Nonlinear Dynamics and Covered Interest Rate Parity

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Abstract

This paper examines the dynamics of deviations from covered interest parity using daily data on the UK/US spot, forward exchange rates and interest rates over the period January 1974 to September 1993. Like other studies we find a substantial number of instances during the sample in which the covered interest parity condition exceeds the transactions cost band, implying arbitrage profit opportunities. While most of these implied profit opportunities are relatively small, there is also evidence of some very large deviations from covered interest parity in the sample. In order to examine the persistence of these deviations, we estimated a threshold autoregressive/threshold ARCH model in which the dynamic behavior of deviations from covered interest parity differs outside the transactions cost band than inside them. We find that while the impulse response functions when inside the transactions cost band are nearly symmetric, those for the outside the bands are asymmetric--suggesting less persistence outside of the transactions cost band than inside the band.

1. Introduction

The theory of covered interest parity (CIP) links money market interest rates to spot and forward exchange rates. Models of foreign exchange rate behavior often assume that CIP holds as a valid approximation. It is thus, not surprising that a fair amount of research has been devoted to the empirical validation of this condition.[1] Practitioners are interested in CIP because this condition may be used to simplify hedging practices for financial decisions. Furthermore, significant violations of CIP can generate arbitrage opportunities for international market participants, resulting in profits. There are a number of important empirical questions that one must consider when examining CIP. The first deals with observed deviations from CIP. A number of studies have identified significant deviations of forward rates from their covered interest parity (see e.g. Frenkel and Levich, 1975, 1977, 1981; Otani and Tiwari, 1981; Bahmani-Oskooee and Das, 1985; Sharpe, 1985; Overturf, 1986; Clinton, 1988; Fletcher and Taylor, 1994; Abeysekera and Turtle, 1995).[2]

Previous research has attempted to rationalize these deviations from CIP in terms of optimizing behavior. Such an approach views deviations from CIP as a response to real world frictions, including transactions costs, [Frenkel and Levich (1975, 1977, 1981)], capital market imperfections such as capital controls and/or political risk (Prachowny, 1970; Frenkel, 1973; Dooley and Isard, 1980; Otani and Tiwari, 1981; and Blenman 1991), imperfect substitutability, political risk (Aliber, 1973), as well as differential tax treatment, inelastic demand and supply schedules, and other risk premia influences. Such market frictions result in 'neutral bands' around the theoretical parity condition within which profitable arbitrage activities are not possible.

A second issue related to the magnitude of deviations from CIP is the speed with which short-run deviations from CIP are eliminated and convergence to equilibrium is achieved. Most studies that examine the empirical validity of CIP deal mainly with the size of raw deviations relative to estimates of transactions costs (referred to as profitable trading opportunities) and pay less attention to the speed with which these profitable trading opportunities are eliminated. However, using informal analysis Clinton (1988) concluded that, at least for the Euromarket, profitable trading opportunities are small and transitory. This result has been corroborated by the work Atkins (1991, 1993). Atkins employed cointegration methodology and reported results which suggest that deviations from CIP in the Euromarket are in general eliminated within two days, with this time decreasing as one moves from the 1970s through the 1980s.[3]

In this paper, we examine the dynamics of deviations from CIP for the UK using daily data over the period January 1974 to September 1993. First, similar to other studies we calculate the percentage of observations found to lie within the transactions costs bands (i.e. the so called 'neutral zone') as well as the percentage above and below these bands. To avoid indirect measures of transactions costs, our empirical investigation uses direct measures embedded in the bid-ask spread.[4] We find numerous observations in which the covered interest parity condition exceeds the transaction costs bands. In addition, we examine the persistence of these deviations over time.

The presence of transaction costs bands suggests that deviations from CIP should exhibit some nonlinear dynamics. One would expect that the persistence of deviations from CIP should be substantially lower outside the transactions cost bands than inside them as agents act to exploit the implied profit opportunities. Thus, the presence of transactions costs implies that deviations from covered interest parity might be modeled as a threshold autoregression (TAR) in which the dynamic behavior of deviations from CIP changed if they exceed the transactions cost bands.[5] In addition, to capture the variable volatility and the "fat-tailed" nature of deviations from CIP, we allowed for threshold-ARCH (TARCH) effects in which the conditional variance of deviations from CIP can change over time and across thresholds. Using this threshold autorgression/threshold ARCH (TAR/TARCH) framework, we examine the difference in the dynamics of deviations from CIP that occur within the transactions costs bands versus the dynamics of those which occur outside the neutral zone by employing nonlinear impulse response analysis. By calculating impulse response functions conditional on whether one starts inside or outside the transactions cost band, we can compare the persistence of deviations from CIP that imply exploitable profit opportunities with those in which no profit opportunities exist.

The outline of the paper is as follows. Section 2 presents a brief review of the literature concerning covered interest parity and transactions costs. Section 3 presents the theoretical underpinnings of the literature on covered interest parity including a discussion of the role of transactions costs in the context of covered interest parity. Section 4 describes the data used. Section 5 presents an empirical examination of deviations from CIP and compares findings with previous work in this area. Section 6 describes the threshold autoregression/threshold ARCH model employed to capturel these dynamics. Section 7 examines dynamics through the use of impulse response functions. Section 8 presents a summary and conclusion.

2. Brief Literature Review

A large portion of the empirical literature on deviations from covered interest parity has focused on the size of transactions costs. In two important papers Frenkel and Levich (1975, 1977), define a neutral zone as the area which surrounds the CIP condition above and below, within which observed deviations from CIP can occur without yielding any profit after netting out transactions costs. They estimate these transactions costs in the market for foreign exchange by using data on triangular arbitrage and conclude that CIP holds net of transactions costs. They also find evidence of a regular flow of profit opportunities in which the return exceeds transactions costs. However, the later work of Deardorff (1979), Callier (1981), and Bahmani-Oskooee and Das (1985) argued that the size of the transactions costs were in reality much smaller than those reported by Frenkel and Levich.

Much of the CIP literature debates the magnitude of the neutral zone in the presence of transaction costs, liquidity risk, political risk, and other market frictions which would cause violations of CIP. Clinton (1988), for example, demonstrated that the neglect of the swap market resulted in a serious overstatement of transactions costs and its introduction made the neutral zone even narrower than those found by Deardorff, Callier, and Bahmani-Oskooee and Das. Using daily observations over the period November 1985 to May 1986, in which careful attention was given to accurate timing,[6] Clinton (1988) found that in the Euromarket, transactions costs should not give rise to deviations from CIP in excess of .06 percent between well traded currencies.[7] Although Clinton found that net deviations (i.e. net of transactions costs) from CIP were transitory and small enough to support the assumption of CIP, he also found that raw deviations often occurred outside transactions costs bands, and thus there were times in which profit opportunities were available.

More recently, Fletcher and Taylor (1994, 1996) examine whether CIP holds in markets for long-term assets.[8] They examine covered arbitrage boundary conditions in the Eurobond and foreign bond markets in the 5-, 7-, and 10 year maturities for five currency pairs. The empirical evidence which they present suggest that deviations from CIP (in excess of transactions costs) do exist. They find that these disequilibrium states can have long memories (that dissipate over time) which lead to a window of profitable trading opportunities. They also find that in every long-term market there is a set of outliers that substantially violate the CIP condition. Most recently, Abeysekera and Turtle (1995), using the Johansen VAR/error-correction methodology and employed weekly data over the period 1984-1991, for Canada, Germany, Japan, and the UK, find substantial deviations from CIP over this period.

Abeysekera and Turtle (1995; p. 433) may have anticipated our current research when they made the following points.

> "Without data on the level of market imperfections such as transaction costs or bid-ask spreads, we cannot comment on the presence of arbitrage opportunities." "...future research should attempt to incorporate bid-ask spreads and transaction costs directly into the analysis."

In the next section, we present the theoretical foundations of the literature on CIP along with a discussion of transactions costs in the context of CIP.

3. The Covered Interest Rate Parity Condition

A. CIP without Transactions Costs

In markets where arbitrage is active and unfettered, the net return offered by a financial instrument denominated in foreign currency should be approximately equal to the net return offered by a similar financial instrument denominated in domestic currency. This is the basis of the CIP condition. The concept of interest parity recognizes that portfolio investors at any time t have the choice of holding assets denominated in the domestic currency (say dollars) offering the rate of interest $i_\$$ between time t and $t+1$ or assets denominated in foreign currency offering a rate of interest i_f. Thus, an investor beginning with one unit of domestic currency needs to compare the option of accumulating $1+i_\$$ units with the option of converting (at the spot exchange rate) into S units of foreign currency, and investing in foreign assets to accumulate $S(1+i_f)$ units of foreign currency at time $t+1$, and then reconverting back into domestic currency. If domestic and foreign assets differ only in their currency denomination, and if investors have the opportunity to cover against exchange rate uncertainty by arranging at time t to reconvert from foreign to domestic currency one period later at the forward exchange rate F (units of foreign currency per units of domestic currency), then market equilibrium requires the CIP condition holds.

Without transactions costs, the no arbitrage condition of covered interest parity implies that

$$\frac{F}{S} = \frac{(1+i_f)^T}{(1+i_\$)^T} \qquad (1)$$

where F is the T-period forward exchange rate (foreign currency per domestic currency--in this case the US dollar), S is the spot exchange rate (foreign currency per US dollar), i_f is the interest rate on foreign assets, $i_\$$ is the interest rate on dollar denominated (domestic) assets, and T is the time to maturity of the assets.[9] The left-hand-side of equation (1) is the forward exchange premium (FP) (or discount) and the right-hand-side of equation (1) is the nominal interest rate differential (ID).

B. Lender and Owner Arbitrage and Transaction Costs Bands

With transaction costs, the covered interest parity condition implied by no arbitrage given by equation (1) is replaced by a pair of conditions. Consider the case of no "lender" arbitrage. Lender arbitrage is the case in which a trader can make riskless profits by borrowing one currency and then lending the other. For no lender arbitrage, the speculator does not take a position. One simply borrows, say $, and lends, say pounds, to make a riskless profit. In this case the investor puts up no capital of his own. The absence of "lender" arbitrage for borrowing dollars and lending the foreign currency implies the following condition

$$(1+i_{\$}^{A})^{T} \geq \frac{S^{A}}{F^{B}}(1+i_{f}^{B})^{T}, \tag{2}$$

where S^A is the asked spot rate (foreign currency per dollar) and F^B is the bid forward rate (foreign currency per dollar), $i^A_\$$ is the asked interest rate on dollar deposits and i^B_f is the bid interest rate on foreign deposits. A similar condition holds for no lender arbitrage for borrowing the foreign currency and lending dollars and is given by

$$(1+i_{f}^{A})^{T} \geq \frac{F^{A}}{S^{B}}(1+i_{\$}^{B})^{T}. \tag{3}$$

Combining these conditions and rearranging implies

$$\frac{S^{A}}{F^{B}}\frac{(1+i_{f}^{B})^{T}}{(1+i_{\$}^{A})^{T}} \leq 1 \leq \frac{S^{B}}{F^{A}}\frac{(1+i_{f}^{A})^{T}}{(1+i_{\$}^{B})^{T}}$$

Some additional algebra yields

$$[\frac{S^{B}}{S^{A}}\frac{F^{B}}{F^{A}}\frac{(1+i_{f}^{A})^{T}}{(1+i_{f}^{B})^{T}}\frac{(1+i_{\$}^{A})^{T}}{(1+i_{\$}^{B})^{T}}]^{-1/2} \leq [\frac{F^{B}F^{A}}{S^{B}S^{A}}\frac{(1+i_{\$}^{B})^{T}}{(1+i_{f}^{B})^{T}}\frac{(1+i_{\$}^{A})^{T}}{(1+i_{f}^{A})^{T}}]^{1/2}$$

$$\leq [\frac{S^{B}}{S^{A}}\frac{F^{B}}{F^{A}}\frac{(1+i_{f}^{A})^{T}}{(1+i_{f}^{B})^{T}}\frac{1+i_{\$}^{A})^{T}}{(1+i_{\$}^{B})^{T}}]^{1/2} \tag{4}$$

The middle term of (4) is the covered interest parity condition based on the geometric mid-point, or average, of the bid/ask prices while the outer terms are essentially the geometric average of the bid/ask spreads and their reciprocals. If equation (2) is violated, then it is profitable to borrow domestic currency (dollars) and lend foreign currency (pounds). If equation (3) is violated, then it is profitable to borrow foreign currency (pounds) and lend domestic currency (dollars). We can relate this to equation (4). If the right hand side of equation (4) is violated (i.e. one is above the upper bounds) this implies the violation of equation (3). Hence, if CIP (evaluated at geometric average of bid-ask spread) is greater than the upper bound then, this is equivalent to saying that it pays (there are arbitrage opportunities) to borrow pounds and lend dollars at the existing bid-ask spreads. Similarly, if the left hand side of (4) is violated (i.e. below the lower bounds) this implies a violation of equation (2) and it will pay to borrow dollars and lend pounds at the existing bid-ask spread.

Taking logarithm of equation (4), yields

$$\theta^{l} \leq cip \leq \theta^{u} \tag{5}$$

where

$$cip = 1/2 \log[\frac{F^{B}}{S^{B}}\frac{F^{A}}{S^{A}}\frac{(1+i_{\$}^{B})^{T}}{(1+i_{f}^{B})^{T}}\frac{(1+i_{\$}^{A})^{T}}{(1+i_{f}^{A})^{T}}]$$

$$\theta^{u} = 1/2 \log[\frac{S^{B}}{S^{A}}\frac{F^{B}}{F^{A}}\frac{(1+i_{f}^{A})^{T}}{(1+i_{f}^{B})^{T}}\frac{(1+i_{\$}^{A})^{T}}{(1+i_{\$}^{B})^{T}}]$$

$$\theta^{l} = -1/2 \log[\frac{S^{B}}{S^{A}}\frac{F^{B}}{F^{A}}\frac{(1+i_{f}^{A})^{T}}{(1+i_{f}^{B})^{T}}\frac{(1+i_{\$}^{A})^{T}}{(1+i_{\$}^{B})^{T}}]$$

The term cip is approximately the percentage deviation from the covered interest parity relationship evaluated at the geometric average of the bid and asked prices. The transaction cost bands are given by θ^l and θ^u. Note that for lender arbitrage deviations from covered interest parity fluctuate in a region symmetric around zero. This region is determined solely on the basis of the ratio of bid and asked prices or the transactions costs.

We can also derive a similar condition for no "owner" arbitrage. Owner arbitrage is the case where a trader initially has a cash position in one currency and can invest in assets denominated in that currency or of another currency. Unlike lender arbitrage, owner arbitrage requires traders to put up their own capital. In this case where the investor has a cash position in \$, the question is whether one should keep the \$ or sell \$ and purchase foreign currency. The absence of "owner" arbitrage implies the following conditions:

$$(1+i^B_\$)^T \geq \frac{S^A}{F^B}(1+i^B_f)^T$$

and

$$(1+i^B_f)^T \geq \frac{F^A}{S^B}(1+i^B_\$)^T.$$

After some algebraic manipulation these conditions imply:

$$\theta^l_o \leq cip \leq \theta^u_o \tag{6}$$

where

$$\theta^u_o = \theta^u - T\log(\frac{1+i^A_f}{1+i^B_f})$$

$$\theta^l_o = \theta^l + T\log(\frac{1+i^A_\$}{1+i^B_\$}).$$

The transaction band is smaller for owner than for lender arbitrage since there is one less transaction that needs to take place--no borrowing has to be undertaken as the investor already has one of the assets. Note also that for owner arbitrage, cip is not necessarily bounded by a symmetric band; the band is only symmetric if the bid/ask ratio for the interest rates are the same.

4. Description of Data

Daily data on bid and ask prices for spot and forward exchange rates for the British pound are obtained from Data Resources Incorporated (DRI) for the period January 1974 - September 1993. Currencies are expressed as foreign currency per U.S. dollar. The forward rates are for a "one-month" term. Interest rates are also obtained from DRI and are 1-month Eurorates quoted on an annual basis. All data prior to October 8, 1986 are 9 a.m. New York open Quotes. Data after October 8, 1986 are London close (11 a.m. New York time).[10]

The decision to employ Euro-deposit rates was motivated by several considerations. First, the use of Euro-deposit rates ensures that the underlying asset is comparable. Euro-deposits denominated in different currencies are issued by banks that have similar default risk. This means that term structures of different countries are comparable because they do not have to be adjusted for differing default risk. In addition, Euro-deposit rates are not subject to capital controls because they are offshore securities, and hence, rates in different countries do not have to be adjusted for differing capital controls. Thus, eurocurrency deposits are comparable in terms of credit risk, maturity, and issuer, but not in terms of currency denomination (see Levich (1985)). Furthermore, high quality data for domestic interest rates are not easily obtained for all countries. In some countries, other than the U.S. and Canada, domestic Treasury bill rates are not always market clearing, and hence will not reflect the true cost of credit, while Euro-deposit rates are market clearing. Treasury bill rates are not always market clearing because in some countries there are either restrictions on the number of participants which can trade in such markets or the government imposes limits on price fluctuations of such securities. That these considerations are important is evidenced by the discussion of Marston (1993).

5. Empirical Analysis: Departures from Covered Interest Parity

Figure 1 plots the logarithm of the forward premium evaluated at the geometric average of bid and asked rates (log(F/S)), the logarithm of the interest rate ratio evaluated at the geometric average of bid and asked rates ($T \log[(1+i_f)/(1+i_\$))]$),[11] as well as deviations from covered interest parity again evaluated at the geometric average of bid and asked prices (cip_t).[12] From the figure it is clear that the deviations from covered interest parity (i.e. cip_t not equal to zero) relative to the fluctuations in forward premium and the ratio of interest rates are quite small. It is also apparent that deviations from covered interest parity can be quite persistent. While deviations from covered interest parity are stationary (the augmented Dickey-Fuller t-stat is -5.61), there are substantial periods in which cip_t is above or below zero.

Figure 2 plots deviations from covered interest parity as well as the transaction cost bands implied by no lender arbitrage. From the figure, there appear to be violations of the covered interest no arbitrage conditions as deviations from covered interest parity exceed the transaction costs bands implied by no lender arbitrage. Table 1 presents the number of times that the no arbitrage conditions are violated for the alternative transactions costs bands. From the diagram, these violations appear to be clustered together suggesting some persistence to these violations as well. Interestingly, while the transactions costs bands are not constant, they are, nonetheless, relatively stable. The results for no owner arbitrage are similar except that the transactions bands are slightly narrower and, hence, there are more violations of the no arbitrage conditions.

While only a small percentage of the observations fall outside the transactions cost bands, there are a surprising number of violations given the findings of Taylor (1987) and (1989). Taylor (1987) examined observations sampled 10 minutes apart during November 11, 12, and 13 of 1985 and failed to find a single violation of no arbitrage. This period is relatively stable compared with other periods in our sample. Even for periods examined in his second study (Taylor (1989)), which overlap those in this study, the CIP condition was relatively stable. Clinton (1988), on the other hand, finds similar percentages to those shown in Table 1 in a sample taken over the period November 1985 to May 1986.

There is also evidence of some very large deviations from covered interest parity in the sample. These coincide with several events such as the attack on the British pound and subsequent withdrawal of the United Kingdom from the European Exchange Rate Mechanism in September 1992. Many of these same observations also violate the no arbitrage conditions. Nonetheless, even after the outliers are removed (see second column of Table 1) there are still numerous violations of the no arbitrage conditions.[13]

In Table 2, we present the mean, median and standard deviations of the gross deviation from CIP and the transaction costs implied by no lender and no owner arbitrage. The mean deviation is statistically different from zero[14], this indicates that despite the symmetric transactions bands implied by no lender arbitrage some type of wedge causes the CIP condition for the US and UK to systematically deviate from zero in one direction. Nonetheless, the mean deviation from CIP is dwarfed by its standard deviations, indicating that deviations are highly variable. As a comparison, the average lender transactions cost (i.e. θ^u) is 0.0008 or 0.08 percent. This figure is slightly higher than that of Clinton (0.06 percent) but smaller than that of McCormick (0.09). The mean deviations from CIP is less than the mean of transactions costs which suggest that one could not make profits on average by randomly engaging in CIP arbitrage.

As suggested by the results in Table 1, there are a substantial number of instances during the sample in which the covered interest parity condition exceeds the transaction costs band. These instances imply arbitrage profit opportunities. To better understand the nature of these opportunities, Figure 3 plots a histogram of the implied lender arbitrage profits over the sample. For ease of interpretation we display these profits in terms of the approximate rate of return over the course of a year if these opportunities were available for every trading day during that period.[15] From Figure 3, it is clear that most of the actual profit opportunities are relatively small--less than four percent on an "annual" basis. There appear to have been some very rare opportunities for extremely large profits over the course of the sample--on twelve occasions arbitrage profits entailed "annual" returns over 100%! Nevertheless, because arbitrage profit opportunities in general and large ones in particular are relatively rare, the scope to make large systematic profits from engaging in covered interest parity arbitrage is limited. Looking at the entire sample, including observations in which no profits were available, the average net profit was .0056 percent.[16] This translates into an "annualized" return of 1.4 percent--a fairly paltry returns from engaging solely in dollar/pound covered interest arbitrage. The "annualized" rate of return from owner arbitrage is a more (respectable) 2.3 percent (average net profit of .0091 percent per transaction), although as we suggested above, to engage in owner arbitrage, arbitragers must put up their own capital.

Not only are profit opportunities from covered interest arbitrage relatively small, they are typically of short duration. Table 2, Panel B presents the frequency of durations outside the transactions cost band. An overwhelming majority of durations outside of the transactions cost band are of one or two days. Nonetheless, there are several episodes in which the duration outside the transactions band lasted five or more days. We conduct a more formal analysis of the persistence of arbitrage opportunities in Section 7 below.

This discussion of profit opportunities is just meant to be suggestive rather than an exact accounting. The sampling interval of one day may be too long and it may be that adjustment actually takes place hourly. To the extent that this is a problem, the result would be a shorter adjustment time, and thus, the findings of this paper may be viewed as upper bounds on adjustment periods.

6. Empirical Analysis: Threshold Autoregressions for Covered Interest Parity

If the no arbitrage conditions strictly hold then deviations from covered interest parity should be bounded by the transactions costs bands. Yet, as we saw above there appear to be numerous and persistent deviations from CIP that exceed the transactions cost bands. Nonetheless, even if deviations from CIP exceed the transactions bands, one might suspect that deviations from CIP outside the transactions cost bands would be substantially less persistent than those inside the transaction cost bands as market participants will eventually respond to large and/or persistent arbitrage opportunities.

A relatively simple model that can capture the possible change in persistence as covered interest parity condition moves outside the transactions cost band is a threshold autoregression. Here the parameters of an autoregression for cip_t change depending on whether cip_{t-1} is above, inside, or below the transactions cost bands. Specifically, let cip_t be described by a threshold autoregression (TAR):

$$
\begin{aligned}
cip_t = {} & [a_0^u + \sum_{j=1}^{J} a_j^u cip_{t-j}]\ I(cip_{t-1} > \theta^u_{t-1}) \\
& + [a_0^m + \sum_{j=1}^{J} a_j^m cip_{t-j}]\ I(\theta^l_{t-1} \leq cip_{t-1} \leq \theta^u_{t-1}) \\
& + [a_0^l + \sum_{j=1}^{J} a_j^l cip_{t-j}]\ I(cip_{t-1} < \theta^l_{t-1}) + \varepsilon_t
\end{aligned}
\tag{8}
$$

where I(.) is an indicator function that is one if the condition holds and zero otherwise. θ^u_{t-1} is the upper bid/ask transaction band while θ^l_{t-1} is the lower bid/ask transaction band.[17] In our empirical application, we take the thresholds to be the upper and lower transactions bands from lender arbitrage (i.e. $\theta^l_{t-1} = -\theta^u_{t-1}$).[18] While threshold autoregressions have been used in economics before (see for example Teräsvirta and Anderson (1992), Potter (1995), Balke and Fomby (1997)), one difference in the application here is that the thresholds (i.e. the bid/ask spread) are not constant over time as θ^u and θ^l change as the bid/ask spreads change.[19] The other difference is that we can take the thresholds as known which greatly simplifies estimation and inference.

In addition, as in many financial time series, the volatility of cip_t appears to change over time and that shocks to cip_t appear to be characterized by a "fat-tailed" distribution (hence the numerous outliers). As a result, we allow for the conditional distribution of ϵ_t to differ across regimes and over time. In particular, $\epsilon_t = (h^i_t)^{1/2} v_t$ where $h^i_t = E[\epsilon_t^2 | \Omega_{t-1}]$ is the conditional variance of ϵ_t given information at t-1 (Ω_{t-1}) and differs across regimes (i = u, m , or l indicates whether the covered interest parity condition is above, inside, or below the transactions cost band). The standardized shock v_t is assumed to have a t-distribution with υ^i degrees of freedom which may also differs across regimes.[20] Here we specify the conditional variance by an ARCH model of the form:

for i = u, m, or l. An examination of autocorrelation and partial autocorrelation functions of

$$h_t^i = b_0^i + \sum_{k=1}^{K} b_k^i \epsilon_{t-k}^2 \qquad (9)$$

the squared residuals from the basic TAR suggests an ARCH model of order K = 7.

Because we take the thresholds to be the bid/ask transactions cost band, the thresholds are assumed to be known and, hence, need not be estimated. Therefore, we estimated the above model given the actual bid/ask transactions cost bands. To test whether a threshold autoregression is appropriate for covered interest parity, one simply tests if the autoregressions are the same across regimes, i.e. if $a^u_j = a^m_j = a^l_j$ for j = 0, ..., J. Similarly, we can test whether the conditional distribution of ϵ_t is constant across regimes by testing $b^u_k = b^m_k = b^l_k$, k = 1 to K, and $\upsilon^u = \upsilon^m = \upsilon^l$.

Table 3 presents tests of parameter equality across regimes.[21] We present results for a basic TAR estimated by OLS as well as for the threshold ARCH (TARCH) model which was estimated by maximum likelihood. Clearly, for both the basic TAR and the TAR/TARCH models we can reject the hypothesis that the parameters are constant across regimes.[22] Both the autoregressive and the ARCH parameters are statistically different across regimes; only the parameters of the t-distribution are not significantly different across regimes. While there is some latent residual correlation and ARCH effects in the residual from the basic TAR, the standardized residuals from the TAR/TARCH model do not appear to be serially correlated or contain additional ARCH effects.[23]

In our discussion above, we conjectured that the persistence of deviations from covered interest parity should be substantially less when outside the transactions band than inside the bands as market participants begin to take advantage of arbitrage profits. Usually, a rough and ready measure of persistence is the sum of the autoregressive coefficients; these indicate that the regimes are not too different in this dimension. The sum of the AR coefficients in the upper, middle and lower regimes for the basic TAR model are 0.75, 0.85, and 0.74 and are not statistically different from one another. For the TAR/TARCH model, the sum of the AR coefficients for the upper and lower regimes (0.78 and 0.87 respectively) are smaller than the sum of AR coefficients in the middle regime (0.92), but only the upper regime is statistically different. However, in nonlinear models such as the TAR/TARCH model above, analysis of persistence is substantially more subtle than in a linear model. The interaction between the autoregressive coefficients, the intercepts, the thresholds, and even the conditional variance can all effect the persistence exhibited by the model. As a result, in the next section we turn to nonlinear impulse response analysis in order to examine the persistence implied by the model as a whole and by the individual regimes.

7. Understanding Dynamics: Impulse Response Analysis

To better understand the dynamics implied by the threshold model, we calculate impulse response functions for the covered interest parity condition. The nonlinear structure of the model makes impulse response analysis substantially more complex than in the linear case.[24] The reason is that the moving average representation is not linear in the shocks.

The impulse response function (IRF) is the change in the forecasted value for cip_{t+K} as a result of knowing the value of an exogenous shock ϵ_t, or

$$E[cip_{t+k}|\Omega_{t-1},\epsilon_t] - E[cip_{t+k}|\Omega_{t-1}],$$

where Ω_{t-1} is the information set at time t-1 and ϵ_t is a particular realization of the exogenous shock. Unlike linear models, impulse response functions for the nonlinear model is, in general, conditional on the entire past history of the variables and the size and direction of the shock. Furthermore, because the moving average representation of cip_{t+k} for the threshold model is not linear in the ϵ_t's, one cannot calculate the conditional expectations, $E[cip_{t+k}|\Omega_{t-1},\epsilon_t]$ and

$E[cip_{t+k}|\Omega_{t-1}]$, by projecting the model forwards and setting future shocks (ϵ_{t+i}) to zero as is the case with a linear model.

In order to calculate the conditional expectations for the nonlinear model, we essentially simulate the model. Because there is a single shock and that shock affects the one-step-ahead forecast linearly, in the initial period change in conditional expectations is just the value of the shock. In order to calculate the conditional expectations, $E[cip_{t+k}|\Omega_{t-1},\epsilon_t]$ and $E[cip_{t+k}|\Omega_{t-1}]$, in each subsequent period, however, we must simulate two separate histories: one in which the shock at time t is known and one in which the at time t is not known but determined randomly. In each period we draw a standardized shock, v_{t+i}, using resampled standardized residuals (standardized by the conditional variance). Note this shock is conditional on regime because the distribution of actual standardized residuals may differ across regimes. Thus, when the simulated value for cip_{t+i-1} is above the transaction cost band, we draw a standardized residual from observation in which the upper regime was entered. The innovation ϵ_{t+i} is calculated by scaling up v_{t+i} by the conditional standard deviation, h_{t+i}. Again, h_{t+i} depends on the simulated values of cip_{t+i-1} and ϵ^2_{t+i-1}. This simulation gives a hypothetical history for cip_{t+i}, $i = 0$ to k. We repeat this simulation 200 times, keeping the values of Ω_{t-1} and ϵ_t the same for each simulation but drawing different realizations of v_{t+i}. We average the simulations to obtain estimates of the conditional expectations, $E[cip_{t+k}|\Omega_{t-1},\epsilon_t]$ and $E[cip_{t+k}|\Omega_{t-1}]$.

As suggested above, the IRFs are a function of the value of the shock, ϵ_t, and the initial conditions, Ω_{t-1}. To evaluate the sensitivity of the IRF to the size and direction of the shock, we calculated IRFs for positive versus negative, and small versus large shocks. Here we considered two alternative ways to of specifying "small" versus "large" shocks. First, to get a clear sense of the difference in persistence across regimes, we conducted an experiment in which the size of the shock was the same regardless of the current regime. To determine size of the shock, we then took a small shock to be equal to the 84th percentile of the distribution of actual nonstandardized residuals while a large shock was set to be the 97.7th percentile.[25] Because in reality the distribution of shocks differs across regimes, we considered a second way of specifying the initial shock. In this case, $\epsilon_t = h_t^{1/2} v_t$ where both h_t and the distribution of v_t are conditional on regime. If, for example, $cip_{t-1} > \theta_{t-1}$, then a "small" v_t shock was set to be the 84th percentile of standardized residuals for observations in the upper regime while a large shock was set the 97.7th percentile. Selecting v_t shocks when in the other regimes was conducted in a similar fashion. The end result is that in this case "small" and "large" ϵ_t shocks could differ across regimes and over time.

We also calculated IRFs for two different types of initial conditions. For the first, we determined the initial condition by randomly drawing an initial condition, unconditionally, from the actual data. This was repeated 500 times and the resulting IRFs were averaged to yield an IRF for cip_t, unconditional on Ω_{t-1}.[26] Alternatively, we calculate impulse response functions conditional on regime. For example, for the IRF in the middle regime we randomly selected as initial conditions dates in which the cip_t series was in the middle regime. Likewise for the upper and lower regimes. Again, we repeated these experiments 500 times and took the average to estimate the IRF conditional on regime.[27] By comparing these conditional IRFs, we can get an indication of how the dynamics (and persistence) differs across regimes.

Finally, one last complication presents itself. Because the transaction cost band is not constant over time, we had to specify the behavior of the thresholds when calculating the impulse response function. The actual transaction band at time t-1 was taken as part of the initial condition (Ω_{t-1}). However, current and future values of the thresholds were required for the simulations used to calculate $E[cip_{t+k} | \Omega_{t-1}, \epsilon_t]$ and $E[cip_{t+k} | \Omega_{t-1}]$. Again, we set values for the thresholds in periods t to t+k equal to the actual transactions cost band in those periods.[28]

Figure 4 displays the IRF for the covered interest parity condition for the TAR/TARCH model for the case where the initial shock is the same across regimes. Because episodes in which the transactions band is exceeded are relatively rare, the average (or unconditional) IRF and the IRF for the middle regime are nearly symmetric. However, the IRF for the upper and lower regimes are asymmetric, particularly in the few of periods immediately following a "large" shock. When CIP is initially in the upper regime, large positive shocks get dissipated faster than large negative shocks. The opposite is the case in the lower regime. We argue then that shocks in the outer regimes display less persistence than do shocks in the middle regime. The reasoning is as follows. Starting in the upper regime, a large positive shock is likely to cause the CIP condition to remain outside the transactions cost bands in the initial period while a negative shock is likely to push the CIP condition inside the transaction band. In the subsequent period the different response to a positive and negative shock reflect primarily the dynamic structure of the upper regime versus that of the middle regime. As a result, the different response in the outer regimes to positive and negative shocks reflects different degrees of persistence in the various regimes. The difference in persistence can also be seen by comparing the middle and upper (lower) regime response to a "large" positive (negative) shock. Again, positive (negative) shocks are dissipated faster in the upper (lower) regime than in the middle regime.

Figure 5 displays IRFs for the case where the size of the initial shock is conditional on current regime. Once more, the impulse response function for the lower regime is asymmetric--suggesting less persistence outside of the transactions band than inside the band. On the other hand, the asymmetry is not as apparent for the upper regime In addition, one can see that, on average, "large" shocks in the outer and lower regimes are substantially larger than those in the middle regime (nearly twice as large). Also, the fact that the distribution of shocks for the middle and upper regimes has fatter tails than that of the lower regime (see also the estimated values of t-distribution degrees of freedom, υ^i, in Table A2 of the Appendix) shows up in Figure 5. "Large" shocks for both the middle and upper regimes are nearly three times larger than the "small" shocks for these regimes while for the lower regime this ratio is less than 2.5.

8. Summary and Conclusion

A large amount of research has been devoted to the empirical validation of the covered interest parity (CIP). Most studies that examine the empirical validity of CIP deal mainly with the size of raw deviations relative to estimates of transactions costs and pay less attention to the speed with which these profitable trading opportunities are eliminated. This paper contributes and extends the above research on CIP in a number of respects. We argue the presence of transaction cost bands suggests that deviations from CIP should exhibit some nonlinear dynamics. In particular, the persistence of deviations from CIP should be substantially lower outside the transaction cost bands (where there are potential profit opportunities) than inside them. Thus, we model deviations from covered interest parity as a threshold autoregression with threshold ARCH effects (TAR/TARCH) in which the dynamics of deviations from CIP within the transaction cost bands differ from the dynamics of those occur outside the transactions cost band. Using nonlinear impulse response analysis, we compare the persistence of deviations from CIP that imply exploitable profit opportunities with those in which no profit opportunities exist.

Using daily data for the US and UK over the period January 1974 to September 1993, we find numerous observations in which the covered interest parity condition exceeds the transaction cost bands. Such findings call into question the practice of constructing forward exchange rates using spot exchange rates and interest rate differentials, assuming CIP holds.[29]

Nonetheless, because arbitrage profit opportunities in general, and large ones in particular, are relatively rare, the scope to make large systematic profits from engaging in covered interest parity is limited. Furthermore, using impulse response functions implied by the threshold autoregressive/threshold ARCH model, we find that deviations from covered interest parity that are outside the transaction cost bands are less persistent than those inside the bands. Thus, not only are profit opportunities from covered interest arbitrage relatively small, they are typically of short duration.

References

Abeysekera, Sarath P. and Harry J. Turtle, "Long-run Relations in Exchange Markets: A Test of Covered Interest Parity," Journal of Financial Research, 18, (Winter, 1995): 431-447.

Agmon, T. and S. Bronfeld "The International Mobility of Short-Term Arbitrage Capital," Journal of Business, Finance, and Accounting, 2, (1975), 269-278

Aliber, R. Z., "The Interest Rate Parity Theorem: A Reinterpretation," Journal of Political Economy, 81, (1973): 1451-1459.

Anderson, Heather M., "Transactions Costs and Nonlinear Adjustment Towards Equilibrium in the U.S. Treasury Bill Market," (1994) unpublished paper, University of Texas.

Atkins, Frank J., "Covered Interest Parity Between Canada and the United States: Another Look Using Modern Time Series Methods," Empirical Economics, 16, (1991): 325-334.

__________, "The Dynamics of Adjustment in Deviations from Covered Interest Parity in the Euromarket: Evidence From Matched Daily Data," Applied Financial Economics, 3, (1993): 183-187.

Bahmani-Oskooee, M. and S. P. Das, "Transactions Costs and the Interest Parity Theorem," Journal of Political Economy, 93, (August 1985): 793-799.

Balke, Nathan S. and Chih-Ping Chang, "Credit and Economic Activity: Shocks or Propagation Mechanism?" (1995), unpublished paper, Southern Methodist University.

Balke, Nathan S. and Thomas B. Fomby, "Threshold Cointegration," (1997), forthcoming, International Economic Review.

Blenman, Lloyd, P., "A Model of Covered Interest Arbitrage Under Market Segmentation," Journal of Money, Credit and Banking, 23, (November 1991): 706-717.

Callier, P., "One Way Arbitrage, Foreign Exchange and Securities Markets: A Note," Journal of Finance, 36, (December 1981): 1117-1186.

Clinton, K., "Transactions Costs and Covered Interest Parity," Journal of Political Economy, 96, (April, 1988): 358-370.

Deardorff, A.V., "One Way Arbitrage and its Implications for the Foreign Exchange Markets," Journal of Political Economy, 87, (April 1979): 351-364.

Dooley, M.P. and P. Isard, "Capital Controls, Political Risk, and Deviations From Interest-Rate Parity," Journal of Political Economy, 88, (1980): 370-84.

Fletcher, Donna J. and Larry W. Taylor, "A Non-parametric Analysis of Covered Interest Parity in Long-Data Capital Markets," Journal of International Money and Finance, 13, (1994): 459-475.

__________, "'Swap' Covered Interest Parity in Long-Date Capital Markets," The Review of Economics and Statistics, 78, (August 1996), 530-538.

Frenkel, J. A., "Elasticities and the Interest Parity Theorem," Journal of Political Economy, 81, (1973): 741-747.

Frenkel, Jacob A. and Richard M. Levich, "Covered Interest Arbitrage: Unexploited Profits?" Journal of Political Economy, 83, (April 1975): 325-338.

__________, "Transactions Costs and Interest Arbitrage: Tranquil versus Turbulent Periods," Journal of Political Economy, 85, (December 1977): 1209-1226.

__________, "Covered Interest Arbitrage in the 1970s," Economic Letters, 8, (March 1981): 267-274.

Gallant, A. Ronald, Peter E. Rossi, George Tauchen, "Nonlinear Dynamic Structures," Econometrica, 61, (July 1993): 871-908.

Hsieh, D.A., "Tests of Rational Expectations and No Risk Premium in Forward Exchange Markets," Journal of International Economics, 17, (1984) 173-184.

Koop, G., M.H. Pesaran, S.M. Potter, "Impulse Response Analysis in Nonlinear Multivariate Models," Journal of Econometrics, 74, (1996): 119-148.

Levich, R. M., "Empirical Studies of Exchange Rates: Price Behavior, Rate Determination, and Market Efficiency," in Handbook of International Economics (Eds.) R. W. Jones and P.B. Kenen, Vol. 2, (Elsever Publishers B.V./North-Holland, Amsterdam, 1985): 1025-1035.

__________, "Is the Foreign Exchange Market Efficient?" Oxford Review of Economic Policy, 5, (1989): 40-66.

Liu, P.C. and G.S. Maddala, "Rationality of Survey Data and Tests of Market Efficiency in the Foreign Exchange Markets," Journal of International Money and Finance, 11, (1992): 366-381.

Maasoumi, Esfandiar, and John Pippenger, "Transaction Costs and the Interest Rate Theorem: Comment," Journal of Political Economy, 97, (1989): 236-243.

MacDonald, R. and M. P. Taylor, "International Parity Conditions," in A.S. Courakis and M.P. Taylor (eds.), Private Behavior and Government Policy in Interdependent Economies, (1990): Oxford, Oxford University Press.

Marston, R.C., "Interest Differentials Under Fixed and Flexible Exchange Rates: The Effects of Capital Controls and Exchange Risk," in M.D. Bordo and B. Eichengreen (Eds.), A Retrospective on the Bretton Woods System: Lessons for International Monetary Reform (Chicago: Chicago University Press for NBER, 1993): pp. 515-46.

McCormick, Frank, "Covered Interest Arbitrage: Unexploited Profits? Comment," Journal of Political Economy, 87, (April 1979): 411-422.

Officer, L.H., and T.D. Willett, "The Covered Arbitrage Schedule: A Critical Survey of Recent Developments," Journal of Money, Credit and Banking, 2, (1970): 247-57.

Otani, I. and S. Tiwari, "Capital Controls and the Interest Parity Rate: The Japanese Experience, 1978-81," IMF Staff Papers, 28, (December 1981): 793-815.

Overturf, S., "Interest Rate Expectations and Interest Parity," Journal of International Money and Finance, 5, (March 1986): 91-98.

Pippenger, J., "Interest Arbitrage Between Canada and the United States: A New Perspective," Canadian Journal of Economics, 11, (1978): 183-93.

Poitras, Geoffrey, "Arbitrage Boundaries, Treasury Bills, and Covered Interest Parity," Journal of International Money and Finance, 7, (1988): 429-445.

Popper, H., "Long-term Covered Interest Parity: Evidence From Currency Swaps," Journal of International Money and Finance, 12, (August 1993): 439-448.

Potter, Simon M., "A Nonlinear Approach to US GNP," Journal of Applied Econometrics, 10, (1995): 109-125.

Prachowny, M. F., "A Note On Interest Parity and the Supply of Arbitrage Funds," Journal of Political Economy, 78, (1970): 540-545.

Rhee, S. Ghon, and Rosita P. Chang, "Intra-Day Arbitrage Opportunities in Foreign Exchange and Eurocurrency Markets," Journal of Finance, XLVII, (March 1992): 363-379.

Sharpe, I., "Interest Parity, Monetary Policy, and the Volatility of Australian Short-term Interest Rates: 1978-82," Economic Record 61, (December 1985): 436-444.

Taylor, Mark P., "Covered Interest Parity: A High-frequency, High-quality Data Study," Economica, 54, (1987): 429-438.

______________, "Covered Interest Arbitrage and Market Turbulence," Economic Journal, 99, (1989): 376-391.

Terasvirta, Timo, and Heather M. Anderson, "Characterizing nonlinearities in Business Cycles Using Smooth Transition Autoregressive Models,," Journal of Applied Econometrics, 7 (December, 1992): S119-S136.

Thornton, D., "Tests of Covered Interest Rate Parity," Federal Reserve Bank of St. Louis Review (July/Aug 1989): 55-66.

Tsay, Ruey S., "Outliers, Level Shifts, and Variance Changes in Time Series," Journal of Forecasting, 7, (1988): 1-20.

Wakeman, L., "The Portfolio Approach to Swaps Management," in C.R. Beidleman (ed.), Interest Rate Swaps, Homewood, Illinois, Dow Jones, Irwin, 1990.

TABLE 1

Violations of Covered Interest No Arbitrage

Sample Period: January 1, 1974 to September 30, 1993

Number of observations violating:	Full sample	Outliers Removed
No Lender Arbitrage		
Upper Band	506 (10.2)	494 (10.0)
Lower Band	121 (2.4)	106 (2.1)
No Owner Arbitrage		
Upper Band	942 (19.0)	927 (18.7)
Lower Band	143 (2.9)	128 (2.6)
Sample Size	4955	4920

Note: The number in parentheses are the percentage of observations.

TABLE 2

Panel A

Means and Standard Deviations

	θ^u	cip_t	θ^l
No Lender Arbitrage			
Mean	.000802826	.0002129	-.000802826
Standard Deviation	.000379211	.0005635	.000379211
No Owner Arbitrage			
Mean	.000630971	.0002129	-.0007047389
Standard Deviation	.000382521	.0005635	.0003767729

Panel B

Frequency of Durations Outside the Lender Transaction Costs Band*

	Full Sample		Outliers Removed	
Duration (days)	Upper Regime	Lower Regime	Upper Regime	Lower Regime
1	164 (62.8)	43 (70.5)	161 (62.6)	30 (63.8)
2	54 (20.7)	8 (13.1)	55 (21.4)	7 (14.9)
3	20 (7.7)	3 (4.9)	19 (7.4)	3 (6.4)
4	5 (1.9)	2 (3.3)	6 (2.3)	2 (4.3)
5	5 (1.9)	2 (3.3)	4 (1.6)	2 (4.3)
6-10	9 (3.5)	2 (3.2)	8 (3.2)	2 (4.3)
11-15	1 (0.4)	0 (0.0)	1 (0.4)	0 (0.0)
16+	3 (1.1)	1 (1.6)	3 (1.2)	1 (2.1)

*Percentages in Parentheses

TABLE 3. Tests of Equality Across Regimes and Residual Diagnostics[*]

A. Threshold Autoregression (TAR) Model Estimated by OLS

<u>Tests of Equality Across Regimes</u>

Autoregressive coefficients (including constant) are equal across regimes:	
Homoskedastic errors:	F(22,4912) = 6.45 (0.0000)
Heteroskedastic consistent covariance:	$\chi^2(22) = 56.94$ (0.0000)
Sum of autoregressive coefficients (not including constants) are equal across regimes:	
Homoskedastic errors:	F(2,4910) = 1.92 (0.147)
Heteroskedastic consistent covariance:	$\chi^2(2) = 1.52$ (0.467)

<u>Residual Diagnostic Tests</u>

Tests for serial correlation in the OLS residuals	
LM-test (F-test version, 20 lags):	F(20,4872) = 7.64 (0.000)
Ljung-Box Q-Statistic (60 lags):	Q(60) = 97.39 (0.000)
Tests for ARCH	
LM-test (F-test version, 20 lags):	F(20,4904) = 5.91 (0.000)
Ljung-Box Q-Statistic for squared residuals (60 lags):	Q(60) = 161.91 (0.000)

B. Threshold AR/Threshold ARCH Model (TAR/TARCH) Estimated by Maximum likelihood (ML)

<u>Test of equality across regimes:</u>

AR, ARCH coefficients, and t-distributions are equal across regimes:	$\chi^2(40) = 198.99$ (0.000)
AR Coefficients (including constant) are equal across regimes:	$\chi^2(22) = 78.56$ (0.000)
Sum of AR coefficients (not including constant) are equal across regimes:	$\chi^2(2) = 10.73$ (0.005)
ARCH parameters are equal across regimes:	$\chi^2(16) = 65.31$ (0.000)
t-distributions are the same across regimes ($\upsilon^u = \upsilon^m = \upsilon^l$):	$\chi^2(2) = 2.97$ (0.227)

<u>Residual Diagnostic Tests</u>

Tests for serial correlation in the standardized residuals:	
LM-test (F-test version, 20 lags):	F(20,4865) = 1.32 (0.155)
Ljung-Box Q-Statistic (60 lags):	Q(60) = 40.84 (0.819)
Tests for ARCH in the standardized residuals:	
LM-test (F-test version, 20 lags):	F(20,4897) = 0.73 (0.797)
Ljung-Box Q-Statistic for squared standardized residuals (60 lags):	Q(60) = 15.55 (0.999)

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[*] The tests of parameter equality across regimes are based on Wald statistics. The p-values are in parentheses.

Table A1.
Basic Threshold AR Model Estimated By OLS

Variable	Upper Regime	Middle Regime	Lower Regime
Constant	$1.95\text{x}10^{-4*}$ $(6.00\text{x}10^{-5})$	$2.73\text{x}10^{-5*}$ $7.12\text{x}10^{-6}$	$-.1.93\text{x}10^{-4}$ $(1.6\text{x}10^{-4})$
cip_{t-1}	$.168^{*}$ (.043)	$.403^{*}$ (.024)	.065 (.065)
cip_{t-2}	$.131^{*}$ (.051)	$.071^{*}$ (.015)	.055 (.100)
cip_{t-3}	.080 (.050)	$.093^{*}$ (.015)	.187 (.144)
cip_{t-4}	$.144^{*}$ (.050)	$.076^{*}$ (.016)	.147 (.078)
cip_{t-5}	.022 (.043)	$.074^{*}$ (.016)	.163 (.138)
cip_{t-6}	.070 (.052)	-.044 (.015)	-.021 (.158)
cip_{t-7}	-.042 (.054)	-.011 (.015)	.317 (.169)
cip_{t-8}	$.126^{*}$ (.055)	$3.10\text{x}10^{-3}$ (.015)	-.334 (.171)
cip_{t-9}	.033 (.040)	$.112^{*}$ (.016)	-.036 (.213)
cip_{t-10}	.019 (.059)	$.073^{*}$ (.014)	.200 (.165)
SEE	$6.02\text{x}10^{-4}$	$4.05\text{x}10^{-4}$	$7.16\text{x}10^{-4}$

Table A2. TAR/TARCH Model Estimated by ML

Coefficients	Upper Regime	Middle Regime	Lower Regime
Constant	$1.24\text{x}10^{-4*}$ $(3.21\text{x}10^{-5})$	$-1.00\text{x}10^{-6}$ $(2.35\text{x}10^{-6})$	$-9.32\text{x}10^{-5}$ $(1.28\text{x}10^{-4})$
cip_{t-1}	$.241^{*}$ (.041)	$.447^{*}$ (.016)	.056 (.108)
cip_{t-2}	.055 (.036)	$.043^{*}$ (.014)	.143 (.093)
cip_{t-3}	.081 (.046)	$.092^{*}$ (.013)	$.303^{*}$ (.133)
cip_{t-4}	$.198^{*}$ (.042)	$.083^{*}$ (.013)	.153 (.117)
cip_{t-5}	.016 (.047)	$.178^{*}$ (.015)	$.211^{*}$ (.088)
cip_{t-6}	$.123^{*}$ (.039)	-.013 (.012)	-.012 (.099)
cip_{t-7}	-.026 (.038)	-.000 (.012)	.112 (.130)
cip_{t-8}	.045 (.035)	.005 (.010)	-.059 (.097)
cip_{t-9}	.010 (.028)	$.034^{*}$ (.010)	-.047 (.144)
cip_{t-10}	.040 (.035)	$.050^{*}$ (.009)	.009 (.107)
ARCH Coefficients			
Constant	$1.30\text{x}10^{-8}$ $(8.00\text{x}10^{-8})$	$2.30\text{x}10^{-8}$ $(1.70\text{x}10^{-8})$	$1.82\text{x}10^{-7}$ $(1.48\text{x}10^{-7})$
ϵ^2_{t-1}	$.377^{*}$ (.139)	$.591^{*}$ (.098)	.051 (.035)
ϵ^2_{t-2}	.086 (.073)	$.113^{*}$ (.038)	.022 (.173)
ϵ^2_{t-3}	$.439^{*}$ (.214)	$.097^{*}$ (.030)	.027 (.212)
ϵ^2_{t-4}	.010 (.052)	$.105^{*}$ (.035)	-.009 (.042)
ϵ^2_{t-5}	$.512^{*}$ (.220)	$.575^{*}$ (.097)	.003 (.036)
ϵ^2_{t-6}	.036 (.067)	-.000 (.014)	.024 (.114)
ϵ^2_{t-7}	.077 (.067)	$.076^{*}$ (.025)	.039 (.097)
υ (df t-dist.)	2.833^{*} (.386)	2.565^{*} (.060)	4.281^{*} (1.082)

Endnotes

1. For surveys of some of this literature see Officer and Willett (1970), Thornton (1989), and MacDonald and Taylor (1990).

2. One exception is Rhee and Chang (1992) who test arbitrage violations directly using high frequency (intradaily) data and find only a small number of violations of CIP over limited periods of time.

3. This is in contrast to Pippenger (1978) who presents empirical results for the Canada-US CIP, that indicate adjustment can take weeks.

4. Rhee and Chang (1992) have argued that indirect measures of transactions costs, such as those used by Frenkel and Levich are not appropriate for examining the frequency of market equilibrium for at least two reasons. First, the validity of indirect measures of transactions costs require that costs structures built into triangular arbitrage remain stable. Unfortunately, equilibrium conditions tend to be violated when markets are unstable. Second, the indirect measures represent only an average cost which does not capture the degree of uncertainty associated with each and every arbitrage transaction. To be exact, the frequency of market disequilibrium should be compiled based on individual transactions.

5. Balke and Fomby (1997) argue that transactions costs could give rise to time series that are threshold cointegrated in which movement back towards a long-run equilibrium occurs only if deviations from the equilibrium are "large". Along these lines, Anderson (1994) applies threshold cointegration to the term structure of interest rates and estimates threshold error correction models for the term structure.

6. Other studies which have demonstrated that timing and accuracy of data is important include McCormick (1979), Maasoumi and Pippenger (1989), and Taylor (1987, 1989). McCormick (1979) has analyzed the effects of using different closing prices from markets in different time zones (e.g. close in New York for the DM and the close in London for the British pound) and finds that deviations from triangular arbitrage declines substantially when exchange rates are quoted simultaneously. Taylor (1987, 1989) use high quality, high-frequency data (five- and ten-minute) to examine the hypothesis that the apparent unexploited profit opportunities for arbitrage may be the result of inappropriate data, including issues of measurement error and timing. He finds very few deviations from CIP when institutional detail was considered. More recently, Rhee and Chang (1992) examined the frequency of simultaneous equilibrium on four markets using real-time quotations drawn from Eurocurrency and interbank foreign exchange markets during the morning trading hours of New York. Profit opportunities were examined not only for one-way but also for covered interest arbitragers. Their results indicate that i) profit opportunities from traditional covered interest arbitrage are rarely available, ii) the frequency of attaining market equilibrium was low, thus, opening the door for one-way arbitrage, and iii) profits from one-way arbitrage persist, indicating why one-way arbitragers do not search for the least-cost arbitrage route.

7. These results were in contrast to those of Frenkel and Levich (1981). Frenkel and Levich (1981) employed Treasury bill rates for the US and Canada over the period 1973-1979 and calculated a transaction cost equivalent to 0.125 percent per annum from bid-ask spreads, which is twice as large as those reported in Clinton (1988).

8. If short- and long-term assets were perfect substitutes within currencies, then CIP among long-term assets could be regarded as an extension of the short-term CIP literature discussed above. However, Popper (1993) points out that assets of different maturities are not easily substitutable, and thus a different analysis is required for markets in which assets with long maturities are traded.

9. Much of the literature examining CIP assumes that forward contracts are the relevant instrument for evaluating CIP. But a large amount of 'forward' trading in foreign exchange is done through swap transactions. As Clinton (1988) illustrates, this has important implications for evaluating the transactions cost bands for a CIP-based arbitrage. Another caveat that should be pointed out is that it is usually assumed that $i_\$$ and i_f are interest rates on the assets with the same characteristics. This is why in this study we employ euro-deposit rates. If the interest rates used are on Treasury bills, the two securities of the two different countries will usually not have the same risk characteristics.

10. Several filters were run on the data to check for errors, and unfortunately some errors were found. After consultations with the staff at DRI the errors were corrected.

11. $T=1/12$ here as euro-deposit rates are annual and forward rates have a 1 month maturity. We could have alternatively multiplied the forward premium by 12, however, the chosen specification is consistent with the model used in this paper.

12. Point estimates of deviations from CIP calculated from posted bids and asks will not in general be equal to the actual deviations on either side of the bid or ask. The quotes actually only define a range within which trades may take place, while dealers normally negotiate for finer spreads than those posted. Thus, we calculate all interest rates variables as the geometric average of the bid-ask spread.

13. We removed observations in which the standardized residuals from a linear autoregression were greater than four. The rather large sample size made more formal, iterative outlier searches such as Tsay (1988) impracticable.

14. The standard error of the sample mean is 8.0053×10^{-6}.

15. The approximate annual profit lender arbitrage = $(1 + \pi_t)^{250} - 1$, where π_t is equal to $|cip_t| - \theta^u_t$ if $|cip_t| - \theta^u_t > 0$ and equal to zero otherwise. π_t is the rate of return for a given arbitrage opportunity, so to get annual return we assume 250 trading days or (arbitrage opportunities) in a year. As these profits apply to the no lender arbitrage case, the number of days in figure 3 sum to 527 (506 in upper regime and 121 in the lower--see Table 1: full sample, No Lender Arbitrage).

16. This is similar to the profits for dollar/pound arbitrage found by Clinton.

17. The threshold autoregression for covered interest parity would imply threshold cointegration (see Balke and Fomby (1997)) for the forward premium for exchange rates and the interest differential if the autoregression in the middle regime contained a unit root. However, in this case deviations from covered interest parity appear to be stationary in all three regimes.

18. We did not separately examine a TAR/TARCH model for no owner arbitrage transactions bands. The lender arbitrage case is the more the binding of the two as all instances of lender arbitrage will also be instances of owner arbitrage. Furthermore, estimation of the basic TAR

model with the no owner arbitrage transactions bands yielded very similar results to those presented in the paper. Thus, to save space we present results only for the no lender arbitrage case.

19. We also experimented with the estimation of a smooth transition autoregressive model but difficulties in estimating the curvature of the transition functions forced us to settle on the discrete threshold model as it is a more parsimonious model which does not require the specification of transition functions.

20. Our use of a parametric distribution for v_t only affects our estimation of the threshold model. In the simulations used to construct impulse responses described below, we use the realized standardized residuals as v_t shocks.

21. Tables A1 and A2 in the appendix present the details of the estimated threshold models. All calculations including the impulse response analysis discussed below were conducted using RATS Version 4.1.

22. One can also reject the hypothesis that the autoregressive models for the upper and lower regimes are equal. Similarly, for the ARCH models.

23. The lag length for the TAR was set at ten lags. For the TAR model estimated by OLS, this was not sufficient to eliminate all the serial correlation in the residuals; however, when examining the autocorrelation function of the residuals, it appears that this remaining serial correlation is the result of correlation of residuals at infrequent and irregular lags. This correlation is eliminated once ARCH effects and a "fat-tailed" distribution for standardized shocks are allowed.

24. See Koop, Pesaran, and Potter (1996) and Gallant, Rossi, Tauchen (1993) for a discussion of nonlinear impulse response analysis.

25. If the shocks were normally distributed, these would correspond to approximately one and two standard deviation shocks.

26. For example, we first draw an initial date τ_1 from the actual data and calculate the IRF conditional on that date. We then reselect another date τ_2, with replacement, and calculate another IRF. This is continued until 500 initial dates have been selected for the model and then take the average to obtain an IRF for cip.

27. When conditioning on each regime, we draw 500 different initial dates from the respective regime and then take averages of the resulting IRFs. This gives us three conditional IRFs--one for each regime, upper, lower, middle. These three, combined with the IRF obtained from drawing initial dates from the full sample yields the four IRFs displayed in Figures 4 and 5.

28. In a previous version of this paper, we considered using a threshold autoregression to model the bid/ask spread itself. However, the results were not substantially different from those reported here. In future work, we hope the develop a more interesting model of the bid/ask spread, so that we better explore the joint dynamics between the covered interest parity condition and the bid/ask spread.

29. For example Liu and Maddala (1992) follow Hsieh (1984) and construct one-week forward rates (in their tests of foreign exchange market efficiency) assuming CIP holds.

Figure 1.

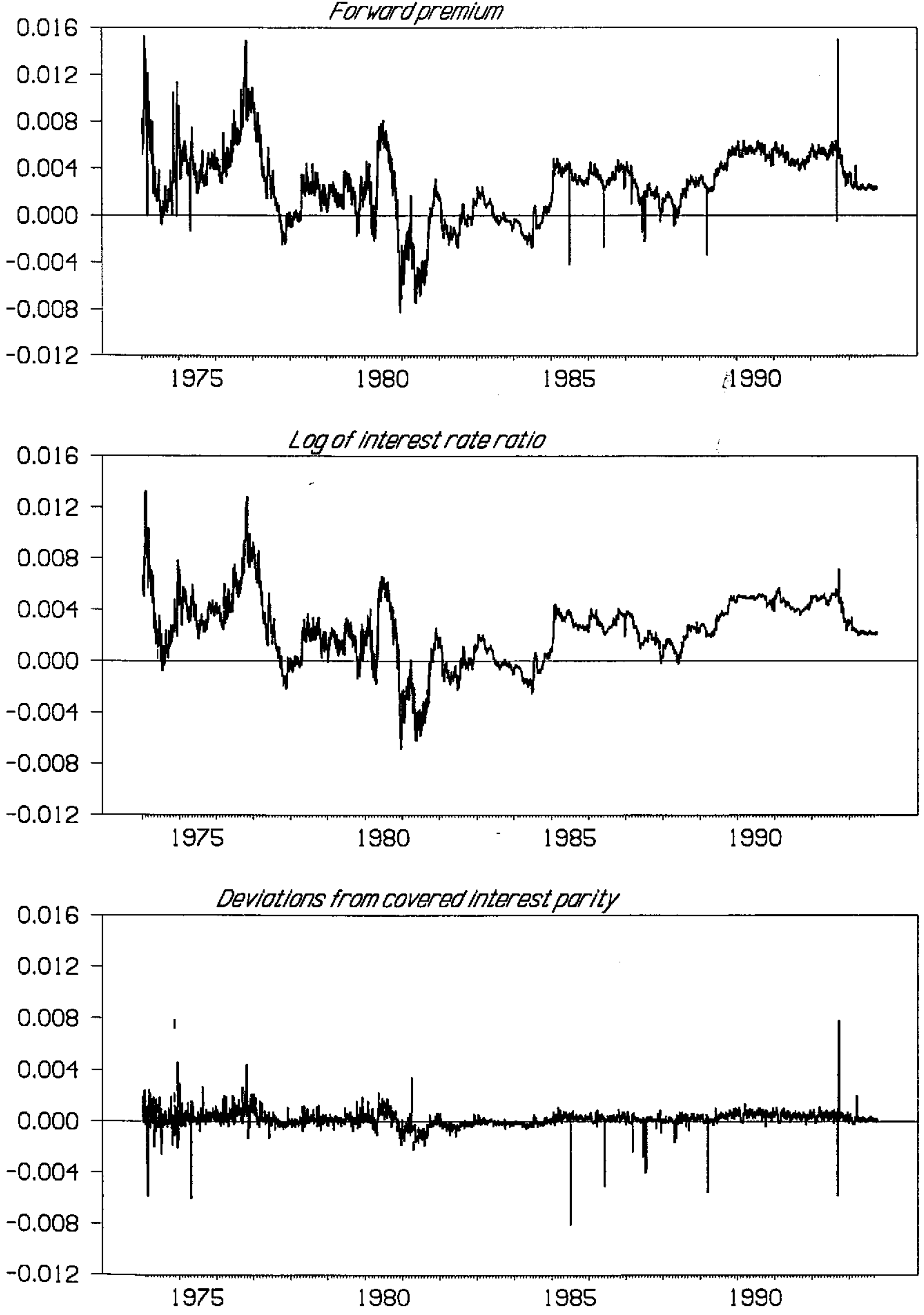
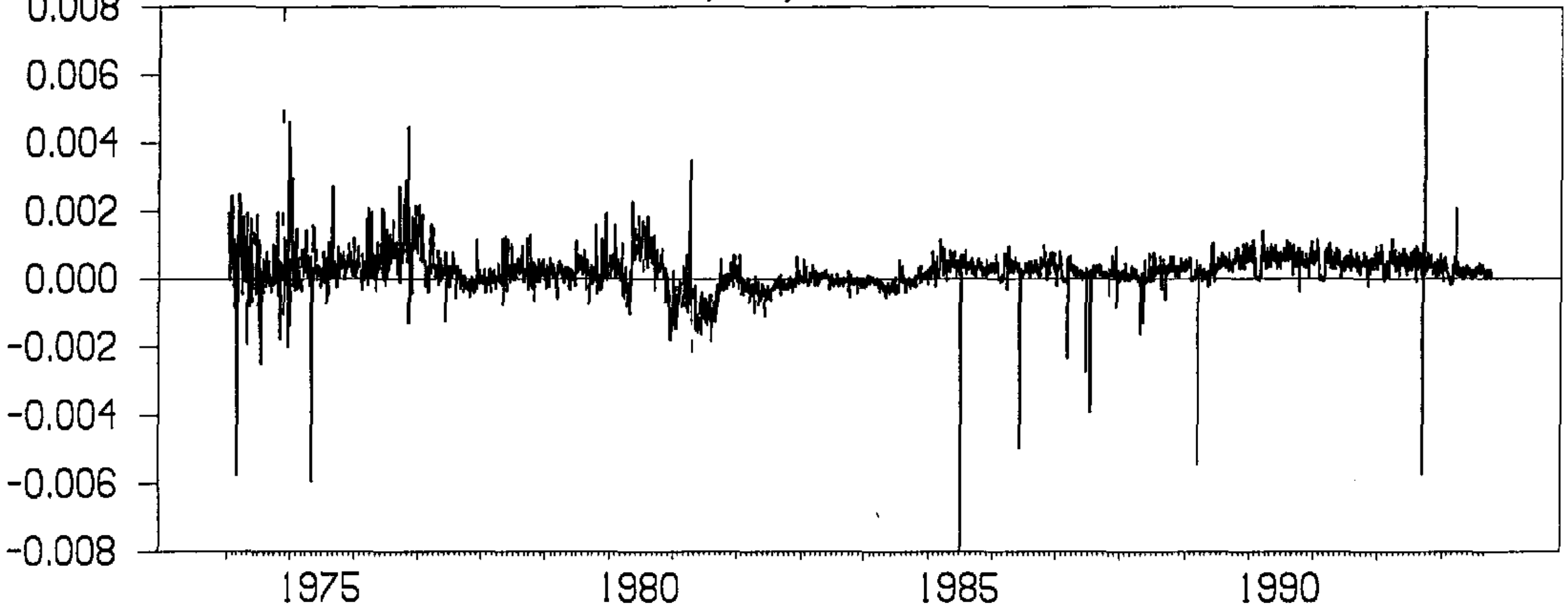

Forward premium
0.016
0.012
0.008
0.004
0.000
-0.004
-0.008
-0.012
1975
1980
1985
1990
Log of interest rate ratio
0.016
0.012
0.008
0.004
0.000
-0.004
-0.008
-0.012
1975
1980
1985
1990
Deviations from covered interest parity
0.016
0.012
0.008
0.004
0.000
-0.004
-0.008
-0.012
1975
1980
1985
1990

Figure 2.

Covered interest parity condition



Lender transactions costs bands

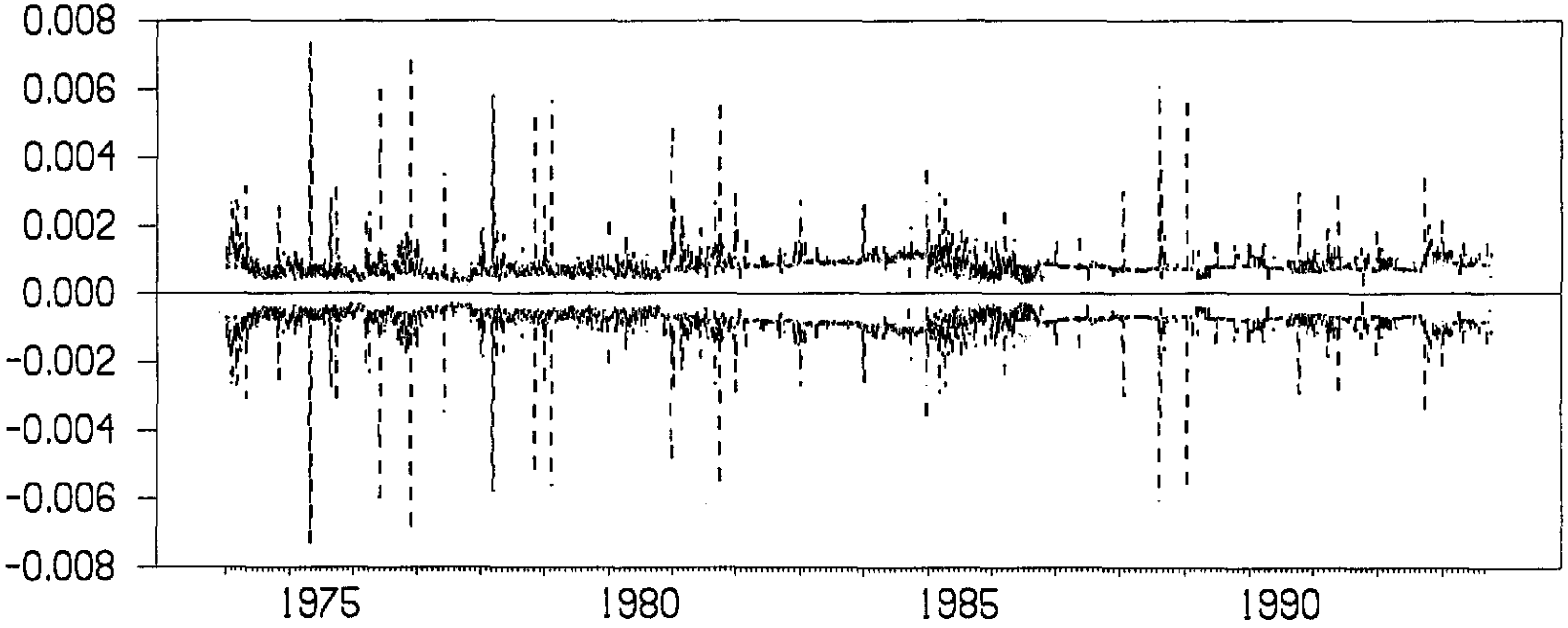
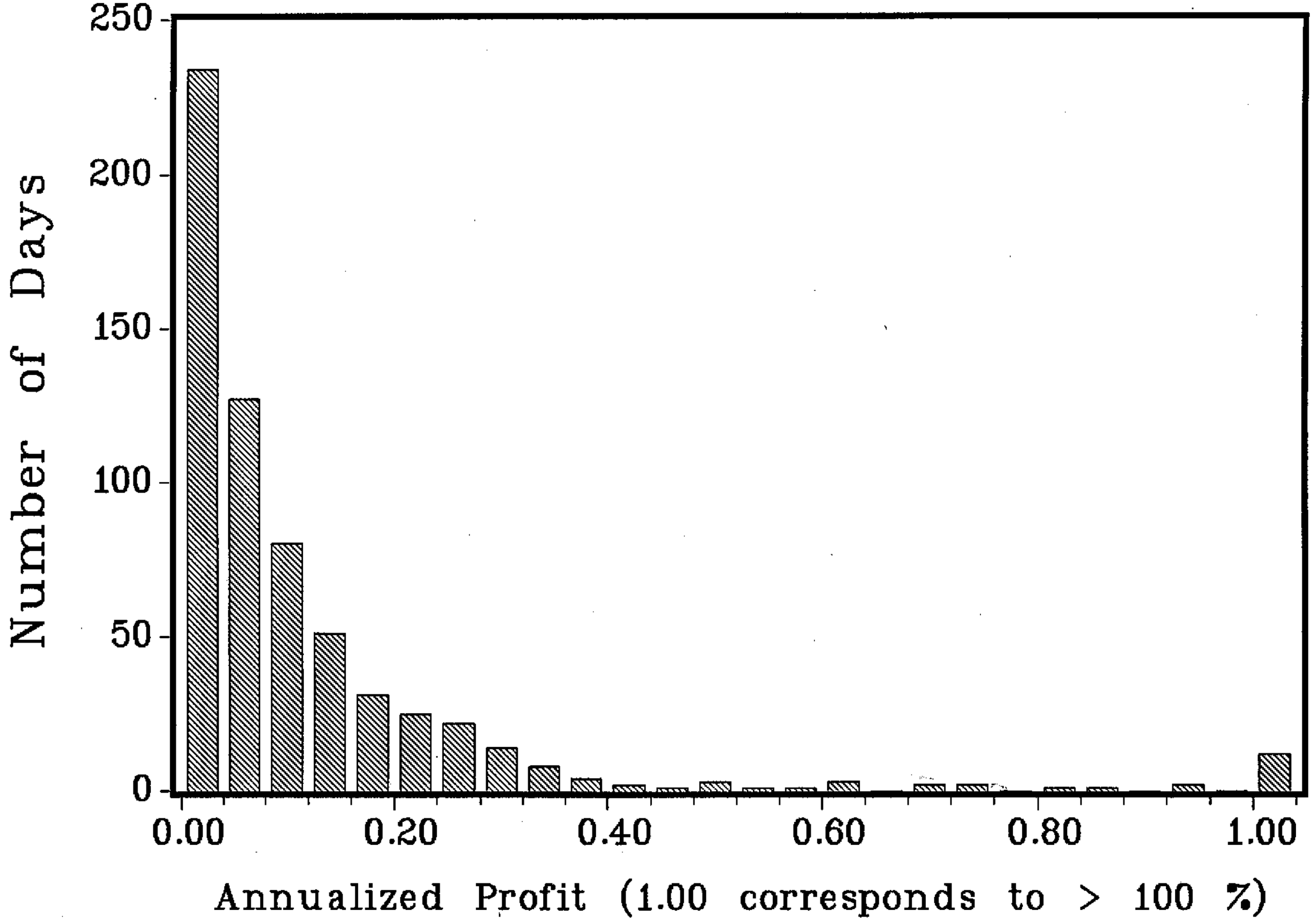


FIGURE 3



Number of Days
250
200
150
100
50
0
0.00
0.20
0.40
0.60
0.80
1.00
Annualized Profit (1.00 corresponds to > 100 %)

Figure 4. Impulse Response Functions
Same Initial Shock Across Regimes

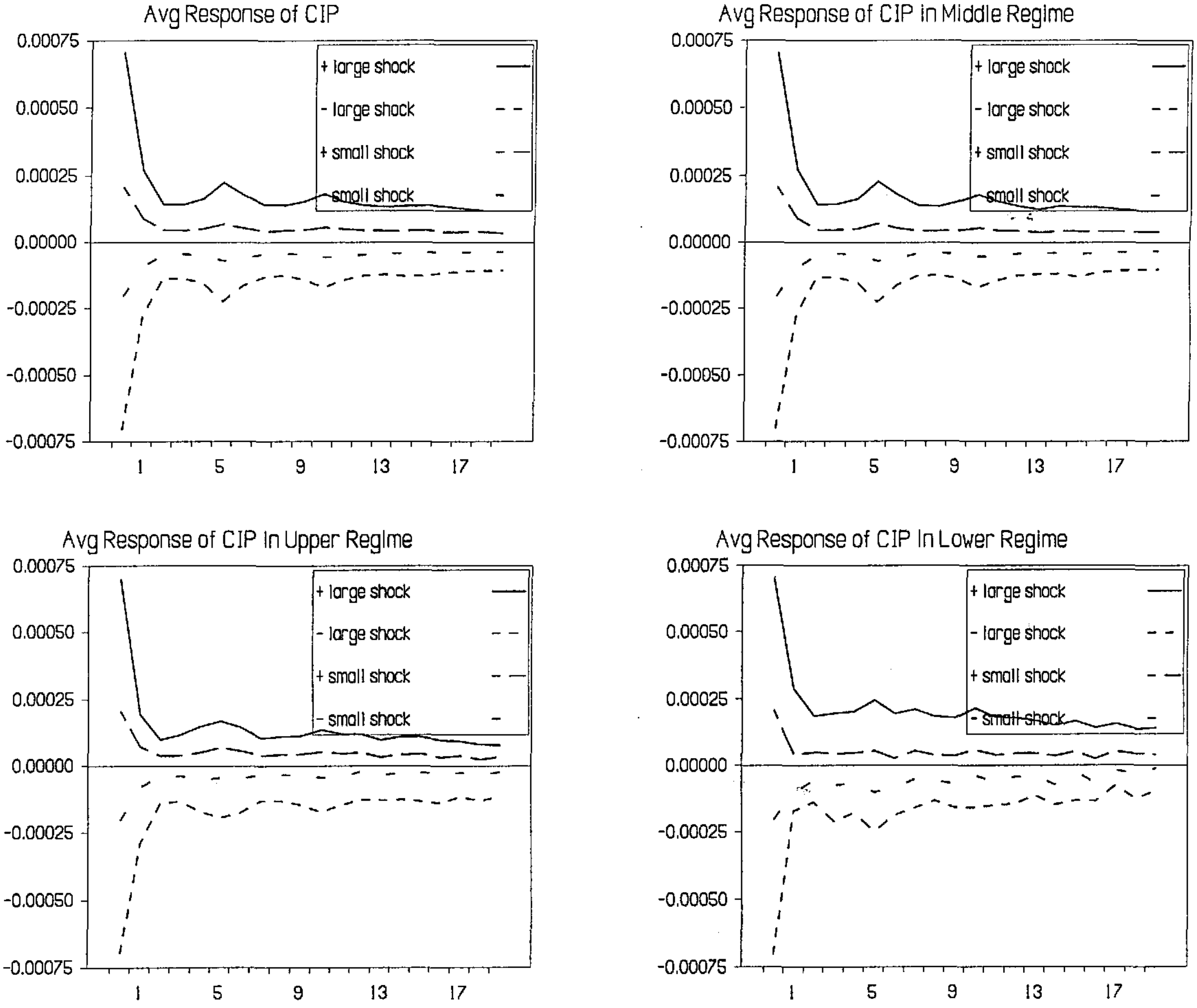
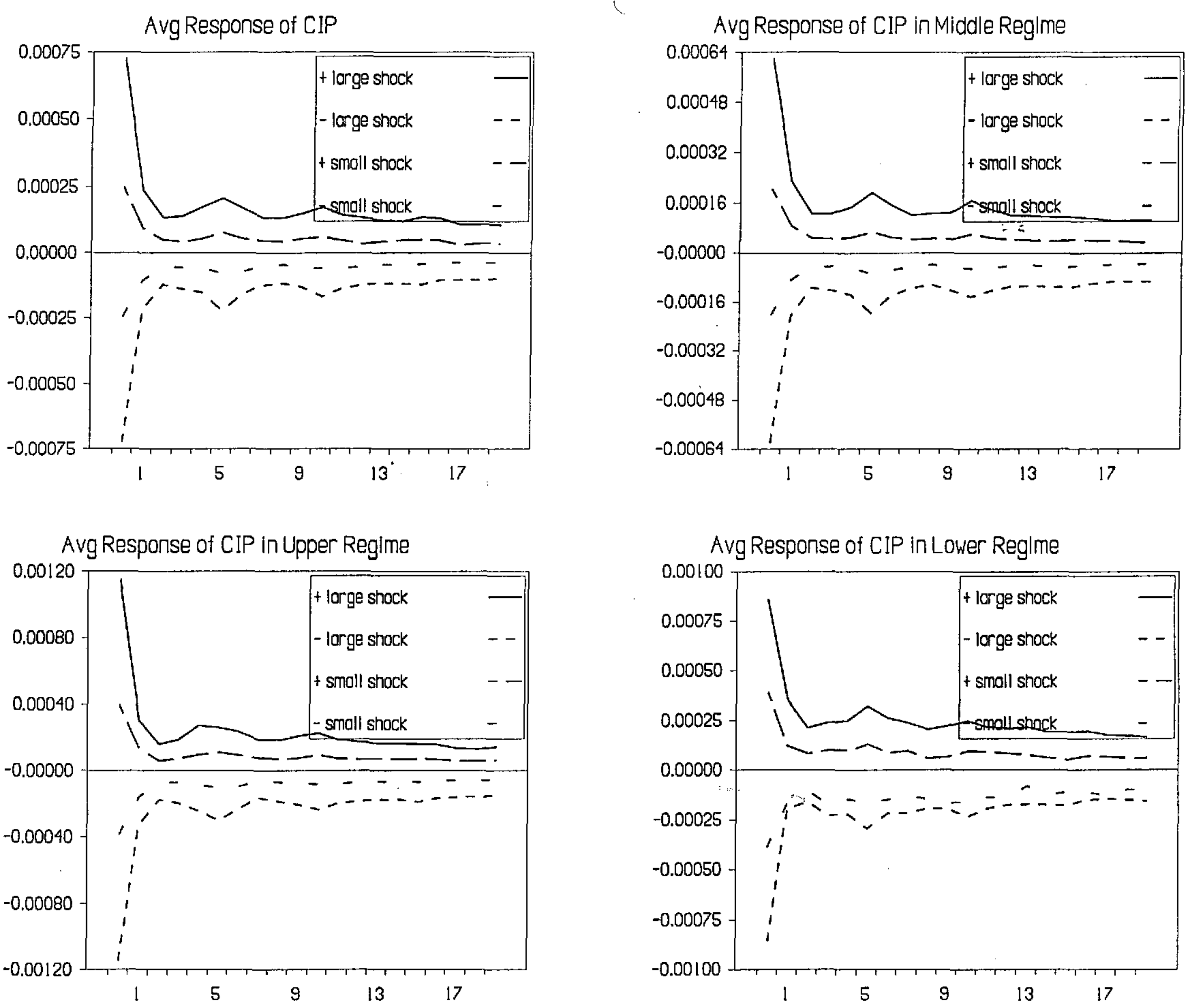


Figure 5. Impulse Response Functions
Initial Shock Conditional on Regime



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