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Stochastic risk premiums, stochastic skewness in currency options, and stochastic discount factors in international economies ☆

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Abstract

We develop models of stochastic discount factors in international economies that produce stochastic risk premiums and stochastic skewness in currency options. We estimate the models using time-series returns and option prices on three currency pairs that form a triangular relation. Estimation shows that the average risk premium in Japan is larger than that in the US or the UK, the global risk premium is more persistent and volatile than the country-specific risk premiums, and investors respond differently to different shocks. We also identify high-frequency jumps in each economy but find that only downside jumps are priced. Finally, our analysis shows that the risk premiums are economically compatible with movements in stock and bond market fundamentals.

JEL classification: G12; G13; F31; C52

Keywords: Stochastic discount factors; International economy; Stochastic risk premium; Stochastic skewness; Currency options; Foreign exchange rate dynamics; Time-changed Lévy processes; Unscented Kalman filter

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1. Introduction

At the core of financial economics is to infer the dynamic structure of stochastic discount factors, which determines how investors price various sources of risks differently. In particular, because the ratio of the stochastic discount factors in two economies governs the exchange rate between them, the exchange rate market offers a direct information source for assessing the relative risk-taking behavior of investors in international economies. Exploiting this link, Brandt and Santa-Clara (2002) gauge the degree of market incompleteness and estimate the risk premium dynamics using the time series of a currency pair and its short-term at-the-money option implied volatility. Brandt, Cochrane, and Santa-Clara (2006) compare the stock portfolio return variance with the variance of the exchange rate to analyze the degree of international risk-sharing between two economies. They find that, compared with the large return variance on stock portfolios, the currency return variance is small, which could be an indication of a high degree of international risk-sharing or an anomaly by itself.

In this paper, we propose to identify the multi-dimensional structure of stochastic discount factors in international economies using the time series of currency returns and option prices. Specifically, using three currency pairs that form a triangular relation, i.e., dollar–yen, dollar–pound, and yen–pound, we study the dynamic behaviors of the stochastic discount factors and stochastic risk premiums in the three economies: the US, Japan, and the UK.

Compared with the extant literature, we make contributions in several dimensions. First, instead of trying to identify the stochastic discount factors in two economies using one currency pair, we identify the stochastic discount factors in three economies using three currency pairs that form a triangular relation. Exploiting the currency triangle facilitates identification of the stochastic discount factors and enables us to draw a sharper distinction between the risk premium dynamics on global versus country-specific risks. Second, we make full use of currency options data across all available strikes and maturities underlying all three currency pairs through an option pricing model that is internally consistent with our stochastic discount factor specification across the three economies. Third, our stochastic discount factor specification incorporates a realistic jump structure that not only allows differential pricing for upside and downside jumps, but also accommodates a wide variety of jump behaviors, ranging from the compound Poisson jumps used in traditional studies (e.g., Merton, 1976) to infinite-activity jumps that can arrive an infinite number of times within any finite time interval. Fourth, our model accommodates stochastic risk premiums from both the global and the country-specific risk components in each economy, and it generates stochastic skewness in the currency return distribution, both of which are salient features of the currency and currency options market.[1]

Given our stochastic discount factor specification, we derive currency return dynamics and price options on the three currency pairs analytically. By casting the theoretical model into a state-space form, we estimate the model parameters and extract the global and country-specific risk premium rates from the time series of currency returns and option prices. Through model estimation, we empirically study how the risk premiums of an economy react differently to shocks on different types of risks.

Our estimation reveals several results about the structure of risk premiums in the three economies. First, during our sample period, the average risk premium in Japan is significantly higher than the average risk premium in the US or the UK. Second, risk premiums on the global risk component and the country-specific risk components show distinct dynamics. The risk premium rate on the global risk factor is both more persistent and more volatile than the risk premium rate on the country-specific risk factors. Third, investors respond to global and country-specific shocks differently. Investors increase their risk premium when the country-specific risk receives a negative shock. In contrast, the risk premium declines when the global risk component receives a negative shock.

Estimation also shows that, to capture the currency return dynamics and to generate realistic currency option pricing behaviors, it is crucial to incorporate a high-frequency jump component in the stochastic

[1]Many studies show strongly time-varying currency risk premiums, e.g., Fama (1984), Bekaert and Hodrick (1992), McCurdy and Morgan (1992), Dumas and Solnik (1995), Saá-Requejo (1995), Engel (1996), Bansal (1997), Backus, Foresi, and Telmer (2001), Brandt and Santa-Clara (2002), Brandt, Cochrane, and Santa-Clara (2006), and Brennan and Xia (2006). Most recently, Carr and Wu (2007) find that the risk-neutral currency return distribution inferred from currency options shows strongly time-varying skewness.