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One-Way Arbitrage-Based Interest Parity: An Application of the Fletcher-Taylor Approach in Short-Date Markets

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Abstract

This study is motivated by two major considerations. First, the Fletcher and Taylor (1996) approach has yet to be applied to *short-date* markets to assess the diminishing role of transaction costs in explaining the deviations of observed forward foreign exchange prices from interest parity forward prices. Second, the role of transaction costs in one-way arbitrage-based interest parity has not been examined. Applying the Fletcher and Taylor approach to one-way arbitrage-based interest parity in short-date capital markets, we document three major findings: (i) a narrower neutral band around interest parity line, as implied by one-way arbitrage, does not diminish the role of transaction costs; (ii) the variances of the estimated deviations are a decreasing function of the time spent outside the transactions cost band; and (iii) the magnitude of arbitrage profits tends to be small and economically insignificant though profitable opportunities are not rare in the short-date markets studied.

One-Way Arbitrage-Based Interest Parity: An Application of the Fletcher-Taylor Approach in Short-Date Markets

I. Introduction

Based on covered interest arbitrage, Frenkel and Levich (1975, 1977) and McCormick (1979) demonstrate that the covered interest parity line is bounded by a neutral band defined by the sum of transaction costs in securities markets (both domestic and foreign) and in foreign exchange markets (both spot and forward). Early empirical studies demonstrate that a large proportion of deviations of actual forward prices from the covered interest rate parity prices are explained by transaction costs.[1]

With equilibrium conditions on both foreign exchange and securities markets recognized, however, Deardorff (1979), Callier (1981), Bahmani-Oskooee and Das (1985), Clinton (1988), and Rhee and Chang (1992) demonstrate that one-way arbitrage narrows the neutral band around the interest parity line more than perceived under covered interest arbitrage. As a result, the role of transaction costs appears diminished in explaining the deviations of observed forward foreign exchange prices from interest parity forward prices.

Bahmani-Oskooee and Das (1985) are the first to examine the diminishing role of transaction costs as implied by the one-way arbitrage. They rely on an ordinary least squares regression model. Recognizing the bias introduced by the Bahmani-Oskooee and Das model against the importance of transaction costs, however, Maasoumi and Pippenger (1989) suggest that an endogenous switching regression model be considered to capture the states of market equilibrium and disequilibrium.

[1] Refer to Frenkel and Levich (1975, 1977), McCormick (1979), Bhamani-Oskooee and Das (1985), Poitras (1988), Woodward (1988), Maasoumi and Pippenger (1989), among others.

Responding to the above suggestion, Fletcher and Taylor (1996) employ an endogenous switching model to examine covered interest parity in long-date currency and securities markets in the five-, seven-, and ten-year maturities. Their approach makes it possible to: (i) conduct formal statistical tests on the frequency and duration of profitable trading opportunities as well as the magnitude of arbitrage profits; and (ii) capture the stabilizing dynamics of the observed deviations in excess of transaction costs over time.[2] Fletcher and Taylor (1996) report that transaction costs account for a sizable proportion of deviations from parity in long-date markets but that arbitrage profit opportunities do exist though they dissipate over time.

This study is motivated by two major considerations. First, the Fletcher and Taylor approach has yet to be applied to *short-date* markets to assess the diminishing role of transaction costs in explaining the deviations of observed forward foreign exchange prices from interest parity forward prices. Although a number of past studies report that a sizable number of actual forward prices are located within the transaction costs band in short-date markets, their analyses have relied on the conventional tests originated by Frenkel and Levich (1975 and 1977).[3] No studies have taken advantage of the Fletcher and Taylor approach to conduct parametric statistical tests on the arbitrage profit opportunities in short-date markets. Second, the role of transaction costs in one-way arbitrage-based interest parity has not been examined. It seems ironical that previous empirical studies have focused on covered interest arbitrage when studying the diminishing role of transaction costs, while ignoring the impact of one-way arbitrage in

[2] They confirm their earlier study's (1994) findings that are built on nonparametric analyses in a similar setting of long-date markets.

[3] See Poitras (1988), Clinton (1988), and Woodward (1988).

reducing the size of the neutral band around the interest parity line.[4] As illustrated in the next section, transaction costs under covered interest arbitrage are the sum of the four component costs in the securities markets and foreign exchange markets, while the magnitude of the transaction costs in one-way arbitrage is smaller than the sum of these four component costs. Hence, detailed analyses are warranted to evaluate the performance of the Fletcher and Taylor approach within the one-way rather than covered interest arbitrage setting.

While applying the Fletcher and Taylor approach to one-way arbitrage-based interest parity in short-date capital markets, this study also improves on past empirical tests in two areas: First, we use a set of real-time data drawn simultaneously from Eurocurrency deposit markets and interbank foreign exchange markets. The use of intraday real-time data allows us to satisfy McCormick's (1979) simultaneity and Aliber's (1973) comparability requirements. Furthermore, the use of real-time data allows us to conduct a more realistic analysis of the lagged effect of transaction costs under a switching regression model than would the use of weekly or daily observations. Additionally, the use of intraday real-time data drawn from Reuters News Service quotations mitigates Fletcher and Taylor's (1996) concern about the reliability of the published data as one source of measurement error. Second, we introduce bid-ask spreads as a proxy for transaction costs to avoid the estimation of transaction costs using triangular arbitrage in the currency markets and using Demsetz's (1968) measure in the securities markets.[5] Bid-ask spreads are also used as a proxy for transaction costs by Clinton (1988), Rhee and Chang (1992), and Fletcher and Taylor (1996).

[4] Although Clinton (1988) argues that covered interest arbitrage in combination with swap transactions can also narrow the band around the interest parity line, his equilibrium conditions are the same as those under one-way arbitrage.

[5] Rhee and Chang (1992) raise three concerns about using triangular arbitrage and Demsetz's measure for the estimation of transaction costs.

The paper is organized as follows: Section II defines transaction costs in the one-way arbitrage environment. Section III describes the estimation techniques and the data. Empirical results are reported in Section IV. Section V summarizes the findings.

II. Transaction Costs under One-Way Interest Arbitrage

Under covered interest arbitrage, the interest parity line is bounded by a neutral band defined as:

$$(F - F_0) / F_0 = T + T^* + T_f + T_s, \tag{1}$$

where F = the actual forward price defined in units of home currency per unit of foreign currency and F_0 = the interest rate parity forward price [Frenkel and Levich (1975, 1977) and McCormick (1979)]. The four components on the right-hand side of equation (1) represent transaction costs in the following four markets: the domestic securities market (T), the foreign securities market (T*), the forward foreign exchange market (T_f), and the spot foreign exchange market (T_s).[6]

Given market equilibrium in the spot and forward foreign exchange markets, Deardorff (1979) demonstrates that the neutral band narrows as market participants opt for the least-cost method of acquiring foreign currencies under one-way arbitrage:

$$(F - F_0) / F_0 = T + T^* - |T_f - T_s|. \tag{2}$$

Callier (1981), Bahmani-Oskooee and Das (1985), and Clinton (1988) prove that the width of this band is further narrowed as equilibrium conditions are considered in both foreign exchange and securities markets:

$$(F - F_0) / F_0 = \min (T + T^* - |T_f - T_s|, T_f + T_s - |T - T^*|). \tag{3}$$

[6] Transaction costs represent just one of many explanations for deviations of observed forward prices from theoretical forward prices. Other explanations include: capital controls and political risk [Dooley and Isard (1980)], government intervention [Chang and Taylor (1998), Baillie and Osterberg (1997), Goodhart and Hesse (1993), Pippenger and Phillips (1973)], announcement effects [Horgan, Melvin, and Roberts (1991), Husted and Kitchen (1985)], interest rate-related arbitrage difficulty [Poitras (1988), Pippenger (1978)], non-substitutability of assets with different maturities [Popper (1993)], etc.

Using simultaneously observed data from eurocurrency money markets and foreign currency markets, Rhee and Chang (1992) document that the traditional covered interest arbitrage is rarely profitable while one-way arbitrage profit opportunities exist in the short-date markets with the maturities ranging from one- to 12-months.

III. Estimation Method and Data

A. Data

We use real-time empirical data for estimation. This is the same data set used by Rhee and Chang (1992) for their study of simultaneous equilibrium in both foreign exchange and securities markets. One important advantage of using this data set is that the frequency estimates of market equilibrium and arbitrage profit measures can serve as a useful benchmark in evaluating the overall performance of the Fletcher and Taylor approach in the short-date market. Rhee and Chang's data cover the one-month period, April 11 - May 13, 1988. Intraday bid and ask quotations of foreign exchange (British pound, German mark, Japanese yen, and Swiss franc) and eurocurrency (including eurodollar) deposit markets for five maturities (one-, two-, three-, six-, and 12-months) are collected from Reuters News Service during New York morning trading hours, from 8:30 a.m. to 12:00 noon. The time interval between each set of observations is approximately 35 minutes.

B. Estimation Method

We examine the diminishing role of transaction costs as implied by one-way arbitrage-based market equilibrium. While so doing, we apply the Fletcher and Taylor (1996) approach to conduct parametric statistical tests on the frequency and duration of profitable trading opportunities as well as the magnitude of arbitrage profits. In the one-way arbitrage setting, a simple measure of equilibrium condition is expressed as:

$$|Y| - OC \leq 0, \tag{4}$$

where $|Y| = |(F - F_0)/F_0|$ and $OC = \min [(T+T^*-|T_f-T_s|), (T_f+T_s-|T-T^*|)]$ = transaction costs under one-way arbitrage. If this inequality condition holds, one-way arbitrage will cease to be profitable. On the other hand, if some observations violate this condition, there exist profitable arbitrage opportunities since OC represents the upper bound of the absolute value of deviations from one-way arbitrage.

We estimate the following model by currency and maturity. For notational convenience, time subscript is suppressed.

$$Y^* = \alpha + (OC)\beta + Z'\delta + \varepsilon \qquad (5)$$

where ε is a normally distributed, serially uncorrelated but potentially heteroskedastic disturbance term, OC is transaction costs under one-way arbitrage, and Z represents lagged OC and lagged, uncensored values of the dependent variable which captures the dynamics of the stochastic process of intraday observations. The dependent variable Y* measures the difference between actual and theoretical forward prices or one-way arbitrage profits. The estimation of theoretical forward price, F_0, is the critical hurdle in applying equation (5) to the empirical test. It is not as straightforward as it appears because theoretical forward prices must be re-defined in the one-way arbitrage setting. Specifically, one-way arbitrage-based parity forward "ask" and "bid" prices must be estimated. Fortunately, Rhee and Chang (1992) offer ready solutions in the context of one-way arbitrage.[7]

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[7] The dependent variable Y* measures one-way arbitrage profits. Depending on whether arbitrageurs are suppliers or demanders of foreign currency, their profits are defined as:

$$\pi_a = \text{Max}\,[S_a(1+r_b)/(1+r_a^*), S_b(1+r_b)/(1+r_a^*)+(F_a - F_b), S_b(1+r_a)/(1+r_a^*), S_b(1+r_b)/(1+r_b^*)] - F_{oa} \text{ and}$$

$$\pi_b = F_{ob} - \text{Min}\,[S_a(1+r_a)/(1+r_b^*) - (F_a - F_b), S_b(1+r_a) / (1+r_b^*), S_a(1+r_a)/(1+r_a^*), S_a(1+r_b)/(1+r_b^*)],$$

where F_{oa} and F_{ob} are the forward "ask" and "bid" prices, respectively; S_b and S_a are bid and ask prices of spot foreign exchange; F_b and F_a are the corresponding forward prices; r_b and r_a are the bid and ask interest rates on the domestic securities markets; and r_b^* and r_a^* are the corresponding rates on the foreign securities market. Refer to Table I in Rhee and Chang (1992) and accompanying discussions for further details.

Table 1 summarizes the mean, standard deviation, and autocorrelations of the dependent variable. Two important findings emerge. First, large standard deviations frequently accompany the large mean values of the discrepancies from one-way arbitrage-based parity, varying widely within the five maturities examined in each of the four currencies. Second, estimated autocorrelations strongly suggest a need for dynamic regressors since Y* is highly correlated with its own lags, indicating persistence in the deviations of Y*. These findings in short-date markets parallel the deviations from covered interest parity under long-date markets observed by Fletcher and Taylor (1996).

[Insert Table 1]

We follow Fletcher and Taylor (1996) to estimate equation (5). First, we determine the appropriate lag length by first overfitting and then testing for exclusion restrictions with the likelihood ratio statistic. The likelihood ratio statistic indicates that a maximum of four lags are sufficient for all currency and maturity combinations. Second, because |Y| is bounded from above by OC, an ordinary least squares (OLS) analysis is unsuitable and the equation is estimated using censored-normal model.[8]

As Fletcher and Taylor demonstrate, equilibrium condition (4) would not hold if β is positive. When β is positive, an increase in the upper bound of market equilibrium, as proxied by transaction costs, will lead to an increase in the net deviations from parity. Thus, such a relation between Y* and OC is indicative of the market anomalies that lead

[8] The dynamic structure allowed under the switching regression is less restrictive than OLS because no restrictions are imposed on the coefficients of the lags within the endogenous switching model. We also follow Fletcher and Taylor (1996) in modeling the variance structure. Although there is an initially large dispersion in Y* when a profitable trading opportunity is first discovered, the variance should decrease over time as the system stabilizes. Therefore, the variance of ε is modeled as $\sigma_t^2 = \exp[\theta + \tau(\frac{1}{h_t})]$ where h_t = 1 when a profitable arbitrage trading opportunity is first discovered, h_t = 2 in the following intraday observation, and so on. A priori, we expect τ to be non-negative. Since it is the abatement of profitable arbitrage trading opportunities that is relevant, the homoskedastic variance (τ = 0) is used for equilibrium observations. Then the maximum likelihood estimation function for the full model is

$$L = \Pi_{Y^*=0}[1 - \Phi(X'\Gamma/\sigma)] * \Pi_{Y^*>0} \frac{1}{\sigma\sqrt{2\pi}} * \exp[-\frac{(Y^* - X'\Gamma)^2}{2\sigma^2}]$$

where X' includes constant, OC, and Z'. The Gauss program is used to estimate this model.

to instability in the market although a negative α can offset this instability. Likewise, a positive α is an indication of market disequilibrium unless a larger negative β offsets its effect. Hence, equilibrium condition (4) cannot be supported, if both α and β are positive.

IV. Empirical Results

Table 2 presents the estimation results by currency and maturity. The first and second columns present the coefficients of α and β, while columns three through ten report the estimated coefficients of the dynamic regressors. The last two columns report the estimates of two parameters, θ and τ, as defined in footnote no. 8. The results exhibit that β is negative and statistically significant for all currencies and maturities except the German mark with the three-month maturity. This is a strong signal of market equilibrium, suggesting that transaction costs explain a large percentage of the discrepancies between actual and theoretical forward prices. Though estimated α's are negative for six out of the 20 maturities examined, large negative β estimates offset positive α estimates for the majority of the cases we examine. Overall, censored regression results indicate that transaction costs can explain the majority of deviations of actual forward prices from one-way arbitrage-based interest parity prices, though some profit opportunities exist.

[Insert Table 2]

The varying lag length of the market depends on currency and maturity as indicated by the estimates of the dynamic regressors. As Frankel and Levich (1975, 1977), Rhee and Chang (1992), and Fletcher and Taylor (1996) demonstrate, there may be a delay between the receipt of information and the execution of arbitrage trades. The length of time for such a delay should be reflected in the lag length. The six- and 12-month maturities appear to have longer memories than shorter maturities. However, the number of lags is four at most, which is approximately two hours. The results are consistent with Rhee and Chang's (1992) observation that one-way arbitrage opportunities persist rather than decline quickly. Fletcher and Taylor (1996) also observe the persistent effects of lagged transaction costs over a long period of time in the long-date market. A direct comparison between the results of the two studies is not possible due to the differences in market settings (short-date markets versus long-date markets), the types of arbitrage (one-way arbitrage versus covered interest arbitrage), and the data (intraday real-time quotes versus weekly quotes).

The duration of arbitrage opportunities is revealed by the heteroskedastic variance structure. For 15 out of 20 markets, the estimate of the heteroskedastic parameter, τ, is positive and mostly significant. The estimates of τ are statistically insignificant when they are negative. The variances of the estimated deviations are a decreasing function of the time spent outside the transactions cost band. Thus, this finding is consistent with Fletcher and Taylor's (1996) finding under covered interest arbitrage in long-date markets. It also appears that the short-date capital markets have shorter memories than long-date markets. Hence, their observation that deviations from parity are more volatile at the beginning of a disequilibrium interval applies more forcefully to the short-date markets than the long-date markets. Arbitrageurs tend to show some weakness in stabilizing the markets for Swiss francs (one- and 12-month maturities), British pounds (12-month maturity), and Japanese yen (six-month maturity).

Table 3 presents summary statistics that reveal the predicted probability of equilibrium as defined by equation (5).[9] For comparative purposes, we also report Rhee and Chang's (1992) actual percentage of observations within the transaction cost band

[9] This is calculated by a formula, $1 - \phi[(\hat{\alpha} + \hat{\beta} OC + Z'\hat{\gamma}) / \sqrt{\exp(\theta)}]$ where $\phi(\cdot)$ is the standard normal probability distribution function. Corresponding variables are evaluated at their means.

in the second column.[10] The predicted probabilities of reaching equilibria are similar to those reported by Rhee and Chang. For example, 59% of the deviations of actual forward prices from interest parity forward prices are predicted to be within the transaction cost band for German mark, while actual frequency of market equilibrium tabulated by Rhee and Chang (1992) is 54%. The predicted probabilities of reaching equilibrium for all currencies range from 19% (one-month maturity) to 56% (three-month maturity). These figures are contrasted with actual frequencies of 23% (one-month maturity) and 52% (three-month maturity). Among the four currencies examined, the highest predicted value within the transaction cost band is recorded for the German mark (59%), followed by the British pound (50%), the Swiss franc (31%), and the Japanese yen (20%). These figures are comparable to Rhee and Chang's estimates of actual equilibrium frequencies of the German mark (54%), the British pound (48%), the Swiss franc (35%), and the Japanese yen (24%). The overall effectiveness of the Fletcher and Taylor approach is remarkably high in the short-date market with intraday real-time data. The robustness of their approach remains unaffected by the narrower transaction costs band around the one-way arbitrage interest parity line.

The estimated frequencies of reaching market equilibrium summarized in Table 3 have strong relevance to the diminishing role of transaction costs. The frequencies indicate how much of the discrepancy between actual and theoretical forward prices can be explained by transaction costs. This figure can be compared to Maasoumi and Pippenger's result of 60% even though their figure is biased given the inadequacy of the OLS approach to estimating this relation. Using intraday real-time data and one-way arbitrage-based equilibrium conditions, our results indicate that about 40% of the discrepancies are explained by transaction costs. Of course, these figures vary across currencies. Although the neutral band around the interest parity line narrows under one-

[10] Refer to Table IV of Rhee and Chang (1992).

way arbitrage, the lowest frequency of 20% recorded for the Japanese yen does not indicate that transaction costs are unimportant in explaining the deviations of actual from theoretical forward prices.

[Insert Table 3]

Following Fletcher and Taylor (1996), we also estimate the average size of one-way arbitrage profits for the five maturities of each of the four currencies.[11] The reported profits are expressed in U.S. cents per unit of foreign currency except for the Japanese yen for which they are in hundredths of a cent. The results in the third and fourth columns indicate that the expected profits estimated by the Fletcher and Taylor model are remarkably similar to those reported by Rhee and Chang, demonstrating the effectiveness of their approach in the short-date markets. Although not reported in Table 3, the average percentage returns range from approximately six basis points for German marks and British pounds to 12 basis points for Swiss francs and Japanese yen. These figures are smaller than those tabulated by Fletcher and Taylor (10 to 33 basis points) and by Clinton (1988)(no greater than 20 basis points). This finding is not surprising considering Fletcher and Taylor's results are based on long-date market data and Clinton's results are based on daily observations in the short-date markets, while our results are based on intraday data. As Clinton (1988) and Rhee and Chang (1992) report, we also confirm that profitable opportunities are not rare in the short-date markets investigated but the magnitude of arbitrage profits is rather small, raising the question of the economic significance of these profits.

[11] For the non-zero observations, we calculate $E(Y^* \mid Y^* > 0) = \hat{\beta} + \hat{\beta} OC + Z'\hat{\beta} + \sqrt{\exp(\theta)}\,\frac{\phi(\cdot)}{\Phi(\cdot)}$ where ϕ and Φ represent standard normal probability distribution function and cumulative density function,

V. Conclusion

This study has examined the role of transaction costs in explaining the differences between actual and theoretical forward prices after adjusting the size of the neutral band around the interest parity line for one-way arbitrage. A set of real-time data drawn from both the currency and securities markets is used and the Fletcher and Taylor's model has been modified to make it applicable to one-way arbitrage in short-date capital markets. Based on parametric tests of the frequency and duration of profitable trading opportunities as well as the magnitude of arbitrage profits, the following three major findings are obtained.

First, the results suggest that a narrower neutral band around interest parity line, as implied by one-way arbitrage, does not diminish the role of transaction costs. Thus, our results support Maasoumi and Pippenger's (1989) conclusion even though their results should be interpreted with caution due to the unsuitability of OLS models for testing the role of transaction costs. Second, the variances of the estimated deviations are a decreasing function of the time spent outside the transactions cost band, which is consistent with the findings of Fletcher and Taylor (1996) under covered interest arbitrage in long-date markets. Rhee and Chang (1992) also observe that arbitrage profits do not decline as fast as they should when the persistence of one-way arbitrage profits is examined. It also appears that the short-date capital markets have much shorter memories than long-date markets. Finally, though profitable opportunities were not rare in the short-date markets studied, the magnitude of arbitrage profits tends to be small and economically insignificant. The short-date markets, therefore, do not appear to yield excessive profit opportunities over time, which is consistent with Clinton (1988) and Rhee and Chang (1992).

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respectively. Corresponding variables are evaluated at their means. See Maddala (1983) for details. The results are presented in columns 3 of Table 3.

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Table 1. Summary Statistics on Net Deviations from Parity (Y*)

	Maturity	Mean	Standard Deviation	Autocorrelations			
				Y*(-1)	Y*(-2)	Y*(-3)	Y*(-4)
German mark	1-month	0.0482	0.0674	0.7715	0.5508	0.3624	0.2191
	2-months	0.0141	0.0189	0.5732	0.4174	0.2586	0.1684
	3-months	0.0065	0.0185	0.7616	0.6114	0.4616	0.2838
	6-months	0.0098	0.0178	0.5960	0.3814	0.2107	0.0845
	12-months	0.0099	0.0166	0.5260	0.2081	0.0050*	0.1059
Swiss franc	1-month	0.1319	0.1048	0.6696	0.5201	0.4112	0.3079
	2-months	0.0799	0.1030	0.8227	0.7179	0.6010	0.4976
	3-months	0.0222	0.0343	0.5460	0.3389	0.2426	0.1842
	6-months	0.0293	0.0428	0.7115	0.4641	0.2754	0.1505
	12-months	0.0356	0.0398	0.6536	0.4024	0.3906	0.4254
British pound	1-month	0.0730	0.1007	0.6374	0.5158	0.3766	0.2802
	2-months	0.0416	0.0691	0.5782	0.4209	0.2317	0.3296
	3-months	0.0378	0.0674	0.5921	0.4336	0.2847	0.1788
	6-months	0.0499	0.0857	0.7323	0.5632	0.4588	0.4696
	12-months	0.0725	0.0756	0.5889	0.3228	0.2240	0.2447
Japanese yen	1-month	0.1531	0.0979	0.7383	0.4597	0.3050	0.1952
	2-months	0.1024	0.0765	0.8106	0.7032	0.5454	0.4459
	3-months	0.0550	0.0505	0.7607	0.6851	0.5881	0.5452
	6-months	0.0552	0.0988	0.0042*	-0.0053*	-0.0172*	-0.0359*
	12-months	0.0124	0.0228	0.4991	0.3829	0.2562	0.1797

Notes: 1. The reported mean and standard deviations includes both equilibrium and disequilibrium values. They are expressed in U.S. cents per unit of foreign currency except for the Japanese yen for which they are in hundredths of a cent. Profits for differing maturities are annualized for ease of comparison.

2. * Not significantly different from zero at 5 percent level of significance.

Table 2. Censored Regression Results

	Maturity	Constant	OC	Y*(-1)	Y*(-2)	Y*(-3)	Y*(-4)	OC(-1)	OC(-2)	OC(-3)	OC(-4)	θ	τ
DM	1-month	0.0467***	-11.0950***	0.9211***				-0.2005				-6.4693***	1.2409***
		(0.0166)	(2.2912)	(0.0638)				(2.1898)				(0.0871)	(0.4353)
	2-months	0.0043	-4.2429***	0.8200***	0.3595***			1.3661*	1.2532*			-8.3325***	1.8028***
		(0.0151)	(0.8198)	(0.1215)	(0.1235)			(0.9336)	(0.8981)			(0.0977)	(0.4290)
	3-months	-0.0613**	0.4226	1.2672***				0.9171				-7.9849***	2.7522***
		(0.0331)	(1.0249)	(0.1258)				(1.0296)				(0.1408)	(0.7099)
	6-months	-0.0462*	-0.7164**	0.8698***	0.2609**	-0.0819		0.1400	0.8109**	0.4046		-8.3087***	1.8928***
		(0.0341)	(0.3630)	(0.1318)	(0.1486)	(0.1305)		(0.4154)	(0.4832)	(0.4353)		(0.1171)	(0.4665)
	12-months	-0.0364**	-0.5034***	0.9979***	0.1232	-0.3055**		0.3360**	0.5253***	-0.0124		-8.0796***	1.0800***
		(0.0166)	(0.1425)	(0.1570)	(0.1744)	(0.1591)		(0.1581)	(0.1584)	(0.1610)		(0.1093)	(0.4332)
SF	1-month	0.0332***	-3.7483***	0.7435***				3.1160***				-5.1424***	0.2082
		(0.0114)	(1.0021)	(0.0620)				(1.0143)				(0.0512)	(0.4048)
	2-months	0.0029	-2.8756***	0.7519***	0.2045**			0.0050	1.5082*			-5.5589***	0.9781***
		(0.0154)	(1.0198)	(0.0951)	(0.0962)			(0.6447)	(0.9760)			(0.0580)	(0.4086)
	3-months	-0.0020	-1.2137**	0.9810***				0.0336				-7.2046***	2.3453***
		(0.0103)	(0.5545)	(0.1018)				(0.5225)				(0.0967)	(0.4321)
	6-months	0.0276*	-1.4848***	0.8647***				0.2010				-6.9260***	1.8950***
		(0.0193)	(0.3345)	(0.1149)				(0.3531)				(0.0983)	(0.5769)
	12-months	0.0242**	-0.6554***	0.6564***	-0.0727	0.1236	0.2013**	0.1582	0.0740	-0.0644	-0.1007	-6.6355***	-0.1333
		(0.0130)	(0.1214)	(0.1188)	(0.1318)	(0.1295)	(0.1125)	(0.1373)	(0.1401)	(0.1373)	(0.1291)	(0.0806)	(0.4694)
UK	1-month	0.0761*	-26.0837***	0.9079***				7.1152				-4.7963***	0.9813**
		(0.0508)	(6.7837)	(0.1013)				(7.1653)				(0.0797)	(0.5158)
	2-months	0.0584	-14.2363***	0.8329***	0.2780**	0.0603		5.3943	-2.4945	2.4999		-5.0134***	0.9916**
		(0.1030)	(5.2586)	(0.1446)	(0.1658)	(0.1432)		(6.0715)	(5.5531)	(5.2241)		(0.0762)	(0.5692)
	3-months	0.0105	-7.0512***	1.1530***				3.9608**				-6.2867***	3.0103***
		(0.0614)	(2.1057)	(0.1041)				(2.0248)				(0.0983)	(0.4543)
	6-months	0.0035	-4.5014***	0.9775***	0.0050	-0.0673	0.3586***	1.3158	2.1899	-1.2557	0.4058	-5.4439***	1.7817***
		(0.1558)	(1.6058)	(0.1320)	(0.1495)	(0.1489)	(0.1279)	(1.7475)	(1.9126)	(1.7034)	(1.8052)	(0.0831)	(0.4555)
	12-months	-0.0203	-1.3325***	0.6724***	-0.0368	0.1681**		0.6147	0.2254	0.8562**		-5.1560***	-0.2099

		(0.0593)	(0.4797)	(0.1031)	(0.1209)	(0.1020)		(0.5136)	(0.5093)	(0.4979)		(0.0683)	(0.3842)
JY	1-month	0.0016***	-0.0327**									-13.8053***	0.3624
		(0.0001)	(0.0159)									(0.0843)	(0.5353)
	2-months	0.0025***	-0.1245***									-14.4213***	-0.3739
		(0.0002)	(0.0161)									(0.0827)	(0.5534)
	3-months	0.0001	-0.0378***	0.8686***				0.0344***				-15.9149***	-0.4329
		(0.0001)	(0.0064)	(0.0614)				(0.0065)				(0.0917)	(0.4654)
	6-months	0.0004***	-0.0295***	0.7070***				0.0224***				-16.0189***	-0.1834
		(0.0002)	(0.0008)	(0.0794)				(0.0026)				(0.0976)	(0.6157)
	12-months	-0.0005**	-0.0073***	0.8395***	0.3466**			0.0072***	0.0033*			-16.1990***	0.9283**
		(0.0003)	(0.0023)	(0.1755)	(0.1752)			(0.0025)	(0.0026)			(0.1529)	(0.4984)

Notes: 1. ***, **, and * denote the significance level at 1%, 5%, and 10%, respectively.

2. The number of observations is 153 for each currency-maturity. Figures in parentheses are standard errors.

Table 3. Summary Statistics: Predicted and Actual Values

		Probability (Y* = 0) (%)	Actual Frequency of equilibrium (%)	Expected Profit [E(Y*)|Y*>0]	Actual Profit (Y*>0)
German mark	1-month	22.98	32.48	0.0661	0.0714
	2-months	49.68	49.68	0.0247	0.0281
	3-months	89.44	77.07	0.0385	0.0285
	6-months	69.46	56.69	0.0231	0.0226
	12-months	63.29	54.78	0.0267	0.0219
	All maturity	58.97	54.14	..	0.0386
Swiss franc	1-month	4.64	7.14	0.1468	0.1419
	2-months	16.48	26.62	0.1076	0.1100
	3-months	58.05	51.30	0.0408	0.0447
	6-months	49.81	51.95	0.0521	0.0622
	12-months	25.10	36.36	0.0624	0.0570
	All maturities	30.81	34.67	..	0.0920
British pound	1-month	41.80	43.31	0.1407	0.1288
	2-months	60.26	54.78	0.1281	0.0919
	3-months	67.37	59.87	0.0704	0.0942
	6-months	59.80	54.78	0.1038	0.1104
	12-months	20.82	27.39	0.1229	0.0999
	All maturities	50.01	48.03	..	0.1058
Japanese yen	1-month	6.83	7.64	0.1774	0.1658
	2-months	9.94	14.65	0.1280	0.1200
	3-months	7.68	21.02	0.0702	0.0696
	6-months	5.99	15.29	0.0660	0.0647
	12-months	71.14	63.69	0.0524	0.0341
	All maturities	20.31	24.46	..	0.0999
All currencies	1-month	19.06	22.64	..	..
	2-months	34.09	36.43	..	..
	3-months	55.64	52.32	..	..
	6-months	46.27	44.68	..	..
	12-months	45.09	45.56	..	..
	All maturities	40.03	40.33		

Note: The reported profits are expressed in U.S. cents per unit of foreign currency except for the Japanese yen for which they are in hundredths of a cent. Profits for differing maturities are annualized for ease of comparison. The reported profits are all statistically significant at 1% significance level.