are positive. The stock duration and size factors also appear to be mostly nation specific.

For all factors but value, average correlation is higher and the percentage positive is higher within the EU than worldwide. This result confirms our earlier finding from Table 2 that EU capital markets are more integrated than those in the world at large.

We refined our analysis by examining the correlation of each country's factors with those of Germany, Japan, and the United States. The results are shown in Table 7. Germany and the United States were chosen to represent the core of two geopolitical blocs: the EU and North America. One would expect correlations between countries within these two geopolitical blocs to be higher than worldwide. Japan provides a counterpoint because it is a large economy not affiliated with either the EU or North American geopolitical bloc.

For the market and shift factors, all the correlations between Germany and other EU countries are positive and significant.

As expected from the results in Table 6, the correlations between value factors are low both within the EU and worldwide. Value is the only factor for which the correlation between Germany and France (the "twin pillars" of the EU) is not significantly positive. The only case of a reliably positive value correlation might be between the United States and Canada. These two national markets are so closely integrated that even this (generally very local) stock market factor is correlated between them.

Correlations between market factors are generally high and significant. The U.S. market factor has a significant positive correlation with the market factor from all countries except Sweden.

In contrast with the higher correlations generally observed between Germany and the EU and between the United States and Canada, the correlations with Japan are generally lower than average. For the market factor, 8 out of 12 correlations with Japan are below the worldwide average. For the shift and twist factors, 7 and 10 out of 11 correlations, respectively, are below the worldwide average.

The evidence from Tables 6 and 7 confirms our previous findings from Table 2 that the EU stock and bond markets form a geopolitical bloc within which integration is stronger than worldwide. The same holds for the United States and Canada. We found (again as in Table 2) that bond market factors are more international than stock market factors. Most of the international correlation of stocks comes from the positive correlations of the market factors. The value factor is notable for its particularly weak cross-national correlations.

EXCHANGE RATE RETURNS AND STOCK AND BOND MARKET FACTOR RETURNS

In the analysis above, stock and bond returns are measured in local currencies and in excess of the local risk-free return. Working with local-currency excess returns is desirable for two reasons. First, it removes the distorting effects of currency changes and so allows clearer analysis of the worldwide comovements in stock and bond market returns. Second, it conforms to best practice, which views the currency decision as an independent "overlay" on stock and bond decisions made in fully hedged terms (e.g., see Gastineau 1995). (Because of covered interest parity, excess local-currency returns are equivalent to fully hedged returns.)

We rounded out the analysis by relating the stock and bond market risk factors to exchange rate movements. For each country, we calculated the realized local-currency return to a basket of foreign currencies, with the basket weights proportional to each foreign country's national income. We call this amount the foreign exchange return.[7]

Table 8 shows the correlations between each country's foreign exchange return and its domestic stock and bond market factors. Only 18 of the 76 correlations are significant, and the correlations across countries or across factors have no consistent pattern. France, Japan, and the United States show the most significant coefficients, but the signs and magnitudes of the coefficients are too variegated to suggest any meaningful interpretation. As a general conclusion from Table 8, the relationship between the stock and bond market factors and foreign exchange returns showed few, if any, reliable patterns. This finding justifies the approach taken throughout this study: The currency investment decision is best viewed separately from the stock and bond selection decision. Because local stock and bond market returns and currency movements have no reliable patterns of correlation, the global stock and bond decisions are best analyzed in local currency terms, and the currency decision should be studied separately.

CONCLUSION

The global portfolio management problem is multidimensional. It includes decisions on country allocation; stock versus bond allocation; and allocation across asset risk characteristics such as duration, size, and value, and individual asset selection.

Table 8. Correlations between Foreign Exchange Returns and National Factor Returns

Country	Market	Size	Value	Stock Duration	Shift	Twist
Australia	–0.291*	–0.072	0.002	–0.230*	–0.067	0.194
Belgium	0.215*	–0.225*	–0.067	0.000	0.219	–0.007
Canada	0.172	0.190	–0.241	–0.201	–0.173	–0.213*
Denmark	0.269*	0.063	–0.172	–0.050	0.036	0.014
France	0.138	–0.060	0.187*	0.125	0.257*	0.296*
Germany	0.118	–0.144	0.157	0.096	0.082	0.115
Italy	0.028	0.104	–0.041	–0.142	–0.026	0.059
Japan	–0.227*	0.003	0.360*	0.189*	–0.338*	–0.044
The Netherlands	0.226*	–0.111	0.147	0.120	0.062	0.051
Spain	0.102	0.054	–0.127	0.051	0.130	0.128
Sweden	0.056	0.012	0.144	0.008	NA	NA
United Kingdom	0.095	–0.086	–0.044	0.029	0.049	0.326*
United States	–0.042	0.230*	–0.214*	–0.109	0.200*	0.152
Average	0.066	–0.003	0.007	–0.009	0.036	0.089

*Significant at the 5 percent level.

NA = not available.

The main attraction of a global stock and bond model is that it can help harmonize the investment decision process across all those dimensions. Such a model can provide a common framework for measuring risk and predicting return. Different types of assets in various countries can be analyzed within this single framework, and the work of country analysts, local portfolio managers, and the asset allocation committee thereby can be made more coherent.

Using six simple and intuitive factors, we built a worldwide factor model of stock and bond returns. The global version of the model explains 21 percent of the return of the typical stock and 60 percent of the return of a typical bond. The two dominant factors, shift for bonds and the market factor for stocks, also happen to be the most global influences on stocks and bonds. Global asset allocation should weigh the global influence of these two factors against the diversifying potential of more local influences such as value, size, or twist.

Portfolio managers should take account of geopolitical blocs, within which a higher level of integration holds than worldwide. The two geopolitical blocs examined in this study are the EU and North America (represented by Canada and the United States). Within each of these blocs, cross-national correlations of the factors are higher than between blocs, so that a more "regional" perspective is appropriate, particularly within bond markets.

Currency returns have no stable, reliable patterns of correlation with stock and bond market factor returns. The currency investment decision is best studied independently from the stock and bond investment decision because the influences on currency returns are quite distinct from those on stock and bond returns.

APPENDIX

We estimated the factor returns using a standard procedure. For each month, we regressed the cross-section of asset excess returns against the cross-section of factor exposures; the resulting regression coefficients are the factor returns for that month. We estimated the regressions separately for stocks and bonds. For the global model, the regression equations for stocks and bonds are

$$r_i = 1 \times f_{\text{mkt}} + \text{SIZE}_i \times f_{\text{size}} + \text{VALUE}_i \times f_{\text{value}} + \text{SDUR}_i \times f_{\text{sdur}} + \varepsilon_i \text{ for stocks;}$$

$$r_i = \text{SHIFT}_i \times f_{\text{shift}} + \text{TWIST}_i \times f_{\text{twist}} + \varepsilon_i \text{ for bonds.}$$

For the worldwide sample, these cross-sectional regressions include all stocks and bonds for which we have data in a given month, whereas for the EU-only sample, the regressions are limited to those securities in the eight EU member states.

For the nation-specific model, we allowed the factor returns to differ among each of the C countries in the sample (in particular, C = 13 for the worldwide sample and C = 8 for the EU sample):

$$r_i = \sum_{c=1}^{C} d_{i,c}(1 \times f_{\text{mkt},c} + \text{SIZE}_i \times f_{\text{size},c} + \text{VALUE}_i \times f_{\text{value},c} + \text{SDUR}_i \times f_{\text{sdur},c}) + \varepsilon_i \text{ for stocks; and}$$

$$r_i = \sum_{c=1}^{C} d_{i,c}(\text{SHIFT}_i \times f_{\text{shift},c} + \text{TWIST}_i \times f_{\text{twist},c}) + \varepsilon_i \text{ for bonds.}$$

The dummy variable $d_{i,c}$ equals 1 if stock or bond i is in country c, and 0 otherwise.

The explanatory power is 1 minus the ratio of the average unexplained variance to average total variance; thus,

$$EP = 1 - (DF)\frac{\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{\varepsilon}_{i,t}^{2}}{\sum_{i=1}^{N}\sum_{t=1}^{T}(r_{i,t}-\bar{r}_i)^2},$$

where $\bar{r}_i = \frac{1}{T}\sum_{t=1}^{T} r_{i,t}$.

The variable DF is a degrees of freedom correction that equals the total number of observations divided by the total number of observations minus the number of estimated factor returns. For asset return factor models, this measure of explanatory power is superior to the more conventional R^2 measure, as pointed out in earlier work (see Connor 1995 and Beckers et al. 1996). We also calculated explanatory power for each individual country, using the estimates from the nation-specific model and restricting the cross-sectional sample to the stocks or bonds in a single country.[8]

NOTES

1. For more details on cash flow allocation in this bond database, see BARRA (1991).
2. For the original results, see Macaulay (1938). For a modern treatment, see Chapter 21, Elton and Gruber (1995).
3. See Fama and French (1993), who showed that in a multifactor model such as ours, individual stock market betas differ very little from 1. Imposing the prior assumption that all market betas equal 1 eliminates a large amount of estimation error from the market betas (because we need not use time-series regression to estimate them) and sacrifices very little accuracy in the model.
4. Although Sweden is at present a member of the EU, we did not include it in our EU sample because it was not a member for most of the time period studied. The eight EU countries included in our sample are Belgium, Denmark, France, Germany, Italy, the Netherlands, Spain, and the United Kingdom. We use the term "global model" regardless of the estimation universe. "Regional model" would be a more accurate term in the case of the EU-only estimation universe.
5. For a detailed discussion of this approach to measuring the power of individual factors, see Connor (1995).
6. We used the standard large-sample approximation to the distribution of a time-series estimated correlation coefficient. That is, given that that true correlation is zero, the estimated correlation coefficient is approximately normally distributed with mean equal to zero and standard error equal to 1 over the square root of the number of time-series observations. For example, with 112 months of data, to be significantly different from zero with 95 percent confidence, a correlation coefficient must have absolute value greater than 0.185. We used the same test for averages of correlation coefficients (as in Table 5), which is conservative because averaging tends to lower the true standard error.
7. For each month in a given year, we used the previous year's gross domestic product, measured in U.S. dollars at the end-of-December exchange rate. Gastineau (1995) suggests adding the difference between the local and foreign risk-free returns to the currency returns. For correlation analysis, including the difference between the risk-free returns has no meaningful effect on the results. For simplicity, therefore, we show the results using pure currency returns and ignoring differences in risk-free returns.
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