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Miscellany

Pricing Quanto Equity Swaps in a Stochastic Interest Rate Economy

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Abstract

This paper derives a pricing model for a quanto foreign equity/domestic floating rate swap in which one party pays domestic floating interest rates and receives foreign stock returns determined in the foreign currency, but is paid in the domestic currency. We use the risk-neutral valuation technique developed by Amin and Bodurtha to generate an arbitrage-free pricing model. A closed-form solution is obtained under further restrictions on the drift rates of the asset price processes. Pricing formulae show that the value of a quanto equity swap at the start date does not depend on the foreign stock price level, but rather on the term structures of both countries and other parameters. However, the foreign stock price levels do affect the swap value times between two payment dates. The numerical implementations indicate that the domestic and foreign term structures, the correlation between the foreign interest rate and the exchange rate, and the correlation between the exchange rate and the foreign

stock are more important factors in pricing a quanto equity swap than other correlations.

Keywords:

Equity swaps | term structure of interest rates | risk-neutral valuation | arbitrage-free pricing model

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Notes

In this article, the ‘domestic’ setting is where the investor lives and receives his/her payoff. For example, to a US investor, US dollar and S&P 500 are his/her domestic currency and equity index, respectively.

In other words, the exchange rate between the US dollar and Japanese Yen during the whole life of the swap is set initially to be one.

Chance and Rich (1998) price cross-currency equity swaps in which a party pays a domestic equity return and receives a return on a foreign index. The valuation problem considered in their paper is relatively simple, because the foreign index returns are converted into the domestic currency using a floating exchange rate. By contrast, we consider a fixed exchange rate (quanto) effect on the equity swap pricing in this paper.

It should be noted that a superscript * indicates that the variable is denominated in the foreign currency.

The values of the drifts $\alpha_d(t, T,.)$, $\alpha_f(t, T,.)$, $\alpha_s(t,.)$, and

under the

measure are shown in Lemma 1.

This assumption implies that both the domestic and foreign interest rates are normally distributed. Kijima and Muromachi (2001) make the same assumption so as to derive closed-form solutions for other types of equity swaps.

Under this assumption, the HJM model corresponds to the spot rate (extended-Vasicek) model of Hull and White (1990) with mean-reversion coefficients k_d (domestic) and k_f (foreign).

The properties of lognormally distributed variables used here are that the followings hold for normally distributed variables x and y:

Please see the Appendix for the key steps of the derivations.

As pointed out by the referee, this is a simple consequence of the fact that the payment of the equity leg is defined as a ‘return’ over two consecutive payment dates. If it is defined in the other ways, e.g. a ‘return’ from the beginning date to the payment date, the results will be different.

The difference is due to the fact that the payment at time t_i on the foreign leg is predetermined at time t_{i-1} for a differential swap, while it is determined at time t_i for an equity swap.

As pointed out by the referee, the pricing duality is useful only under one foreign equity case. For swaps or options written on baskets of foreign assets in many countries, the duality property becomes irrelevant.

Remenber that our analyses are based on the viewpoint of an investor who pays domestic floating rates and receives foreign equity returns.

It should be noted that cash flows other than the first one after time t can still be priced by equation (7) since the equity leg is defined as a ‘return’ over two consecutive payment dates.

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