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Was it risk? Or was it fundamentals? Explaining excess currency returns with kernel smoothed regressions

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ABSTRACT

This paper uses recently developed kernel smoothing regression procedures and uniform confidence bounds to investigate the forward premium anomaly. These new statistical methods estimate the local time-varying slope coefficient of the regression of spot returns on the lagged interest rate differential. Uniform confidence bands are used to test when uncovered interest parity is violated. The estimated betas in the forward premium smoothed regression are found to vary substantially over time and to be partially explicable in terms of lagged fundamentals and money growth volatilities arising from risk premium. Frequentist model averaging procedures indicate the relative importance of these variables in terms of explaining movements in the betas and hence the apparent causes of regimes where *UIP* fails.

1. Introduction

One of the long standing issues in international finance has been the apparent failure of the theory of uncovered interest rate parity (*UIP*). The classic method for testing *UIP* is to estimate the slope coefficient in a regression of spot returns on the lagged forward premium, or equivalently, the lagged interest rate differential. While the slope coefficient should be unity under *UIP*, most studies have found statistically significant rejections of the *UIP* hypothesis, with the slope coefficient estimate invariably being quite large and negative. This has become known as the *forward premium anomaly*. Hence most research has been directed at understanding the reasons for the apparent rejection of *UIP* and to try to account for it in terms of (i) time dependent risk premium, (ii) irrational agents and segmented markets, (iii) peso problems, or (iv) econometric issues with the testing of *UIP*. The dominant approach has been to explain the phenomenon by modeling a time dependent risk premium. Overall, this approach has not been particularly successful empirically.

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The theory of *UIP* under rational expectations and a constant risk premium implies that

$$E_t(\Delta s_{t+1}) = (f_t - s_t) = (i_t - i_t^*) \quad (1)$$

is always an approximation which neglects the Jensen inequality terms, and possible time dependent risk premium. It has become standard to test the theory from the regression equation

$$\Delta s_{t+1} = \alpha + \beta(f_t - s_t) + u_{t+1}, \quad (2)$$

where the theory of *UIP* implies $\alpha = 0, \beta = 1$ and u_{t+1} being serially uncorrelated.[1] However, an increasing number of studies have come to recognize the fact that departures from *UIP* are more pronounced in some periods than others. The usual way of representing the potential variation in the slope coefficient is by *rolling regressions*, as in Baillie and Bollerslev (2000), Lothian and Wu (2011), etc. Other studies by Wolf (1987) have used Kalman filtering with the β following a random walk or stationary autoregression; while Bansal (1997) and Bansal and Dahlquist (2000) have allowed β to have two states depending on the sign of the interest rate differential; and Baillie and Kilic (2006) use a logistic smooth transition regression to allow the β parameter to move slowly between the two states which correspond to either *UIP* holding,[2] or alternatively a state with the forward premium anomaly being apparent. These parametric specifications for the time series behavior of the slope coefficient over time are necessarily heavily dependent on the parametric specification of the time series process for β_t.

While simple to apply in practice, the rolling regression technique is, however, highly arbitrary in the sense that the number of observations used in the window is very subjective. That is, there is no dependable criterion that one can use in choosing the right window size. The method also tends to produce quite wide confidence intervals from *OLS* regressions but does not allow any clear method for conducting statistical inference between different regressions.

One major novelty in this paper is to introduce the concept of Local Deviation from Uncovered Interest Parity (*LDUIP*), which is the specific amount that the parity condition is violated at each time point and is based on non-parametric and local smoothing techniques developed for the *local-linear regression* introduced by Stone (1977) and by Cleveland (1979). These techniques avoid the problems with rolling regressions and produce kernel smoothed regressions. They also allow *statistical inference* to be conducted on the parameters. The method assumes that the regression parameters are *smoothly varying* functions of time, and circumvents possible abrupt and sudden changes in the parameters. The method also enables the construction of *uniform confidence bands* (*UCB*) of the slope coefficient from its local-linear regression estimate. Hence the slope coefficient of the forward premium regression can be tested for any parametric specification of the unknown function. The generated *LDUIP* process and its associated *UCB* indicate the extent and significance of possible violations of *UIP* at any point of time.

The estimated betas in the forward premium kernel smoothed regression are found to vary substantially over time and an important question concerns the extent to which these variations can be explained in terms of lagged fundamentals and money growth volatilities arising from risk premium. Frequentist model averaging procedures indicate the relative importance of variables explaining movements in the betas and hence the apparent causes of regimes were *UIP* fails. Evidence is presented in Section 4 of the paper that indicates a substantial role for lagged macroeconomic fundamentals and variables associated time risk premium, to have predictive power in explaining the movements of the time varying parameter in the forward premium regression. Given that the *LDUIP* are in some sense "model free", deterministic estimates of the slope parameter in the *UIP* regression, interest focuses on the reasons for the time variation in these coefficients. Various fundamental based explanations and also models based on some models developed to explain time-dependent risk premium are used in a second step analysis, where the generated deterministic β_t are regressed on five different risk premium models, which typically contain estimated second moments, or conditional variances and covariances of some variables associated with previously developed economic models of risk premium. The validity and relative strength of each model is then assesses through a classical frequentist based model averaging based procedure. This method indicates the most likely reason for the breakdown of *UIP* over the whole sample and also for certain sub periods such as the financial crisis.

The organization of the paper is the following: Section 2 introduces the model framework, and the forward premium regression with smoothly varying coefficients is explained. Section 3 then discusses the kernel smoothing regression and the construction of uniform confidence bands (*UCB*) for inference. Section 4 presents the empirical results including the estimates of the time varying, estimated slope coefficients. The *UCBs* determine the precise time and extent of the violation of *UIP* for each currency over the sample period. This section also includes evidence from regression tests and *VARs* on the role of some fundamentals and financial variables that appear

[1] Some studies such as Hansen and Hodrick (1980), Hakkio (1981) and Baillie et al. (1983) tested the theory with overlapping data where the maturity time of the forward contract exceeds the sampling interval of the data. These studies still find rejection of *UIP*.

[2] It should be noted that a more general representation of *UIP* is to begin with a standard discrete time, consumption based asset pricing model where the real returns of the representative investor are $E_t(\frac{S_{t+1}-F_t}{P_{t+1}})(\frac{U'(C_{t+1})}{U'(C_t)}) = 0$, where *S* and *F* are the spot exchange rate and forward rate in levels, *P* is domestic price level and *C* is domestic consumption, and $U'(C_t)$ is the marginal utility of consumption in period *t*. Then,

$$E_t(\Delta s_{t+1}) = (f_t - s_t) - \left(\frac{1}{2}\right) Var_t(\Delta s_{t+1}) + Cov_t(\Delta s_{t+1} p_{t+1}) + \rho_t,$$

where ρ_t is the natural logarithm of the intertemporal marginal rate of substitution and is generally called the "risk premium". The above theory dates back at least to Hansen and Hodrick (1983).