Interest Parity Cambist Versus Academic Interpretation

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Major Paper presented to the
Department of Economics of the University of Ottawa
In partial fulfillment of the requirements of the M.A. Degree
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ECO 7997

Ottawa, Ontario
January 2005

ABSTRACT

This paper examines the theoretical plausibility of the uncovered interest parity and tests its validity by empirical evidence. I try to show that the spot and forward exchange rates are related by a contemporaneous relationship, as represented by covered interest parity, rather than a lagged relationship, as represented by uncovered interest parity. Test results show that the forward exchange rate is not a reliable estimator of the future spot exchange rate because two rates are determined contemporaneously. The failure of the uncovered interest parity implies the failure of the real interest parity. Thus, it can be concluded that monetary authorities can control domestic interest rates within a wide spectrum of their choice.

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Introduction

The cambists [1] have a different interpretation of the forward exchange market than that of the mainstream economists (Coulbois and Prisset, 1974). This difference leads to a different approach to open economy macroeconomic analysis. As has been put forward by Lavoie (2000), the Post Keynesian view, which is based on cambist approach, is such that "even in an open economy with financial mobility, central banks retain the ability to set interest rates of their choice, within a wide spectrum" (Lavoie, 2000, p. 163).

This view is in contrast with the mainstream view, according to which it is impossible for a country to control or determine the level of interest rates in the contemporary environment characterized by the globalization of capital markets. The mainstream interpretation depends on the real interest parity (RIP) condition, arguing that "it is impossible for real interest rates to be any different from those ruling in the rest of the world" (ibid.). In other words it stipulates that real interest rates must be equated across countries. The RIP condition implies that "there is no possibility for any independent control over the real rate of interest for any individual jurisdiction". Then in spite of various imperfections, "interest rates in the small open economy must conform to interest rates established in world markets or possibly by the world central bank" (Smithin, 2002-03, p.224).

RIP holds when three other parities hold, covered interest parity (CIP), uncovered interest parity (UIP), and purchasing power parity (PPP). But, empirical evidence shows significant deviations from PPP and UIP, but not from CIP. Relative versions of PPP assert that the exchange rate moves with inflation rate differentials. On the other hand, according to neoclassical analysis, inflation rate differentials are determined by net money supply growth. Thus, the exchange rate moves with net money supply growth. But the problem is that "all versions of the PPP theory do badly in explaining the facts" (Krugman and Obstfeld, 2000, p. 406). At the same time, the UIP condition states that in

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Cam"bist\, n. [F. cambiste, It. cambista, fr. L. cambire to exchange. See {Change}.]\ A banker; a money changer or broker; one who deals in bills of exchange, or who is skilled in the science of exchange, http://www.hyperdictionary.com/dictionary/cambist a riskless environment, expected changes in exchange rates determine the interest rates differential. It can thus be concluded that real interest rates will be equated across countries - real interest parity (RIP) - when PPP holds.

The UIP must also be consistent with covered interest parity. The CIP condition expresses that interest rate differentials must be equal to forward exchange changes (premium or discount) with respect to the spot exchange rate. Comparing CIP and UIP, this implies that the forward exchange rate must be equal to the expected future spot exchange rate. Consequently, the forward exchange rate should be equivalent to the expected value of future spot exchange rate. But, it has been shown by several empirical studies that the forward rate is not a good predictor of the spot rate. Then it can be concluded that "RIP does not necessarily hold. Central banks may still retain the ability to fix real interest rates that are different from those prevailing in the rest of the world" (Lavoie, 2000, p.165). Thus, monetary authorities may have the ability to set short-term rates of interest at the level of their choice, in view to the optimum level of the desired key economic variables.

The objective of this paper is to examine the theoretical plausibility of the UIP and test its validity by empirical evidence. I will try to show that the spot and forward exchange rates are related by a contemporaneous relationship (CIP) rather than a lagged relationship (UIP), as has been addressed by Moosa (2004).

Literature Review

Mainstream economists believe that the RIP condition holds. From this, they conclude that the real interest rate must be equal across countries, and that the interest rate cannot be a useful policy instrument, especially in small economies. By contrast, Post Keynesians believe RIP does not hold and the interest rates can be an effective policy instrument in an open economy as well as in a closed economy.

The Post Keynesian approach is based on the cambists' interpretation of forward exchange markets, which was put forward by P. Coubois and P. Prissert. They re-examined the relationship between short term capital flows and monetary policy in light of a new theoretical approach of the forward exchange market (1974). They contended that the traditional forward exchange market theory is misleading as it fails to give proper attention to the distinction between covered and uncovered exchange transactions and to the actual role of the "arbitrages". As a result, they put forward a new approach, which they called the "cambist" view of forward exchange markets. It should be mentioned here that Keynes' theory about forward exchange markets (1923) goes somehow against the cambist theory and is closer to the analysis developed by the mainstream.

Cambists believe there is no arbitrage function in forward exchange markets to put this market into equilibrium. They argued that equilibrium in the forward exchange market is not brought about by the intervention of arbitrageurs, but simply by that of banks, which cover on the spot market the excess forward orders, borrow the currency which is sold and lend the currency which is bought. According to cambist theory, banks charge their customers forward rates which reflect the interest rate differential (Coulbois and Prisset, 1974, p. 290). Thus, they conclude that covered interest parity always holds.

They demonstrate that the problem of monetary management in an open economy must be portrayed in a new way and conclude that monetary policy and central banks intervention on foreign exchange markets can still have some efficiency.

Marc Lavoie (2000) put forward the Post Keynesian approach to the real interest parity on the basis of the cambist interpretation of forward exchange markets. He denies that, despite the modern international economy, central banks are forced to accept the interest rates ruling on international markets. Lavoie argues that two out of the three assumptions upon which the RIP is built are not correct, theoretically or empirically. He rejects the claim that forward exchange rates are a good and reliable predictor of future exchange rates by arguing that if agents operating in the financial markets were relying on them, they would be consistently wrong. Adding to this, the failure of purchasing power parity, concludes that real interest parity cannot hold. He also shows how covered interest parity always holds through the cambist approach to forward exchange markets. And finally, he uses the reflux principle to show that central banks are able to manage domestic interest rates lower than those in the rest of the world, if they are willing to do so. It is advised that some sort of capital control be put in place, to confront bouts of international turbulence. The paper by Lavoie (2000) seems to have attracted the attention of Post Keynesian authors interested in interest parity theorems and it is the base of the present paper.

There is also another argument supporting the view that central banks can fix real interest rates that are different from real interest rates prevailing elsewhere in the world. This is a modification of uncovered interest parity based on a portfolio analysis where currency and political risks are taken into account. Smithin (2002-03) argues that premium risk might be a negative function of the real net foreign credit position. This currency risk is required for interest rates on one currency to be different from those on another currency. He argues that short term nominal interest rates are essentially a policy-determined variable set by the central bank, and in the absence of a Wicksellian "natural rate" in any real world economy, the implication is that the central bank must have substantial influence over real interest rates also. Thus, he concludes that the real exchange rate is a monetary variable and hence is subject to policy manipulation. Much depends on the nature and determinants of the currency risk premium, especially in an environment in which separate monetary systems in different economies continue to exist and are characterized by imperfect asset substitutability, whether there is capital mobility or not. And he claims that in a credible fixed exchange rate regime, interest rate discrepancies cannot occur.

Lavoie (2002-03) develops his own previous view of forward exchange rates, based on imperfect asset substitutability, the peculiarities of fixed exchange rates, and the impact of speculation in forward exchange markets. He believes that the uncovered interest parity theorem could only hold if perfect asset substitutability held, devoid in addition of any currency risk or credit risk, which is precisely the point that Smithin makes by introducing a risk premium (z variable). He states that covered interest parity and uncovered interest parity can hold at the same time only if perfect asset substitutability and perfect capital mobility hold true. He also believes, even with fixed exchange rates, that there can be wide variations in interest rates. The presence of forward exchange markets does not prevent these variations. These could be explained to some extent by variations in inflation rates, the perspective of future modifications to the parity rate, and the highly imperfect mobility of capital for several countries.

Moosa (2004) tries to examine the Post Keynesian proposition that the forward rate is determined by covered interest parity and that it is not a predictor of the future spot rate, in contrast to what is suggested by the mainstream. He runs some econometric tests to demonstrate that the relationship between spot and forward rates is indeed contemporaneous rather than lagged, which supports the Post Keynesian view. The results of his work show that the forward rate cannot be used to forecast the spot rate because the two rates are determined jointly and contemporaneously. He also shows that what appears to be a risk premium is a stochastic trend reflecting missing variables, or in the case of a correctly specified model, such factors as transaction costs. He argues the CIP condition represents the correct specification of the spot-forward relationship.

Harvey (2004) tries to put forward a source thereof that can account for the specific pattern of deviations from uncovered interest parity. Drawing on the work of Lavoie (2000) and Smithin (2002-03) and extending it with some basic Post Keynesian propositions regarding endogenous money, uncertainty, and nonergodicity, he shows that it can be devised as a comprehensive explanation of UIP, where factors other than risk are responsible for deviations. He believes it is only the lack of compensating flows that prevents UIP to hold. He denies that risk can cause deviations from UIP. He argues that Keynes' "confidence" variable along with changes in money and share prices is capable to explain most deviations from UIP. He concludes that solving the riddle of UIP leads directly to the consideration of the factors that cause it to fail. This brings a more realistic understanding of global financial investment rather than one based on rational expectations, ergodicity, and exogenous money.

Empirical Evidence regarding real interest rates

Before entering the theoretical justifications for the existence of the real interest parity theorem, we look at real interest rates among G-7 countries to examine the stylized facts.

The nominal rates of interest are the annual averages of the money markets rates in each country, that is, the federal funds rate in the United States, and overnight rates in most of the other countries. The rates of inflation used to obtain the real rates are based on the growth rate of the consumer indices[2].

Table 1 shows the evolution of prevailing real interest rates among G-7 countries from 1994 to 2003. Table 2 shows the real interest rate in the United States and differences between real interest rates in the relevant country and those of the United States. As it can be seen, there is a large degree of autonomy for each central bank. Even in Canada real interest rates do not follow real interest rates in the United States [the country that is pointed out as the rest of the world for Canada (Smithin, 2002-03, p. 228)], except perhaps for the 1996 to 2002 period, which can be interpreted as a "deliberate policy decision on the part of the Bank of Canada rather than the power of the real interest parity theorem" (Lavoie, 2000, p. 165).

Wide ranges of differentials in real interest rates among countries hardly can be attributed to any model of interest parity, even to the one adjusted by the "risk premium". We know that inflation rates are given in the short run, and central banks acknowledge that they set the shortest-term nominal rate, thus it can be concluded that "it is possible for central banks to set short-term real rates of interest which are different from the real rates ruling in the rest of the world" (ibid).

[2]The real rate of interest is $r = (i - \pi)/(1 + \pi)$, where r is the real interest rate, i is the nominal rate of interest, and π is the inflation rate. But, for low rates of inflation, as is the case here, this is a close enough approximation of $r = i - \pi$.

Table 1. Real Money Market Interest Rate among G-7 Countries from 1994 to 2003

Year	United States	Canada	United Kingdom	Japan	France	Germany	Italy	European Union
1994	2.00	4.95	2.78	1.50	4.59	2.95	5.21	Na
1995	3.44	4.92	3.18	1.31	4.65	2.90	6.08	Na
1996	2.70	2.92	3.86	0.37	1.93	1.87	5.32	Na
1997	3.36	2.76	3.81	-1.32	2.04	1.38	4..98	Na
1998	3.85	3.87	4.10	-0.23	2.59	2.51	3.19	Na
1999	2.97	3.14	3.70	0.36	2.24	2.13	1.35	1.10
2000	2.94	2.82	2.97	0.81	2.42	2.71	1.89	2.30
2001	1.09	1.61	3.28	0.76	2.68	2.37	1.46	2.10
2002	-0.03	0.15	2.59	0.91	1.38	0.08	0.82	2.30
2003	-1.17	0.03	0.59	0.30	0.12	1.22	-0.47	2.20

Source: IMF, International Financial Statistics,
http://ifs.apdi.net/imf/ifsBrowser.aspx?sType=Country_Tables&QueryType=Country&ShowSeries=Country

Table 2. Real Money Market Interest Rate in the US and differentials with respect to other G-7 members from 1994 to 2003

Year	United States	Canada	United Kingdom	Japan	France	Germany	Italy	European Union
1994	2.00	2.95	0.78	-0.50	2.59	0.95	3.21	Na
1995	3.44	1.48	-0.26	-2.13	1.21	-0.54	2.64	Na
1996	2.70	0.22	1.16	-2.33	-0.77	-0.83	2.62	Na
1997	3.36	-0.60	0.45	-4.68	-1.32	-1.98	1.62	Na
1998	3.85	0.02	0.25	-4.08	-1.26	-1.34	-0.66	Na
1999	2.97	0.17	0.73	-2.61	-0.73	-0.84	-1.62	-1.87
2000	2.94	-0.12	0.03	-2.13	-0.52	-0.23	-1.05	-0.64
2001	1.09	0.52	2.19	-0.33	0.78	1.28	0.37	1.01
2002	-0.03	0.18	2.62	0.94	1.41	0.11	0.85	2.33
2003	-1.17	1.20	1.76	1.47	1.29	2.39	0.70	3.37

Source: IMF, International Financial Statistics,
http://ifs.apdi.net/imf/ifsBrowser.aspx?sType=Country_Tables&QueryType=Country&ShowSeries=Country

Real Interest Parity

Normally, in mainstream texts, the RIP condition is derived from the models for determining the exchange rate in an open economy. They believe that "the foreign exchange market is in equilibrium when deposits of all countries offer the same expected rate of return. This condition is called 'Interest Parity' (Krugman and Obstfield, 2000, p. 347).

We start with the CIP condition. It is given by:

$$i_t - i_t^* = \frac{F_t - S_t}{S_t} = f_t - s_t \tag{1}$$

where i_t is the domestic nominal rate of interest at time t, i_t^* is the foreign or rest of the world nominal rate of interest at time t, F_t is the forward exchange rate quoted at time t for delivery of foreign exchange at time t+1, S_t is the spot exchange rate at time t. The lowercase letters stand for the logarithm of the variables denoted by the corresponding uppercase letters. For a small enough amount, the Taylor expansions yield the approximate equalities.

CIP states that rates of return on similar financial instruments should be equal across different financial centers when the investors' position is covered by a forward contract.

The UIP condition is given by:

$$i_t - i_t * = \frac{S_{t+1}^e - S_t}{S_t} = s_{t+1}^e - s_t \tag{2}$$

where S_{t+1}^e is the expected spot exchange rate for time t+1 at time t.

If CIP and UIP are both supposed to hold at the same time, then we must have:

$$f_t = s_{t+1}^e \tag{3}$$

It is consistent with rational expectations and the unbiased efficiency theorem, indicating that the forward exchange rate is the best and unbiased predictor of the future spot rate (Moosa, 2004, p. 399).

In the neoclassical approach to the foreign exchange, agents are assumed to believe in purchasing power parity (PPP). It is derived from the law of one price: "in competitive markets free of transaction costs and official barriers to trade, identical goods sold in different countries must sell for the same price when their prices are expressed in terms of the same currency (Krugman and Obstfeld, 2000, p. 395). It can be written as:

$$P = S.P^*$$

Then it can be concluded that the exchange rate equals the relative price level, which is known as the absolute version of PPP:

$$S = \frac{P}{P^*}$$

The relative version of PPP states that the percentage change in the exchange rate between two countries over any period equals the difference between the percentage changes in national price levels. It can be put in equation form as follows:

$$\log S = LogP - LogP^*$$

Taking derivatives from both sides, we get:

$$\frac{\Delta S}{S} = \frac{\Delta P}{P} - \frac{\Delta P^*}{P^*}$$

$$\frac{S_{t+1} - S_t}{S_t} = \frac{P_{t+1} - P_t}{P_t} - \frac{P^*_{t+1} - P^*_t}{P^*_t}$$

$$s_{t+1} - s_t = \pi_{t+1} - \pi^*_{t+1} \qquad (4)$$

where π_{t+1} is the expected domestic inflation rate and π^*_{t+1} is the expected foreign inflation rate. This equation is correct for a small enough amount of π and π^*.

In the monetary approach to equation (4), "inflation rate differentials as determined by money supply growth differentials net of output growth, should provide the correct expectation" of changes in exchange rates (Lavoie, 2000, p. 164).

By combining equations (2), (3), and (4), we get the real interest parity (RIP) condition as:

$$r - r^*_t = (i_t - \pi_{t+1}) - (i^*_t - \pi^*_{t+1}) \qquad (5)$$

where r_t is the real domestic rate of interest at time t, and r^*_t is the equivalent real foreign rate of interest. The RIP implies that in an open economy there is no possibility for any independent control over the real rate of interest for any central bank. In the mainstream approach, any violation of RIP must be the result of mistaken expectations, either due to the wrong prediction of inflation rates or because nominal exchange rates did not move in line with the PPP theorem.

To show the requirements for RIP to hold, following Mossa (2004, p. 397), the right hand side of equation (5) can be manipulated by adding and subtracting the percentage change in the exchange rate, $\Delta s_{t+1} = s^e_{t+1} - s_t$, and rearranging to obtain:

$$r_t - r^*_t = (i_t - i^*_t - \Delta s_{t+1}) + (\pi^*_{t+1} - \pi_{t+1} + \Delta s_{t+1}) \qquad (6)$$

It shows that deviations from RIP (as represented by the real interest differential) are equal to deviations from UIP (represented by the interest differential) and deviations from PPP. Equation (6) can be modified further by adding and subtracting the forward spread, f_t, and rearranging to obtain:

$$r_t - r_t^* = (i_t - i_t^* - f_t) + (f_t - \Delta s_{t+1}) + (\pi_{t+1}^* - \pi_{t+1} + \Delta s_{t+1}) \tag{7}$$

or

$$r_t - r_t^* = (i_t - i_t^* - f_t + s_t) + (f_t - s_{t+1}^e) + (\pi_{t+1}^* - \pi_{t+1} + \Delta s_{t+1}) \quad 8)$$

Here, deviations from UIP are split into deviations from CIP and unbiased efficiency (the forward rate forecasting error). As it is obvious from equation (8), RIP holds when the three other parities hold: CIP, UIP, and PPP.

The Critique of Real Interest Parity

If the RIP condition holds, then logically central banks have no ability to influence real rates of interest in their own jurisdiction. However, as it shown, real interest parity requires the validity of purchasing power parity, uncovered interest parity, and covered interest parity. Thus, if any of these three conditions can be challenged, or even questioned, then the final conclusion may also be subjected to a decisive challenge. So, the validity of each condition is discussed here.

PPP. Due to various imperfections, it is proved by a very large number of empirical works that PPP is not a successful explanation of exchange rate variations in short or even medium run. It only might yield significant information for the very long run (Krugman and Obstfeld, 2000, chapter 5). There is also another issue about causality: "It may be that changes in exchange rates influence relative inflation rates, rather than relative inflation rates determining exchange rates" (Lavoie, 2000, p.164).

UIP. From equation (3), UIP and CIP can simultaneously be true only when:

$$f_t = s_{t+1}^e$$

It means, on the basis of the expectation theorem that we should have:

$$s_{t+1} = s_{t+1}^{e} + \varepsilon_{t+1}$$

where s_{t+1} is the realized spot exchange rate at time t+1, s_{t+1}^{e} is the expected spot exchange rate for time t+1 at time t, and ε_t is a white-noise error term. By substituting we get:

$$s_{t+1} = f_t + \varepsilon_t$$

or

$$E(s_{t+1}) = f_t$$

But empirical studies show poor support for this parity (Harvey, 2004).

According to the mainstream point of view, UIP is based on "international financial markets efficiency, perfect capital mobility, and perfect asset substitutability" (Gandolfo, 2001, chapter 4). This means that international investors are indifferent to hold different currencies in their portfolios. But considering the inefficient financial markets, imperfect capital mobility, and imperfect asset substitutability, as well as existing political, currency, and liquidity risks that are observed in the real economy, this assumption is unlikely. To modify UIP, some economists add a (time-varying) risk premium term to the model (Smithin, 2002-3, p. 276):

$$f_t = s_{t+1}^{e} + z_t$$

where z_t stands for a risk premium factor. Smithin and several mainstream economists argue that since there is a relationship between the forward rate and the expected future spot rate, while UIP does not hold, then something like a z_t term must exist and there must be some explanation of its value. It is either just a constant or the residual difference between two other exogenously determined variables. Interest rate differentials on different currencies would then be based on a currency premium (discount) which depends on accumulated net foreign debt. When a country has had net capital outflows, a creditor nation, it should benefit from a risk discount and would then be able to lower domestic real interest rate below the average world rates. With the same logic, an economy with net debt, should have the real interest rate above the average world rates.

But, there is still only weak empirical evidence for this modified version of UIP (Lavoie, 2000, p. 173).

Another interpretation for failures of UIP can be the irrationality of expectations (Moosa, 2004, p.400). It is argued that homogeneity and the related rational expectations are a bizarre assumption in the foreign exchange market. Heterogeneity is a much more consistent assumption in foreign exchange markets compared to homogeneity or the "representative agent hypothesis" that are the basis of rational expectations. It is shown by many studies that in the short and medium run, spot exchange rates mostly behave like a random walk (Lavoie, 2000, p. 174).

And finally, Harvey (2004, p. 20) believes that UIP does not prevail only due to a "lack of compensation capital flows". While Moosa (2004, p. 401) argues that "the least emphasized, but the most plausible explanation among those that have been put forward (peso problem, central bank intervention, transaction cost, political risk, foreign exchange risk, purchasing power risk, differences in real interest and exchange rates, and effect of news) is that of CIP, which reflects the Post Keynesian view". Because the CIP condition implies that spot and forward rates are related contemporaneously, it logically follows that the lagged model, as represented by equation (3), is incorrect.

It should be said, as Lavoie (2002-03) mentions, that the uncovered interest parity as described by equation (2), $i_t - i_t = s^e_{t+1} - s_t$, cannot be falsified directly, for it depends on market expectations about future spot rates. Since "there is no reliable data on these expectations, survey data on exchange rate expectations being highly suspect (Lavoie, 2002-03, p. 240) What has been tested instead is this hypothesis that forward exchange premia are unbiased predictors of changes in the spot exchange rate, which has been falsified time and time again. "The reason for which the validity of UIP has come to be associated with the predicting power of the forward exchange rate is that neoclassical authors believe; (1) the exchange rate expectations ought to be right on average; and (2) that forward rates, relative to the current spot rate, reflects the expected change in future spot exchange rates. The former belief is doubtful, since large econometric models fail to make out-of-sample predictions that are any better than those of random walk models, and the second belief is definitely wrong" (ibid, p. 240).

CIP. It is conceded by Post Keynesian and mainstream economists that the CIP condition holds very well. According to the neoclassical view which assumes that "international financial markets are efficient and there exists perfect capital mobility" (G. Gandolfo, 2001, chapter 4), CIP holds simply by arbitrage, which equalizes the rates of return of assets with similar characteristics.

In the neoclassical approach to forward exchange markets, the value of the forward exchange rate, f, is determined by expectations regarding the change of future values of the spot exchange rate compared to the current spot rate, $\Delta s_{t+1} = s^{e}_{t+1} - s_t$. Suppose, there is an intrinsic interest differential due to a potential rise in interest rate. Thus, there is a potential profit for arbitrageurs in covered arbitrage. Then, arbitrageurs sell their foreign currencies spot and buy domestic currency spot, and buy back the foreign currencies forward for the end of period. Now, according to the neoclassical interpretation, there is a tendency for domestic currency appreciation on spot markets and a tendency for depreciation in forward markets, that is a decrease in s and an increase in f.

This process will continue till the positive spread $(f - s)$, becomes equal to the interest differential $(i - i^*)$ again. Any intervention by the central bank to resist against the appreciation of domestic currency will be followed by an increase in foreign reserves and a money supply increment. This will diminish the spread between domestic and world interest rates, till the two rates are back to equality again. In addition, any difference between the forward exchange rate and speculators' expected future spot rate will be eliminated by speculators intervention. Thus, to the neoclassical economists, the forward exchange rate and the expected future spot rate are closely related.

In the Post Keynesian approach to CIP which was put forward by Lavoie (2000), covered interest parity holds at all times, regardless of the efficiency of financial markets and whether or not there is "perfect capital mobility". The only restriction is that "the forward rate paid by a foreign customer, because of capital controls, will be partly disconnected from the domestic money markets" (Lavoie, 2002-03, p. 238). Consequently, two different forward rates can exist when the domestic money market interest rates is different from those in international financial markets (the euro market of the domestic currency)

Post Keynesians believe "interest rates are not endogenous but are the result of the decisions taken by monetary authorities. Central banks are the ultimate providers of liquidity, and hence have the ability to set short-term interest rates" (Lavoie, 2000, p. 171). This interpretation, which is the basis of the Post Keynesian interpretation to CIP, asserts that the spread between forward rates and spot exchange rates are administratively set by foreign dealers on the straight forward basis of the interest rate differentials on the euro-currency markets that are accessible to the banks making deals (Coulbois and Prissert, 1974).

According to the cambist interpretation, CIP always holds perfectly at least in a single financial center, using money markets interest rates, rather than other rates like the rate of return on Treasury bills. The forward exchange rate is not an expectational variable, as mainstream authors claim by equation (3), but rather as Lavoie calls it (2000, p. 172) "the result of a simple arithmetic operation". Thus, it is determined mechanically by commercial banks at a rate that allow banks to cover their costs, exactly like a cost-determined price. The commercial banks make a "profit by setting a small profit margin between the selling and buying prices they quote to their customers on the forward exchange market" (ibid). Thus, the forward exchange rate itself is endogenous and is computed by the banks, not by demand and supply forces. It can be expressed by manipulating equation (1) to:

$$f_t = s_t + (i_t - i_t^*) \qquad (9)$$

The cambist approach may be described in another way, as suggested by Smithin (2002-03, p. 226), inverting the original form of equation (1):

$$f_t - s_t = i_t - i_t^*$$

Smithin believes that what equation (1) or CIP actually determines is the forward premium (discount) rather than the forward rate itself. But, Lavoie (2002-03, p. 242) argues that the "forward rate is the result of a markup over the spot rate, to cover the costs faced by bank". As a result, it would seen to be more logical to keep the relationship in the form of equation (9).[3]

It can be concluded from what has been said above that "it is the differential interest rates on the international financial markets that, at any given point in time determines the differential between the forward and the spot exchange rates, rather than the converse" (Lavoie, 2002-03, p. 238). Then, CIP always holds, because it is a simple example of "mark up pricing" translated to the international arena.

As shown above, the UIP and PPP conditions do not hold. Neither of them is supported theoretically nor empirically. Thus, it can be concluded that RIP does not hold either. In other words, central banks are able to set interest rates at the level of their choice.

Model

Here, we follow Moosa's work (2004) with daily data to examine if the relationship between forward and spot exchange rates is "contemporaneous", as Post Keynesians believe, or if it is "lagged", as mainstream authors claim.

If CIP and UIP hold at the same time, from equation (8) we write:

$$f_t - s_t = i_t - i_t^* \tag{10}$$

$$f_t = s_{t+1}^e \tag{11}$$

Since there is no empirical evidence supporting the hypothesis that the exchange rate moves by a rate that is equal (or even related) to the interest rate differential, at least as long as perfect asset substitutability and perfect capital mobility do not hold together, equation (10) and (11) cannot be mutually consistent, and one of them must be invalid, at least empirically. This paper tries to find out which of these two relationships is invalid.

First, by taking antilogs from the first two terms of the right hand side of equation (8) we get

$$F_t = S_t\left[\frac{1+i_t}{1+i_t^*}\right] \tag{12}$$

$$F_t = S_{t+1} \tag{13}$$

where F and S are the forward and spot exchange rates, respectively. To write them in general linear model form for empirical work, equations (12) and (13) can be written as

$$S_t = \alpha + \beta F_t + v_t \tag{14}$$

$$S_t = \gamma + \delta F_{t-1} + u_t \tag{15}$$

where $\alpha = 0$, $\beta = (1+i_t)/(1+i_t^*)$, $\gamma = 0$, and $\delta = 1$. β is a measure of the interest rate differential, such that $\beta = 1$ when $i_t = i_t^*$. Equation (14) is the other form of equation (12), taking into account transaction cost and measurement errors. Equation (14) which represents the CIP condition, illustrates the contemporaneous relationship between the spot and forward exchange rates while equation (15), which represents unbiased efficiency, states this relation as a lagged model.

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[3] Both, equations (1) and (9) lead to $F_t = S_t(\frac{1+i_t}{1+i_t^*})$, which can be derived either as an arbitrage or a hedging condition. See, Mossa (2004, p. 402-404).

In order to allow time variation in the coefficient over time, the last two equations are written in a time-varying parametric (TVP) form:

$$S_t = \alpha_t + \beta_t F_t + v_t \tag{16}$$

$$S_t = \gamma_t + \delta_t F_{t-1} + u_t \tag{17}$$

where α_t and γ_t represent time-varying stochastic trends, which may represent the variables not appearing explicitly on the right-hand side of the equations (16) and (17), missing variables, if any. According to the deterministic versions of these equations, there are no missing variables. In equation (17), γ_t may be taken to represent a time varying risk premium. These trends are specified in such a way as to allow for possibilities ranging from I(0) to I(2) variables, without having to worry about unit root testing, as the data will speak for itself. For example, in equation (16), α_t is specified as $\alpha_t = \alpha_{t-1} + \phi_{t-1} + \eta_t$, where $\Phi_t = \Phi_{t-1} + \xi_t$, $\eta_t \approx NID(0, \sigma_\eta^2)$, and $\xi_t \approx NID(0, \sigma_\xi^2)$. Whether the underlying time series is I(0), or I(2) depends on the variation of σ_η^2 and σ_u^2. Since exchange rates typically follow a random walk with little or no drift, the most likely the case is that $\phi_t = 0$.

The estimation method is maximum likelihood coupled with the recursive routine of the Kalman filter. This requires writing the two equations in state space[4] model form

$$S_t = [\alpha_t \beta_t][1 F_t] + v_t$$

$$S_t = (\gamma_t \delta_t)[1 F_{t-1}] + u_t$$

[4] A very brief discussion of the specification and estimation of a linear state space model is presented in appendix 1.

The empirical results presented in this paper are based on noon-daily rates of spot exchange and three-month forward exchange contract. The data covers from January 04, 1999 to October 29, 2004 on three exchange rates for which **daily** data is available on Bank of Canada's web site: the Canadian dollar (CAN), the US dollar (USD), and the Great Britain Pound(GBP). [5]

The results of estimating equations (16) and (17) in a time-varying form are presented in Table 3. They are similar to the results that Moosa (2004) got with quarterly data. It shows the estimated coefficients of the final state vector (with the t-statistics in parentheses), as well as some diagnostics and goodness of fit measures. H is ARCH(1) to show the conditional heteroscedasticity and serial autocorrelation, AIC is Akaike's Information Criterion and BIC is Schwartz Information Criterion.

The results tell us that equation (16), which represents CIP, fits better than equation (17), which represents unbiased efficiency. The coefficients of equation (16) have the anticipated values, with $\alpha_t = 0$ and β_t greater than zero, while coefficient restrictions of equation (17), $\gamma_t = 0$ and $\delta_t = 1$ are rejected consistently. Equation (16) has better diagnostic and goodness of fit results compared to equation (17). The rejection of the restriction $\gamma_t = 0$ is interpreted in the literature to indicate the presence of a risk premium, to which the failure of UIP is attributed (Smithin, 2002-03). In fact, this result is taken to be a salvation for the unbiased efficiency hypothesis. The argument goes as follows: if the risk premium is allowed for, then the forward rate, with the help of the risk premium, can predict the future spot rather well. Hence, we move from "simple efficiency" to "general efficiency". Furthermore, Smithin (2002-03) believes in the existence of this term, although he argues that whatever is called a "risk premium" seems to be primarily a "terminological issue".

It is not difficult to expose this myth of the "risk premium" and "general efficiency". It can be shown that, in the presence of a contemporaneous relationship between the spot

[5] In order to introduce one period lag to run the model for equation (17), observations of spot rates have been put ahead for 64 observations (90/7 $\approx$ 13 number of weeks in a forward contract, 13*2=26 number of days that market is closed, vacations, and finally 90-26=64).

and forward rates, the effect of the alleged "risk premium" disappears. This can be done by estimating

$$S_t = \gamma_t + \beta_t F_t + \delta_t F_{t-1} + \nu_t \tag{18}$$

The results of estimating equation (18) are presented in Table 4. The equation fits well. What is more important about these results is the significance of the estimated coefficients. We can see that once the effect of the contemporaneous forward rate is allowed for, the coefficient representing the risk premium is no longer significant. This shows that this coefficient does not represent a risk premium as such, but rather it represents the missing contemporaneous rate in equation (17). Thus, the term α_t in equation (16) is representative of transaction costs as well as the effect of other factors that cause deviations from CIP, and hence it may or may not be statistically significant. It should be pointed out here, that this result is not inconsistent with Smithin's (2002-03) argument about γ_t.

Table 3. Estimation results of equations (16) and (17)

	GBP/CAN	USD/CAN
Equation (16)		
α_t	-0.003 (0.686)	0.005 (3.205)
β_t	1.007 (604)	0.995 (1085.343)
R^2	0.999	0.999
DW	1.987	2.094
H	0.41	0.176
AIC	-5.75	-7.324
BIC	-5.74	-7.317
Equation (17)		
γ_t	1.153 (27.038)	1.534 (33.696)
δ_t	0.502 (27.273)	0.025 (.857)
R^2	0.26	.876
DW	0.032	0.117
H	0.978	1.039
AIC	-5.76	-7.328
BIC	-5.75	-7.321

Table4. Estimation results of equation (18)

	GBP/CAN	USD/CAN
γ_t	0.002 (0.292)	0.008 (0.058)
β_t	1.007 (453)	0.999 (3023.4)
δ_t	0.0003 (0.150)	0.0003 (1.015)
R^2	0.999	0.999
DW	0.150	1.114
H	-5.758	0.249
AIC	-5.758	-7.321
BIC	-7.735	-7.299

Conclusion

The results of this paper show that day-to-day movements in forward rates tend to be accompanied by almost identical day-to-day movements in current spot rates, not future rates. The explanation which is supported by the empirical results presented here, is that the spot-forward relationship is contemporaneous, as represented by covered interest parity, rather than lagged, as represented by the unbiased efficiency hypothesis.

According to the test results, it is obvious that the forward exchange rate is not a reliable estimator of the future spot exchange rate, because the two rates are determined contemporaneously. The failure of the unbiased efficiency hypothesis can be interpreted in several ways, most probably due to a failure of the rational expectations hypothesis. Whereas the previous empirical results implied that the failure of the unbiased effect could be attributed to the presence of the 'risk premium", or whatever it may called, other results show that what appears to be a risk premium is a stochastic trend reflecting missing variables or, in the case of a correctly specified model, factors such as transaction costs. The results show that the CIP condition is more appropriate to specify the spot-forward exchange rate relationship than is UIP or the unbiased efficiency hypothesis.

The failure of the UIP condition, which is a necessary condition for RIP to hold, implies the empirical failure of RIP, irrespectively of the validity of purchasing power parity: which is another necessary condition for RIP. "Thus, it can be concluded that the Post Keynesian view that monetary authorities can control domestic interest rates is valid, or at least to say that the mainstream view on this is invalid" (Moosa, 2004, p. 416).

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Appendix 1: State Space Model and Kalman Filter

A wide range of time series models, including the classical linear regression model and ARIMA models, can be written and estimated as special cases of a state space specification. State space models have been applied in the econometrics literature to model unobserved variables: (rational) expectations, measurement errors, missing observations, permanent income, unobserved components (cycles and trends), and the non-accelerating rate of unemployment. Extensive surveys of applications of state space models in econometrics can be found in Hamilton (1994) and Harvey (1989, chapters 3, 4).

State-Space Models

State-space analysis deals with dynamic time series models that involve unobserved state variables such as inflation expectation, permanent income, time-varying parameters, etc.. The basic tool used to study the state-space model is the Kalman Filter, which is a recursive algorithm for estimating the unobserved component or state vector at time t, based on available information through time t-1.

Model Representation: A state-space model consists of two equations:

- Measurement Equation (Observation Equation): The relationship between observed variables (nx1 data vector Y_t) and unobserved state variables (kx1 parameter vector β_t).

  $$Y_t = H_t\beta_t + a_t + u_t$$

  where H_t is an nxk matrix and a_t is an nx1 vector, which may be either data on exogenous variables or constant paramters. That is, given the exogenous or predetermined observed variables X_t, we may define $H_t = H(X_t)$ and $a_t = a(X_t)$.

  We assume $u_t \sim nii(0_{nx1}, R_{nxn})$. Note that the covariance matrix R may also depend on X_t.

- Transition Equation (State Equation): The first-order difference equation describing the dynamics of the state variables.

  $$\beta_t = c_t + F_t\beta_{t-1} + v_t$$

where F_t is an kxk matrix and c_t is an kx1 vector.

We assume $v_t \sim nii(0_{kx1},Q_{kxk})$ and $Cov(u_t,v_s) = E(u_t v_s') = 0_{nxk}$. Note that $c_t = c(X_t)$, $F_t = F(X_t)$, and the covariance matrix Q may depend on X_t.

Conditional to the information available at time t-1, the expected value of β_t is $E_{t-1}(\beta_t) = c_t + F_t E_{t-1}(\beta_{t-1})$. Similarly, the conditional covariance is $Var_{t-1}(\beta_t) = F_t Var_{t-1}(\beta_{t-1})F_t' + Q$. For notational convenience, let $\beta_{t|t-1} = E_{t-1}(\beta_t)$ and $\Omega_{t|t-1} = Var_{t-1}(\beta_t)$. Then:

$$\beta_{t|t-1} = c_t + F_t\beta_{t-1|t-1}$$

$$\Omega_{t|t-1} = F_t\Omega_{t-1|t-1}F_t' + Q$$

Combining the measurement and transition equations, we have;

$$Y_t = (H_tF_t)\beta_{t-1} + (H_tc_t+a_t) + (H_tv_t+u_t)$$

Given the information at time t-1, the conditional expectation and covariance of Y_t are:

$$Y_{t|t-1} = E_{t-1}(Y_t) = H_t\beta_{t|t-1} + a_t$$

$$\Sigma_{t|t-1} = Var_{t-1}(Y_t) = H_t\Omega_{t|t-1}H_t' + R$$

Since Y_t is distributed according to normal$(Y_{t|t-1},\Sigma_{t|t-1})$, the log-likelihood is evaluated as:

$$ll_t = -\tfrac{1}{2}\, ln(2\pi\Sigma_{t|t-1}) - \tfrac{1}{2}\,(Y_t-Y_{t|t-1})'\Sigma_{t|t-1}^{-1}(Y_t-Y_{t|t-1})$$

Kalman Fileter

The computation of log-likelihood function for parameter estimation is based on the algorithm of Kalman Filter as follows:

- Prediction:

$$\beta_{t|t-1} = c_t + F_t\beta_{t-1|t-1}$$

$$\Omega_{t|t-1} = F_t\Omega_{t-1|t-1}F_t' + Q$$

Define the prediction error $\varepsilon_{t|t-1} = Y_t - Y_{t|t-1}$. Then:

$$\varepsilon_{t|t-1} = Y_t - H_t\beta_{t|t-1} - a_t$$

$$\Sigma_{t|t-1} = H_t\Omega_{t|t-1}H_t' + R$$

Then the log-likelihood is defined by:

$$ll_t = -\tfrac{1}{2}\, ln(2\pi\Sigma_{t|t-1}) - \tfrac{1}{2}\,\varepsilon_{t|t-1}'\Sigma_{t|t-1}^{-1}\varepsilon_{t|t-1}$$

- Updating:

$$\beta_{t|t} = \beta_{t|t-1} + K_t\varepsilon_{t|t-1}$$
$$\Omega_{t|t} = \Omega_{t|t-1} - K_tH_t\Omega_{t|t-1}$$

where $K_t = \Omega_{t|t-1}H_t'\Sigma_{t|t-1}^{-1}$ is the Kalman gain.

The above basic filter (prediction and updating) is carried out iteratively from t=1 to t=T. At the end, the sum of log-likelihoods is maximized with respect to the model paramters. To begin at time t=1, the initial values $b_{0|0}$ and $W_{0|0}$ must be given. If b_t is stationary, then the unconditional expectation and covariance may be used:

$$\beta_{0|0} = (I-F)^{-1}c$$
$$vec(\Omega_{0|0}) = (I-F\otimes F)^{-1}vec(Q)$$

If β_t is nonstationary, then we can use a wild guess of $\beta_{0|0}$ (e.g. zeros vector) with large diagonal elements in the covariance matrix $\Omega_{0|0}$. In this case, the evaluation of log-likelihood and inference should not include the first few observations of the guess values.

As a by product of maximum likelihood estimation, we obtain the estimated (updated) parameter vector and the corresponding covariance matrix at time t: $\beta_{t|t}$ and $\Omega_{t|t}$, for t=1,...,T. For a better inference, the smoothed parameter vector and the corresponding covariance matrix based on all information in the sample are:

$$\beta_{t|T}=\beta_{t|t}+K^*_{t+1}(\beta_{t+1|T}-c_{t+1}-F_{t+1}\beta_{t|t})$$
$$\Omega_{t|T} = \Omega_{t|t} + K^*_{t+1}(\Omega_{t+1|T}-\Omega_{t+1|t})K^*_{t+1}{}'$$

where $K^*_{t+1} = \Omega_{t|t}F_{t+1}'\Omega_{t+1|t}^{-1}$. The smoothing is performed from t=T-1 down to t=1 with the initial values $\beta_{T|T}$ and $\Omega_{T|T}$ obtained from the last iteration of the basic filter.

Applications

- AR(p) Model

$$Y_t = \delta + \rho_1 Y_{t-1} + \ldots + \rho_p Y_{t-p} + \varepsilon_t$$
$$\varepsilon_t \sim nii(0,\sigma^2)$$

- Measurement Equation: $Y_t = H\beta_t + a + u_t \sim nii(0,R)$, or

$$Y_t = [1\ 0\ \ldots\ 0]\begin{bmatrix} Y_t \\ Y_{t-1} \\ \vdots \\ Y_{t-p+1} \end{bmatrix}$$

- where a = 0, $u_t = 0$, and R = 0

- Transition Equation: $\beta_t = F\beta_{t-1} + c + v_t \sim nii(0,Q)$, or

$$\begin{bmatrix} Y_t \\ Y_{t-1} \\ \vdots \\ Y_{t-p+1} \end{bmatrix} = \begin{bmatrix} \rho_1 & \rho_2 & \cdots & \rho_{p-1} & \rho_p \\ 1 & 0 & \ldots & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & \ldots & 1 & 0 \end{bmatrix}\begin{bmatrix} Y_{t-1} \\ Y_{t-2} \\ \vdots \\ Y_{t-p} \end{bmatrix} + \begin{bmatrix} \delta \\ 0 \\ \vdots \\ 0 \end{bmatrix} + \begin{bmatrix} \varepsilon_t \\ 0 \\ \vdots \\ 0 \end{bmatrix}$$

where $Q = \begin{bmatrix} \sigma^2 & 0 & \ldots & 0 \\ 0 & 0 & \ldots & 0 \\ \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & \ldots & 0 \end{bmatrix}$

- MA(q) Model

$$Y_t = \mu + \varepsilon_t - \theta_1\varepsilon_{t-1} - \ldots - \theta_q\varepsilon_{t-q}$$
$$\varepsilon_t \sim nii(0,\sigma^2)$$

- Measurement Equation: $Y_t = H\beta_t + a + u_t \sim nii(0,R)$, or

$$Y_t = [1\ -\theta_1\ \ldots\ -\theta_q]\begin{bmatrix} \varepsilon_t \\ \varepsilon_{t-1} \\ \vdots \\ \varepsilon_{t-q} \end{bmatrix} + \mu$$

- where $u_t = 0$, and R = 0

- Transition Equation: $\beta_t = F\beta_{t-1} + c + v_t \sim nii(0,Q)$, or

$$\begin{bmatrix} \varepsilon_t \\ \varepsilon_{t-1} \\ \vdots \\ \varepsilon_{t-q} \end{bmatrix} = \begin{bmatrix} 0 & 0 & \ldots & 0 & 0 \\ 1 & 0 & \ldots & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & \ldots & 1 & 0 \end{bmatrix}\begin{bmatrix} \varepsilon_{t-1} \\ \varepsilon_{t-2} \\ \vdots \\ \varepsilon_{t-q-1} \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ \vdots \\ 0 \end{bmatrix} + \begin{bmatrix} \varepsilon_t \\ 0 \\ \vdots \\ 0 \end{bmatrix}$$

where $Q = \begin{bmatrix} \sigma^2 & 0 & \ldots & 0 \\ 0 & 0 & \ldots & 0 \\ \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & \ldots & 0 \end{bmatrix}$

- Time-Varying Parameters Model:

$$Y_t = X_t\beta_t + \varepsilon_t$$
$$\varepsilon_t \sim nii(0,\sigma^2)$$

  - Measurement Equation: $Y_t = H_t\beta_t + a + u_t \sim nii(0,R)$

    where $H_t = X_t$, $a = 0$, $u_t = \varepsilon_t$, $R = \sigma^2$.

  - Transition Equation: $\beta_t = F\beta_{t-1} + c + v_t \sim nii(0,Q)$

    where F, c and Q may be defined according to a model specification.

Reference: http://www.econ.pdx.edu/staff/KPL/tsinghua/topic7.htm#ss

Readings:

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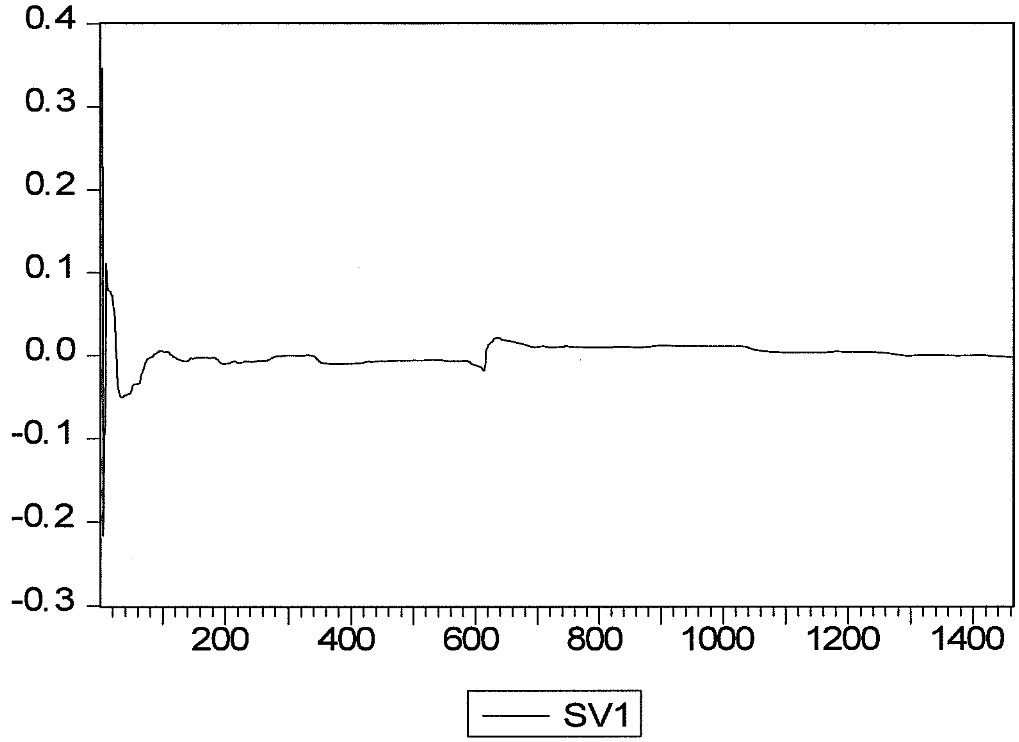
Appendix 2: Statistical Tests Results

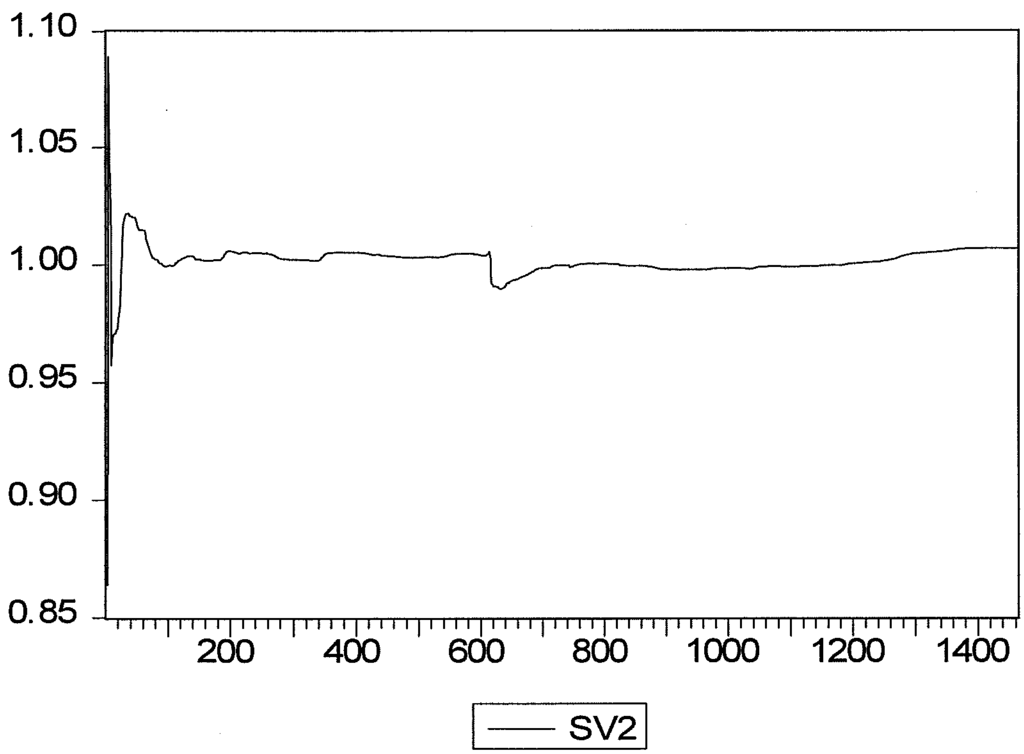
SSpace: UNTITLED
Estimation Method: Maximum Likelihood
Date: 01/13/05 Time: 21:25
Model: Time-Varying Coefficient Model
Sample: 1 1464
Included Observations: 1462
Variance of observation equations: Diagonal
Variance of state equations: Diagonal
Convergence achieved after 17 iterations

	Coefficient	Std. Error	t-Statistic	Prob.
OBVAR(1,1)	3.77E-06	10.87632	3.47E-07	1.0000
SSVAR(1,1)	6.32E-10	4005968.	1.58E-16	1.0000
SSVAR(2,2)	3.86E-09	614898.3	6.28E-15	1.0000
Final SV1	-0.002556	0.003724	-0.686466	0.4925
Final SV2	1.006729	0.001666	604.1433	0.0000
Log Likelihood		6365.356		

UK_S =(SV1)+SV2*UK_F
SV1 = SV1(-1)
SV2=SV2(-1)

R-squared	0.999414	Mean dependent var	2.319698
Adjusted R-squared	0.999415	S.D. dependent var	0.101343
S.E. of regression	0.002451	Sum squared resid	0.008786
Durbin-Watson stat	1.987254		


0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
200
400
600
800
1000
1200
1400
SV1


1.10
1.05
1.00
0.95
0.90
0.85
200
400
600
800
1000
1200
1400
SV2

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(UK_S)
Method: Least Squares
Date: 01/13/05 Time: 21:32

luded observations: 1463 after a

Variable	Coefficient	Std. Error	t-Statistic	Prob.
UK_S(-1)	-0.010349	0.003512	-2.946949	0.0033
C	0.023811	0.008156	2.919558	0.0036

R-squared	0.005909	Mean dependent var	-0.000200
Adjusted R-squared	0.005229	S.D. dependent var	0.013675
S.E. of regression	0.013639	Akaike info criterion	-5.750368
Sum squared resid	0.271787	Schwarz criterion	-5.743139
Log likelihood	4208.394	F-statistic	8.684510
Durbin-Watson stat	1.983817	Prob(F-statistic)	0.003260

Dependent Variable: UK_S
Method: ML - ARCH
Date: 01/13/05 Time: 21:35
Sample: 1 1464
Included observations: 1464
Convergence achieved after 4 iterations

	Coefficient	Std. Error	z-Statistic	Prob.
UK_F	0.998692	0.000191	5223.387	0.0000
C	0.008384	0.000431	19.45333	0.0000
	Variance Equation			
C	4.09E-07	7.34E-08	5.571772	0.0000
ARCH(1)	**0.414422**	**0.064451**	**6.430041**	**0.0000**
GARCH(1)	0.458883	0.024333	18.85862	0.0000

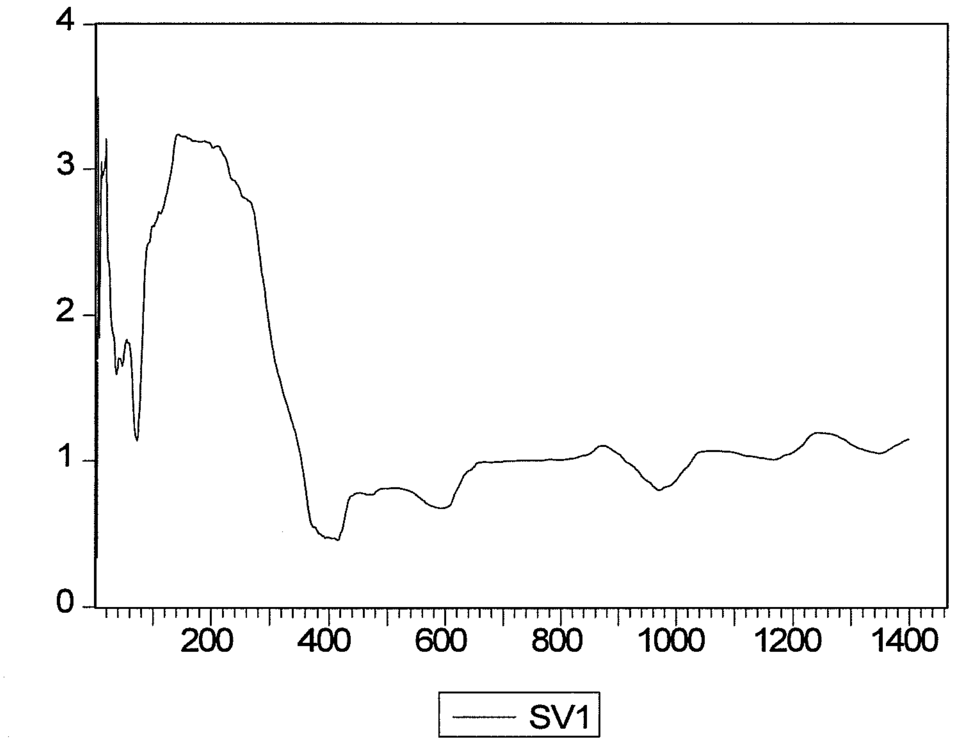
R-squared	0.997317	Mean dependent var	2.319978
Adjusted R-squared	0.997310	S.D. dependent var	0.101558
S.E. of regression	0.005267	Akaike info criterion	-8.694974
Sum squared resid	0.040479	Schwarz criterion	-8.676911
Log likelihood	6369.721	F-statistic	135604.7
Durbin-Watson stat	0.432811	Prob(F-statistic)	0.000000

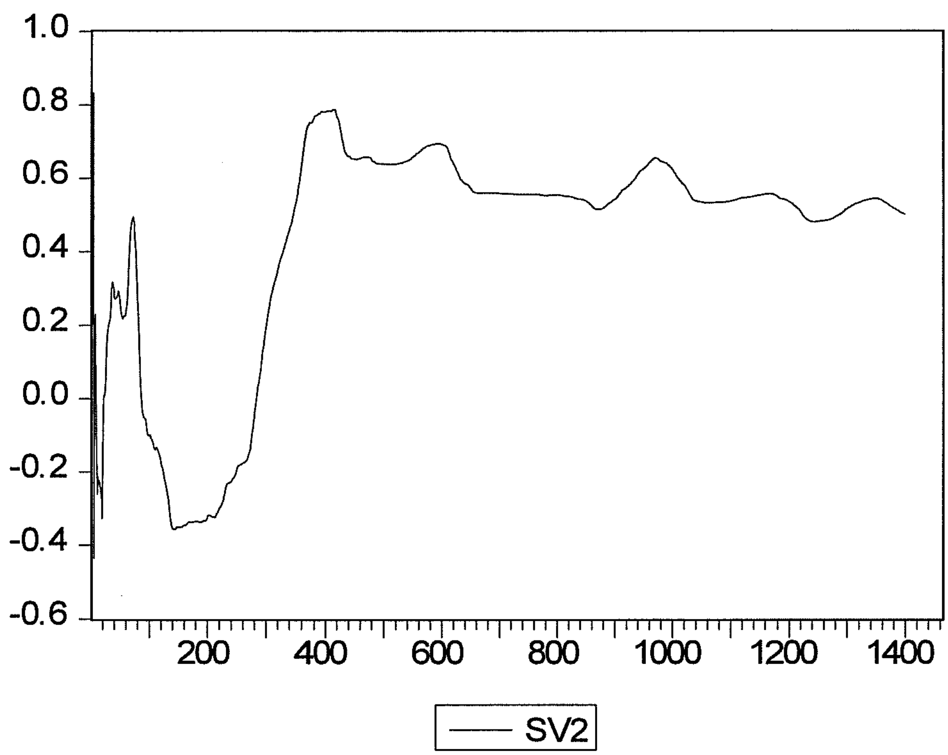
SSpace: UNTITLED
Estimation Method: Maximum Likelihood
Date: 01/13/05 Time: 20:53
Model: Time-Varying Coefficient Model
Sample(adjusted): 1 1399
Included Observations: 1397
Variance of observation equations: Diagonal
Variance of state equations: Diagonal
Convergence achieved after 14 iterations

	Coefficient	Std. Error	t-Statistic	Prob.
OBVAR(1,1)	0.004804	0.024323	0.197517	0.8435
SSVAR(1,1)	5.80E-10	3386187.	1.71E-16	1.0000
SSVAR(2,2)	2.44E-11	71623968	3.41E-19	1.0000
Final SV1	1.152688	0.042632	27.03821	0.0000
Final SV2	0.501666	0.018394	27.27318	0.0000
Log Likelihood		1390.572		

UK_SS =(SV1)+SV2*UK_FF
SV1 = SV1(-1)
SV2=SV2(-1)

R-squared	0.268696	Mean dependent var	2.313068
Adjusted R-squared	0.269220	S.D. dependent var	0.098482
S.E. of regression	0.084188	Sum squared resid	9.901501
Durbin-Watson stat	0.032137		


4
3
2
1
0
200
400
600
800
1000
1200
1400
SV1


1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
200
400
600
800
1000
1200
1400
SV2

Null Hypothesis: UK_SS has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=23)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.596029	0.0940
Test critical values:	1% level	-3.434818	
	5% level	-2.863401	
	10% level	-2.567809	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(UK_SS)
Method: Least Squares
Date: 01/13/05 Time: 21:15
Sample(adjusted): 2 1399
Included observations: 1398 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
UK_SS(-1)	-0.009566	0.003685	-2.596029	0.0095
C	0.022018	0.008532	2.580703	0.0100

R-squared	0.004804	Mean dependent var	-0.000111
Adjusted R-squared	0.004092	S.D. dependent var	0.013591
S.E. of regression	0.013563	Akaike info criterion	-5.761485
Sum squared resid	0.256808	Schwarz criterion	-5.753985
Log likelihood	4029.278	F-statistic	6.739365
Durbin-Watson stat	1.993253	Prob(F-statistic)	0.009530

Dependent Variable: UK_SS
Method: ML - ARCH
Date: 01/13/05 Time: 21:37
Sample(adjusted): 1 1399
Included observations: 1399 after adjusting endpoints
Convergence achieved after 50 iterations

	Coefficient	Std. Error	z-Statistic	Prob.
UK_FF	0.548142	0.008662	63.27905	0.0000
C	1.013063	0.020007	50.63533	0.0000
	Variance Equation			
C	0.000181	2.51E-05	7.204772	0.0000
ARCH(1)	0.977615	0.129532	7.547301	0.0000
GARCH(1)	-0.001474	0.043602	-0.033811	0.9730

R-squared	0.163343	Mean dependent var	2.313186
Adjusted R-squared	0.160942	S.D. dependent var	0.098461
S.E. of regression	0.090191	Akaike info criterion	-3.127846
Sum squared resid	11.33927	Schwarz criterion	-3.109105
Log likelihood	2192.928	F-statistic	68.03867
Durbin-Watson stat	0.029250	Prob(F-statistic)	0.000000

SSpace: UNTITLED
Estimation Method: Maximum Likelihood
Date: 01/13/05 Time: 21:55
Model: Time-Varying Coefficient Model
Sample: 1 1464
Included Observations: 1462
Variance of observation equations: Diagonal
Variance of state equations: Diagonal
Convergence achieved after 17 iterations

	Coefficient	Std. Error	t-Statistic	Prob.
OBVAR(1,1)	7.08E-09	3.22E+09	2.20E-18	1.0000
SSVAR(1,1)	1.43E-11	2.70E+09	5.29E-21	1.0000
SSVAR(2,2)	3.56E-09	3.17E+08	1.12E-17	1.0000
Final SV1	0.004581	0.001429	3.204889	0.0014
Final SV2	0.995476	0.000917	1085.343	0.0000
Log Likelihood		5164.634		

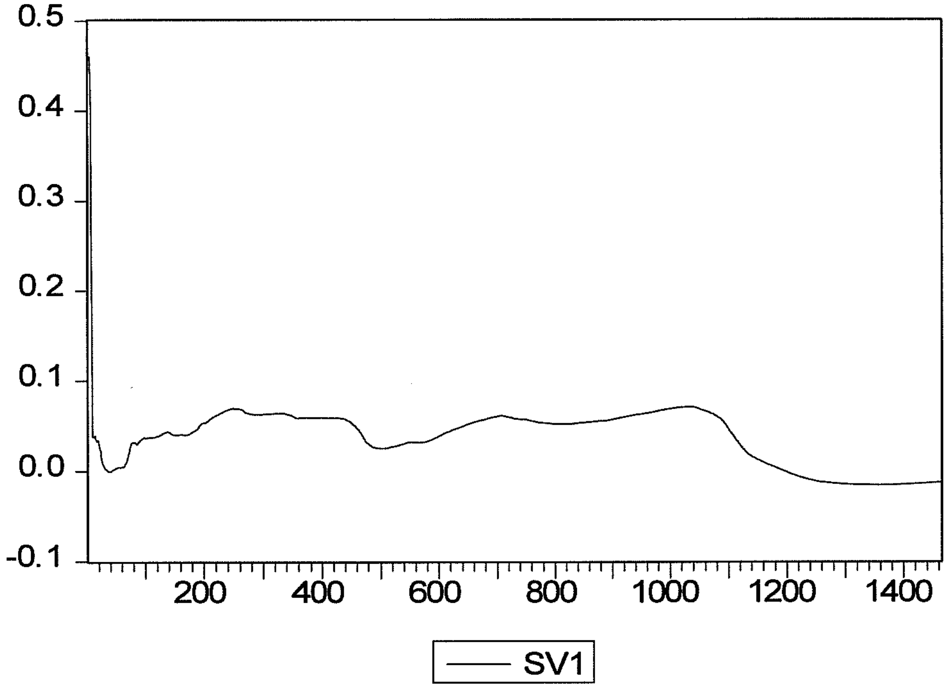
US_S =(SV1)+SV2*US_F
SV1 = SV1(-1)
SV2=SV2(-1)

R-squared	0.999998	Mean dependent var	1.500776
Adjusted R-squared	0.999998	S.D. dependent var	0.034094
S.E. of regression	5.11E-05	Sum squared resid	1.82E-06
Durbin-Watson stat	2.094417		

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(US_S)
Method: Least Squares
Date: 01/13/05 Time: 21:58
Sample(adjusted): 2 1464
Included observations: 1463 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
US_S(-1)	0.000176	0.001766	0.099913	0.9204
C	-0.000469	0.002606	-0.179881	0.8573

R-squared	0.000007	Mean dependent var	-0.000209
Adjusted R-squared	-0.000678	S.D. dependent var	0.006207
S.E. of regression	0.006209	Akaike info criterion	-7.324115
Sum squared resid	0.056333	Schwarz criterion	-7.316886
Log likelihood	5359.590	F-statistic	0.009983
Durbin-Watson stat	2.018450	Prob(F-statistic)	0.920427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200
400
600
800
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1200
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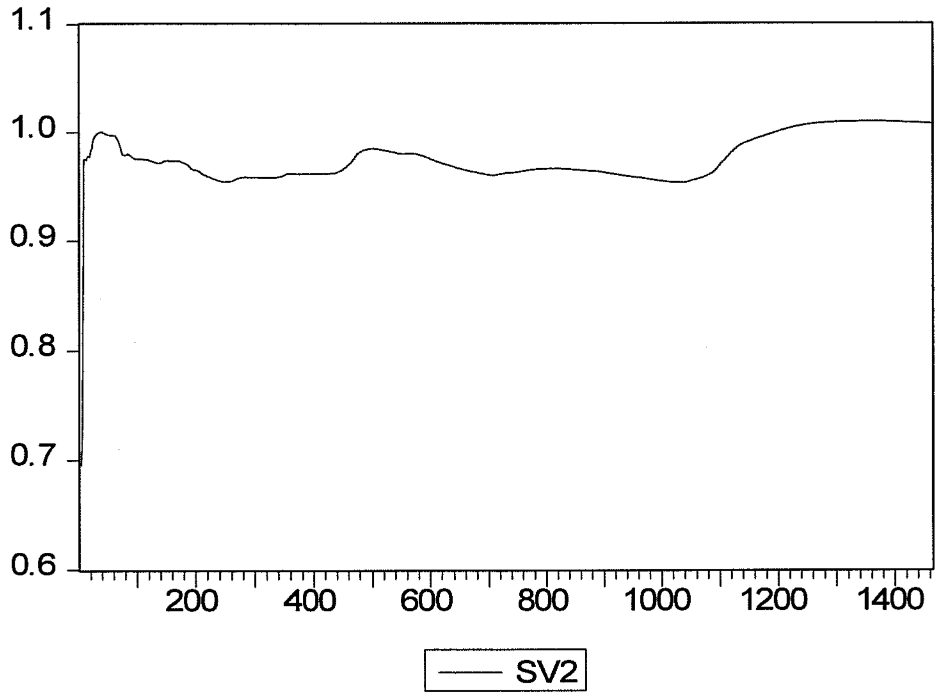
SV1


1.1
1.0
0.9
0.8
0.7
0.6
200
400
600
800
1000
1200
1400
SV2

Dependent Variable: US_S
Method: ML - ARCH
Date: 01/13/05 Time: 22:00
Sample: 1 1464
Included observations: 1464
Convergence after 7 iterations

				Coefficient
C	-0.008733	0.000662	-13.18202	0.0000
US_F	1.004653	0.000457	2200.656	0.0000
		Variance Equation		
C	2.03E-07	2.30E-07	0.885900	0.3757
ARCH(1)	0.175783	0.158025	1.112378	0.2660
GARCH(1)	0.609866	0.343980	1.772969	0.0762

R-squared	0.998620	Mean dependent var	1.472739
Adjusted R-squared	0.998617	S.D. dependent var	0.092178
S.E. of regression	0.003429	Akaike info criterion	-9.158630
Sum squared resid	0.017150	Schwarz criterion	-9.140567
Log likelihood	6709.117	F-statistic	264007.6
Durbin-Watson stat	0.001812	Prob(F-statistic)	0.000000

SSpace: UNTITLED
Estimation Method: Maximum Likelihood
Date: 01/13/05 Time: 22:06
Model: Time-Varying Coefficient Model
Sample: 1 1399
Included Observations: 1397
Variance of observation equations: Diagonal
Variance of state equations: Diagonal
Convergence achieved after 25 iterations

	Coefficient	Std. Error	t-Statistic	Prob.
OBVAR(1,1)	0.000221	1.798261	0.000123	0.9999
SSVAR(1,1)	1.43E-11	1.04E+08	1.37E-19	1.0000
SSVAR(2,2)	4.43E-08	40270.17	1.10E-12	1.0000
Final SV1	1.539940	0.045700	33.69675	0.0000
Final SV2	0.025236	0.029459	0.856653	0.3919
Log Likelihood		1738.654		

US_SS =(SV1)+SV2*US_FF
SV1 = SV1(-1)
SV2=SV2(-1)

R-squared	0.876389	Mean dependent var	1.507805
Adjusted R-squared	0.876566	S.D. dependent var	0.042221
S.E. of regression	0.014834	Sum squared resid	0.153584
Durbin-Watson stat	0.117139		

Null Hypothesis: US_SS has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=23)

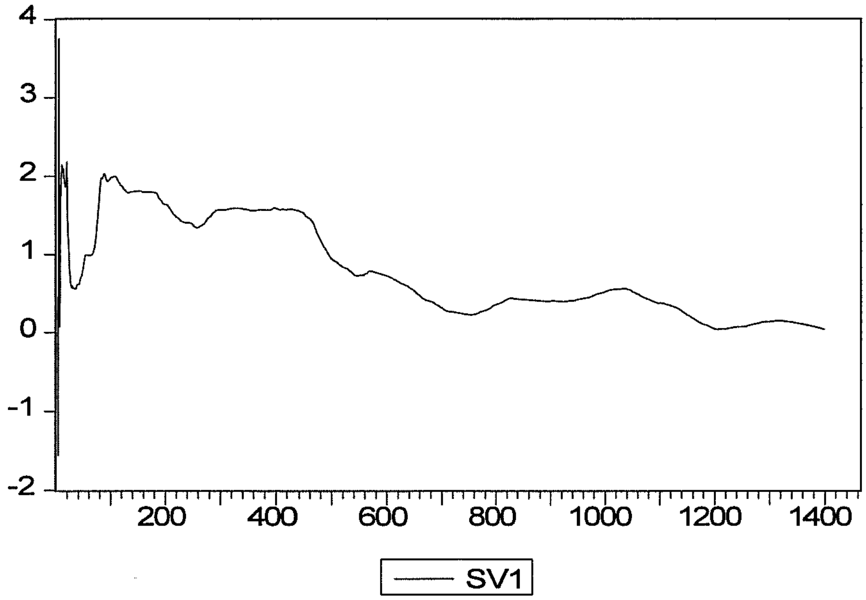
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.184797	0.9716
Test critical values:	1% level	-3.434818	
	5% level	-2.863401	
	10% level	-2.567809	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(US_SS)
Method: Least Squares
Date: 01/13/05 Time: 22:12
Sample(adjusted): 2 1399
Included observations: 1398 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
US_SS(-1)	0.000327	0.001770	0.184797	0.8534
C	-0.000683	0.002609	-0.261933	0.7934

R-squared	0.000024	Mean dependent var	-0.000202
Adjusted R-squared	-0.000692	S.D. dependent var	0.006194
S.E. of regression	0.006196	Akaike info criterion	-7.328323
Sum squared resid	0.053597	Schwarz criterion	-7.320822
Log likelihood	5124.498	F-statistic	0.034150
Durbin-Watson stat	2.024644	Prob(F-statistic)	0.853415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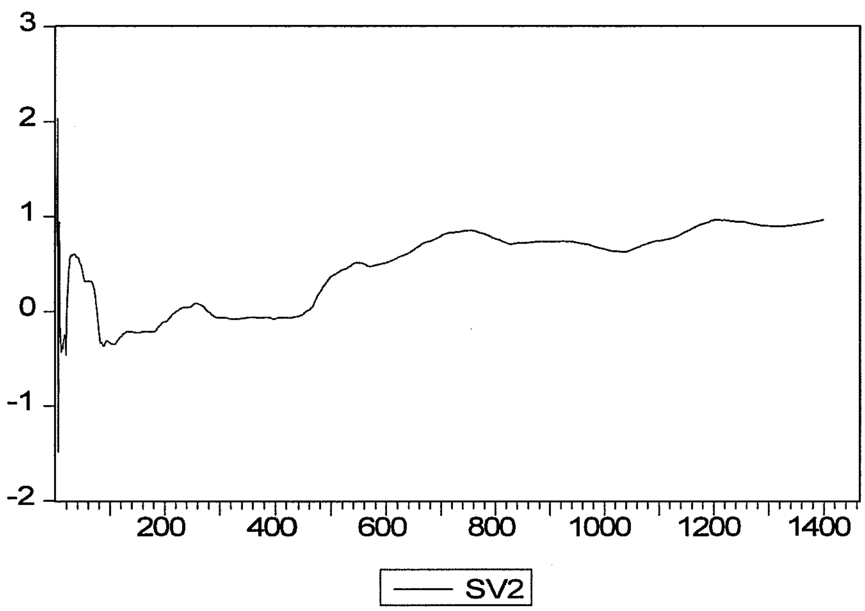
1200
1400
SV1


3
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0
-1
-2
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400
600
800
1000
1200
1400
SV2

Dependent Variable: US_SS
Method: ML – ARCH
Date: 01/13/05 Time: 22:08
Sample: 1 1399
Included observations: 1399
Convergence achd after 31 iterations

	Coefficient	Std. Error	z-Statistic	Prob.
C	0.479708	0.022008	21.79654	0.0000
US_FF	0.680483	0.014707	46.26846	0.0000
Variance Equation				
C	3.25E-05	9.07E-06	3.588147	0.0003
ARCH(1)	1.039216	0.188090	5.525094	0.0000
GARCH(1)	-0.040372	0.086430	-0.467112	0.6404

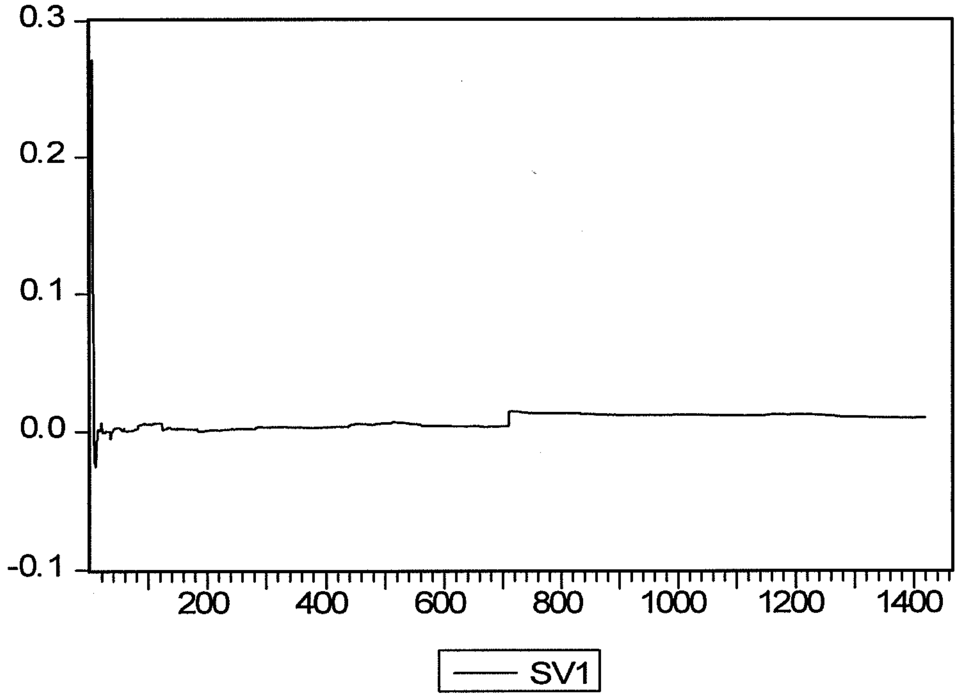
R-squared	0.401835	Mean dependent var	1.507789
Adjusted R-squared	0.398392	S.D. dependent var	0.042162
S.E. of regression	0.032702	Akaike info criterion	-4.806426
Sum squared resid	0.743253	Schwarz criterion	-4.773918
Log likelihood	1687.249	F-statistic	116.7216
Durbin-Watson stat	0.037065	Prob(F-statistic)	0.000000

SSpace: UNTITLED
Estimation Method: Maximum Likelihood
Date: 01/14/05 Time: 21:21
Model: Time-Varying Coefficient Model
Sample(adjusted): 1 1399
Included Observations: 1397
Variance of observation equations: Diagonal
Variance of state equations: Diagonal
Convergence achieved after 20 iterations

	Coefficient	Std. Error	t-Statistic	Prob.
OBVAR(1,1)	6.45E-06	94.56398	6.82E-08	1.0000
SSVAR(1,1)	2.60E-11	1.35E+08	1.94E-19	1.0000
SSVAR(2,2)	1.28E-16	1.27E+13	1.01E-29	1.0000
SSVAR(3,3)	6.88E-09	316998.5	2.17E-14	1.0000
Final SV1	-0.002065	0.007080	-0.291636	0.7706
Final SV2	-0.000325	0.002167	-0.150132	0.8807
Final SV3	1.006860	0.002220	453.5108	0.0000
Log Likelihood		6200.647		

UK_SS=SV1+SV2*UK_FF+SV3*UK_FFF
SV1=SV1(-1)
SV2=SV2(-1)
SV3=SV3(-1)

R-squared	0.999357	Mean dependent var	2.313068
Adjusted R-squared	0.999358	S.D. dependent var	0.098482
S.E. of regression	0.002496	Sum squared resid	0.008703
Durbin-Watson stat	1.997854		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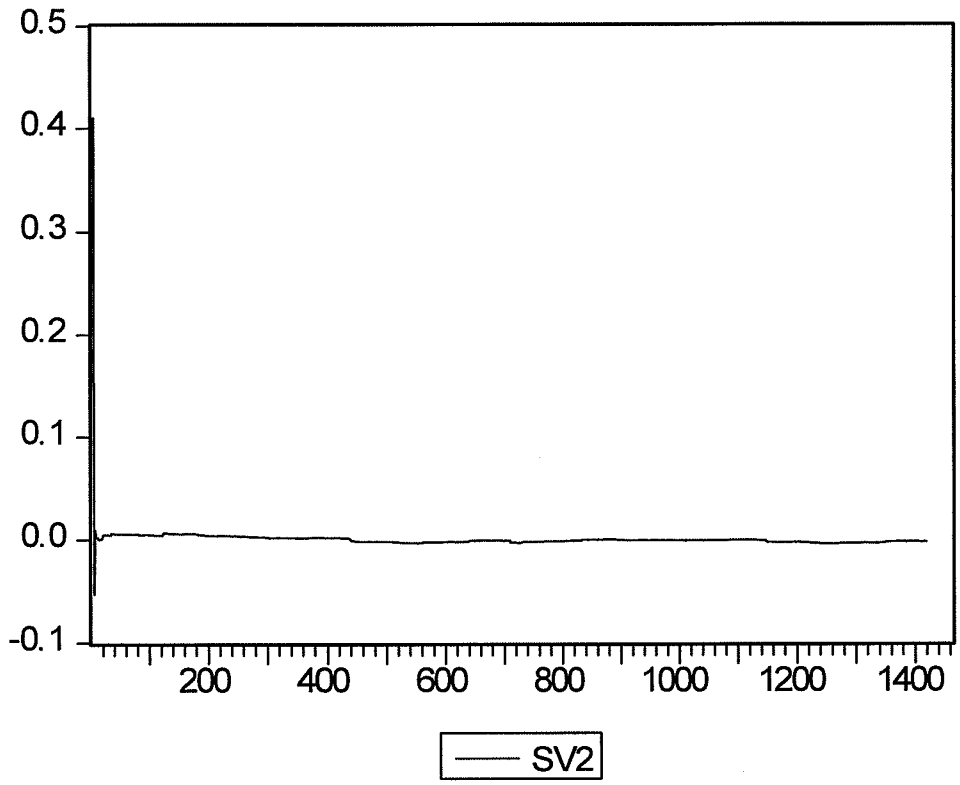
SV1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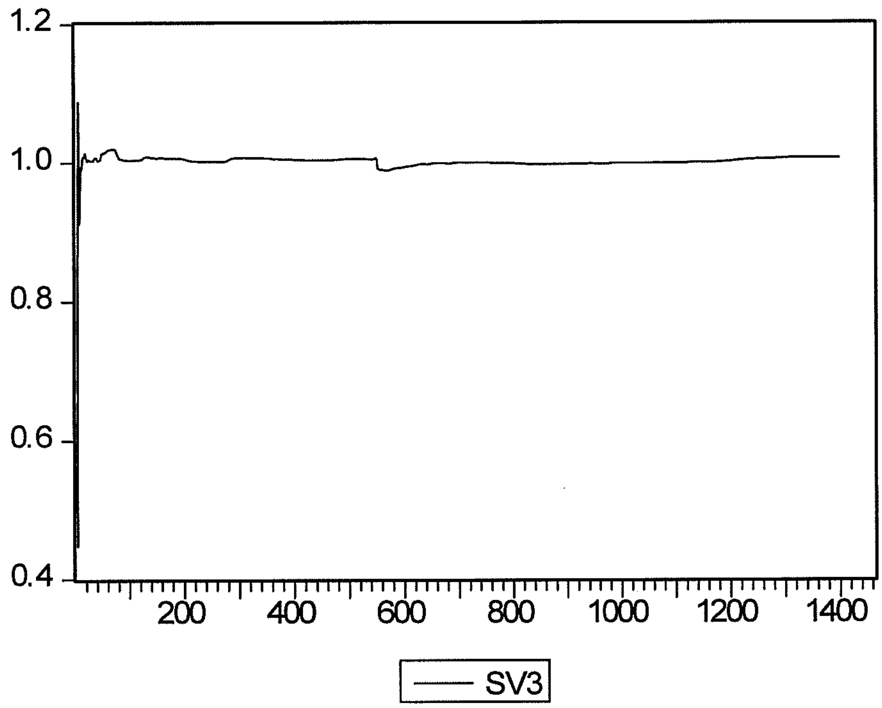
1400
SV2



ADF Test Statistic	-2.465316	1% Critical Value*	-3.4379
		5% Critical Value	-2.8641
		10% Critical Value	-2.5681

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(UK_SS)
Method: Least Squares
Date: 01/14/05 Time: 22:53
Sample(adjusted): 6 1400
Included observations: 1395 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
UK_SS(-1)	-0.009177	0.003723	-2.465316	0.0138
D(UK_SS(-1))	0.002204	0.026846	0.082115	0.9346
D(UK_SS(-2))	-0.020254	0.026794	-0.755912	0.4498
D(UK_SS(-3))	-0.051396	0.026788	-1.918586	0.0552
D(UK_SS(-4))	0.012824	0.026821	0.478117	0.6326
C	0.021097	0.008619	2.447728	0.0145

R-squared	0.008164	Mean dependent var	-0.000125
Adjusted R-squared	0.004594	S.D. dependent var	0.013600
S.E. of regression	0.013568	Akaike info criterion	-5.757846
Sum squared resid	0.255719	Schwarz criterion	-5.735305
Log likelihood	4022.097	F-statistic	2.286604
Durbin-Watson stat	2.000825	Prob(F-statistic)	0.044027

Dependent Variable: UK_SS
Method: ML – ARCH
Date: 01/14/05 Time: 22:55
Sample(adjusted): 1 1400
Included observations: 1400 after adjusting endpoints
Convergence achieved after 1 iterations

	Coefficient	Std. Error	z-Statistic	Prob.
C	8.01E-14	2.63E-06	3.05E-08	1.0000
UK_FF	-1.15E-14	6.55E-07	-1.75E-08	1.0000
UK_SS	1.000000	6.61E-05	15119.24	0.0000
	Variance Equation			
C	6.05E-30	2.07E-06	2.92E-24	1.0000
ARCH(1)	0.150000	0.158612	0.945706	0.3443
GARCH(1)	0.600000	0.390058	1.538232	0.1240

R-squared	1.000000	Mean dependent var	2.313248
Adjusted R-squared	1.000000	S.D. dependent var	0.098454
S.E. of regression	3.06E-15	Akaike info criterion	-63.87549
Sum squared resid	1.30E-26	Schwarz criterion	-63.85301
Log likelihood	44718.84	F-statistic	2.90E+29
Durbin-Watson stat	0.016314	Prob(F-statistic)	0.000000

ADF Test Statistic	-2.465316	1% Critical Value*	-3.4379
		5% Critical Value	-2.8641
		10% Critical Value	-2.5681

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(UK_SS)
Method: Least Squares
Date: 01/14/05 Time: 22:57
Sample(adjusted): 6 1400
Included observations: 1395 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
UK_SS(-1)	-0.009177	0.003723	-2.465316	0.0138
D(UK_SS(-1))	0.002204	0.026846	0.082115	0.9346
D(UK_SS(-2))	-0.020254	0.026794	-0.755912	0.4498
D(UK_SS(-3))	-0.051396	0.026788	-1.918586	0.0552
D(UK_SS(-4))	0.012824	0.026821	0.478117	0.6326
C	0.021097	0.008619	2.447728	0.0145

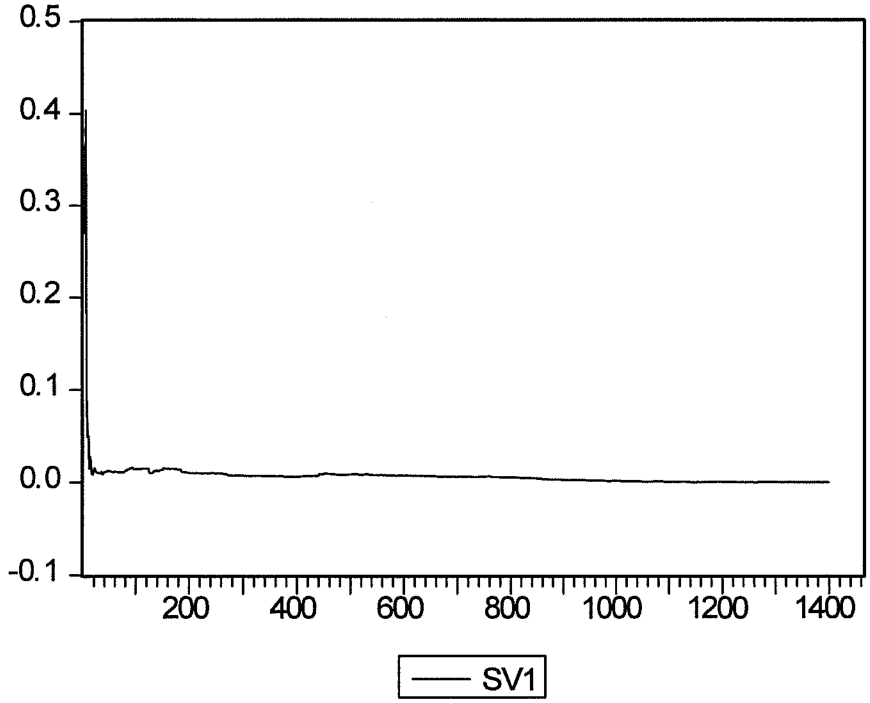
R-squared	0.008164	Mean dependent var	-0.000125
Adjusted R-squared	0.004594	S.D. dependent var	0.013600
S.E. of regression	0.013568	Akaike info criterion	-5.757846
Sum squared resid	0.255719	Schwarz criterion	-5.735305
Log likelihood	4022.097	F-statistic	2.286604
Durbin-Watson stat	2.000825	Prob(F-statistic)	0.044027

SSpace: UNTITLED
Estimation Method: Maximum Likelihood
Date: 01/14/05 Time: 23:02
Model: Time-Varying Coefficient Model
Sample(adjusted): 1 1400
Included Observations: 1397
Variance of observation equations: Diagonal
Variance of state equations: Diagonal
Convergence achieved after 16 iterations

	Coefficient	Std. Error	t-Statistic	Prob.
OBVAR(1,1)	1.86E-09	879592.1	2.11E-15	1.0000
SSVAR(1,1)	1.39E-13	8.07E+09	1.72E-23	1.0000
SSVAR(2,2)	7.08E-10	5881844.	1.20E-16	1.0000
SSVAR(3,3)	1.19E-10	34281885	3.46E-18	1.0000
Final SV1	3.18E-05	0.000547	0.058196	0.9536
Final SV2	-0.000337	0.000332	-1.015455	0.3101
Final SV3	0.998917	0.000330	3023.349	0.0000
Log Likelihood		8943.412		

US_SS=SV1+SV2*US_FF+SV3*US_FFF
SV1=SV1(-1)
SV2=SV2(-1)
SV3=SV3(-1)

R-squared	0.999999	Mean dependent var	1.470905
Adjusted R-squared	0.999999	S.D. dependent var	0.093934
S.E. of regression	0.000110	Sum squared resid	1.69E-05
Durbin-Watson stat	1.114920		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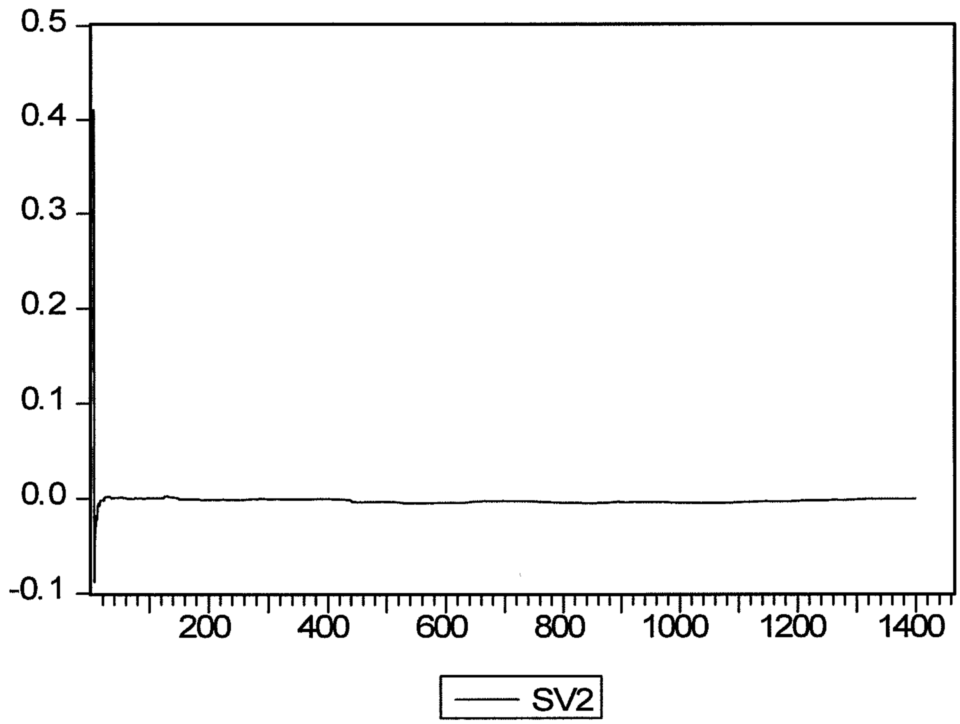
SV1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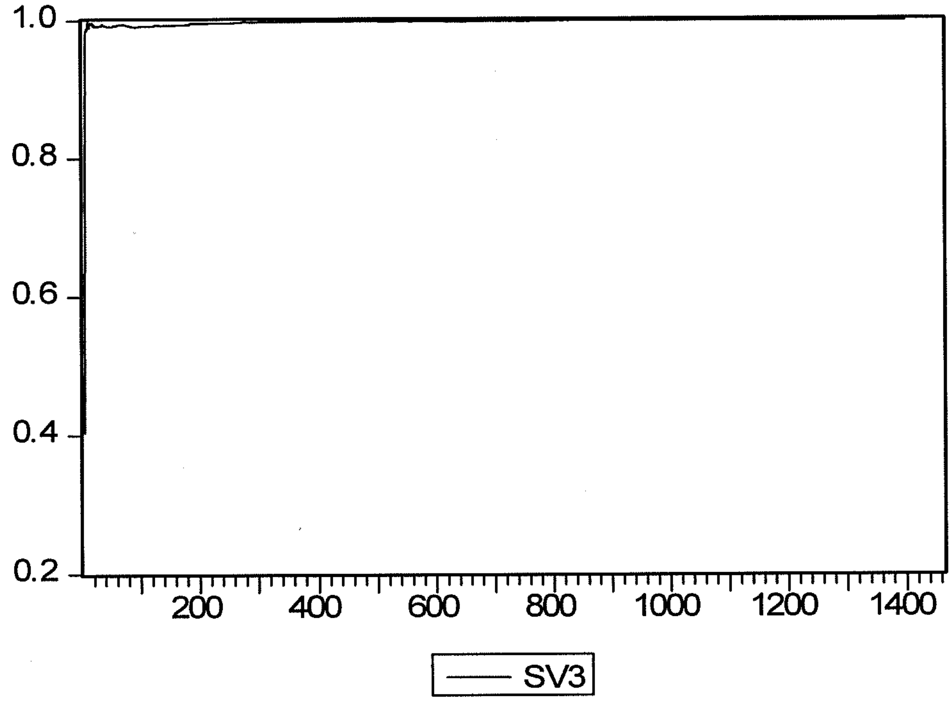
SV2



ADF Test Statistic	0.269922	1% Critical Value*	-3.4379
		5% Critical Value	-2.8641
		10% Critical Value	-2.5681

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(US_SS)
Method: Least Squares
Date: 01/14/05 Time: 23:05
Sample(adjusted): 6 1400
Included observations: 1395 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
US_SS(-1)	0.000484	0.001792	0.269922	0.7873
D(US_SS(-1))	-0.012832	0.026903	-0.476982	0.6334
D(US_SS(-2))	-0.019928	0.026909	-0.740563	0.4591
D(US_SS(-3))	-0.002416	0.026906	-0.089779	0.9285
D(US_SS(-4))	0.001981	0.026899	0.073633	0.9413
C	-0.000920	0.002642	-0.348032	0.7279

R-squared	0.000584	Mean dependent var	-0.000202
Adjusted R-squared	-0.003013	S.D. dependent var	0.006200
S.E. of regression	0.006209	Akaike info criterion	-7.321365
Sum squared resid	0.053547	Schwarz criterion	-7.298824
Log likelihood	5112.652	F-statistic	0.162382
Durbin-Watson stat	1.997897	Prob(F-statistic)	0.976226

Dependent Variable: US_SS
Method: ML – ARCH
Date: 01/14/05 Time: 23:06
Sample(adjusted): 1 1400
Included observations: 1400 after adjusting endpoints
Convergence achieved after 9 iterations

	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.002600	0.001025	-2.536980	0.0112
US_FF	-0.021978	0.001649	-13.32754	0.0000
US_FFF	1.022153	0.001478	691.6010	0.0000
		Variance Equation		
C	5.72E-08	7.31E-07	0.078187	0.9377
ARCH(1)	0.248829	0.306522	0.811781	0.4169
GARCH(1)	0.640414	0.448780	1.427009	0.1536

R-squared	0.998656	Mean dependent var	1.470970
Adjusted R-squared	0.998652	S.D. dependent var	0.093844
S.E. of regression	0.003446	Akaike info criterion	-9.288639
Sum squared resid	0.016553	Schwarz criterion	-9.266164
Log likelihood	6508.047	F-statistic	207236.2
Durbin-Watson stat	0.004777	Prob(F-statistic)	0.000000