WHY INTEREST RATES MOVE THE WAY THEY DO

Applying generally-held beliefs about interest rate movements to risk-management and pricing methodology can be dangerously at odds with what is really happening in the marketplace. KELLY AU and JUNKO YAMAMURA explain.

Interest rates with different maturities (for example, three months, six months, nine months, one year, ... 10 years), although related to each other, do not necessarily move with the same magnitude or even in the same direction. Many institutions postulate that changes affecting rates for different maturities can be decomposed into a collection of independent factors. Empirical evidence for this claim can be found in Carverhill and Strickland (1992) for sterling, and Litterman and Scheinkman (1991) for the US dollar.

Standard market practice assumes two significant factors which cause movement in interest rates. These factors take the form of a parallel shift (all rates shift up or down by an equal amount) and a twist (shorter maturities and longer maturities move in opposite direction). If this is the case, one can ask:

- For a given set of rates, what percentage of the rate movements can be explained by the parallel shifts?
- What percentage can be explained by the twists?
- Where on the time line do the twists occur?
- Are the shifts really parallel?
- More important, how useful is this information to risk-management and fixed-interest instrument pricing?

We answer these questions by modelling interest-rate movements in the two-factor setting of the shift and twist. The factors move randomly and are independent of each other. Each drives the rate movements with different magnitudes (amounts of driving force). Precise profiles and magnitudes of these factors are established from market data by using the statistical techniques of principal component analysis (PCA). The two-factor model not only provides the profiles of the shifts and twists, but also the percentage of contribution to the rate variations.

In the context of risk management, a data-driven risk measure can be established by "shocking the rates" at magnitudes and directions suggested by the profiles and recalculating the dealers' positions with these shocked rates. (This term means assumed changes in rates.)

In fixed-interest instrument pricing, the volatility functions of the forward rate movements in several versions of the Heath, Jarrow and Morton (HJM) (1992) model are estimated by applying PCA.

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Specifically, the magnitudes of these two factors are historical estimates of the volatility functions.

We use PCA to generate monthly profiles for Australian zero and forward rate movements, as well as the factors’ percentage of contribution to the movements. We also relate the profiles to the rate correlations.

DATA AND EXAMPLE

The 90-day zero and forward rates (3-month, 6-month, 9-month, 1-year, ... 10-year) are established from bill, futures and swap rates. This is accomplished by the smoothing algorithm developed by Frishling, Kameron and Stramandinoli (1994). For each month from January to June 1994, the daily proportional changes of yield and forward rates are interpreted by the profiles obtained from PCA.

The January-June 1994 period is simply the period of the study. It was not deliberately selected because it happened to be a period of sharp movements in interest rates.

To illustrate, we consider the daily proportional changes of the yield and forward rates in April 1994. In Figure 1, the first factor represents the “parallel shift”. In contrast to exact parallel shifts, the variation increases for two-and-a-half years at the short end. This phenomenon occurs consistently in the data sets from January to June 1994.

The second factor (the twist) changes sign at 5.25 years. This phenomenon corresponds to the twist of the yield curve. While the two-factor model explains 99 per cent of the movements, the first factor explains 98 per cent; the second factor explains only 1 per cent.

In the context of risk management, the yield should be shocked cautiously by using the data-driven magnitudes and twists as guidelines. Figure 1 demonstrates that one should apply shock values for short rates significantly less than those for longer rates.

Figure 2 provides the variation profiles for forward rates. The profiles are very different from those of yields. They only explain 89 per cent of the forward rate variations. The first factor is in a “shift” pattern of different magnitudes. The second factor changes direction at several maturities. The magnitudes of the factors are empirical estimates of volatility functions in fixed interest instrument pricing in the HJM model.

FORWARD RATE CORRELATIONS

From the matrix of correlations among the 0.25, 0.5, 0.75, 1, ... 10-year forward rates, Figure 3 demonstrates the correlations of 0.25 and 2.5-year rates with other rates. Note that both rates perform similarly. For example, both are more correlated with the 7.5-year than with the 6.25-year rate. This correlation relationship is preserved when we look at Figure 2. For
example, the 2.5-year rate moves in a similar magnitude and direction to the 7.5-year rate in both factors, while the 2.5-year and 6.25-year rates move in different magnitudes in the first factor, and opposite directions in the second factor. Thus, the two-factor rate movements can also explain the correlations.

In Figure 4, we demonstrate the correlation between short and long rates. The correlation coefficients of 3 and 5-year, 3 and 7-year, and 3 and 10-year rates are selected to be plotted against each month (from January to June 1994). We note that 3 and 5-year rates are more closely correlated than 3 and 10-year and 3 and 7-year rates. While the correlation of 3 and 5-year rates is stable over time, the correlations with longer maturities (7 and 10-year) drop in May.

CONCLUSIONS

This article generates monthly profiles, empirical magnitudes and directions of rate variations via the statistical techniques of PCA. In contrast to generally held market beliefs, this analysis shows that the main contributing factor of Australian interest rate movements is not parallel shift.

Rather, the parallel shift only applies after maturities beyond 2.5 years, since for shorter maturities the variation increases considerably with the maturity date.

Moreover, "twists" are not very important in explaining yield movements (only 1 per cent of the explanation) but have slightly more explanatory power for forward rate movements (8 per cent of the explanation).

REFERENCES


