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The Forward Premium Puzzle Across Maturities

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Abstract

This paper tests the forward premium puzzle in a wide range of maturities from 1-day to 5-year. It finds that the forward premium puzzle appears to be most significant for medium maturities, while disappearing for both very short and long maturities.

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1. Introduction

The forward premium puzzle has been extensively studied over the past two decades. The majority of empirical research has employed forward data with medium maturities– mostly 1-month or 3-month. Recently, due to the availability of new data, economists have started examining the puzzle for more unusual maturities. Chinn and Meredith (2004 and 2005) inspected the puzzle with long maturities up to 10-year, while Ding (2007) focused on the short end, examining the puzzle for the maturity of 1-day. The new studies suggest that the existence of the puzzle depends on the maturity of forward rates. However, there has yet to be a study that examines the puzzle based on the data in the same period and in a complete range of maturities to show a clear pattern of the term structure of the puzzle.

This paper adds to the literature by providing such an examination. The data in this study include recent spot and forward rates for several major currencies with the maturity ranging from 1-day to 5-year. The sampling period covers a time frame of over ten years, and all data were taken from the same period,[1] which will greatly facilitate the comparison across maturities. The paper finds that the *beta* in the typical test that regresses the spot exchange rate change on the forward premium is quite different for different maturities. Specifically, the puzzle does not exist for the 1-day maturity, but emerges, and becomes more significant for medium maturities. It once again disappears for long maturities.

These results are consistent with the previous studies and not completely novel. However the paper makes contributions to the literature in the following senses. First, in contrast to the previous studies that only focus on one subset of the maturities, this paper examines the puzzle in the most complete range of maturities, so the results are more continuous and the turning point of each regime can be seen. Second, the results of the previous studies were obtained based on the data of different currencies and from different periods. Instead, this study used the most comparable data across maturities, which contain the observations of same currencies and from the same period, so the pattern displayed in this paper about the term structure of the puzzle is clearer and more reliable. Third, this paper shows the relationship between the R-square of the testing and the maturities, which is often ignored in other studies, while this relationship has great implications for the FX market trading practices.

The empirical findings in this paper suggest that the relationship between the forward rate and the future spot rate is governed by at least three different regimes that are based on the maturities of the forward contracts. Future efforts to search for the explanation of the puzzle should focus on factors that can affect the forward and spot markets differently in various maturities.

The paper is constructed as follows: Section 2 introduces the data and econometric methodology; Section 3 presents the results; and Section 4 concludes.

[1] The data come from two different sources, with the sampling period for 1-day forward rates being shorter than that of other maturities. However, the sampling periods do overlap.

2. Data and methodology

With the exception of the 1-day forward rates that were extracted from DataStream, all data in this study are taken from JP Morgan DataQuery.[2] In order to compare our results with the existing literature, we studied the exchange rate of the U.S. dollar against four other major currencies: the British pound (GBP), Canadian dollar (CAD), Japanese yen (JPY), and Euro (EUR). Spot exchange rates are available daily, together with mid-rate forwards, for the following maturities: 1-day, 1-week, 1-month, 2-month, 3-month, 6-month, 9-month, 12-month, 18-month, 2-year, 3-year, 4-year and 5-year. For 1-day forward rates, the sampling period for CAD and JPY is from 10/27/1997 to 11/15/2004; GBP is from 12/29/97 to 2/11/2005; and EUR is from 1/4/1999 to 11/15/2004. The forward rates for all other maturities are from 1/3/1994 (1/4/1999 for EUR) to 3/26/2007. Weekend rates are excluded, and several missing values are replaced by values from the previous day.

To test the unbiasedness hypothesis of the forward rate in the FX market, the most commonly used method is to regress the following equation:

$$s_{t+\tau} - s_t = \alpha + \beta(f_{t,\tau} - s_t) + \varepsilon_{t+\tau} \quad (1)$$

where $f_{t,\tau}$ is the logarithm of the forward exchange rate with maturity τ at time t, and $s_{t+\tau}, s_t$ are the logarithms of the spot rates at time $t+\tau$ and t respectively. Usually, equation (1) is regressed using OLS with non-overlapping data. However, had we used only non-overlapping forward data – i.e. choosing a representative data point from the beginning of each period, such as every month for the 1-month forward rate or every year for the 12-month forward rate – the sample size would have been greatly reduced for long maturities. Moreover, comparing the puzzle across various maturities would have been less consistent because of the different samples used. On the other hand, using overlapping forward rates must introduce inefficiency to the estimates from OLS. Therefore, we employed the Generalized Methods of Moments (GMM), a method that requires much weaker assumptions and can account for heteroskedasticity and/or serial correlation, to estimate the overlapping data. The weighting matrix used in the estimation is Newey and West (N-W), and the instrument variable is one period lag of explanatory variables.

3. Results

Table 1 reports the estimate of *beta*, the corresponding t-statistic and R-square for each regression. Figure 1 then plots these *beta* estimates for various maturities. Several interesting patterns are evident in both the table and figure. The estimation for the 1-day maturity is strikingly different from the 1-week and other medium maturities. Across the various currency pairs, the *beta* appears to be a positive number near its theoretical value of one for the 1-day maturity. Then beginning with the 1-week observations and continuing through the other medium maturities, there are significant negative coefficients, as has been reported in most previous studies.

[2] JP Morgan's access to their comprehensive database.

The estimations for medium maturities are not a surprise. However, they do show an interesting pattern: as maturity increases, *beta* goes deeper into negative territory. When maturity reaches 12 or 18 months, this negative tendency begins to reverse, as shown clearly in Figure 1. The pattern is quite robust, applying to all currencies except JPY. As the only exception in our study, JPY's *beta* is actually less biased going from 1-week to 2-month, but then reverts to the commonly shared pattern.

As the maturity goes to the long end, the *beta* moves to the right direction and gets closer to its theoretical value across currencies. At the maturity of 5-year, except for EUR, all currencies actually obtain significant positive *beta* and they seem to be around one. Thus, the puzzle is absent for very short and long maturities, but becomes more severe during medium time maturities. As shown graphically in Figure 1, beta and maturity have a U-shaped relationship.

These results of the study are consistent with previous research. Ding (2007) found that the forward premium puzzle disappeared in very short maturities, such as one day. Chinn and Meredith (2004 and 2005) showed that the puzzle does not exist in long maturities, such as 5 and 10 years. Most papers using the medium maturities data reported the existence of the puzzle as well.

Finally, another noteworthy item in the results is the fit of the model in regression (1) measured by R-square, which is reported in Table 1. For all currencies, the R-square is very small for the 1-day maturity, but then increases when the maturity lengthens. R-square reaches its peak at 18-month (12-month for JPY) and then decreases dramatically for all currencies as maturity continues to lengthen. At 3-year (4-year for CAD), R-square reaches a low point, almost as small as (and, in the case of CAD, equaling) the R-square found for the 1-day maturity. After this low point, R-square again increases greatly, with its value at 5-year higher than the peak value found in medium maturities across all currencies except for CAD.

This result has a great practical implication for investors in the FX market. Low R-square for short maturity of 3-month or less is to say, although there is predictable excess return, the risk involved is very large, the returns can swing sign from very positive to very negative in short period of time, discouraging investors to take advantage of the bias of the forward rate. Only in the medium long or very long run, in which case the R-square is relatively high, an investor should expect to use the "carry trade," buying the high interest currency and selling the low interest currency to lock in average positive return. An investor would expect to make more stable excess return using the "carry trade" for forward contracts of longer maturity.

4. Conclusion

This paper examines the forward premium puzzle based on recent data for multiple maturities from one day to five years, finding that 1.) the traditional negative-beta forward premium puzzle does not exist for a 1-day maturity; 2.) the puzzle does not exist for long maturities; 3.) the puzzle is indeed significant for medium maturities, becoming more severe as the maturity increases in that range; and 4.) the R-square also changes for various maturities, usually spiking at maturities of 18-month and 5-year, with low points at 1-day and 3-year maturities.

These results have great implications for the further research of the puzzle: 1.) at least three different regimes – corresponding to short, medium and long time maturities – that govern the relationship between forward and spot rates; 2.) in each regime, the determinants of the relationship may be different, with some determinants being significant for only certain maturities; and 3.) further search for the explanations of the puzzle should focus on the factors that might affect the foreign exchange market and the behavior of investors in different ways for various maturities.

This study finds new patterns concerning the forward premium puzzle, but also raises additional questions – the primary one being why the results are so different for various maturities? Naturally, the next step in this research should be to search for a theoretical explanation.

References

Chinn, M. and G. Meredith (2004) “Monetary policy and long horizon uncovered interest parity” *IMF Staff Papers* 51, 409-430.

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Table 1: Results of beta, t-statistics and R-square

This table reports the results of the following testing equation $s_{t+\tau} - s_t = \alpha + \beta(f_{t,\tau} - s_t) + \varepsilon_{t+\tau}$. The numbers in the parenthesis are t-statistics for the estimate of *beta*. The R-square of the each regression is reported next to the estimate of *beta*.

	CAD		EUR		GBP		JPY	
	Beta	R-square	Beta	R-square	Beta	R-square	Beta	R-square
1-day	0.5810 (2.12)	0.0025	2.4688 (3.68)	0.0088	1.7399 (1.3731)	0.0010	0.4950 (0.4687)	0.0001
1-week	-2.125 (-1.47)	0.003	-4.561 (-2.31)	0.010	-1.212 (-0.62)	0.001	-3.358 (-2.09)	0.005
1-month	-2.456 (-2.25)	0.019	-4.803 (-3.32)	0.050	-1.443 (-0.96)	0.004	-3.107 (-2.49)	0.017
2-month	-2.759 (-3.35)	0.044	-5.022 (-4.66)	0.099	-1.670 (-1.51)	0.011	-2.894 (-3.22)	0.028
3-month	-2.918 (-4.55)	0.076	-5.119 (-5.89)	0.152	-1.791 (-2.10)	0.021	-2.935 (-3.86)	0.041
6-month	-2.986 (-6.62)	0.156	-5.303 (-9.86)	0.346	-1.737 (-2.99)	0.041	-3.055 (-5.90)	0.091
9-month	-3.158 (-8.11)	0.251	-5.398 (-12.05)	0.471	-1.734 (-3.57)	0.058	-3.067 (-8.35)	0.158
12-month	-3.315 (-9.86)	0.327	-5.517 (-13.27)	0.521	-2.012 (-4.41)	0.095	-2.851 (-8.48)	0.166
18-month	-3.453 (-12.89)	0.401	-5.334 (-14.30)	0.573	-2.202 (-4.99)	0.131	-2.085 (-6.66)	0.123
2-year	-3.220 (-11.09)	0.346	-4.660 (-13.26)	0.501	-1.826 (-4.48)	0.096	-1.239 (-4.48)	0.056
3-year	-1.787 (-5.36)	0.118	-2.129 (-5.52)	0.187	-0.510 (-1.50)	0.008	0.327 (1.74)	0.006
4-year	-0.246 (-0.63)	0.0025	-1.444 (-6.53)	0.243	1.409 (4.61)	0.072	1.315 (6.06)	0.183
5-year	1.534 (6.68)	0.1206	-2.466 (-15.24)	0.637	2.516 (16.41)	0.433	1.001 (8.23)	0.172

Figure 1: The estimate of *beta* along maturities