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VIOLATIONS OF THE 'RULES OF THE GAME' AND THE CREDIBILITY OF THE CLASSICAL GOLD STANDARD, 1880-1914

Michael D. Bordo
Ronald MacDonald

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ABSTRACT

This paper examines the recently noted finding that the Classical gold standard represented a credible, well-behaved target zone system from the perspective of the well-documented failure of countries to play by the rules of the game in the classical period. In particular, we test an hypothesis of Svensson (1994) that a credible target zone can confer on a country a degree of independence in the operation of its monetary policy. We propose a number of ways of testing this proposition and implement them for a newly created monthly data base over the period 1880-1913. We demonstrate that the Classical gold standard worked in the way predicted by Svensson's model. This would seem to have an important bearing on the kind of institutional framework required for a modern day target zone (such as the Exchange Rate Mechanism of the European Monetary System) to function effectively and, in particular, to weather speculative attacks.

Michael D. Bordo
Department of Economics
Rutgers University
New Brunswick, NJ 08903
and NBER
bordo@fas-econ.rutgers.edu

Ronald MacDonald
Department of Economics
University of Strathclyde
Glasgow G4 0LN
SCOTLAND

1. Introduction

An extensive literature on the role of monetary policy and the operation of the `rules of the game' leads to an important puzzle. The puzzle is why did the gold standard work so well for the advanced countries of Western Europe, in the sense that they adhered to gold convertibility at the same parity and that the gold standard facilitated, a yet to be surpassed, transfer of capital from the old to the new world; while at the same time there exists considerable evidence that every central bank violated the `rules of the game' that they were supposed to follow, i.e. of using the tools of monetary policy solely for the purpose of speeding up the adjustment to disturbances to the balance of payments.

The answer we provide to the puzzle builds upon a recent view on the gold standard which maintains that the credibility of commitment to gold convertibility by the core countries of the gold standard (England, France and Germany) allowed their central banks to temporarily depart from following the rules of the game, i.e. to sterilize gold flows and to follow domestic policy goals independent of the concern for convertibility (Eichengreen, [1992], [1996]; Bordo and Kydland, [1996]; Bordo and Schwartz, [1996]). The belief that central banks were committed to maintain gold convertibility at the pre existing parity and would take whatever steps were necessary to do so encouraged the stabilizing private short-term capital flows that were necessary to allow short-term interest rates to depart from interest rate parity.

This belief that the monetary authorities were credibly committed to gold convertibility in turn derived from the historical record of past successful adherence and especially adherence to the gold standard as a contingent rule -- of following the requisite deflationary policies to restoring convertibility at the original parity after a suspension in the event of well understood emergencies such as war or financial crisis (Bordo and Kydland, 1996; Eichengreen, 1996).

The paper treats the operation of monetary policy and the `rules of the game' within the context of the recent literature on target zones (Krugman, 1991). We argue that under the classical gold standard, gold parity was bounded by a two-sided target zone set by the gold points. Within the zone, stabilizing expectations allowed monetary authorities to use their policy tools to set short-term interest rates independently of those in the rest of the world.

Our approach builds upon a recent paper by Svensson (1994). He argues that the conventional view on fixed exchange rate systems in a world of perfect capital mobility, under which central banks have no power to conduct independent monetary policy because any changes in domestic credit would be immediately offset by reserve outflows, does not hold in a system with exchange rate bands such as the EMS.[1] In a fixed exchange rate system with bands, monetary authorities have the latitude for independent action because of stabilizing rational expectations. In the case where a central bank lowers short-term rates, instead of an immediate capital outflow as in the textbook case, the exchange rate (domestic currency price of foreign currency) rises above the central parity rate (depreciates) until the expected rate of depreciation relative to central parity has become so negative as to match the initial decline in the short-term rate. When the short-term interest rate is raised, the exchange rate declines (appreciates) relative to central parity such that the expected rate of depreciation relative to central parity matches the initial rise in the exchange rate. Thus, when central banks gear monetary policy to domestic goals they are simply exploiting mean reversion of the exchange rate relative to central parity towards the long-run mean (Svensson, 1994, p. 162).

The classical gold standard is an example of a fixed exchange rate system with bands and with a high degree of capital mobility, where the bands are determined by the gold points. Within the gold points monetary authorities had the scope to conduct independent policies and thereby violate the `rules of the game.'[2] The scope for violation was limited by the size of the bands and could only be temporary because the exchange rate must eventually revert towards central parity (Svensson, 1994, ibid).

This paper applies Svensson's hypothesis to the monetary policy conducted by the central banks of the three core countries of the gold standard: England, France and Germany, over the period 1880-1913. Building upon earlier work by Hallwood, MacDonald and Marsh (1996a) we present evidence based on time series analysis consistent with Svensson's interpretation. These results accord well with the recent approaches to the gold standard of Bordo and Kydland (1996) and Eichengreen (1996).

Part 2 surveys the literature on monetary policy and the `rules of the game' under the classical gold standard. Part 3 motivates the empirical procedures used to test the hypotheses. In part 4 we consider some econometric issues. Part 5 describes the data set and some preliminary results. The econometric results are contained in Part 6. Part 7 gives our conclusions and discusses suggestions for future research.

2. Monetary Policy and the `Rules of the Game' under the Classical Gold Standard

The traditional view of the classical gold standard that prevailed before 1914 is that it

[1] McCloskey and Zecher (1976, 1984) argue that the `rules of the game' of the classical gold standard were inconsequential, since in their world of perfect arbitrage in goods and capital markets even the Bank of England had no control over its domestic credit.

[2] According to Svensson (1994, p.158) Keynes (1930, pp. 319-331) had this insight.

worked smoothly to achieve balance of payments adjustment without active government involvement. The only role for the monetary authorities was to maintain gold convertibility (Bordo, 1984). This view was amended after World War I, with the publication in England of the Cunliffe Committee Report in 1919. The description of how the classical gold standard operated in the Cunliffe Report included central banks as an integral part of the smooth operation of the system. The gold standard became a managed gold standard. Central banks, having evolved as the government's banker and as a lender of last resort to the commercial banking system, would use their tools of monetary policy to speed up adjustment to shocks to the balance of payments.

In this view central banks were supposed to follow `the rules of the game,' a phrase coined by Keynes in 1925. According to the `rules,' when a country was running a balance of payments deficit and a gold outflow, the central bank on observing a decline in its gold reserve ratio, would respond by contracting domestic credit. The typical way to do this would be to raise its discount rate. Because commercial banks and other financial intermediaries would rediscount commercial paper (and other eligible securities) with the central bank, the rise in the discount rate would affect bank loan rates and other interest rates in the money market. The resultant rise in short-term interest rates would speed up adjustment in two ways: by attracting short-term capital from abroad; and by depressing aggregate domestic expenditure. The rise in the discount rate by raising domestic money market rates would reduce domestic investment, both on inventories and on plant and equipment. The reduction in investment and in expenditure would reduce both income and the price level and hence reduce the demand for imports, stimulate exports and offset the current account deficit.

In the case of a balance of payments surplus and a gold inflow, the central bank was supposed to speed up adjustment by expanding domestic credit. It would do this by reducing the discount rate.

This stylized view of the managed gold standard has been the subject of extensive research for the past fifty years. Scholars have investigated: a) whether monetary policy was conducted according to the stylized story in different countries; b) whether the channels of adjustment worked as posited; and c) above all whether central banks followed the `rules of the game.' We focus on a) and c). [3]

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[3] Most of the literature on the gold standard has viewed the evidence for the external channel of adjustment via capital flow as highly effective but in the case of the domestic channel, adjustment was weak and protracted. For England, two problems were raised with the domestic channel. First that the domestic money supply was not responsive to changes in the Bank of England's gold reserve (Goodhart, 1972. Also see Jeanne, 1995). Second, that domestic economic activity was not very responsive to changes in interest rates (Tinbergen, 1950).

2.1 Monetary Policy Under the Classical Gold Standard

A considerable literature developed in the post war period on the operations of the Bank of England in the years before 1914, much of which led to the conclusion that the Bank of England did not operate according to the stylized account. Sayers (1957) examined the issue whether the Bank of England by raising the discount rate could affect money market rates according to the stylized approach. In the period from 1870 to 1890, in the face of growing competition by the London clearing banks, the Bank on occasion encountered difficulties in making Bank rate effective, in the sense of linking it tightly to short-term money market rates. As a consequence, the Bank developed methods to make Bank rate effective including the use of open market operations, eligibility requirements and instituting a penalty rate. In addition, under special circumstances, the Bank would protect the gold reserve by using `gold devices,' i.e. by direct operations in the gold market to widen the gold points.[4] By 1890, according to Sayers, the Bank was able to make the discount rate fully effective.

Like the Bank of England, the German Reichsbank used the discount rate as its key policy tool. On occasion it would supplement its use with changes in the Lombard rate, open market operations and the use of gold devices (McGouldrick, 1984; Eschweiler and Bordo, (1994); Eichengreen, 1992).

In contrast to the two other core central banks, the Banque de France infrequently changed its discount rate.[5] In testimony to the U.S. National Monetary Commission (1910) officials described how the Banque's huge gold reserves (one third of the world monetary gold stock in 1900) shielded it from external disturbances, hence obviating the need to raise its discount rate. The Banque also used gold devices in periods of stress.[6]. In addition, to avoid changing its discount rate, the Banque engaged in various forms of credit rationing.[7] Finally, the Banque may have been adverse to raising its discount rate so as to avoid raising the cost of servicing the government's debt (Eichengreen, 1992, p.29).

In sum, two of the three core central banks conducted monetary policy in accordance with the stylized view. Further study is required to more fully understand how the Banque de France controlled the money market before we can safely reach a similar conclusion for it. However, as

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[4] These practices included modifying the prices at which the Bank paid out gold and extending interest free advances to gold importers to compensate them for time spent in transit (Eichengreen, 1992, p.39).

[5] Between 1870-1907, the Banque altered its discount rate 41 times, versus 273 by the Bank of England and 138 by the Reichsbank (Patron, 1910).

[6] Including the option (because after 1878 France was on a limping gold standard) of paying out depreciated silver rather than gold (Eichengreen, 1992, p. 52).

[7] According to Patron (1910, p. 125) methods used included forbidding the opening of accounts and new credits and reducing the maximum limit of maturity of paper discounted.

we argue below, the fact that French interest rates and exchange rates behaved similar to those of the other two core countries suggests that the Banque, using different methods, followed the same principles as they did.

The Rules of the Game

According to the stylized account central banks were supposed to use discount rate policy primarily for the purpose of facilitating the adjustment to shocks to external balance. The classic study of the `rules of the game' was written by Bloomfield (1959). Following the approach taken by Nurkse (1944) in a study of central bank behavior during the interwar Gold Exchange Standard, Bloomfield interpreted the `rules' as meaning that central banks were supposed to reinforce the effects of gold flows on commercial bank reserves, not merely neutralize them.

The test that Nurkse devised for the interwar period was to compare year to year changes in international and domestic assets held by the central bank. A positive correlation would be evidence that the `rules' were being followed, a negative or zero correlation would be a violation. Bloomfield found for 12 central banks in the 1880-1914 period, that in every case the year to year changes in international reserves and domestic credit were more often than not in the opposite direction. A number of subsequent studies for individual countries confirmed this result (Jonung, 1984; Fratianni and Spinelli, 1984; McGouldrick, 1984).

More recently a number of studies have used the central bank reaction function approach to test for violation or adherence to the `rules.' Dutton (1984) argued that in addition to testing for adherence to Bloomfield's meaning of the `rules,' whereby a central bank should reinforce the effects of payments imbalances and vary domestic credit with international reserves, obeying the rules meant avoidance of the use of countercyclical domestic monetary policy.

Using monthly data for the U.K. 1870-1913, he estimated the Bank of England's Bank rate reaction to several measures of its gold reserves and several measures of domestic economic conditions. Dutton assumed the the Bank of England acted as if it were reacting to forecasts of the target variables and to avoid the problem of two-way causality between policy tools and policy targets generated forecasts using an Arima model on predetermined variables. Dutton's key finding was that although Bank rate responded strongly and negatively to the Bank's reserve position, it also responded positively to measures of domestic economic conditions (railroad freight receipts, the WPI and unemployment [negative]). The findings of a significant response of Bank rate to economic conditions as indicating the presence of countercyclical action by the Bank in his view is a violation of the `rules.'

Dutton's finding is in accord with an earlier study by Goodhart (1972) based on weekly data which showed that the Bank of England accommodated commercial bank lending, which in turn reflected variations in economic activity. It did so by varying its holdings of domestic assets, independent of the level of gold reserves. Pippenger (1984) reinterpreted Goodhart's results. He examined both the long-run and short-run operations of the Bank. His regressions led him to conclude that although in the short-run the Bank may have accommodated domestic activity, in the long-run the Bank did comply with the `rules' by its primary concern with convertibility.

Giovannini (1986) criticized the approach taken by his predecessors to test for the `rules of game' based on the central bank's reaction function, as being ad hoc. He derived a reaction function for an optimizing central bank which sets its policy instruments so as to minimize the expected squared deviation of its target values. Playing by the `rules' is defined as targeting international gold shipments. If the instruments available to the bank do not help predict international gold flows and at the same time imports of gold Granger-cause the instruments, the hypothesis that the `rules of the game' are being complied with cannot be rejected.

Tests for the Bank of England using monthly data 1980-1909, with Bank rate and two other variables as instruments, suggest that the Bank violated the `rules.' Giovannini finds that past changes in the instruments Granger cause net imports of gold. This means that the Bank could have exploited the observed correlation to improve its performance at targeting net imports of gold. Similar tests for the Reichsbank leads to the opposite conclusion, that the hypothesis that it followed the `rules' in terms of minimizing gold flows can not be rejected.[8]

Recently Jeanne (1995) used a structural VAR approach to test whether the Bank of England followed the `rules.' His results echo those of earlier studies. On the one hand Bank rates responded to gold flows as postulated by the traditional view, but on the other hand there is evidence of partial sterilization. In addition, he finds evidence for Bagehot's expectation effect -- that market interest rates responded to gold flows independent of Bank rate as if in anticipation that the Bank of England would respond.

Finally, Davatyan and Parks (1995) extend the dynamic probit estimation technique employed earlier in Eichengreen, Watson and Grossman's (1985) study of Bank rate policy under the interwar gold standard, to the Bank of England 1890-1908. Like Pippinger, they find that in the long-run the Bank attached greater weight to convertibility. Bank rate was influenced by

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[8] Eschweiler and Bordo (1994) tested the Reichsbank's reaction function based on optimizing behavior using monthly data, 1880-1913. The bank is assumed to trade off two objectives, stabilizing the exchange rate around parity and smoothing the discount rate around some target. The monthly regressions showed that the Reichsbank violated the `rules' in the sense that it attached greater weight to interest rate smoothing than to stabilizing the exchange rate. However, with annual data the results are reversed, suggesting that in the long-run the Reichsbank attached greater weight to convertibility.

three considerations in descending order: convertibility, profitability and domestic economic activity.

In sum, previous research suggests that the `rules' were often violated by the Bank of England, the Reichsbank and other central banks in the sense that some short-run sterilization occurred; and in the sense that central banks responded to domestic goals including the level of output, the price level and interest rate stability. It also suggests that central banks attached primary importance to preserving convertibility and that this objective became more important, the longer the time period under consideration. The combination of short-run violation of the `rules' and long-run adherence to convertibility may be explained by private agents beliefs that the commitment to maintain convertibility was credible. This gave the monetary authorities the breathing room to satisfy other objectives.

3. Motivation and Methodology

Under rigidly fixed exchange rates the condition of interest rate parity may be expressed as:

$$i_t = i_t^*, \qquad (1)$$

where i_t and i_t^* denote, respectively, the domestic and foreign currency interest rates with maturity k. Expression (1) indicates that the domestic interest rate cannot deviate from the foreign rate even momentarily. This is the standard assumption in many 'textbook' versions of the Mundell-Fleming model and it implies, of course, that domestic monetary policy can only have an effect on domestic variables, such as output and inflation, to the extent that the home country is 'large' (i.e. the US). For a small open economy (1) implies that its monetary policy is determined in the foreign country or, more realistically, the rest of the world. Condition (1) is often taken as a representation of perfect capital mobility.

However as Svensson (1994) indicates there are few, if any, regimes of the international monetary system in which it can be said that exchange rates were rigidly fixed. The Classical gold standard, which is often cited as an example *par excellence* of a rigidly fixed exchange rate regime, in fact had (time-varying) exchange rate bands in the form of the gold export and import points (this is discussed in greater detail below). The existence of such bands introduces a wedge between the domestic and foreign interest rate in the form of a non-zero expected exchange rate change and this, in turn, means that domestic monetary policy will have some independence vis a vis foreign interest rate policy, even for a small open economy. This may be illustrated in the following way.

The ability of the domestic rate to deviate from the foreign rate is clearest when exchange rates are freely flexible. In this case the interest parity condition given in (1) has to be modified to:

$$i_t = i_t^* + \Delta s_{t+k}^e, \qquad (2)$$

where Δs_{t+k}^e represents the expected exchange rate change over the same maity period defined for the interest rates.[9] If Δs_{t+k}^e is negative, the domestic currency is expected to appreciate and the domestic interest rate can fall below the foreign interest rate by the extent of the expected appreciation. The existence of exchange rate bands can have similar implications for interest rates under certain assumptions (discussed below). In the presence of an exchange rate band s_t may be split into two components:

$$s_t \equiv c_t + x_t, \qquad (3)$$

where c_t denotes the central parity rate and x_t denotes the exchange rate's deviation from central parity. It follows from (3) that the expected currency depreciation in a fixed rate regime may be defined as:

$$\Delta s_{t+k}^e = \Delta c_{t+k}^e + \Delta x_{t+k}^e. \qquad (4)$$

Substituting (4) into (2) we obtain:

$$i_t = i_t^* + \Delta c_{t+k}^e + \Delta x_{t+k}^e. \qquad (5)$$

Now if the central rate is credible, in the sense that agents believe there will not be a devaluation or revaluation of the currency over the maturity horizon k, the second term after the equals term, Δc_{t+k}^e, will be zero and the domestic interest rate can rise above or below the foreign rate to the extent that Δx_{t+k}^e is non-zero. For example, if the domestic authorities increase the domestic money supply the domestic interest rate will fall below the foreign rate and, as investors switch funds from the domestic interest bearing asset to the foreign asset, the exchange rate depreciates relative to the central parity. Under the assumption that the central parity is credible the depreciation will produce the expectation of an appreciaton relative to c; i.e. $\Delta x_{t+k}^e < 0$.

As Svensson (1994) emphasises, even a relatively small bandwidth can offer the monetary authorities substantial leverage over interest rates. For example, a one per cent deviation of the exchange rate from the central parity which is expected to be removed in three months implies an annualised expected appreciation of 4 per cent per year - a non-trivial number

[9] In our exposition of the target zone model in this section, it is assumed that the maturity k is equal to unity.

from a monetary policy perspective. It is worth emphasing that all of the above discussion presupposes capital is perfectly mobile. Since the Classical gold standard is widely recognised as a period in which this condition was in fact satisfied, it seems an ideal period for exploring the above-noted relationships.

There are, however, important limitations to the extent of any independence. First, if the assumption that Δc^e_{t+k}, is zero is violated and, in particular, if it is endogenously related to Δx^e_{t+k} and is increasing in the exchange rate's deviation from central parity, then this will reduce the degree of monetary independence; in instances where Δc^e_{t+k}, moves in an equal and opposite fashion to Δx^e_{t+k} there will be no monetary independence. For certain currencies and at certain times in the existence of the Bretton Woods system this may have been a reasonable working assumption. However, for the Classical gold standard system there is considerable evidence to suggest that the exchange rates studied in this paper were highly credible (see Hallwood, MacDonald and Marsh (1996a and b) and Officer (1996)). Second, the monetary independence can only be temporary because unless expectations are systematically violated (which would ultimately mean the expected rate of realignment was non-zero) the exchange rate must eventually revert back to its central parity. This, in turn implies that the monetary independence will be limited to interest rates with short-term maturities.

Svensson argues that the monetary independence remaining after taking account of the above limitations offers a central bank scope to attempt to stabilise output and inflation and engage in interest smoothing objectives. Our main objective in this paper is to test the implications of this view of a banded exchange rate system (which we refer to as a target zone in the following) for three gold standard exchange rates. The main focus of our work concentrates on three interest rate systems (defined below) which are used to assess different aspects of monetary independence in a credible target zone. Before discussing these systems, however, we discuss a way of assessing if a target zone is indeed credible.

In order to to gauge just how credible the gold standard relationships between the UK and Germany and the UK and France actually were for our sample period, we calculate so-called 95% confidence intervals. Although such tests have been conducted before for the Classical gold standard period (by Govannini [1993] and Hallwood, MacDonald and Marsh [1996a]) there are important differences in the data used in this paper and the data used by other researchers (see Section 4) and therefore we believe it important to ascertain if our chosen exchange rates were indeed credible.

Svensson's (1991) credibility test consists of taking the total expected change in the exchange rate, as represented by the interest rate differential, and adjusting for the maximum and minimum possible mean reversion within the band (where such movement is here limited by the gold points) to give a '100%' confidence interval for the expected devaluation. Let x_t^l and x_t^u denote the lower and upper limits of an exchange rate's deviation from the central band, then the maximum possible changes within the band are given by the following weak inequality:

$$(x_t^l - x_t) \leq E_t[dx_t]/dt \leq (x_t^u - x_t)/dt. \quad (6)$$

Assuming that the interest differential measures the total expected change in the exchange rate, the following inequality expresses the 100% confidence interval:

$$(i_t - i_t^*) - (x_t^u - x_t)/dt \leq E_t[dc_t]/dt \leq (i_t - i_t^*) - (x_t^l - x_t)/dt. \quad (7)$$

Rose and Svensson (1995) propose a 95 % credibility band as an alternative to (7). This involves assuming the expected change in the exchange rate within the band is generated from the following linear regression equation:

$$x_{t+k} - x_t = \alpha_0 + \alpha_1 x_t + \nu_t, \quad (8)$$

and subtracting the 95% confidence interval generated from the fitted values of (8) from the interest differential to provide the 95% confidence interval for the expected realignment rate. We calculate 95% confidence intervals for the three exchange rates considered in this paper.

The main focus of our work concerns the behaviour of three different interest rate systems. These systems are designed to gauge the existence of short-run monetary independence and its relationship to the policy variables targeted by the monetary authorities. The systems are: system one which consists of a home short interest rate, i_t^s and a comparable short foreign rate, $i_t^{s,*}$; system two which consists of the variables in system one plus a home long interest rate, i_t^l; system three consists of the variables in system two plus the policy variables (discussed below) targeted by the monetary authorities. We now discuss these systems in a little more detail.

The Svensson story is that in the short-run there should be some scope for the home short interest rate to deviate from the comparable foreign rate, but in the longer term such scope vanishes. By examining system 1 we hope to capture this feature of the Svensson model. In particular, if home and foreign short term interest rates are individually non-stationary, or I(1), then for them not to persistently deviate from each other in the longer term they should form a cointegrating relationship of the form first proposed by Engle and Granger (1987).[10] That is, in the context of an estimated version of equation (9)

$$i_t^s = \alpha + \beta i_t^{s,*} + \nu_t, \quad (9)$$

[10] As we shall demonstrate in Section 4, all of the interest rates considered in this paper are I(1) processes

it would be expected that the error process, v_t, is stationary, or I(0), α would differ insignificantly from zero and β would be insignificantly different from unity (we discuss below how we propose estimating (9)).

The expected change in the exchange rate within the band does not appear in the cointegrating relationship since it is expected to be I(0) and will not affect the long-run result (in a cointegration sense). However, the non-zero expected exchange rate change will be captured in the short-run dynamic equations implied by (9). In particular, if the two interest rates defined in (9) are cointegrated then the Granger Representation theorem implies that a dynamic error correction representation of the following form must exist:

$$\Delta i_t^s = -\varphi(i_{t-1}^s - i_{t-1}^{s,*}) + \sum_{i=1}^{p}\kappa_i \Delta i_{t-i}^s + \sum_{i=1}^{p}\gamma_i \Delta i_{t-i}^{s,*} \qquad (10)$$

$$\Delta i_t^{s,*} = +\varphi(i_{t-1}^s - i_{t-1}^{s,*}) + \sum_{i=1}^{p}\kappa_i^* \Delta i_{t-i}^s + \sum_{i=1}^{p}\gamma_i^* \Delta i_{t-i}^{s,*} \qquad (10')$$

where the first term on the right hand side of each equation represents the error correction mechanism (ECM) recovered from the cointegration tests on (9) (we have imposed the condition α=0 and β=1 on this relationship). The significance of this coefficient will be informative with respect to which of the interest rates adjusts in response to a disturbance to the levels terms. It should be significantly negative in the first equation, to the extent that the home interest rate is adjusting and significantly positive in the second, to the extent that the foreign rate does the adjusting. Additionally, the coefficients on the dynamic terms will give a feel for the amount of short-run policy independence available to the participating countries. Essentially the existence of significant explanatory variables in (9) is *prima facie* evidence that the expected change in the exchange rate is non-zero.

In addition to its implication for short rates, the Svensson model, as we have noted, also has implications for the behaviour of long term interest rates. Therefore, the second system we consider introduces a long rate into system one. We assume long rates are determined by a standard expectations model of the term structure formulation (see Campbell and Shiller (1987)):

$$i_t^l = (1-\delta)\sum_{j=0}^{\infty}\delta^j E_t i_{t+j}^s \qquad (11)$$

where δ is the discount factor and we have assumed, for simplicity, an infinite discounting horizon.

From (11) we see that a current change in short interest rates which is expected to be reversed will have little impact on long bond yields. It follows, therefore, that long rates are not expected to move systematically with short rates and the yield gap, or spread (i.e. i_t^l - i_t^s), should open up after a shock to the short rate, but that this would be expected to be extinguished relatively quickly.

To examine the short-long interest rate interrelationships we again intend exploiting cointegration methods. In particular, Campbell and Shiller (1987) have demonstrated that if (11) is a valid representation of the long-short interest rate relationship, long and short interest rates should be cointegrated with a cointegrating coefficient equal to unity; an equivalent interpretation is that the spread should be stationary. That is, on subtracting $i^s{}_t$ from both sides of (11) we may obtain:

$$i_t^l - i_t^s = \sum_{j=1}^{\infty} \delta^j E_t \Delta i_{t+j}^s . \qquad (11')$$

Therefore, in a trivariate system consisting of a home and foreign short rate and a home long rate we should observe two long-run relationships: one governing short rates, from the interest parity condition, and the other governing the relationship between the home short and long rates given by the term structure relationship. On the basis of the Granger Representation theorem this kind of system will produce the following kind of equation for the change in the domestic short term interest rate

$$\Delta i_t^s = -\varphi(i_{t-1}^s - i_{t-1}^{s,*}) - \delta(i_{t-1}^l - i_{t-1}^s) + \sum_{i=1}^{p} \kappa_i \Delta i_{t-i}^s + \sum_{i=1}^{p} \gamma_i \Delta i_{t-i}^{s,*} + \sum_{i=1}^{p} \mu_i \Delta i_{t-i}^{l,} \qquad (12)$$

where the '*l*' superscript denotes a long rate, the first term on the right hand side denotes the error correction term associated with the short-run interest parity relationship, the second term denotes the term structure effect or 'spread' and the remaining terms are the dynamic terms.

Of course, there would be a further two dynamic equations for the change in the foreign short rate and the change in the domestic long rate. Since with such a relatively complex system it can be difficult interpreting the coefficients on any one variable, we propose examing the interrelationships represented in (12), and the associated equations, using an impulse response analysis. This system will not only help to address the issue of the long-short relationship referred to above, it will also give further insight into the degree of monetary autonomy which a credible target zone confers and the degree of mean reversion which exists for short rates.

Our third system involves examining the interrelationships between short term interest rates and the variables to which they are targeted. In particular, if we can establish that there is some independence for short term interest rates we may ask: how was this indepedence used? The Svensson story is that it should facilitate standard counter-cyclical objectives such as stabilising the output-inflation trade-off and allowing the authorities to engage in interest rate smoothing. More specifically, we are interested in investigating the effect of changes in output (*y*), prices (*p*), unemployment (*u*), gold reserves (*g*) and the volatility of interest rates (*Vol(i)*) on short term interest rates changes (these variables, apart from the interest rate terms are log transformed; the volatility of interest rates is measured using the standard deviation).

Defining the vector $\mathbf{z}_t = [\Delta y_t, \Delta p_t, \Delta u_t, \Delta g_t, Vol(i)]'$ then we may gauge what effect the fundamentals have on the domestic interest rate change, over-and-above the influence of other interest rates, by introducing $\mathbf{z}_t$ into (12) to get:

$$\Delta i_t^s = -\varphi(i_{t-1}^s - i_{t-1}^{s,*}) - \delta(i_{t-1}^l - i_{t-1}^s) + \sum_{i=1}^{p} \kappa_i \Delta i_{t-i}^s + \sum_{i=1}^{p} \gamma_i \Delta i_{t-i}^{s,*} + \sum_{i=1}^{p} \mu_i \Delta i_{t-i}^{l,*} + \sum_{i=0}^{p} \mathbf{f}\mathbf{z}_{t-i} \quad (13)$$

More specifically, the Svensson model implies that the fundamentals can have an impact on the short-run behaviour of the interest rate, but they do not impact on the the long-run equilibrium relationships. This feature of the Svensson approach is captured in (13).

4. Some Econometric Issues

We now present a more formal discussion of our modelling the effects of the fundamentals on the short interest rates and our estimation of the long-run relationships discussed above.

Given that all but one of the systems discussed above contains at least two potentially non-stationary variables, we propose estimating the long-run or cointegrating relationships using the methods of Johansen (1988,1991). Johansen's procedure, which adopts a parametric correction to account for serial correlation and simultaneous equation bias (that may contaminate single equation estimates derived from a two-step estimator - see, for example, Campbell and Perron (1991)), faciliates testing for the number of significant cointegrating vectors and implementing testable restrictions on the vectors. The method is based on the following VAR structure. Define an (nx1) vector x_t which contains the n variables of interest (in terms of system 2 it simply contains three interest rates) and assume it has a vector autoregressive respresentation of the form:

$$x_t = \eta + \sum_{i=1}^{p} \Pi_i x_{t-i} + \varepsilon_t, \quad (14)$$

where η is an (nx1) vector of deterministic variables, and ε_t is an (nx1) vector of white noise disturbances, with mean zero and covariance matrix Ξ. Expression (14) may be reparameterised into the vector error correction mechanism (VECM) as:

$$\Delta x_t = \eta + \sum_{i=1}^{p-1} \Phi_i \Delta x_{t-1} - \Pi x_{t-1} + \varepsilon_t, \quad (15)$$

where Δ denotes the first difference operator, Φ_i is an (nxn) coefficient matrix (equal to $-\sum_{j=i+1}^{p}\Pi_j$, Π is an (nxn) matrix (equal to $\sum_{i=1}^{p-1}\Pi_i - I$) whose rank determines the number of cointegrating vectors. If Π is either full rank, n, or zero rank Π=0, there will be no cointegrating vectors amongst the elements in the long-run relationship. If, however, Π is of reduced rank, r (where r<n), then there will exist (nxr) matrices α and β such that $\Pi=\alpha\beta'$, where β is the matrix whose columns are the linearly independent cointegrating vectors and the α matrix is interpreted as the adjustment matrix, indicating the speed with which the system responds to last periods deviation from the equilibrium level. hence the existence of the VECM model, relative to say a VAR in first differences, depends on the existence of cointegration.

We test for the existence of cointegration amongst the variables contained in x_t using two tests proposed by Johansen. The likelihood ratio, or Trace, test statistic for the hypothesis that there are at most r distinct cointegrating vectors is

$$TR = T\sum_{i=r+1}^{N}\ln(1-\hat{\lambda}_i), \qquad (16)$$

where $\hat{\lambda}_{r+1},.....,\hat{\lambda}_N$ are the N-r smallest squared canonical correlations between x_{t-k} and Δx_t series (where all of the variables entering $\mathbf{x}_t$ are assumed I(1)), corrected for the effect of the lagged differences of the x_t process (for details of how to extract the λ's see Johansen (1988)). Additionally, the likelihood ratio statistic for testing at most r cointegrating vectors against the alternative of r+1 cointegrating vectors - the maximum eigenvalue statistic - is given by (17)

$$LR = T\ln(1-\lambda_{r+1}). \qquad (17)$$

Johansen (1988) shows that (16) and (17) have a non-standard distribution under the null hypothesis. He does, however, provide approximate critical values for the statistic, generated by Monte Carlo methods (see also Osterwald-Lenum (1993)).

The systems containing only interest rates are straighforward to estimate using the methods of Johansen, since these variables will appear in both the long-run relationships and the short-run dynamics. However, the most general system does not lend itself to a standard application of the Johansen methods. This is because the fundamentals contained in the $\mathbf{z}_t$ vector are assumed only to affect the short-run dynamics of interest rates and not the long-run behaviour. They are therefore assumed to be weakly exogenous and to only enter the dynamic component of (15) and not the long-run component.

As a check on our Johansen results we also compute the Phillips-Hansen fully modified estimator for our simplest model. This estimator is a development by Hansen (1992) of the fully modified estimator of Phillips (1991). The intuition underlying this approach is as follows. If, for example, the interest rates in (9) are indeed cointegrated then the error term, ν, should be stationary, that is an I(0) process. If the interest rates are not cointegrated, however, then ν_t is I(1) and it may be thought of as consisting of a random walk component, D_t and a stationary term, φ_t (i.e. $\nu_t = D_t + \varphi_t$). Under these conditions we may rewrite (9) as

$$i_t^s = \alpha_t + \beta i_t^{s,*} + \varphi_t, \qquad (9')$$

where $\alpha_t = \alpha + D_t$. Hence the alternative hypothesis of no cointegration is equivalent to the intercept term in (9) following a random walk.

The Phillips-Hansen method uses a non-parametric correction for simultaneous equation bias and residual autocorrelation / heteroscedasticity and provides estimated coefficients and standard errors which are robust to these nuisance factors. Cointegration is tested using an adjusted F-statistic -F_{nt} - to test the stability of the coefficient vector. Hansen (1992) proposes three test statistics to check the significance of F_{nt} and therefore the stability of the relationship.

The statistics are: the LC, MeanF (simply the mean of the F statistic) and SupF. These statistics are tests of the stability of the estimated relationships and, in particular, the null of cointegration. All of the statistics have power in testing this null, but they have different alternatives. Specifically, LC has as its alternative that the coefficients follow a random walk.; MeanF and SupF also have power in this direction (although they are not specifically targeted to this alternative).

In terms of the stability of the relationship, both MeanF and LC test for a gradual change in parameter variation; the latter is seen as particularly useful in circumstances where the researcher believes that parameter variation is likely to be relatively constant over the sample period. In contrast, SupF tests for an abrupt change in the relationship, due, perhaps, to a regime change.

In attempting to assess the interactions between interest rates, and in particular the leeway given to monetary policy in a target zone system, we adopt an impulse response framework. Although impulse response methods have been used in a number of applications elsewhere, and therefore the method is well known, practically all previous applications ignore the implications of potential cointegrating relationships in the calculation of the impulse respones. In this paper we calculate the impulse responses with the long-run relationships imposed.

The standard impulse response approach involves calculating the moving average (MA) representation of the VAR system (10) and examining the response of an interest rate change to orthogonal impulses. More specifically, the approach involves the following. On the assumption that all of the variables in the vector $\mathbf{x}_t$ are stationary (we return to this assumption below) then Wold's decomposition theorem implies the following canonical MA representation for $\mathbf{x}_t$:

$$\mathbf{x}_t = \eta + \sum_{i=0}^{\infty} \Psi_i \varepsilon_{t-i}, \tag{18}$$

where of terms not previously defined, $\Psi_0 = I_n$ and the infinite sum is defined as the limit in mean square.

This relationship may then be used to examine the effect of shocks, as represented by the white noise disturbances, ε_t, on the elements of the $\mathbf{x}_t$ vector. However, a common problem with this is that since the covariance matrix Σ_ε is unlikely to be diagonal it is difficult to interpret the effects of a particular shock on, say, the exchange rate. This is because the shock will in all likelihood have a contemporaneous effect on other shocks which, in turn, will have an impact on the exchange rate making it impossible to unravel the sole influence of the initial shock. A standard way of dealing with this problem is to use the MA representation with orthogonalised innovations. That is,

$$\mathbf{x}_t = \sum_{i=0}^{\infty} \theta_i \omega_{t-i} \tag{19}$$

where the components of ω are uncorrelated and a matrix P is chosen so that Σ_ω has unit variance (that is, $\Sigma_\omega = P^{-1}\Sigma_\varepsilon(P^{-1})' = I_k$).

The matrix P can be any solution of $PP^{-1} = \Sigma_\varepsilon$ and perhaps the most popular assumption is that P is chosen, using a Choleski factorisation, as a lower triangular nonsingular matrix with positive diagonal elements; other decompositions, such as the 'structural' decompositions of Bernanke (1986) and Blanchard and Quah (1989) also exist. In the (stable) case the Ψ_i converge to zero as $i \to \infty$ and $\Sigma_x(h)$ converges to the covariance matrix of $\mathbf{x}_t$ as $h \to \infty$; however, this does not necessarily occur in the case of unstable, integrated or cointegrated VAR processes. Nevertheless, even for such processes it is still possible, as demonstrated by Lutkepohl (1993), to construct Ψ_i and θ_i. In this paper we follow the approach of Hendry and Mizon (1993) which involves reparameterising the error correction component of the VECM and then proceeding with the standard Choleski factorisation.[11]

5. Data Sources and Some Preliminary Relationships

The data sample runs from January 1880 through to December 1913. The data are collected for France, Germany and the UK. For each of these countries we have collected data on

[11] In particular, this approach involves reparameterising the error correction term into a term in first differences and a lagged levels term.

two short interest rates, a Bank (discount) rate and a market rate, and a single long rate (which is country-specific).[12] Additionally, we have collected data on the spot exchange rates and, using shipping costs, insurance and an opportunity cost variable, have calculated the gold points for each country (the mean value of the gold points is taken to be our central parity rate). The non-financial fundamental variables which complete our data set (where available) are industrial production, a consumer price index, gold reserves and unemployment. All data were originally seasonally unadjusted and have been seasonally adjusted using the X11 filter. A complete listing of all variables, their sources and construction are presented in Appendices A and B of the paper.

Three country pairings are examined, namely the UK-France, the UK-Germany and Germany-France. Given that the UK, and particularly London, was central to the operation of the Classical Gold Standard we regard the two pairings involving the UK as central to our analysis. However, we also implement our set of tests for the Germany-France pairing for comparative purposes; since neither of these countries can be regarded as credible as the UK there is an expectation that this pairing will exhibit different properties to the UK-based pairings.

The calculation of the gold points follows the procedure used by Clark (1984), Officer (1986) and Giovannini (1993) and exploits the following formulae, for the gold import point, G_t^I, and gold export point, G_t^X, respectively:

$$G_t^I = \frac{X}{Y}\left[\frac{1}{(1+i)^{k/365}+c}\right], \tag{20}$$

where X is the official home currency price of an ounce of "fine" gold, Y is the official 'foreign' price of an ounce of fine gold, and X/Y is therefore the official exchange rate or "mint parity", i is the home interest rate, k is the shipping time and c denotes direct shipping costs which includes items such as freight and insurance costs, packing, loading and unloading, abrasion, charges for assay and minting and, finally, incidental expenses.

The gold export point is defined as:

$$G_t^X = \frac{X}{Y}\left[(1+i)^{k/365}+c\right]\left(\frac{1+i^*}{1+i}\right)^{k/365}, \tag{21}$$

[12] In calculating an interest parity relationship it is now common to use offshore interest differentials since the latter are free of so-called political risk. Unfortunately, such rates are not avaliable for our sample period. However, we do not believe that the existence of such rates would affect the tenor of the results reported in this paper. This is because with one or two minor exceptions, the period studied in this paper was one of remarkable political stability, a feature borne out by our credibility tests. Furthermore, our findings of credibility also mean that the the short term interest differentials examined in this paper do not contain a significant time-varying risk premium thereby further enhancing their usfulness in the kinds of tests we undertake.

where, of terms not previously defined, i^* is the 'foreign' or overseas interest rate. For the home and foreign interest rates we have used the market rate of discount. In computing the gold points between London and Berlin (LB) and London and Paris (LP) we follow Einzig's (1931) calculations for shipping time and costs and set k=3 in LB and k=1 in LP. We estimate the cost of shipping for LB to be c = 0.1152 per cent and for LP c = 0.263 per cent.[13]

In Figures 1 through 3 we present plots of the short term interest differentials between the UK and France, the UK and Germany and Germany and France. These graphs illustrate in a simple way that there appear to be both short and fairly prolonged periods in which the differentials deviates from zero. For example, the Germany-UK differential, with a few exceptions, appears to be persistently above zero and this is also true for the France-UK relationship post-1900. Although persistent deviations would in themselves be a violation of the Svensson story, it is important to note that, with the exception of the Germany-France relationship, these deviations are not, on average, significantly different from zero over the period (see Tables 5 and 6). The difference between the Germany-France relationship and the two UK-based systems is, as we shall see, a recurring theme in the paper and underscores the point that when the UK is involved in a bilateral system, the system works well because the UK has the greatest credibility for the period (followed by Germany, then France).

In Figures 4 to 6 the yield gap is presented for each of the three countries. For France (Figure 4) we note that the yield gap, is with one or two exceptions, positive throughout the period. To the extent that the simple expectations model of the term structure is valid for this period this may indicate a non-zero expected inflation rate. Similarly for Germany there is a fairly prolonged period (from 1880 down to 1897) when the yield gap is positive, thereafter the average value is approximately centered on zero. The yield gap for the UK appears to be more closely centered on zero for most of the period although there are some exceptions to this, most notably the apparent deflationary expectations in the period from 1898 to 1907 (approximately).

In Figures 7 to 9 we present our estimates of the gold points and the actual exchange rate movements within the points. We note that for the franc-sterling relationship there are a number of violations in the earlier part of the period (up to the late 1880's), but thereafter there is only a single violation. For the mark-sterling relationship there are a number of violations bunched together in the 1890s and again in the early part of the twentieth century. Given the violations for

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[13] These latter calculations differ slightly from those done by Giovannini (1993) and hence our estimated gold points for LB and LP differ from his. We were unable to obtain his data to explain the source of the difference. As a check on the methods used to calculate the LB and LP gold points, we calculated the gold points for London-New York: our results were similar to both those of Officer (1986,1996) and Giovannini (1993). Although our gold point calculations are qualitatively different from those of Giovannini, it is doubtful that this will have significant effects on our econometric results below.

these two currencies it is not surprising, therefore, that there are comparable violations for the mark-franc rate. The interesting question, though, is do these violations necessarily imply that the system was not credible at the violation points or indeed at other points? We answer this question by calculating equations (7) and (8).

In Figures 10 to 12 we present a graphical picture of the credibility of the gold standard for the three exchange rates using the 95% confidence intervals referred to earlier. Overall we note that there are very few points at which the ranges lie above or below zero suggesting therefore that the pegging of these three currencies to gold conferred considerable credibility on the currency. This should be contrasted with the 95% confidence intervals reported by Svensson for the ERM period in which there are few points which are not significantly above or below zero. It is also worth noting that there is not a one-to-one correspondence between the violations of the gold points noted in Figures 10 to 12 and non-zero expected realignments.

Some insight into the extent to which the three monetary authorities could engage in independent monetary policies may be gleaned from Figures 13 to 15 which contain scatterplots for the short term market interest differential and x_t, the deviation of the exchange rate from the central parity. These plots indicate a clear negative relationship for both UK-France and UK-Germany, but a positive relationship for Germany-France. The former two relationships are significant, but the significance of the latter is weak. We interpret these plots as supporting the basic premise of our approach, at least for two of the country combinations.[14]

6. Econometric Results

In Tables 1 and 2 we present standard Augmented Dickey Fuller t-statistics for our interest rate and exchange rate series in levels and first differences. These statisics are tests of the null hypothesis that each of the series, on a univariate basis, contains a unit root. The lag length for the underlying regression was estimated using a likelihood ratio from a general lag structure of 24 lags. The optimal lag length is noted in the final column of the table. The general tenor of these results is that each series appears to be an I(1) process or contain a root close to the unit circle. These findings are confirmed in Tables 3 and 4 where we present KPSS unit root statistics which test the null that each series is stationary in levels. This null is rejected in all of the levels equations, but not the first difference specifications.

[14] These results essentially confirm the findings of Giovannini (1993).

6.i. System 1 Results

In Table 5a we present our estimates of equation (9) using the methods of Johansen discussed above. In deciding on the deterministic specification, we have used the so-called 'Pantula (1989) principle' of testing the joint hypothesis of rank order and deterministic components. The deterministic elements reported in all Tables containing Johansen estimates are based on this principle. Evidence in favour of a single cointegration vector is fairly clear-cut across the short rate systems. The coefficients on the 'foreign' interest rates are all positive and are numerically close to unity.[15] More specifically, these values range from 0.81, for the UK-Germany bank rate relationship to 1.60 for the UK-France market rate relationship. The French result is interesting since it implies that a 1 per cent increase in the franc short market rate had to be matched by a more than proportionate increase in the UK rate: there was a negative gap in favour of the franc for the period. However, we note that the $t_\beta=1$ statistic, which is a test of the hypothesis that the β coefficient is significantly different from unity, is insignificant in all cases.[16]

It is worth noting that these results are in marked contrast to interest parity results obtained for the recent floating period (see, for example, Frankel (1994) and Obstfeld (1995)) and act as a confirmation that capital was essentially perfectly mobile throughout this period. The reported Lagrange Multiplier tests statistics for up to fourth order autocorrelation indicate that the systems all have tolerably white residuals.

In terms of the long rate systems, reported in the bottom half of the table, the evidence for cointegration is more limited and, indeed, is only marginal at the 90 per cent level when a time trend is included in the cointegrating space (the Pantula principle indicated that both a constant and a time trend were required in the cointegrating space). The existence of the latter could be capturing the long-run change in capital mobility occurring in our period (i.e. an increase in financial market integration).[17]

The Phillips-Hansen fully modified estimates of equation (9) are presented in Table 5b and essentially confirm the results obtained from the Johansen estimator. On the basis of the robust standard errors, reported in square brackets underneath the point estimates, all of these coefficients are significantly different from zero. Using these standard errors to construct t-ratios for the hypothesis that β is equal to one we find (in the column labeled t_β) that this hypothesis cannot be rejected in six out of the nine interest rate combinations.

[15] All of the systems are based on an 8 lag VAR model.

[16] This statistic has a chi-squared distribution with one degree of freedom.

[17] To model violations of the gold points, we experimented with including event dummies in the VECM, but this made little difference to the results.

The three combinations which produce a rejection are UK-France (market interest rates), UK-Germany (Bank rates) and UK-France (long rates). The LC, MeanF and SupF statistics, which are tests for the null of cointegration against different alternatives are also reported in Table 5b. As we have noted, these statistics are tests of the stability of the estimated relationships and, in particular, the null of cointegration. In only one case do these three statistics all point to a rejection of the null and that is for the UK-France market rate equation. Interestingly, there is no rejection of the null of cointegration for the long rate pairings (despite the fact that only a constant enters the cointegrating set), although there is some evidence that in the UK-France relationship the estimate of β is significantly less than one.We therefore interpret the results of Table 5b as confirming the findings contained in Table 5a.

The estimates of interest rate parity for the short rates contained in Table 5, ignore the expected rate of change of the exchange rate within the band, Δx^e_{t+3}. As we have already noted, since this variable can be presumed to be stationary, it will not affect the evidence of cointegration although it may affect the point estimates in small samples. The interest parity relationship modified for the expected exchange rate change within the band is:

$$i_t = i^*_t + \Delta x^e_{t+3}. \tag{22}$$

If it is assumed that Δx^e_{t+3} is formed rationally, that is:

$$\Delta x_{t+3} = \Delta x^e_{t+3} + \nu_{t+3}, \tag{23}$$

and on substituting (23) in (22) we obtain the following representation of interest parity in regression format:

$$i_t = \alpha + \beta i^*_t + \gamma \Delta x_{t+3} + \vartheta_{t+3}, \tag{24}$$

where ϑ denotes a composite error consisting of the forecast error plus a random term. Because the maturity horizon of the expected exchange rate change is greater than the observational frequency (three months relative to one), the disturbance term follows a second order moving average process.

Since the Phillips-Hansen fully modified estimates are robust to such serial correlation, we report in Table 6 fully modified estimates of our interest rate relationships which incorporate the expected change in the exchange rate within the band. The estimates of α and β, in terms of both numerical values and significance, are in fact very similar to those recorded in Table 5b. Consequently, the number of significant t_β values are unchanged. In all cases apart from two, the γ coefficient is positive, but in no case is it statistically different from zero. The insignificance of γ may reflect the way we have generated Δx^e_{t+3}. Given that the exchange rate change is an I(0) variable we would not expect its inclusion to affect the instability of the interest rate relationships reported in Table 5 and, indeed, this is borne out by the fact that the LC, MeanF and SupF statistics are qualitatively unchanged.

Having established evidence of cointegration for nearly all of our interest rate combinations, the next strand in our analysis of interest rate relationships involves estimating the dynamic relationships between interest rates. We do this by exploiting the Granger Representation theorem which states that if two (or more) series are cointegrated then there must exist an error correction representation of the form (10) for the two variables. The resulting error correction models are reported in Tables 7 to 12 for all combinations of short interest rates, with the restriction $\beta=1$ imposed.[18]

The results in Tables 7 to 12 may be summarised in the following way. First, in all of the systems the ECM term enters with a negative sign in the equation for the change in the domestic interest rate and positively in the equation for the foreign rate. Given the way the ECM term is defined this means that adjustment occurs in both markets and given that each system has at least one significant ECM, this confirms the cointegration tests discussed above.

Notice that the adjustment coefficient is always larger, in absolute terms, in the equation featuring the change in the 'domestic' interest rate (i.e. in the equations for the UK, in the UK-France and UK-Germany systems, and for Germany in the Germany-France system). In the UK-France system, the coefficient on the ECM in the UK equation is approximately ten times bigger, in absolute terms, than the corresponding number in the French equation, while in the UK-Germany system the adjustment coefficient in the UK equation is twice as large as the corresponding coefficient in the German equation.

That much of the adjustment occurred in the UK is consistent with the width and depth of capital markets in the UK during this period vis a vis the markets in the other two countries (and also the fact that extensive bank balances were held in London by French and German nationals).[19]

The third point to note from Tables 7 to 12 is the dynamic structure differs depending on which interest rate is analysed. For Bank rates the dynamics are relatively short (one and two months) while the dynamics are much more complicated for market rates. These dynamic processes are confirmed by calculating the implied half-lifes for how long a shock to the parity relationship takes to be extinguished. These are calculated from the coefficients on the error correction terms and in the case of the Bank rate equation indicate a half-life of two months and a

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[18] In constructing these dynamic ECM's we deleted insignificant lags and this resulted in more parsimonious models for the bank rate systems.

[19] For a further discussion on the significance of the UK financial sector during this period see: Eichengreen (1987), Giovannini (1989) and Lindert (1969).

half-life of around six months in the case of the market rate systems. The differing speeds of adjustment reflects the fact that Bank rate was more closely aligned to central bank policy than the market rate.

The other noteworthy point about the ECM interest rate parity results is that when we include dummy variables in the Bank rate systems, to account for large outliers (lying outside 95 per cent confidence intervals), this removes any non-normality in the residual process. However, although many of the dummy variables are statistically significant their inclusion does not upset the evident dynamic pattern and, in particular, the magnitude and significance of the ECM terms.

In summary: the results in Tables 7 to 12 clearly indicate that there were important and significant deviations of interest rates between countries, so that there is evidence of monetary independence for all three countries; as indicated by the relatively short half-lifes, the interest rate deviations were not long lived; and the large, in absolute terms, error correction terms in equations for UK rates, suggest that London, as the primary financial centre, played a fundamental role in attracting capital to restore interest rate parity.

6.ii. System 2 Results.

Having established the simplest of the three systems discussed in section 3, we turn now to an examination of the system consisting of a home and foreign short rate and a home long rate, represented by the VECM system (12). This system gives further insight into the independence conferred on monetary policy by facilitating an examination of the interaction between three interest rates, namely the domestic short and long rates and the foreign short rate.

These three rates give two potential equilibrium relationships: one an interest parity relationship, described by (1) or (2), and the other a term structure relationship linking the domestic short rate to the long rate.

As in the case of the two variable interest rate systems, we used the Johansen method to test for cointegration amongst these three rates.[20] The results are presented in Table 13. In all instances there is evidence of two cointegrating vectors. We attempt to interpret vector one as the interest parity relationship for short term interest rates and vector two as the term structure relationship (i.e. the yield gap). This restriction cannot be rejected, at the 5 per cent level, for any of the systems involving UK rates although it is marginally rejected in the two systems containing Germany and France (the reported χ^2 statistic is the relevant statistic, p-value in parenthesis).

[20] The Hannan-Quinn lag length selection criterion was used to test the optimal lag length, which was 2 for each system.

Using these restricted vectors as our ECM terms we then constructed VECM models of the form (12). Rather than report the actual equations, which are difficult to interpret given the size of the system, we construct impulse response functions based on (19) (with the two cointegrating vectors imposed on the system) for each of the country pairs.

The impulse response functions are reported as Figures 16 to 21. The first two impulses in each of the Figures represents the effect of a one-per-cent increase in the 'domestic' rate on the 'foreign' short rate and the 'domestic' long rate. The remaining two impulses display a similar set of reactions (for the domestic short and long) to a one-per-cent increase in the 'foreign' short rate. The ordering in which the variables are entered into the moving average representation is indicated in parenthesis at the top of each figure and indicates that the long rate is regarded as the most exogenous followed by the foreign short, with the domestic short being the most endogenous.

The plots all have the same general pattern and may be summarised by focussing on Figure 16. This Figure clearly demonstrates that in the short-run there is not a one-to-one lock between UK and French short interest rates: a 1 per cent increase in the UK short rate produces a very small 2 basis point increase in the French rate which is then rapidly offset (by about month 6). The UK long rate actually falls, which through the term structure relationship indicates that investors expect the current rise in short rates to be offset in the near future; however, notice that the long rate change is very small (less than one basis point) and the dynamics die out very rapidly. Interestingly, the corresponding French shock has a much bigger impact on the short UK Bank rate (75 basis points) and the effect on UK rates is very rapidly offset.

We attribute this contrast in the adjustment of the UK and French rates to the importance of London as a financial centre during the period.[21] The kind of patterns that we observe in Figure 16 are, in general terms, repeated for the other interest rate combinations, although we note that the German-French systems (Figures 20 and 21) are not as well behaved as the two UK systems; this is consistent with the view expressed earlier that the UK played an important role in tying down interest relationships for the period. In general then, interest rates seem to behave in the way predicted by the Svensson model.

Thus, the existence of a credible target zone means that in the short-run domestic interest rates can deviate from foreign rates and the yield gap opens up as short rates change. However, such changes are purely transitory and are offset relatively rapidly.

[21] This result is consistent with Eichengreen's (1992, p.53) conclusion that London had considerably greater discretion than Paris to absorb interest rate shocks.

6.iii System 3 Results

The final system estimated is the most general one in which the fundamentals that the monetary authorities are presumed to be using their monetary independence to target, enter the VAR. These fundamentals are defined in section 3 and are the change in the logarithm of gold reserves, the change in the logarithm of the money supply, the change in logarithm of industrial production, the change in the logarithm of the price level and an interest rate volatilty term (measured using the standard deviation of interest rates).[22]

As we stressed in Section 3, these variables do not enter the long-run relationships, rather the authorities change short term interest rates in response to undesirable shocks to these variables, and therefore these variables only feature in the dynamic component of the VECM.

The impulse response functions corresponding to the systems with the vector of fundamentals and market interest rates [23] are reported in Figures 22 to 24. The ordering used to construct the Choleski decompositions is noted in parenthesis at the top of each figure and is intended to capture the relative exogeneity of the different variables. In part 1 of these Figures the response of the domestic short rate to a standardised one per cent shock in each of the fundamentals is presented, while in part 2 the response of the long rate to the same set of standardised shocks is shown.

Figure 22, the UK-French system, is representative of the two UK-based systems and we concentrate on it here. We note that for both short and long rates there is a significant response to fundamentals, but that this is, as predicted by the Svennson model, much smaller for long rates (indeed the impact on long rates is miniscule). Through the term structure relationship, short and long rates move in the same direction in response to the shocks, and the sign pattern is intuitively plausible.

For example, a positive shock to both output and prices generates an initial increase in the domestic interest rate, presumably through the demand for money channel, but this is rapidly offset. An increase in the domestic money supply produces a fall in interest rates of 6 basis points which is reversed by month 4. A one per cent increase in volatility initially produces a fall in the domestic interest rate, but by a miniscule amount. There is no evidence of interest rate overshooting and, indeed, the required interest rate adjustment is relatively small in each instance. The magnitude of the response of the domestic rate to a foreign interest rate shock is essentially unchanged relative to system 2. In common with system 2, we note that the

[22] Since unemployment was not available for the full sample period for any of the countries it does not feature in the results reported here. Robustness checks for shorter sample periods indicates that its absence from the full sample systems does not affect the results in any significant way.
[23] The systems with Bank rates are qualitatively similar and are therefore not reported.

independence conferred on domestic monetary policy is purely transitory and evaporates after approximately 12 months.

The UK-Germany impulse system displays very similar properties to the UK-France system both in terms of sign and and also magnitude, the main difference occurs in the persistently positive (although extremely small) effect a shock to German rates has on UK long rates.

The Germany-France impulse system (Figure 24) has some similarities to the two UK-based systems but also some important differences. In particular, the shocks to German output, money and prices have in the majority of cases an insignificant effect on German short rates (and indeed the output and money shocks have a perverse sign), although note that a positive shock to gold reserves (which was not available for the other two systems) produces a 3 basis points fall in the domestic short rate. Such a small fall in the interest rate tends to confirm the view that central banks did not play by the 'rules of the game' during this period.

It is perhaps worth contrasting some of the interest rate adjustments contained in Figures 22 to 24 with those sometimes required at crisis points during the ERM period. Thus, the majority of adjustments in the figures amount only to a few basis points and this was sufficient to give independence for a number of months. In contrast, the Swedish example of a 75% increase in interest rates in September 1992 only gave the authorities independence for several days at most.

7. Summary and Concluding Comments

In this paper we have used a target zone framework to analyse the behaviour of interest rates and exchange rates for France, Germany and the UK during the classical gold standard period. Our particular focus was to test an hypothesis proposed by Svensson (1994) that the existence of a credible target zone should confer on a country some independence in the operation of its monetary policy. This hypothesis is of particular interest for the Classical gold standard period since it is well known that countries did not play by the rules of the game, in the sense that they did not direct monetary policy to external objectives, yet the system seemed to operate effectively (in contrast to other regimes of the international monetary systems in which governments directed monetary policy to domestic objectives). We devised a number of tests to assess the Svensson hypothesis.

Using a simple test, we reported that for our measures of the gold import and export points the Classical gold standard system appeared to be a highly credible system for France, Germany and the UK. Additionally, we reported evidence in favour of long-run equilibrium relationships between domestic and foreign short and long interest rates for the period. Using these long-run relationships we moved to two sets of dynamic (i.e. short-run) systems to explore if there was in fact any leeway for independent monetary policies during the Classical period. We found significant evidence of independence, although this proved, as expected, to be transitory and it was significantly related to certain key fundamentals. This finding is in agreement with the historical literature (e.g. Sayers (1957)) that the Bank of England (as well as other central banks) were on occasion concerned with the behaviour of domestic macroeconomic variables.

Another aspect of our work was the finding that the particular combination of countries had a bearing on the results. Thus, the two bilateral systems which featured the UK worked well in the sense that adjustment was relatively rapid and fundamentals variables bore a predicatable relationship with interest rates; this was not the case for the system (i.e. Germany-France) which did not feature the UK. We believe this finding reinforces the view already prevalent in the literature that the UK, and particularly London, played a key role in the operation of the Classical gold standard system.

We conclude by noting that our findings have a bearing on the kind of institutional framework required for a modern day target zone (such as the Exchange Rate Mechansim of the European Monetary System) to function effectively and, in particular, to weather speculative attacks. To be effective it requires that credibility ultimately anchors both short term interest rate policy and the term structure of interest rates and has at its centre an anchor country.

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TABLE 1

ADF UNIT ROOT TESTS

INTEREST RATE TYPE IN LEVELS	T-RATIO (WITHOUT TREND)	T-RATIO (WITH TREND)	SIGNIFICANT LAG LENGTH
UK			
BANK RATE (SU)	-4.8374	-4.9936	2
CONSOL YIELD (SU)	-0.92883	-0.89849	22
CONSOL YIELD (SA)	0.4283	-0.21802	7
MARKET RATE (SU)	-2.6800	-2.9953	7
MARKET RATE (SU)	-3.0538	-3.3031	10
GERMANY			
BANK RATE (SU)	-4.0795	-4.4786	2
LONG TERM BOND YIELD (SU)	-1.4661	-1.0116	23
MARKET RATE (SU)	-3.8825	-4.3096	12
MARKET RATE (SA)	-3.7867	-4.1936	12
FRANCE			
BANK RATE (SU)	-2.4639	-2.4984	6
RENTES YIELD (SU)	-1.3401	-0.55364	21
MARKET RATE (SU)	-3.6056*	-3.4287*	23
MARKET RATE (SA)	-3.5191*	-3.4841*	11
CRITICAL	-2.869	-3.423	

SU: Seasonally Unadjusted
SA: Seasonally Adjusted by NBER

TABLE 2

ADF UNIT ROOT TESTS

FIRST DIFFERENCE OF INTEREST RATE	T-RATIO (WITHOUT TREND)	T-RATIO (WITH TREND)	SIGNIFICANT LAG LENGTH
UK			
BANK RATE (SU)	-10.5447	-10.5345	6
CONSOL YIELD (SU)	-2.6837	-3.1720	22
	-8.2019	-8.6920	6
CONSOL YIELD (SA)	-8.0146	-8.4859	6
MARKET RATE (SU)	-10.8517	-10.8475	6
MARKET RATE (SU)	-10.8510	-10.8471	6
GERMANY			
BANK RATE (SU)	-11.1620	-11.1483	3
LONG TERM BOND YIELD (SU)	-3.3096	-3.8218	22
MARKET RATE (SU)	-5.5266	-5.5071	11
MARKET RATE (SA)	-8.2323	-8.2117	6
FRANCE			
BANK RATE (SU)	-10.7721	-10.7608	5
RENTES YIELD (SU)	-3.2269	-3.4774	20
MARKET RATE (SU)	-5.9670	-6.0551	17
MARKET RATE (SA)	-8.9458	-8.9405	6

SU: Seasonally Unadjusted
SA: Seasonally Adjusted by NBER

TABLE 3

KPSS UNIT ROOT TESTS

	LOG OF EXCHANGE RATE IN LEVELS		FIRST DIFFERENCE OF LOG OF EXCHANGE RATE	
	ETA(mu) (WITHOUT TREND)	ETA (tau) (WITH TREND)	ETA (mu) (WITHOUT TREND)	ETA (WITH TREND)
UK				
M: £	1.98730	0.36956	0.02072	0.02065
FR: £	1.30732	0.29680	0.03427	0.02363
GERMANY				
M: £	1.99255	0.32840	0.02386	0.02270
M: 100 FR	2.30300	0.24960	0.01985	0.01761
M: 100 FR*	2.32819	0.25884	0.02835	0.02484
FRANCE				
FR: £	0.89955	0.24956	0.03190	0.02702
FR: 100 M	2.22883	0.31636	0.02844	0.02190
*Seasonally Adjusted by NBER.				
CRITICAL VALUES (5%)	**0.463**	**0.146**	**0.463**	**0.146**

TABLE 4

KPSS UNIT ROOT TESTS

	INTEREST RATE IN LEVELS		FIRST DIFFERENCE OF INTEREST RATE	
	ETA (mu) (WITHOUT TREND)	**ETA (tau) (WITH TREND)**	**ETA (mu) (WITHOUT TREND)**	**ETA (tau) (WITH TREND)**
UK				
BANK RATE	0.50713	0.20656	0.01927	0.01936
CONSOL YIELD	0.94865	0.89897	0.61514	0.07288
CONSOL YIELD *	0.94556	0.89848	0.62596	0.07632
MARKET RATE	0.85054	0.26648	0.02414	0.02380
MARKET RATE *	0.80168	0.26408	0.02280	0.02291
GERMANY				
BANK RATE	1.04791	0.23349	0.01829	0.01880
LONG TERM BOND YIELD	1.04872	0.92801	0.93042	0.04332
MARKET RATE	0.96354	0.17141	0.02062	0.01942
MARKET RATE *	0.96405	0.17652	0.01926	0.01940
FRANCE				
BANK RATE	0.58168	0.50182	0.04490	0.02286
RENTES YIELD	2.52784	0.89910	0.57456	0.15112
MARKET RATE	0.36599	0.36597	0.03378	0.02473
MARKET RATE *	0.35803	0.35802	0.02973	0.02246
* Seasonally Adjusted by NBER				
CRITICAL	**0.463**	**0.146**	**0.463**	**0.146**

Table 5a Johansen FIML estimates of Interest Rate Parity

$$i_t = \alpha + \beta i_t^* + \nu_t$$

Interest Rate Combination	α	β	$t_\beta=0$	$t_\beta=1$	lMax	Trace	LM(4)
<u>Short Rates</u>							
UK-France,	-0.535	1.320	11.57	1.35	24.02*	31.45*	6.67
Bank Rate			(0.00)	(0.24)	7.43	7.43	(0.15)
UK-France,	-1.278	1.601	0.73	2.42	15.79*	23.25*	3.67
Market Rate			(0.01)	(0.12)	7.46	7.46	(0.46)
UK-Germany	0.056	0.805	6.15	0.69	18.71*	28.88*	2.17
Bank Rate			(0.01)	(0.40)	10.17	10.17	(0.70)
UK-Germany	-1.522	1.331	8.65	1.35	16.85*	25.03*	8.07
Market Rate			(0.00)	(0.25)	8.19	8.19	(0.09)
Germany-France,	0.552	1.195	4.61	0.71	17.20*	25.26*	11.02
Bank Rate			(0.03)	(0.68)	8.06	8.06	(0.03)
Germany-France,	2.881	1.290	0.02	1.19	11.32	19.18**	5.24
Market Rate			(0.90)	(0.27)	7.86	7.86	(0.26)
<u>Long Rates</u>							
UK-France, Long Rates	0.007	1.800	1.92	1.27	14.93**	22.82*	
			(0.17)	(0.26)	7.89	7.89	
UK-Germany, Long Rates	0.003	1.172	1.63	0.22	15.53**	20.92*	
			(0.20)	(0.64)	5.39	5.39	
Germany-France, Long Rates	0.004	0.835	1.92	1.27	14.93**	22.82*	
			(0.17)	(0.26)	7.89	7.89	

Notes. The first column describes the interest rate/ country combination. The numbers in the columns labeled α and β are the estimated constant and intercept from the interest parity equation (9). The numbers not in parenthesis in the columns headed $t_\beta=0$ and $t_\beta=1$ are tests of the hypothesis that the slope coefficient is, respectively, zero and unity (significance level in parenthesis). The numbers in the columns labeled lMax and Trace are the estimated values of equations (17) and (16) in the text and LM(4) is a Lagrange Multiplier test for 4-th order serial correlation. A single * denotes significane at the 5% level, while ** denotes significane at the 10% level.

Table 5b Fully Modified Estimates of Interest Rate Parity.

$$i_t = \alpha + \beta i_t^* + \nu_t$$

Interest Rate Combination	α	β	$t_\beta=1$	LC	MeanF	SupF
Short Rates						
UK-France, Bank Rate	0.081	1.119	0.66	0.449	2.612	5.309
	[0.53]	[0.18]		[0.05]	[0.20]	[0.20]
UK-France, Market Rate	-0.576	1.322	2.01	1.490	8.154	13.373
	[0.41]	[0.16]		[0.01]	[0.01]	[0.04]
UK-Germany, Bank Rate	0.504	0.690*	3.44	0.167	1.092	4.549
	[0.41]	[0.09]		[0.20]	[0.20]	[0.20]
UK-Germany, Market Rate	-0.001	0.852*	1.85	0.247	1.602	5.179
	[0.29]	[0.08]		[0.20]	[0.20]	[0.20]
Germany-France, Bank Rate	1.443	0.925*	0.24	0.622	3.611	5.926
	[0.93]	[0.31]		[0.02]	[0.11]	[0.20]
Germany-France, Market Rate	-0.212	1.365*	1.73	1.045	5.964	11.757
	[0.55]	[0.22]		[0.01]	[0.02]	[0.08]
Long Rates						
UK-France, Long Rates	1.415*	0.452*	1.95	0.257	2.839	10.642
	[0.69]	[0.21]		[0.19]	[0.19]	[0.12]
UK-Germany, Long Rates	-0.941	1.035*	0.18	0.146	0.826	2.193
	[0.71]	[0.13]		[0.20]	[0.20]	[0.20]
Germany-France, Long Rates	1.455*	0.689*	1.48	0.373	4.089	13.258
	[0.69]	[0.21]		[0.10]	[0.08]	[0.04]

Notes. See Table 5a for definitions. The numbers not in brackets in the columns headed LC, MeanF and SupF are the estimated values of these statistics as discussed in the text; numbers in parenthesis denote significane levels.

Table 6. Fully Modified Estimates of Interest Rate Parity

$$i_t = \alpha + \beta i_t^* + \gamma \Delta x_{t+3} + \vartheta_t$$

Interest Rate Combination Short Rates	α	β	γ	t_β=1	LC	MeanF	SupF
UK-France, Bank Rate	0.000	1.091	0.060	0.542	0.497	2.973	5.37
	[0.01]	[0.17]	[0.08]		[0.04]	[0.20]	[020]
UK-France, Market Rate	-0.001	1.338	-0.023	2.414	1.978	10.762	16.62
	[0.00]	[0.14]	[0.09]		[0.01]	[0.01]	[0.04]
UK-Germany, Bank Rate	0.001	0.659	0.181	3.788	0.293	1.875	5.509
	[0.00]	[0.09]	[0.08]		[0.17]	[0.20]	[0.20]
UK-Germany, Market Rate	-0.000	0.841	0.088	1.987	0.316	2.074	5.853
	[0.00]	[0.08]	[0.08]		[0.14]	[0.20]	[0.20]
Germany-France, Bank Rate	0.003	0.898	0.029	0.329	0.768	4.648	7.620
	[0.00]	[0.31]	[0.15]		[0.01]	[0.13]	[0.20]
Germany-France, Market Rate	-0.149	1.336	-0.149	1.680	1.284	7.336	14.001
	[0.12]	[0.20]	[0.12]		[0.01]	[0.03]	[0.10]

Notes. See Table 5b for definitions.

Table 7

Bank Interest Rates. (UK / France System.)

$$\Delta i_t = \alpha + \sum_{j=1}^{n} \Delta i_{t-j} + \sum_{j=1}^{n} \Delta i^*_{t-j} + \text{Error Correction}$$

Dependent Variable	Δ UK Rate (t-1)	Δ UK Rate (t-2)	Δ UK Rate (t-3)	Δ UK Rate (t-4)	Δ UK Rate (t-5)	Δ UK Rate (t-6)	Δ UK Rate (t-7)	R^2
Δ UK Rate (t)	0.031 [0.486]	-0.126 [2.028]	-0.066 [1.081]	-0.070 [1.183]	0.0146 [0.279]	-0.044 [0.821]	-0.075 [1.436]	0.146
	Δ French Rate (t-1)	Δ French Rate (t-2)	Δ French Rate (t-3)	Δ French Rate (t-4)	Δ French Rate (t-5)	Δ French Rate (t-6)	Δ French Rate (t-7)	ECM (t-1)
	-0.139 [0.870]	-0.144 [0.916]	0.107 [0.691]	-0.083 [0.555]	-0.079 [0.572]	-0.174 [1.249]	-0.008 [0.057]	-0.212 [4.082]

$$\Delta i^*_t = \alpha + \sum_{j=1}^{n} \Delta i_{t-j} + \sum_{j=1}^{n} \Delta i^*_{t-j} + \text{Error Correction}$$

Dependent Variable	Δ UK Rate (t-1)	Δ UK Rate (t-2)	Δ UK Rate (t-3)	Δ UK Rate (t-4)	Δ UK Rate (t-5)	Δ UK Rate (t-6)	Δ UK Rate (t-7)	R^2
Δ French Rate (t)	0.005 [0.217]	-0.022 [1.062]	0.007 [0.322]	-0.008 [0.415]	0.038 [2.025]	-0.012 [0.698]	0.011 [0.652]	0.087
	Δ French Rate (t-1)	Δ French Rate (t-2)	Δ French Rate (t-3)	Δ French Rate (t-4)	Δ French Rate (t-5)	Δ French Rate (t-6)	Δ French Rate (t-7)	ECM (t-1)
	0.067 [1.260]	-0.056 [1.073]	-0.003 [0.049]	-0.136 [2.736]	-0.051 [1.115]	-0.164 [3.551]	-0.019 [0.414]	0.020 [1.141]

Table 8

Bank Interest Rates. (UK / German System.)

$$\Delta i_t = \alpha + \sum_{j=1}^{n} \Delta i_{t-j} + \sum_{j=1}^{n} \Delta i^*_{t-j} + \text{Error Correction}$$

Dependent Variable.	Δ UK Rate (t-1)	Δ UK Rate (t-2)	Δ UK Rate (t-3)	Δ UK Rate (t-4)	Δ UK Rate (t-5)	Δ UK Rate (t-6)	Δ UK Rate (t-7)	R^2
Δ UK Rate (t)	-0.051 [0.471]	-0.155 [2.267]	-0.114 [1.689]	-0.094 [1.432]	-0.015 [0.239]	-0.110 [1.847]	-0.076 [1.293]	0.124
	Δ German Rate (t-1)	Δ German Rate (t-2)	Δ German Rate (t-3)	Δ German Rate (t-4)	Δ German Rate (t-5)	Δ German Rate (t-6)	Δ German Rate (t-7)	ECM (t-1)
	-0.059 [0.662]	-0.200 [2.280]	-0.043 [0.494]	-0.063 [0.733]	-0.056 [0.676]	0.057 [0.694]	-0.095 [1.159]	-0.096 [1.839]

$$\Delta i^*_t = \alpha + \sum_{j=1}^{n} \Delta i_{t-j} + \sum_{j=1}^{n} \Delta i^*_{t-j} + \text{Error Correction}$$

Dependent Variable.	Δ UK Rate (t-1)	Δ UK Rate (t-2)	Δ UK Rate (t-3)	Δ UK Rate (t-4)	Δ UK Rate (t-5)	Δ UK Rate (t-6)	Δ UK Rate (t-7)	R^2
Δ German Rate (t)	-0.023 [0.471]	-0.006 [0.130]	0.047 [0.990]	0.029 [0.620]	0.055 [1.239]	-0.034 [0.828]	0.082 [2.011]	0.078
	Δ German Rate (t-1)	Δ German Rate (t-2)	Δ German Rate (t-3)	Δ German Rate (t-4)	Δ German Rate (t-5)	Δ German Rate (t-6)	Δ German Rate (t-7)	ECM (t-1)
	-0.021 [0.347]	-0.096 [1.569]	-0.066 [1.085]	-0.129 [2.169]	-0.073 [1.261]	-0.040 [0.695]	-0.110 [1.931]	0.082 [2.238]

Table 9

Bank Interest Rates. (Germany / France System.)

$$\Delta i_t = \alpha + \sum_{j=1}^{n} \Delta i_{t-j} + \sum_{j=1}^{n} \Delta i^*_{t-j} + \text{Error Correction}$$

Dependent Variable	Δ German Rate (t-1)	Δ German Rate (t-2)	Δ German Rate (t-3)	Δ German Rate (t-4)	Δ German Rate (t-5)	Δ German Rate (t-6)	Δ German Rate (t-7)	R^2
Δ German Rate (t-1)	0.020 [0.364]	-0.040 [0.726]	-0.004 [0.069]	-0.091 [1.704]	-0.021 [0.393]	-0.043 [0.809]	-0.065 [1.236]	0.066
	Δ French Rate (t-1)	Δ French Rate (t-2)	Δ French Rate (t-3)	Δ French Rate (t-4)	Δ French Rate (t-5)	Δ French Rate (t-6)	Δ French Rate (t-7)	ECM (t-1)
	-0.051 [0.452]	-0.022 [0.200]	0.083 [0.761]	0.076 [0.719]	0.000 [0.001]	-0.110 [1.119]	0.128 [1.279]	-0.086 [2.938]

$$\Delta i^*_t = \alpha + \sum_{j=1}^{n} \Delta i_{t-j} + \sum_{j=1}^{n} \Delta i^*_{t-j} + \text{Error Correction}$$

Dependent Variable	Δ German Rate (t-1)	Δ German Rate (t-2)	Δ German Rate (t-3)	Δ German Rate (t-4)	Δ German Rate (t-5)	Δ German Rate (t-6)	Δ German Rate (t-7)	R^2
Δ French Rate (t)	-0.070 [2.775]	-0.012 [0.485]	-0.004 [0.069]	0.015 [0.593]	0.008 [0.340]	0.007 [0.287]	0.006 [0.253]	0.092
	Δ French Rate (t-1)	Δ French Rate (t-2)	Δ French Rate (t-3)	Δ French Rate (t-4)	Δ French Rate (t-5)	Δ French Rate (t-6)	Δ French Rate (t-7)	ECM (t-1)
	0.098 [1.888]	-0.064 [1.258]	0.083 [0.761]	-0.127 [2.576]	-0.029 [0.636]	-0.174 [3.797]	-0.029 [0.615]	0.026 [1.912]

Table 10

Market Interest Rates. (UK / France System.)

$$\Delta i_t = \alpha + \sum_{j=1}^{n} \Delta i_{t-j} + \sum_{j=1}^{n} \Delta i^*_{t-j} + \text{Error Correction}$$

Dependent Variable	Δ UK Rate (t-1)	Δ UK Rate (t-2)	Δ UK Rate (t-3)	Δ UK Rate (t-4)	Δ UK Rate (t-5)	Δ UK Rate (t-6)	Δ UK Rate (t-7)	R^2
Δ UK Rate (t)	-0.016 [0.269]	-0.267 [4.608]	-0.089 [1.533]	-0.126 [2.240]	-0.059 [1.067]	-0.113 [2.196]	-0.162 [3.198]	0.181
	Δ French Rate (t-1)	Δ French Rate (t-2)	Δ French Rate (t-3)	Δ French Rate (t-4)	Δ French Rate (t-5)	Δ French Rate (t-6)	Δ French Rate (t-7)	ECM (t-1)
	0.116 [0.994]	0.245 [2.105]	0.100 [0.849]	0.156 [1.347]	0.019 [0.161]	0.156 [1.388]	0.129 [1.153]	-0.145 [3.335]

$$\Delta i^*_t = \alpha + \sum_{j=1}^{n} \Delta i_{t-j} + \sum_{j=1}^{n} \Delta i^*_{t-j} + \text{Error Correction}$$

Dependent Variable	Δ UK Rate (t-1)	Δ UK Rate (t-2)	Δ UK Rate (t-3)	Δ UK Rate (t-4)	Δ UK Rate (t-5)	Δ UK Rate (t-6)	Δ UK Rate (t-7)	R^2
Δ French Rate (t)	0.012 [0.424]	-0.015 [0.558]	0.018 [0.678]	0.007 [0.258]	0.034 [1.346]	-0.025 [1.078]	-0.017 [0.739]	0.096
	Δ French Rate (t-1)	Δ French Rate (t-2)	Δ French Rate (t-3)	Δ French Rate (t-4)	Δ French Rate (t-5)	Δ French Rate (t-6)	Δ French Rate (t-7)	ECM (t-1)
	0.056 [1.053]	-0.204 [3.837]	0.055 [1.019]	-0.134 [2.524]	-0.049 [0.922]	0.034 [0.670]	-0.128 [2.499]	0.015 [0.757]

Table 11

Market Interest Rates. (UK / German System.)

$$\Delta i_t = \alpha + \sum_{j=1}^{n} \Delta i_{t-j} + \sum_{j=1}^{n} \Delta i^*_{t-j} + \text{Error Correction}$$

Dependent Variable.	Δ UK Rate (t-1)	Δ UK Rate (t-2)	Δ UK Rate (t-3)	Δ UK Rate (t-4)	Δ UK Rate (t-5)	Δ UK Rate (t-6)	Δ UK Rate (t-7)	R^2
Δ UK Rate (t)	-0.039 [0.603]	-0.266 [4.155]	-0.103 [1.601]	-0.150 [2.405]	-0.079 [1.294]	-0.104 [1.830]	-0.162 [2.910]	0.143
	Δ German Rate (t-1)	Δ German Rate (t-2)	Δ German Rate (t-3)	Δ German Rate (t-4)	Δ German Rate (t-5)	Δ German Rate (t-6)	Δ German Rate (t-7)	ECM (t-1)
	0.076 [0.897]	-0.016 [0.191]	-0.010 [0.121]	0.050 [0.606]	0.037 [0.458]	-0.091 [1.164]	0.034 [0.443]	-0.094 [2.030]

$$\Delta i^*_t = \alpha + \sum_{j=1}^{n} \Delta i_{t-j} + \sum_{j=1}^{n} \Delta i^*_{t-j} + \text{Error Correction}$$

Dependent Variable.	Δ UK Rate (t-1)	Δ UK Rate (t-2)	Δ UK Rate (t-3)	Δ UK Rate (t-4)	Δ UK Rate (t-5)	Δ UK Rate (t-6)	Δ UK Rate (t-7)	R^2
Δ German Rate (t)	0.052 [1.167]	0.026 [0.605]	0.039 [0.881]	0.021 [0.482]	0.059 [1.402]	-0.040 [1.026]	-0.087 [2.297]	0.131
	Δ German Rate (t-1)	Δ German Rate (t-2)	Δ German Rate (t-3)	Δ German Rate (t-4)	Δ German Rate (t-5)	Δ German Rate (t-6)	Δ German Rate (t-7)	ECM (t-1)
	-0.016 [0.283]	-0.150 [2.566]	0.114 [1.980]	-0.017 [0.301]	-0.027 [0.488]	0.011 [0.198]	-0.087 [1.654]	0.071 [2.253]

Table 12

Market Interest Rates. (Germany / France System.)

$$\Delta i_t = \alpha + \sum_{j=1}^{n} \Delta i_{t-j} + \sum_{j=1}^{n} \Delta i^*_{t-j} + \text{Error Correction}$$

Dependent Variable	Δ German Rate (t-1)	Δ German Rate (t-2)	Δ German Rate (t-3)	Δ German Rate (t-4)	Δ German Rate (t-5)	Δ German Rate (t-6)	Δ German Rate (t-7)	R^2
Δ German Rate (t-1)	0.024 [0.446]	-0.151 [2.801]	0.110 [2.039]	-0.026 [0.480]	-0.043 [0.803]	-0.045 [0.872]	-0.155 [3.015]	0.118
	Δ French Rate (t-1)	Δ French Rate (t-2)	Δ French Rate (t-3)	Δ French Rate (t-4)	Δ French Rate (t-5)	Δ French Rate (t-6)	Δ French Rate (t-7)	ECM (t-1)
	0.100 [1.211]	0.118 [1.427]	0.079 [0.940]	0.015 [0.187]	0.187 [2.246]	0.064 [0.791]	-0.007 [0.084]	-0.078 [2.848]

$$\Delta i^*_t = \alpha + \sum_{j=1}^{n} \Delta i_{t-j} + \sum_{j=1}^{n} \Delta i^*_{t-j} + \text{Error Correction}$$

Dependent Variable	Δ German Rate (t-1)	Δ German Rate (t-2)	Δ German Rate (t-3)	Δ German Rate (t-4)	Δ German Rate (t-5)	Δ German Rate (t-6)	Δ German Rate (t-7)	R^2
Δ French Rate (t)	0.065 [1.879]	0.026 [0.745]	0.017 [0.490]	0.034 [0.995]	0.054 [1.570]	0.005 [0.141]	0.009 [0.265]	0.100
	Δ French Rate (t-1)	Δ French Rate (t-2)	Δ French Rate (t-3)	Δ French Rate (t-4)	Δ French Rate (t-5)	Δ French Rate (t-6)	Δ French Rate (t-7)	ECM (t-1)
	0.024 [0.443]	-0.234 [4.404]	0.032 [0.596]	-0.161 [3.010]	-0.062 [1.144]	-0.003 [0.053]	-0.153 [2.945]	0.010 [0.553]

Table 13. Tri-variate Systems.

$$i_t^s = \alpha + \beta\, i_t^{s,*} + \phi\, i_t^L + v_t$$
$$i_t^s = \delta + \gamma\, i_t^{s,*} + \eta\, i_t^L + w_t$$

Interest Rate Combination				χ^2	L-Max	Trace	LM(4) $\chi^2_{(9)}$
	α	β	ϕ				
UK Short Bank (i_t^s)	-1.434	0.652	0.729	1.72	73.36*	104.5*	4.155
German Short Bank($i_t^{s,*}$)	δ	γ	η	(0.42)	30.56*	31.22*	(0.90)
UK Long (i_t^L)	86.461	-34.07	20.007		0.66	0.66	
	α	β	ϕ				
UK Short Bank (i_t^s)	2.141	1.391	-0.997	3.94	68.91*	94.57*	11.335
French Short Bank ($i_t^{s,*}$)	δ	γ	η	(0.14)	25.18*	25.66*	(0.25)
UK Long (i_t^L)	-13.470	-8.762	14.815		0.49	0.49	
	α	β	ϕ				
UK Short Market (i_t^s)	-3.522	0.901	1.169	5.71	39.57*	70.04*	6.868
German Short ($i_t^{s,*}$)	δ	γ	η	(0.06)	29.55*	30.47*	(0.65)
UK Long (i_t^L)	2.807	-1.380	1.432		0.92	0.92	
	α	β	ϕ				
UK Short Market (i_t^s)	0.639	1.376	-0.474	0.44	74.09*	95.69*	3.513
French Short Market ($i_t^{s,*}$)	δ	γ	η	(0.80)	20.99*	21.60*	(0.94)
UK Long (i_t^L)	-10.547	-6.513	10.205		0.60	0.60	
	α	β	ϕ				
German Short Bank (i_t^s)	-3.956	-0.496	2.603	8.15	86.00*	120.4*	13.081
French Short Bank ($i_t^{s,*}$)	δ	γ	η	(0.02)	31.92*	34.40*	(0.16)
German Long (i_t^L)	12.202	3.758	-5.195		2.49	2.49	
	α	β	ϕ				
German Short Market (i_t^s)	-3.587	-0.208	1.982	9.92	93.84*	137.6*	6.798
French Short Market ($i_t^{s,*}$)	δ	γ	η	(0.01)	41.00*	43.82*	(0.66)
German Market (i_t^L)	13.354	2.855	4.684		2.82	2.82	

Note: See Table 1 for definitions. χ^2 refers to a joint test that $\beta = 1$, $\phi = 0$, $\gamma = 0$, and $\eta = 1$ and has 2 degrees of freedom.

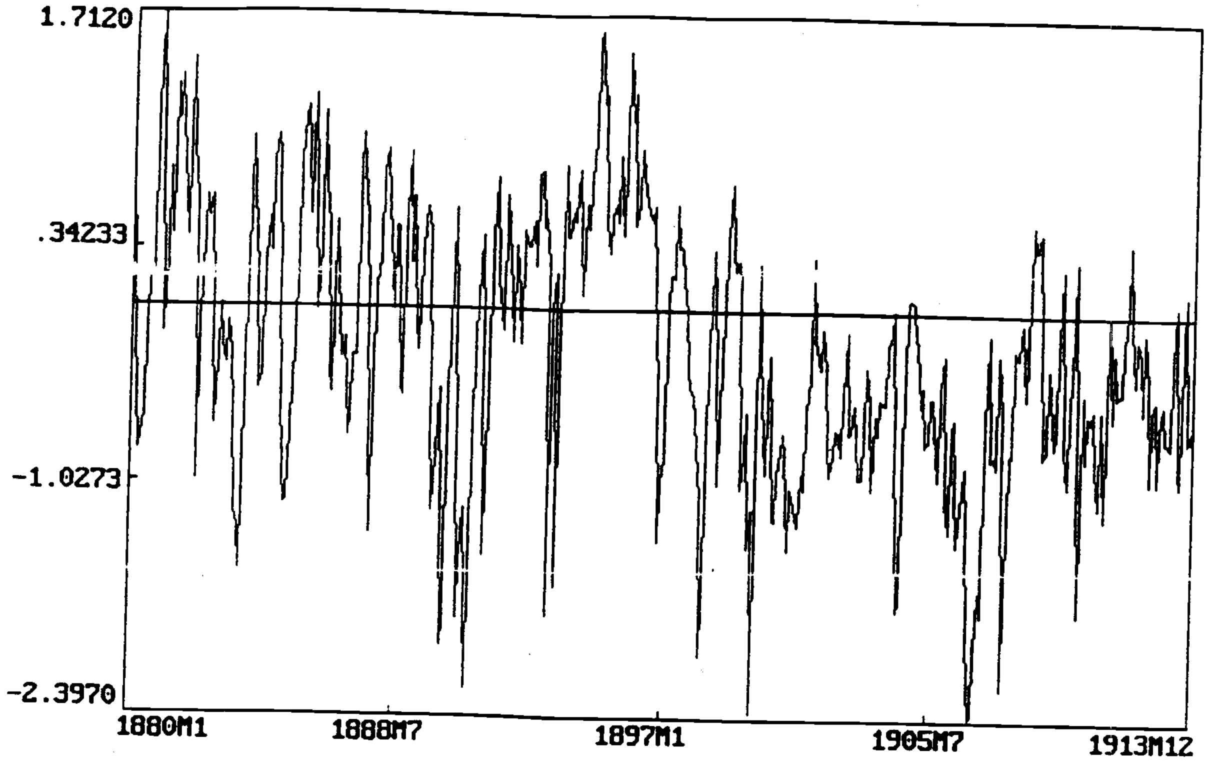


FIG.1: INTEREST RATE DIFFERENTIAL : FRANCE/UK

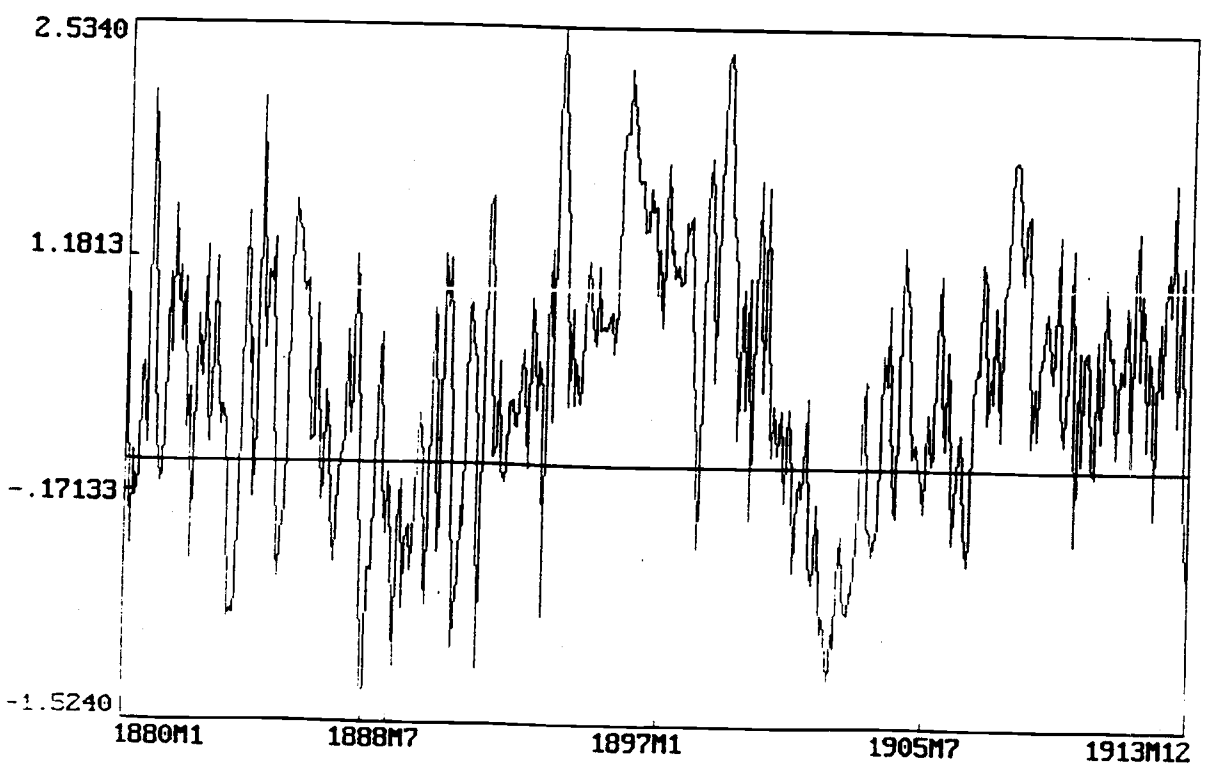


FIG.2: INTEREST RATE DIFFERENTIAL : GERMANY/UK

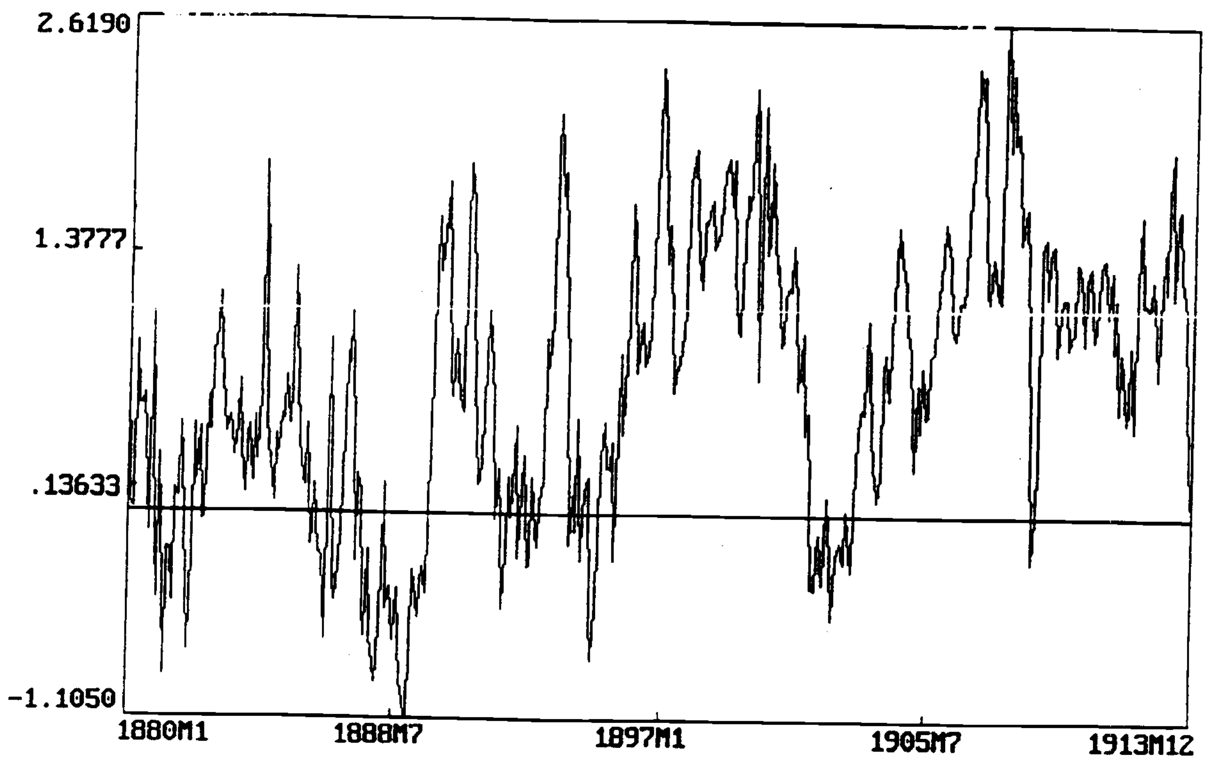


FIG. 3: INTEREST RATE DIFFERENTIAL : GERMANY/FRANCE

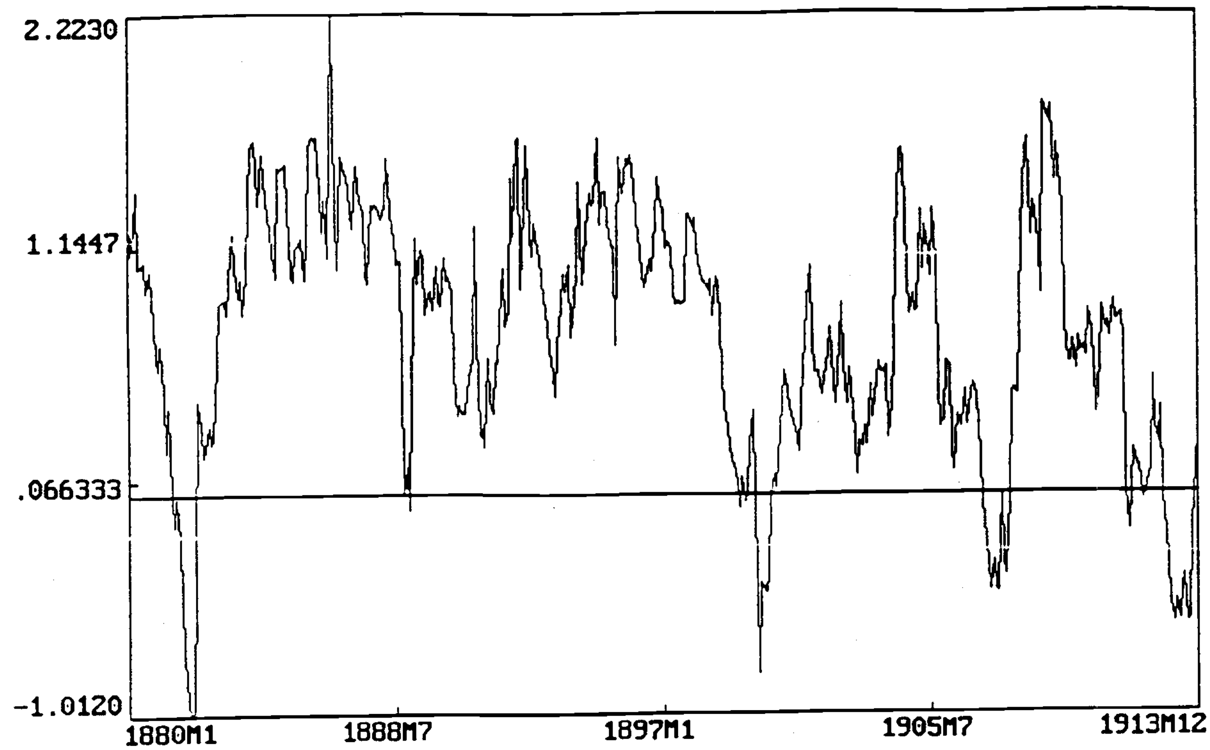


Fig 4: Interest Differential Between Long and Short Rates: France.

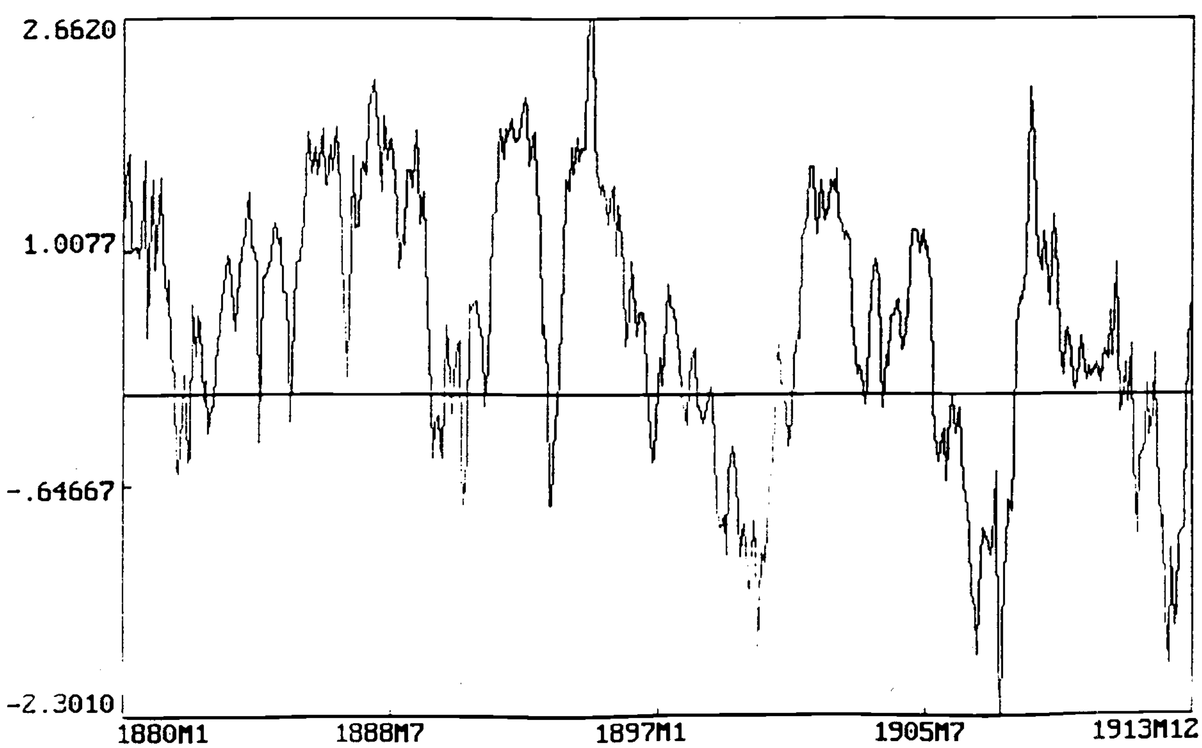


Fig 5: Interest Differential Between Long And Short Rates: Germany.

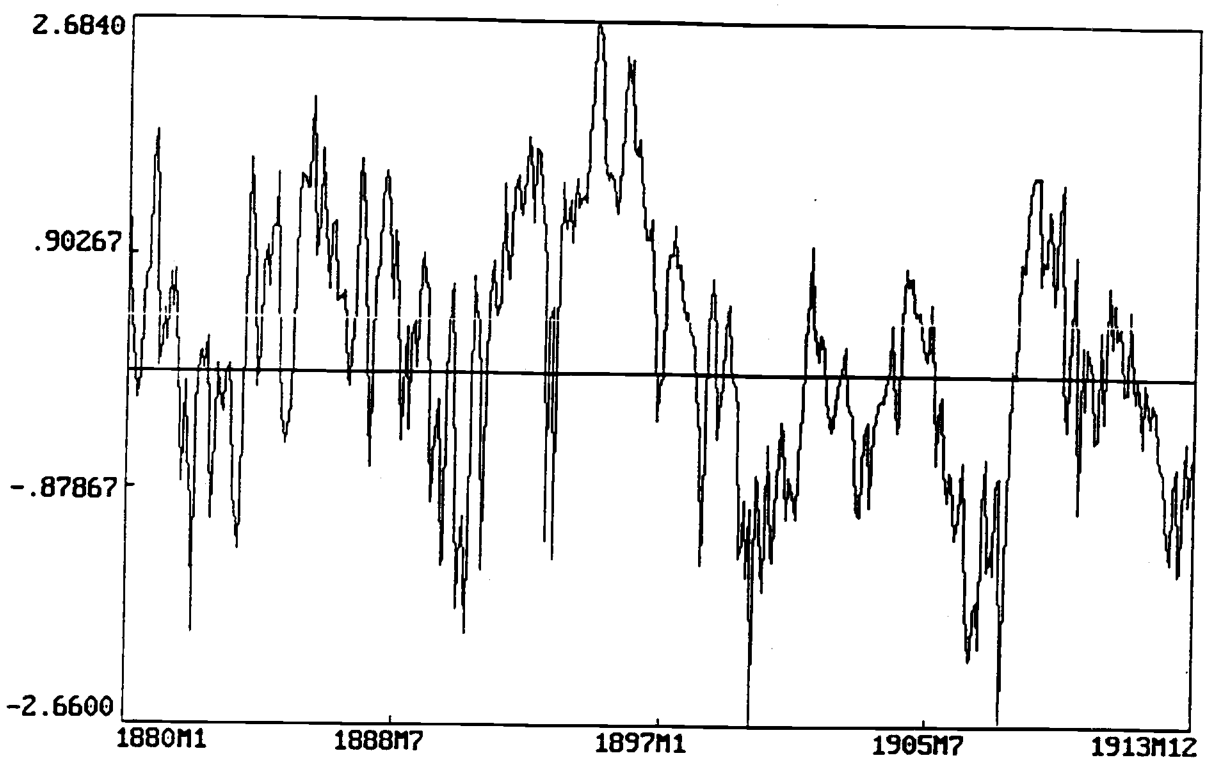


Fig 6: Interest Differential Between Long And Short Rates: UK.

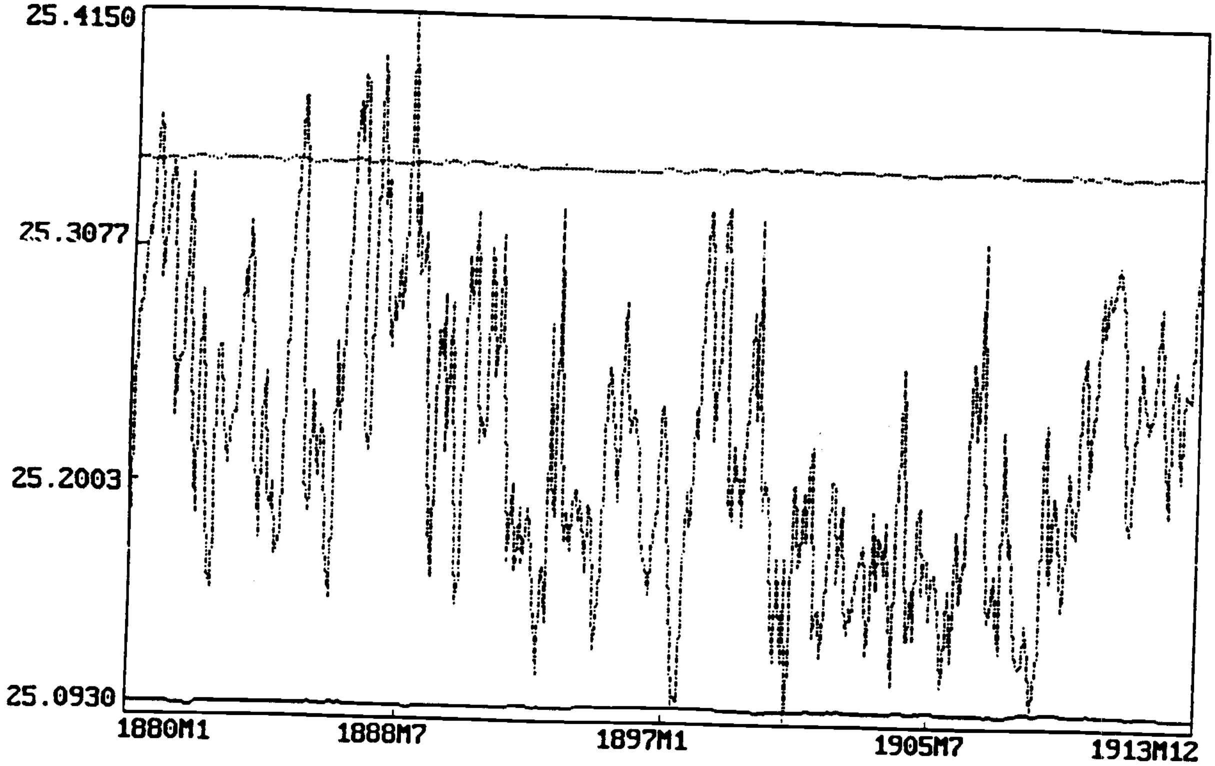


Fig 7: Franc / Sterling Spot Rate with Gold Import and Export Points.

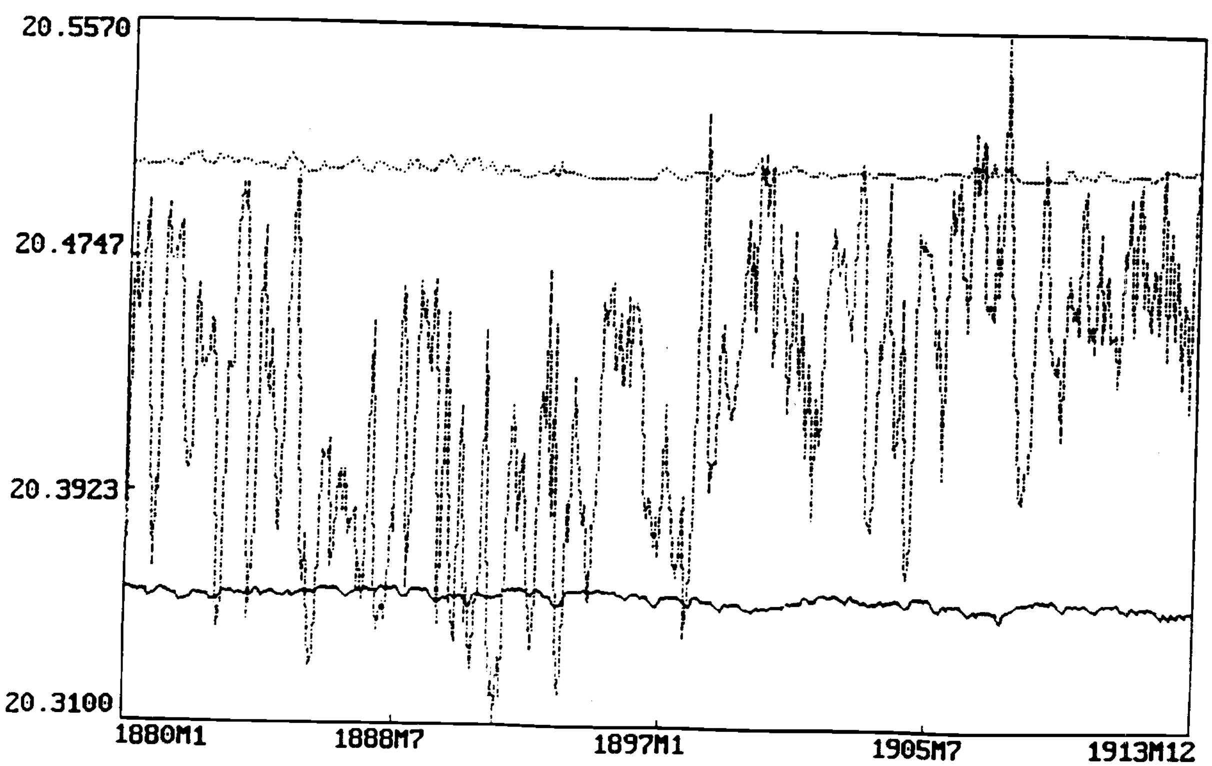


Fig 8 : Mark / Sterling Spot Rate with Gold Import and Export Points.

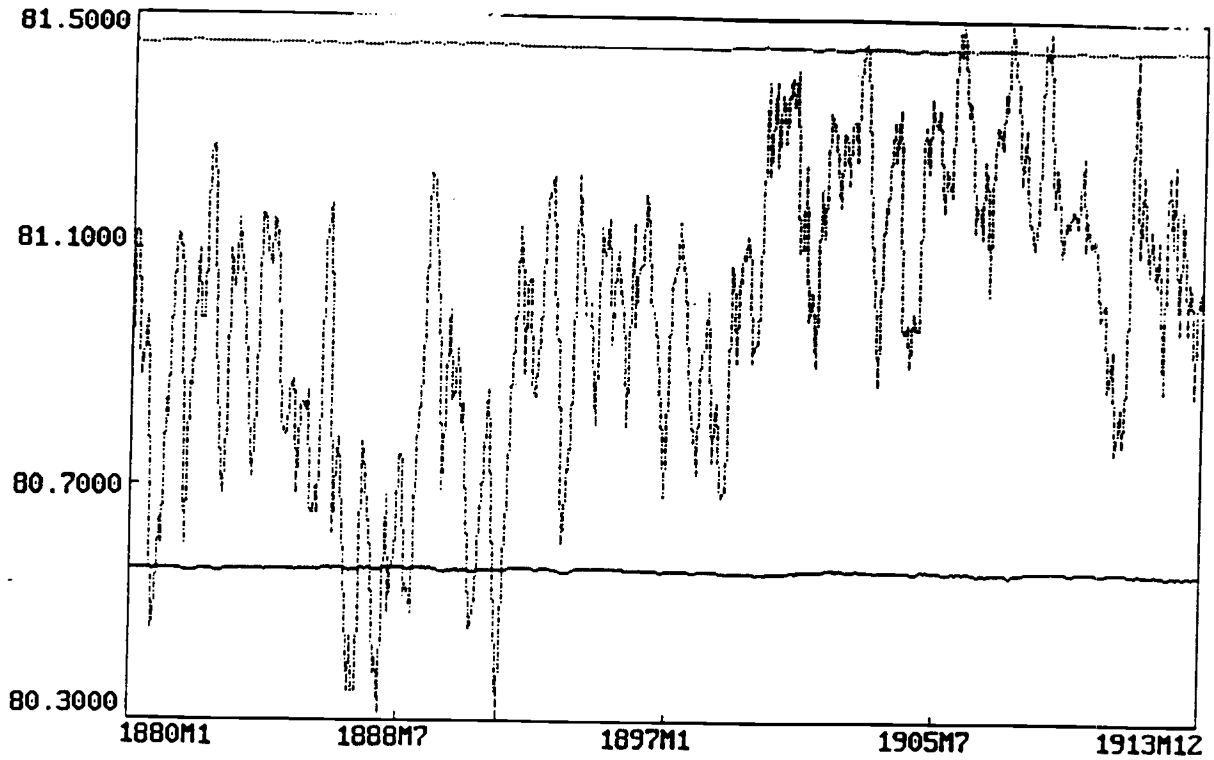


Fig 9 : Mark / Franc Spot Rate with Gold Import and Export Points.

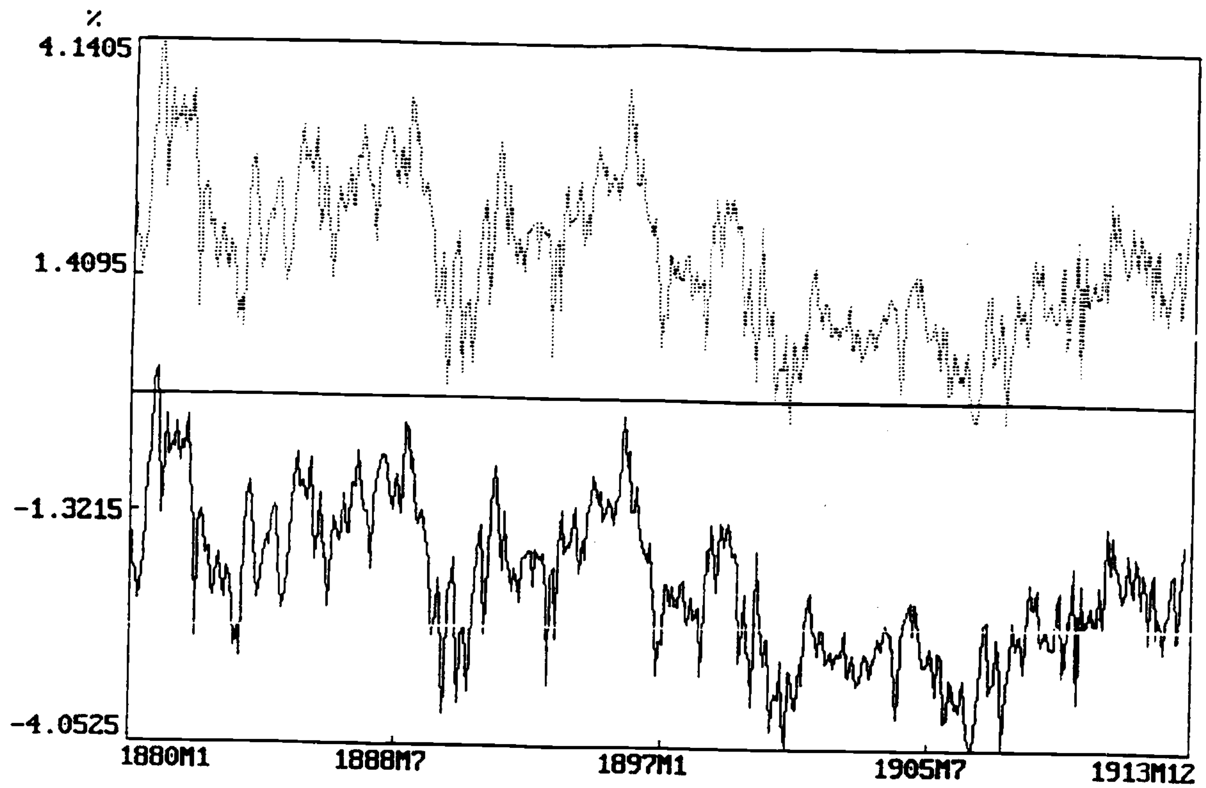


FIG. 10 : EXPECTED REALIGNMENT RATE 95% CI : FRANC-STERLING

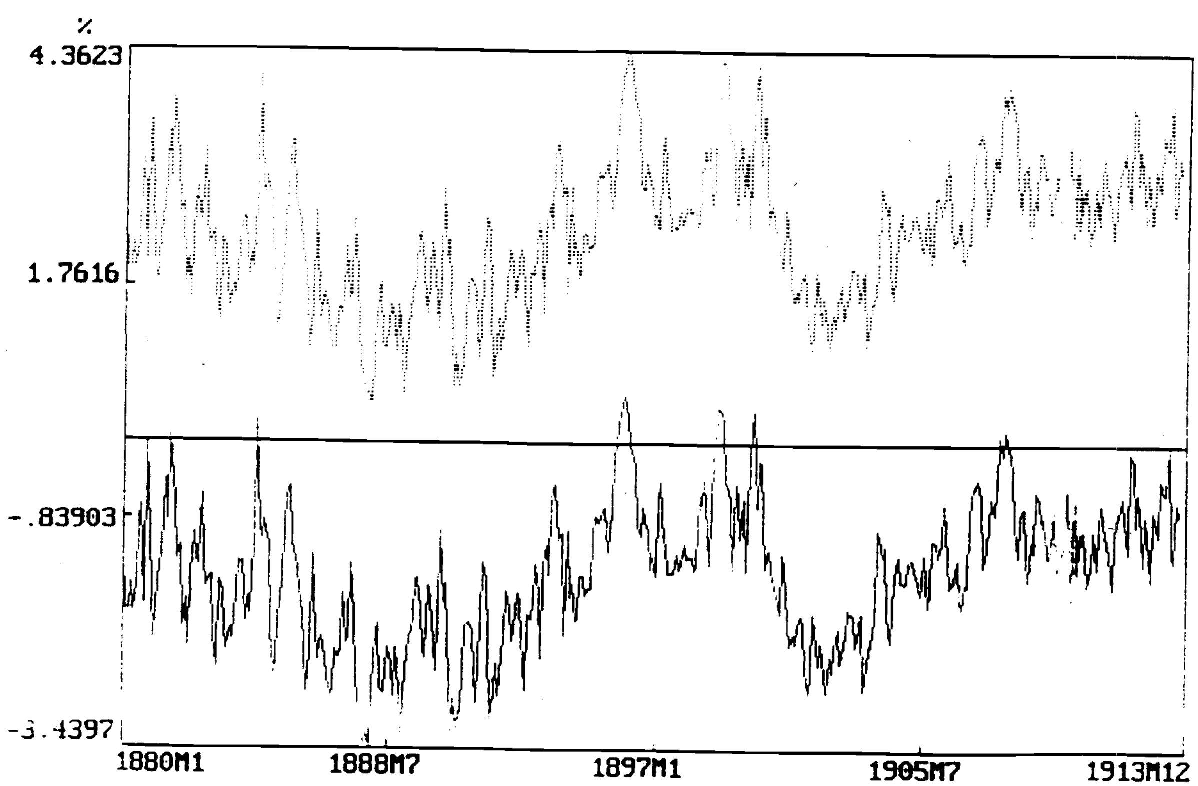


FIG. 11: EXPECTED REALIGNMENT RATE 95% CI : MARK-STERLING

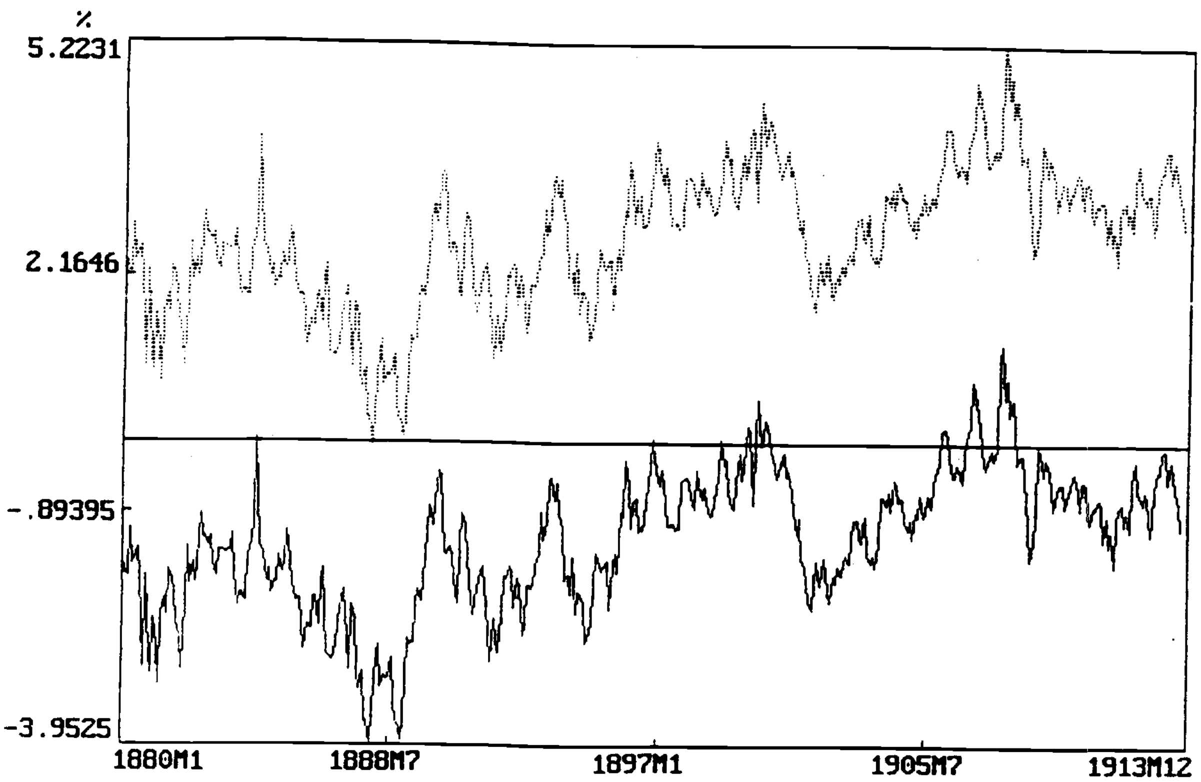


FIG. 12: EXPECTED REALIGNMENT RATE 95% CI : MARK-FRANC

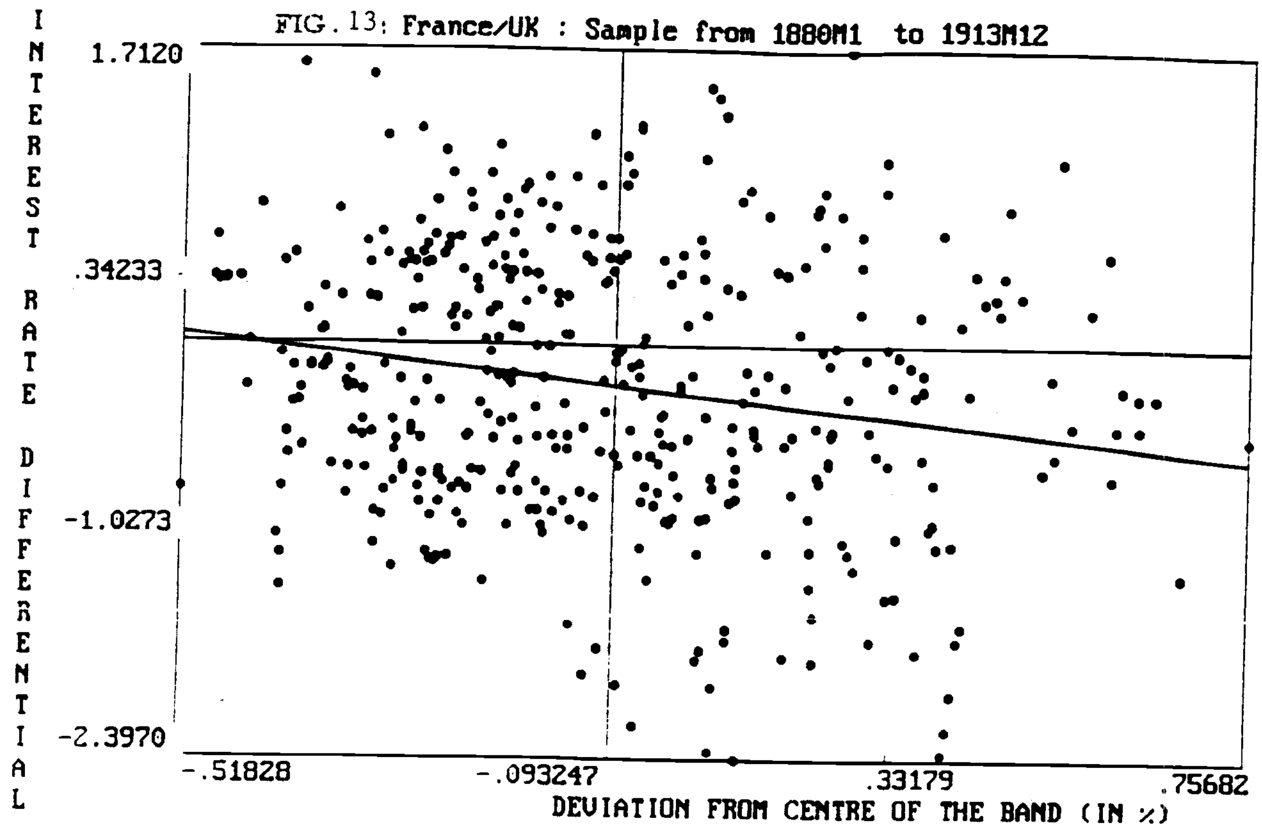


FIG. 13: France/UK : Sample from 1880M1 to 1913M12
INTEREST RATE DIFFERENTIAL
1.7120
.34233
-1.0273
-2.3970
-.51828
-.093247
.33179
.75682
DEVIATION FROM CENTRE OF THE BAND (IN %)

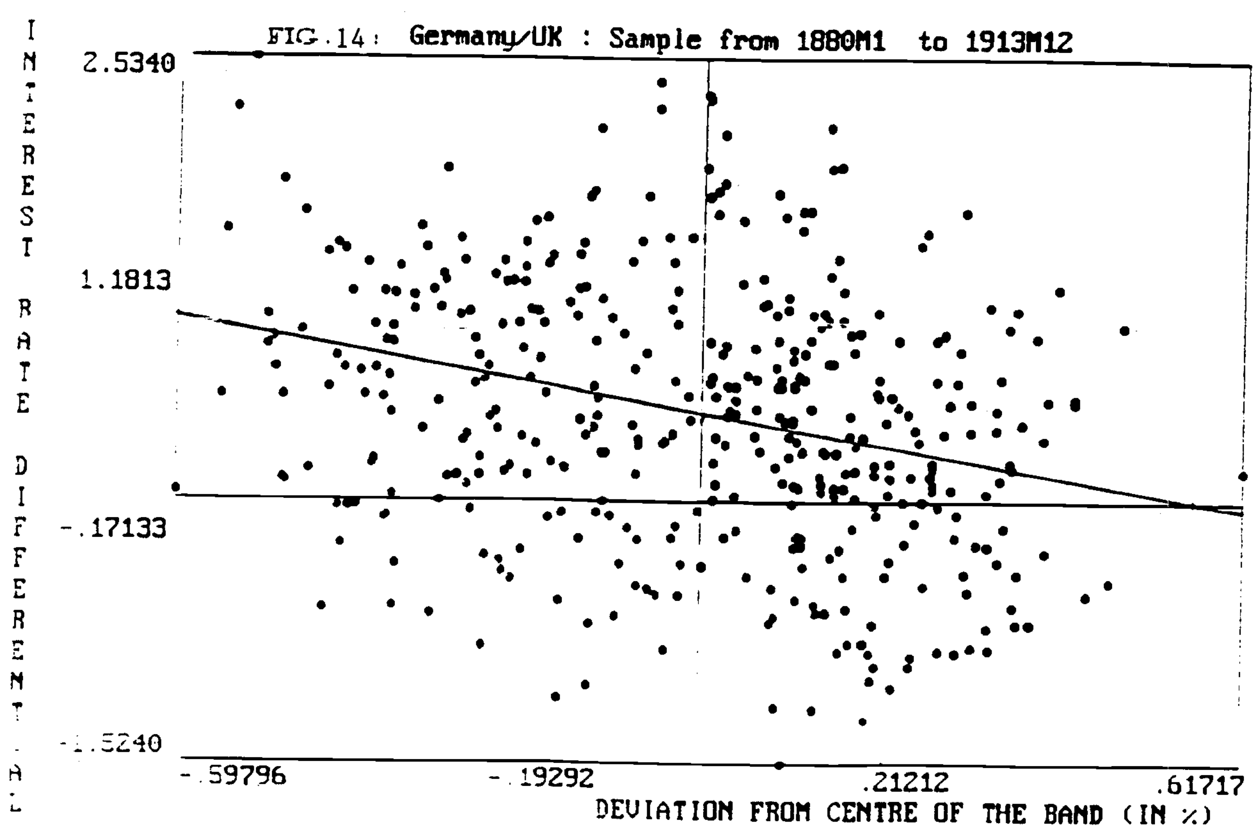


FIG. 14: Germany/UK : Sample from 1880M1 to 1913M12
INTEREST RATE DIFFERENTIAL
2.5340
1.1813
-.17133
-1.5240
-.59796
-.19292
.21212
.61717
DEVIATION FROM CENTRE OF THE BAND (IN %)

FIG.15 : Germany/France : Sample from 1880M1 to 1913M12

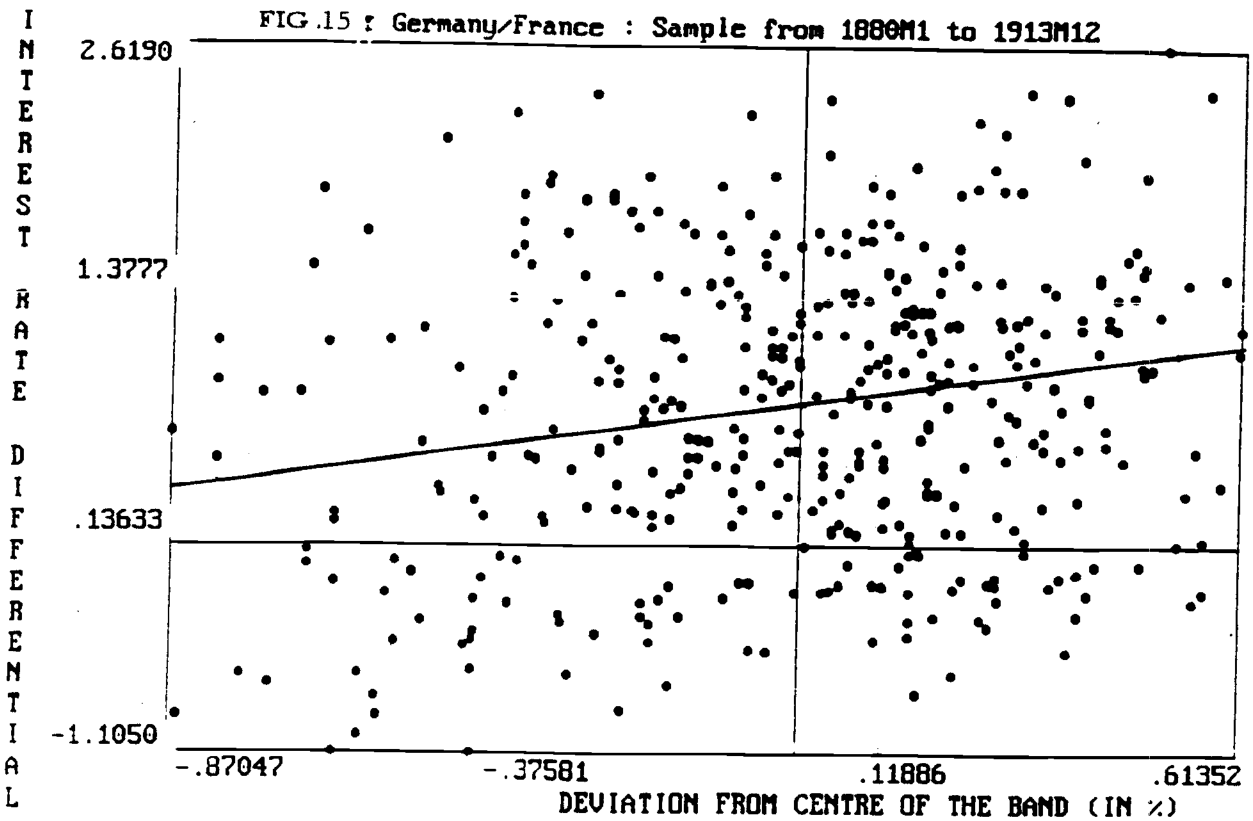
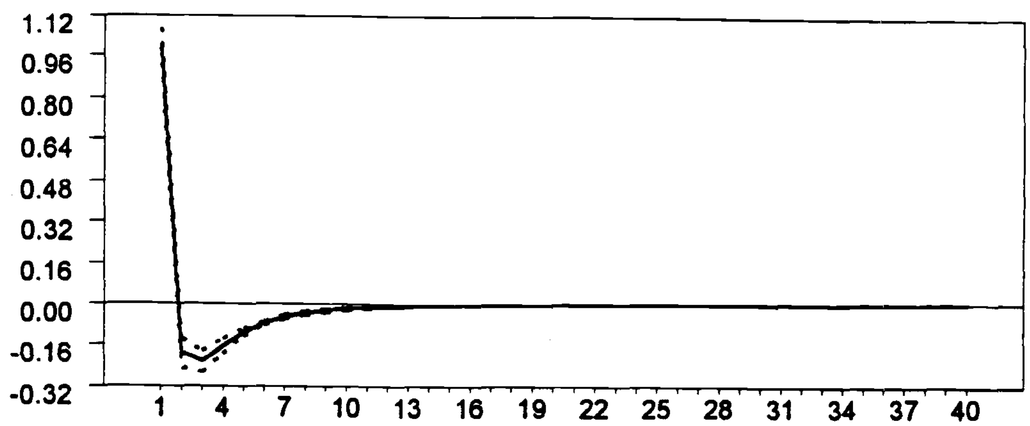


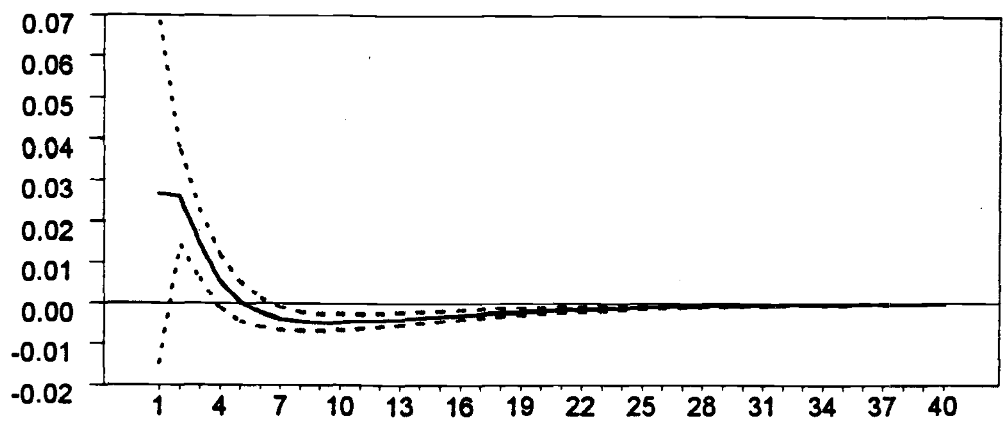
Figure 16A

Shock To UK Short Bank Rate.
(Ordering: UK Short Rate, French Short Rate, UK Long Rate).

Impulse Response of UK Short Rate.



Impulse Response of French Short Rate.



Impulse Response of UK Long Rate.

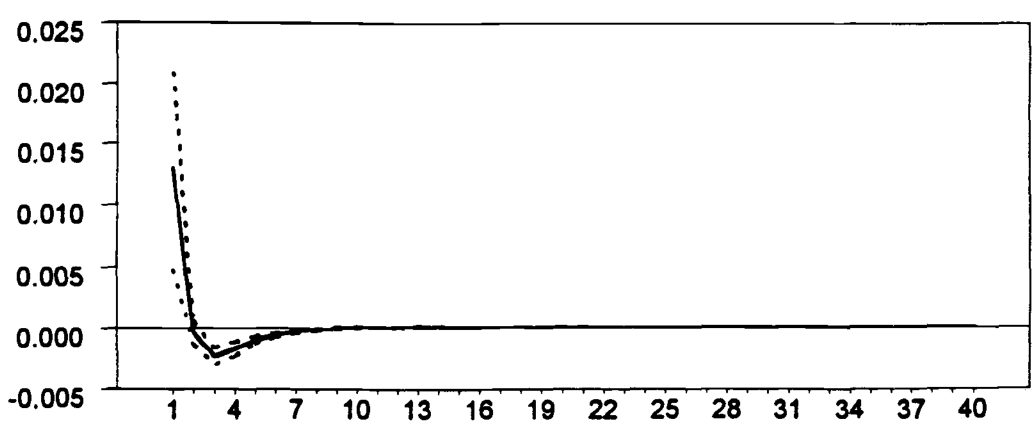
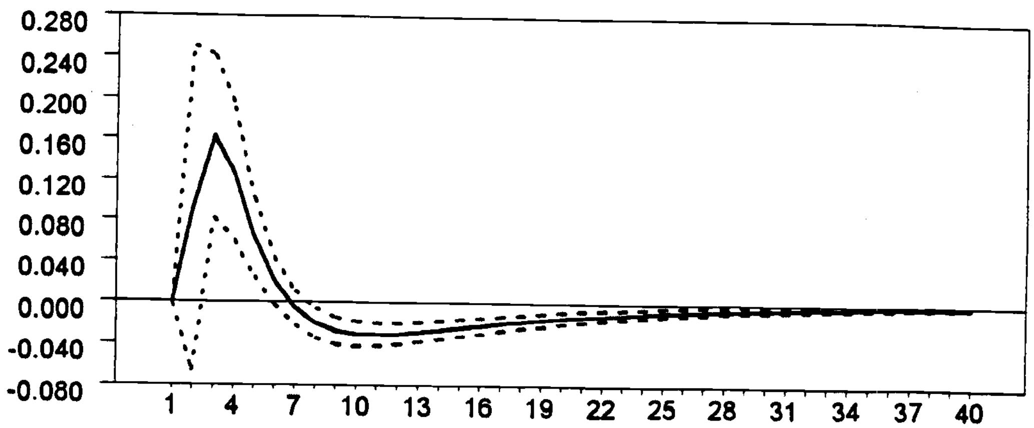


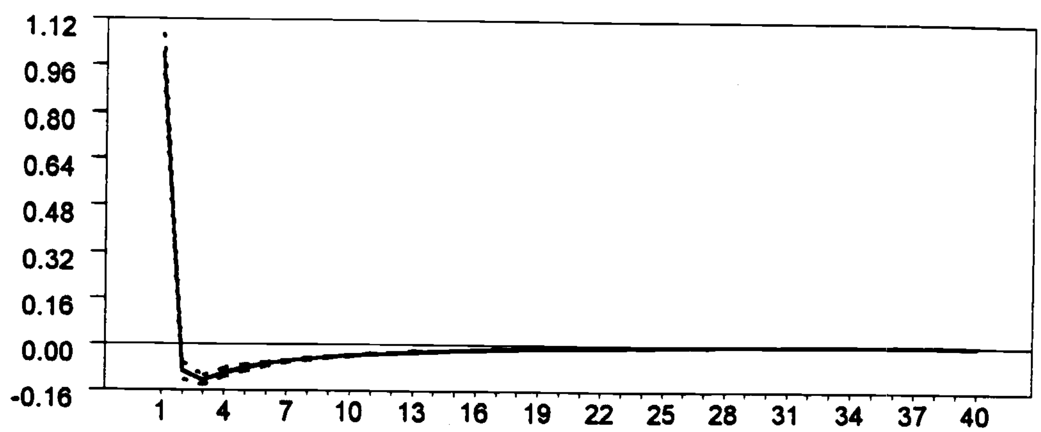
Figure 16B

Shock To French Short Rate.

Impulse Response of UK Short Rate.



Impulse Response of French Short Rate.



Impulse Response of UK Long Rate.

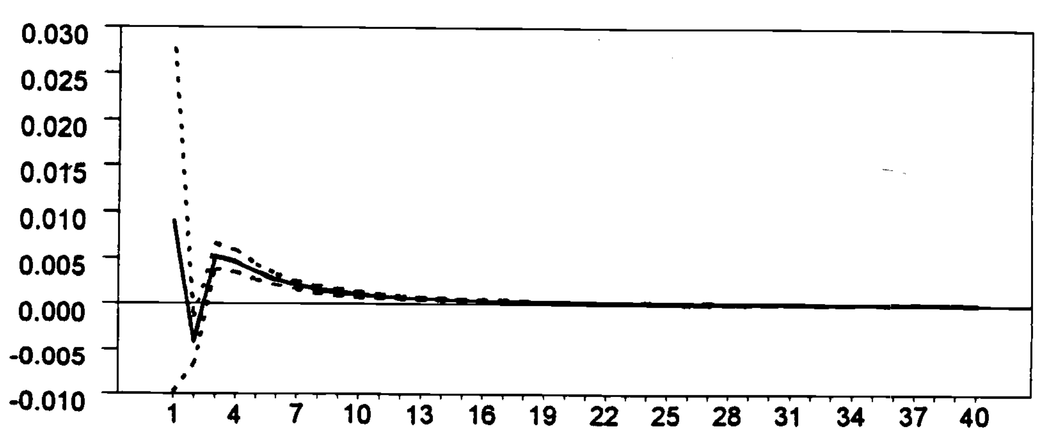
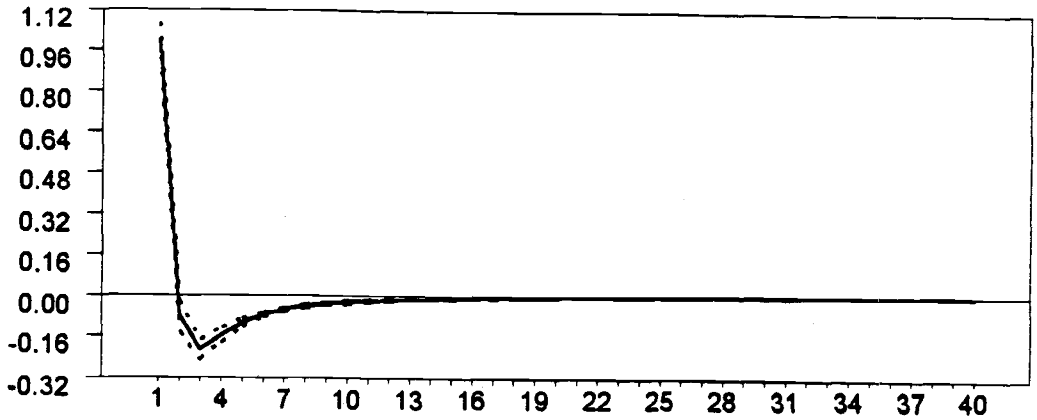


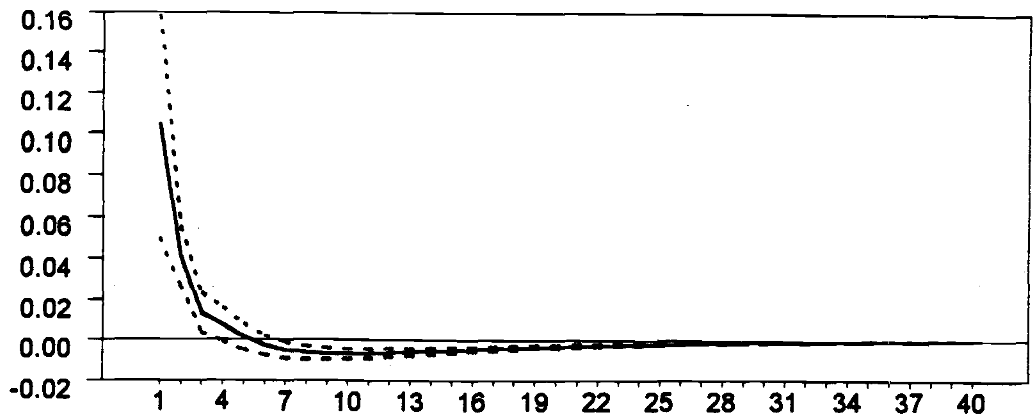
Figure 17A

Shock To UK Short Market Rate.
(Ordering: UK Short Rate, French Short Rate, UK Long Rate).

Impulse Response of UK Short Rate.



Impulse Response of French Short Rate.



Impulse Response of UK Long Rate.

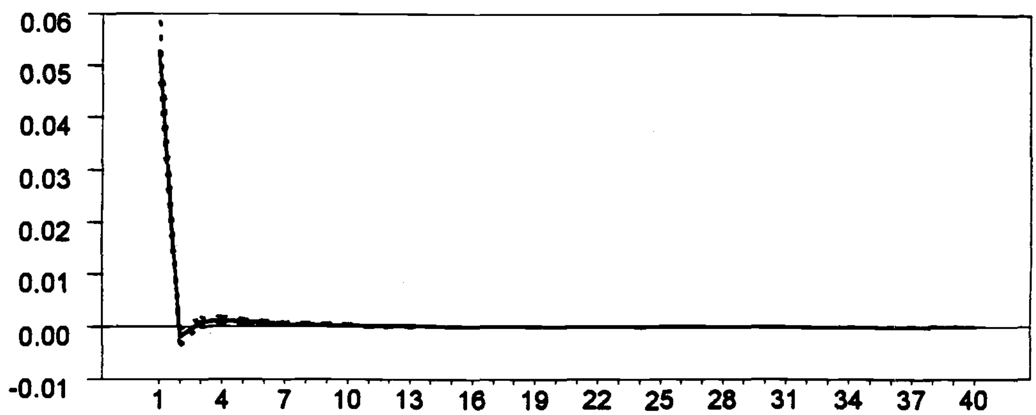
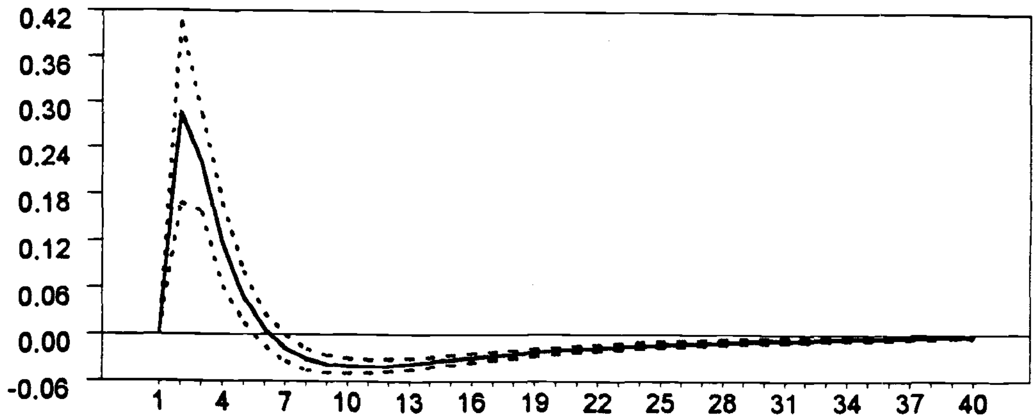
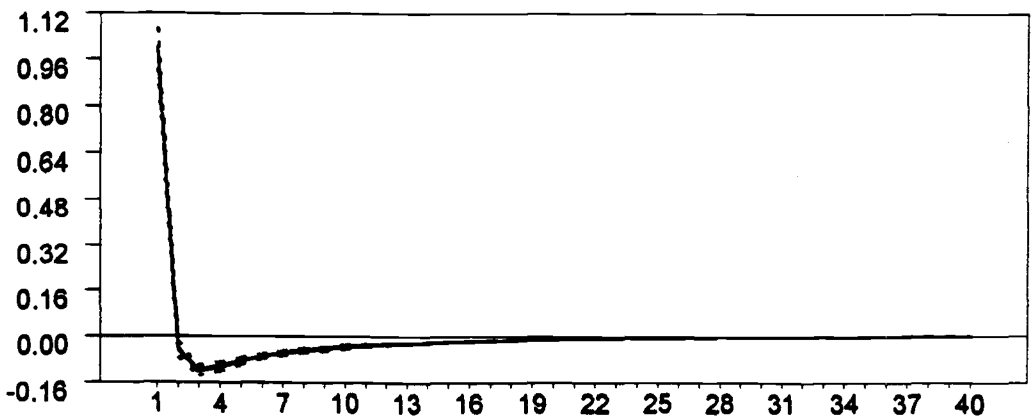


Figure 17B

Shock To French Short Rate.
Impulse Response of UK Short Rate.



Impulse Response of French Short Rate.



Impulse Response of UK Long Rate.

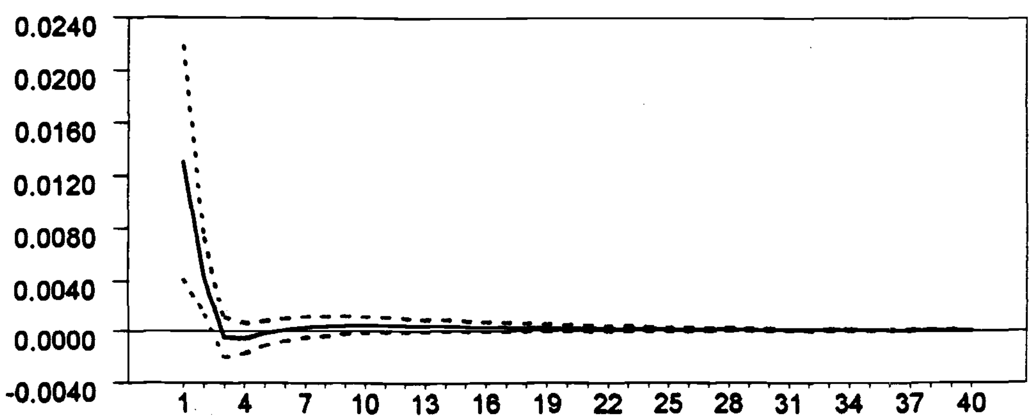
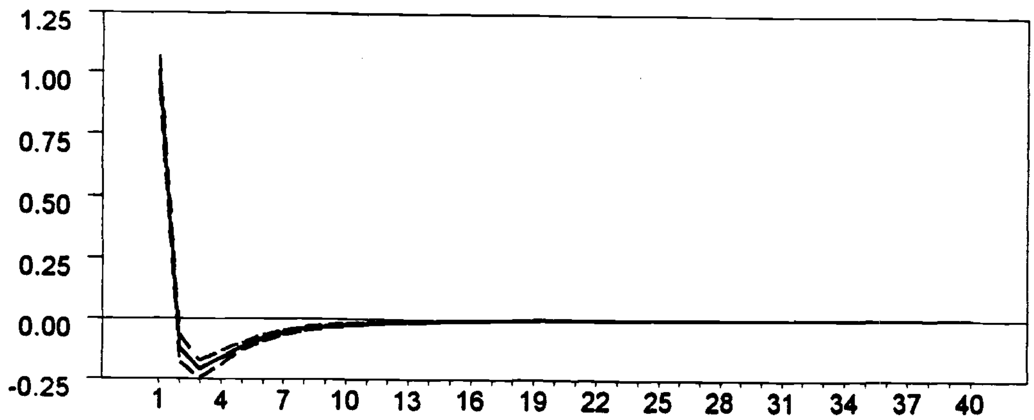


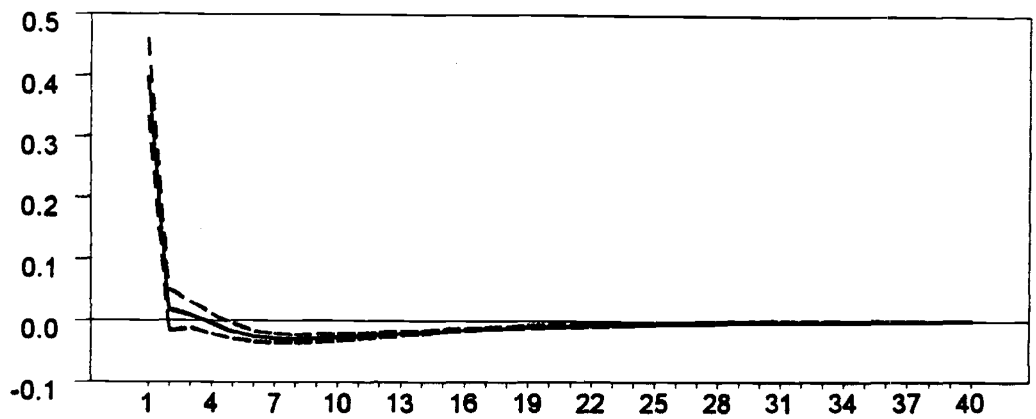
Figure 18A

Shock To UK Short Bank Rate.
(Ordering: UK Short Rate, German Short Rate, UK Long Rate).

Impulse Response of UK Short Rate.



Impulse Response of German Short Rate.



Impulse Response of UK Long Rate.

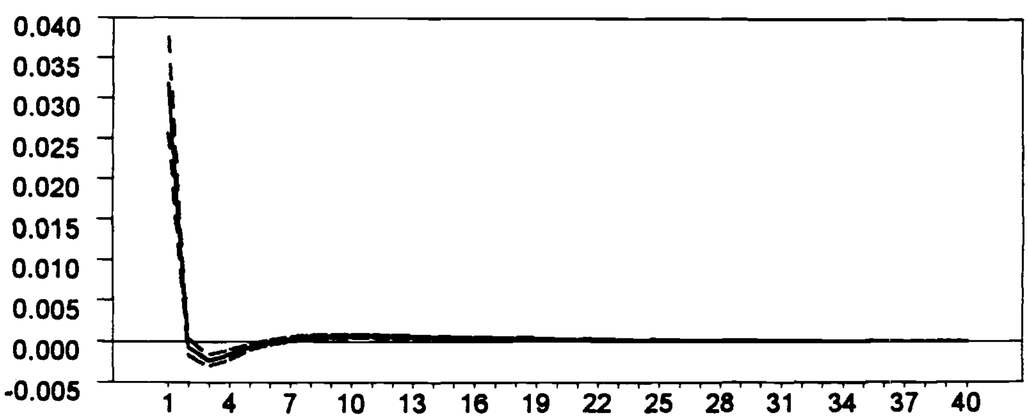
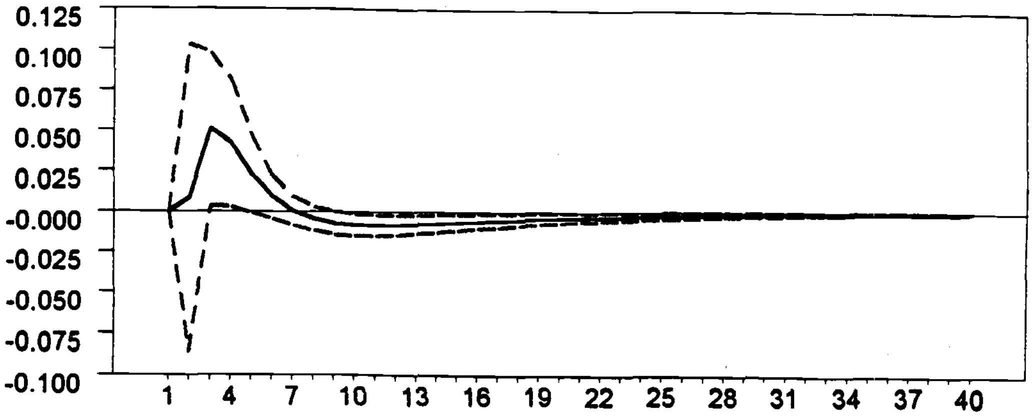
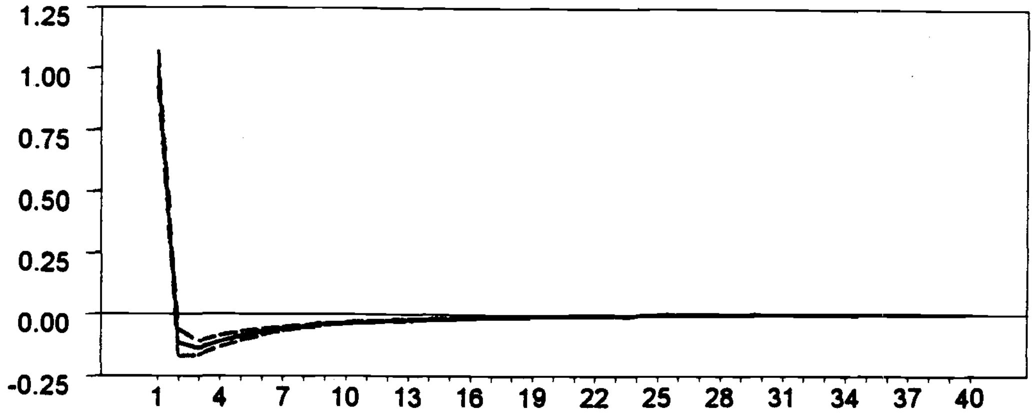


Figure 18B

Shock To German Short Rate.
Impulse Response of UK Short Rate.



Impulse Response of German Short Rate.



Impulse Response of UK Long Rate.

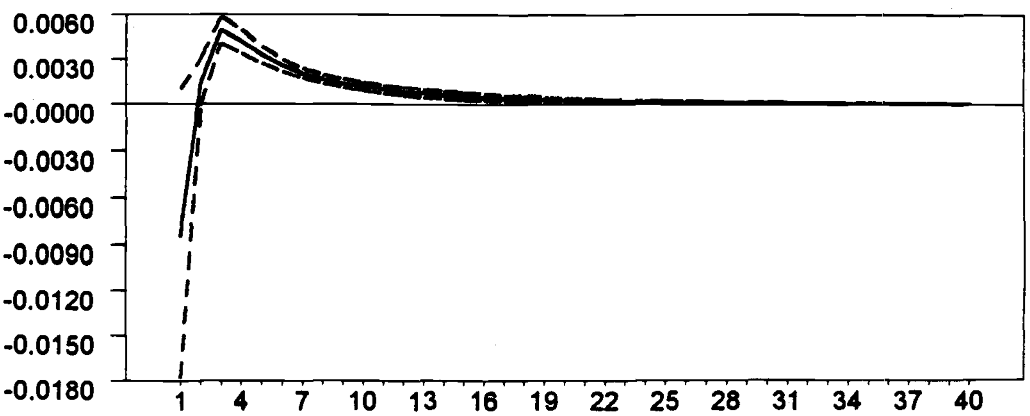
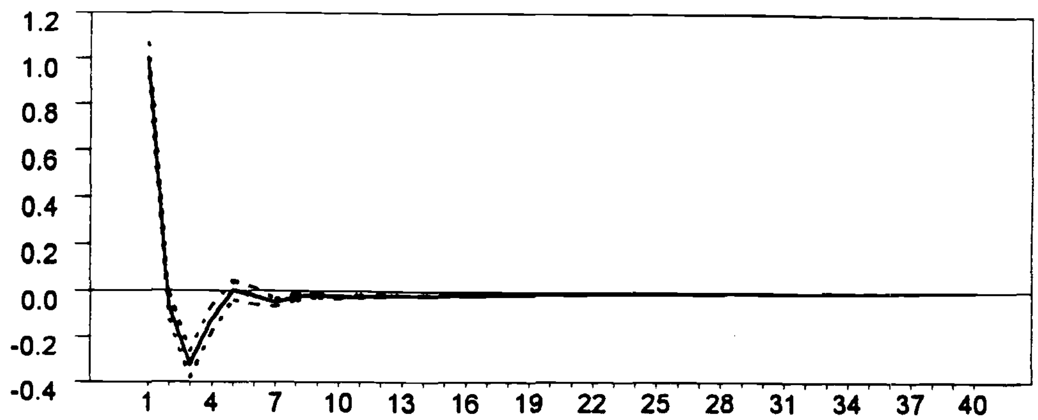


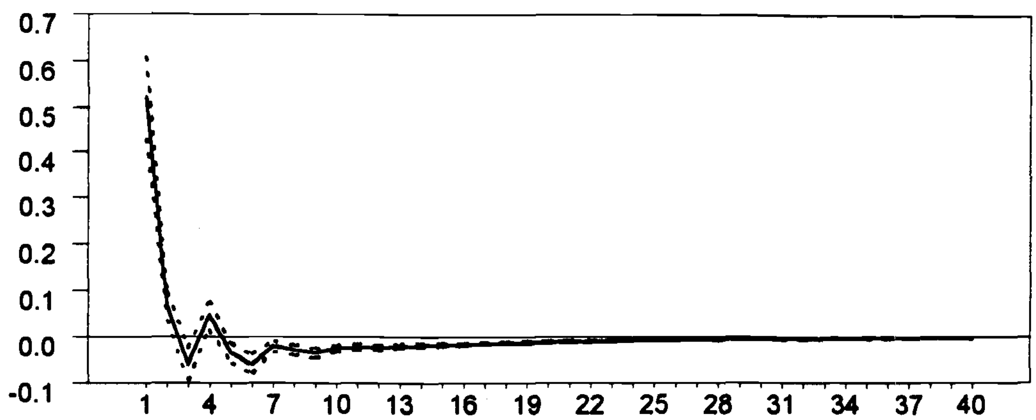
Figure 19A

Shock To UK Short Market Rate.
(Ordering: UK Short Rate, German Short Rate, UK Long Rate).

Impulse Response of UK Short Rate.



Impulse Response of German Short Rate.



Impulse Response of UK Long Rate.

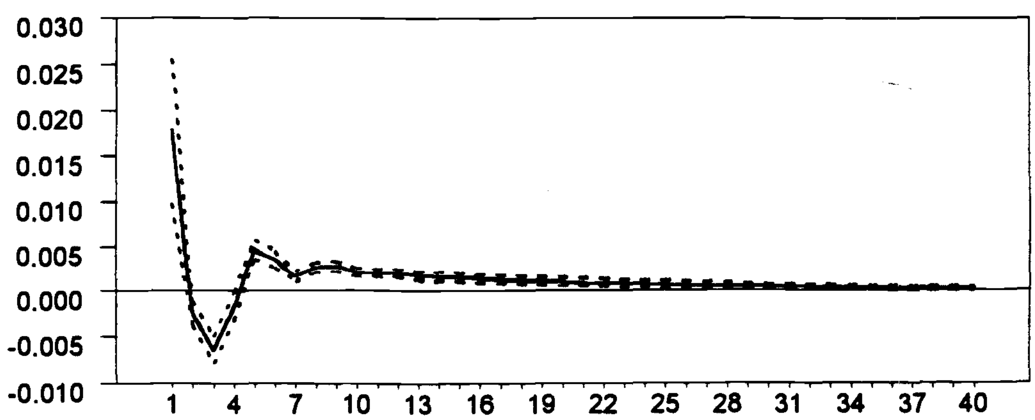
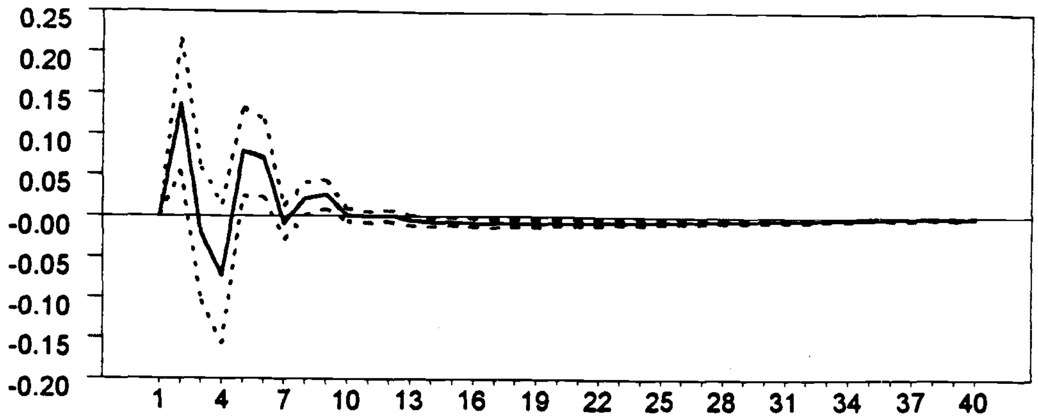
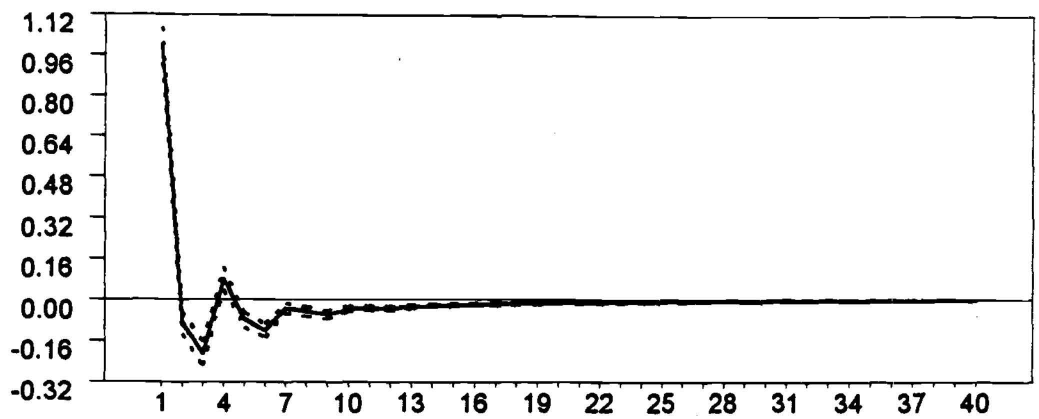


Figure 19B

Shock To German Short Rate.
Impulse Response of UK Short Rate.



Impulse Response of German Short Rate.



Impulse Response of UK Long Rate.

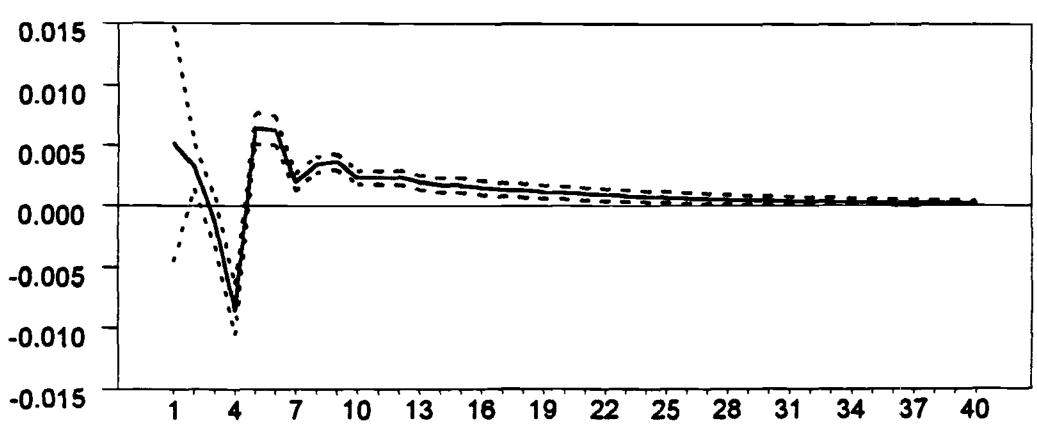
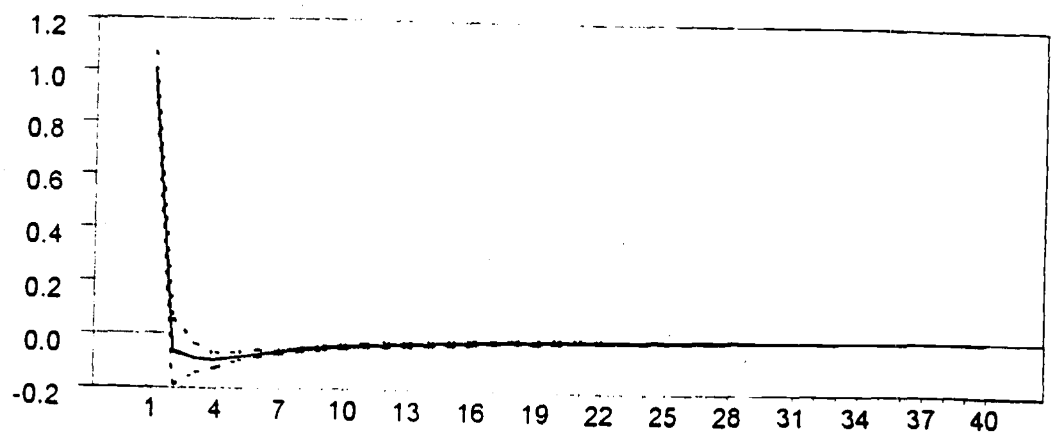


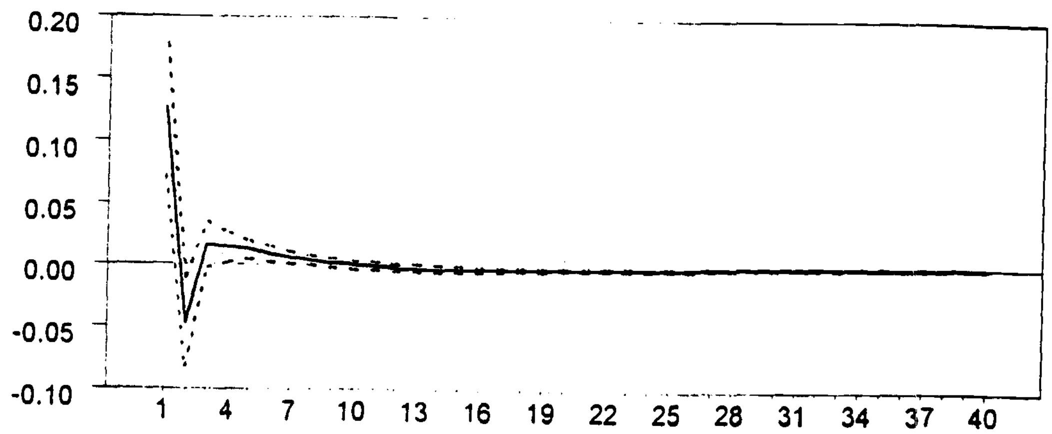
Figure 20A

Shock To German Short Bank Rate.
(Ordering German short rate. French short rate. German long Rate).

Impulse Response Of German Short Rate.



Impulse Response Of French Short Rate.



Impulse Response Of German Long Rate.

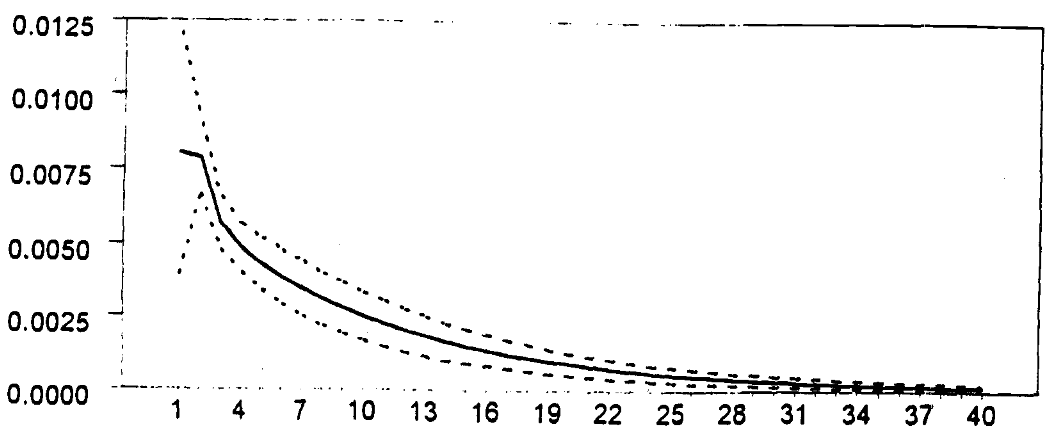
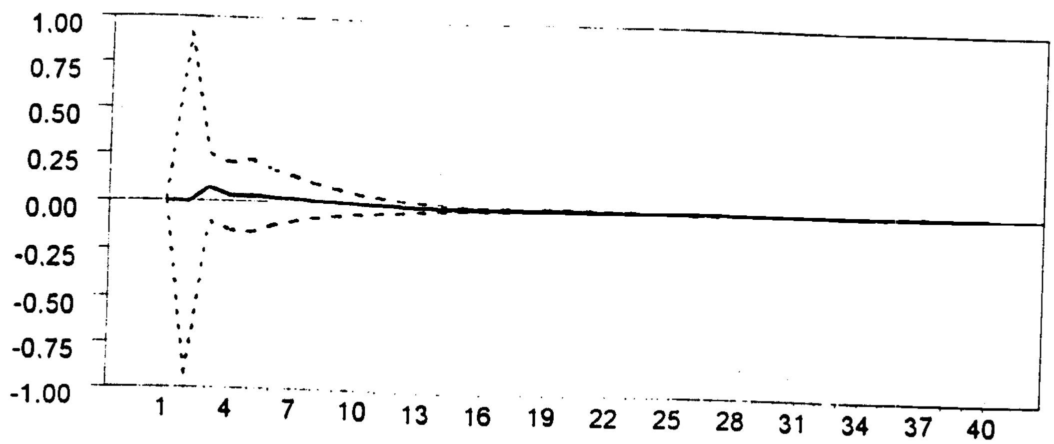


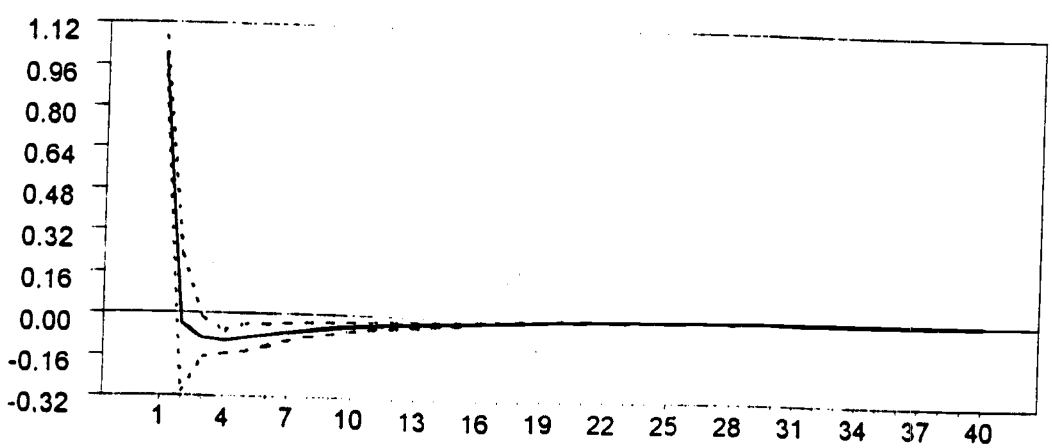
Figure 20B

Shock To French Short Bank Rate.
(Ordering German short rate. French short rate. German long Rate).

Impulse Response Of German Short Rate.



Impulse Response Of French Short Rate.



Impulse Response Of German Long Rate.

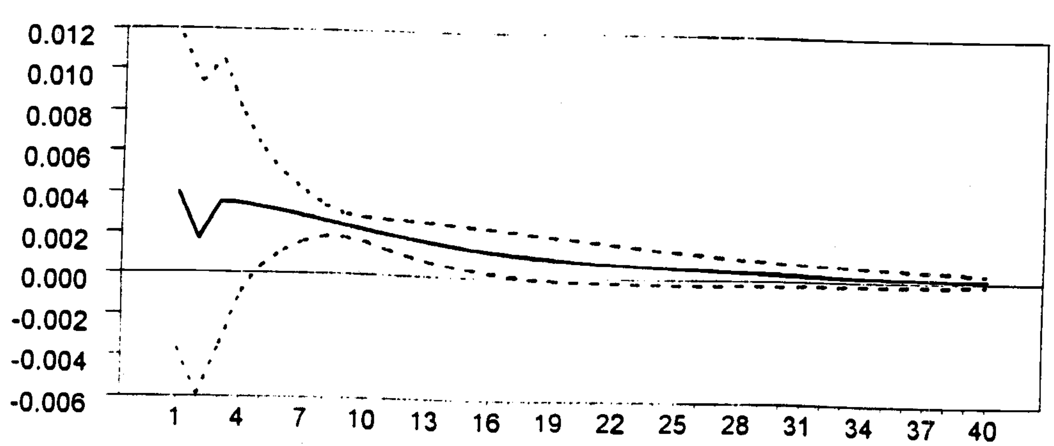
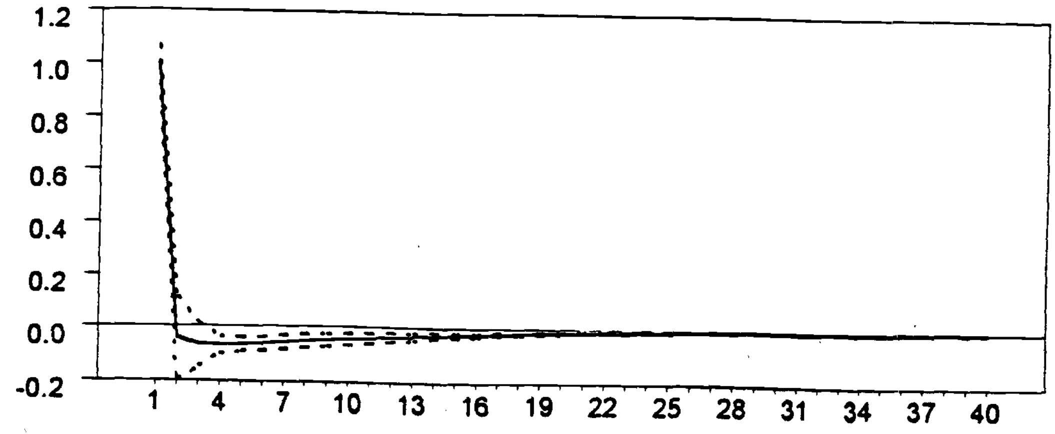


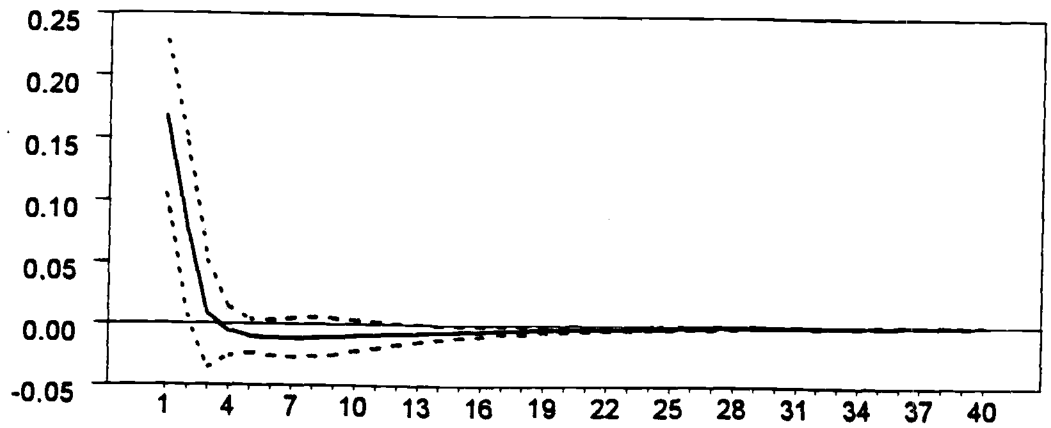
Figure 21A

Shock To German Short Market Rate.
(Ordering German short rate, French short rate, German long Rate).

Impulse Response Of German Short Rate.



Impulse Response Of French Short Rate.



Impulse Response Of German Long Rate.

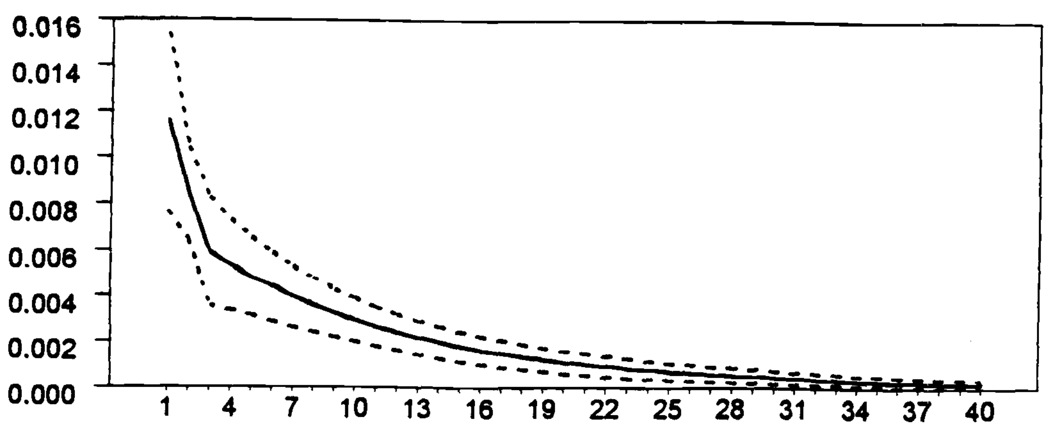
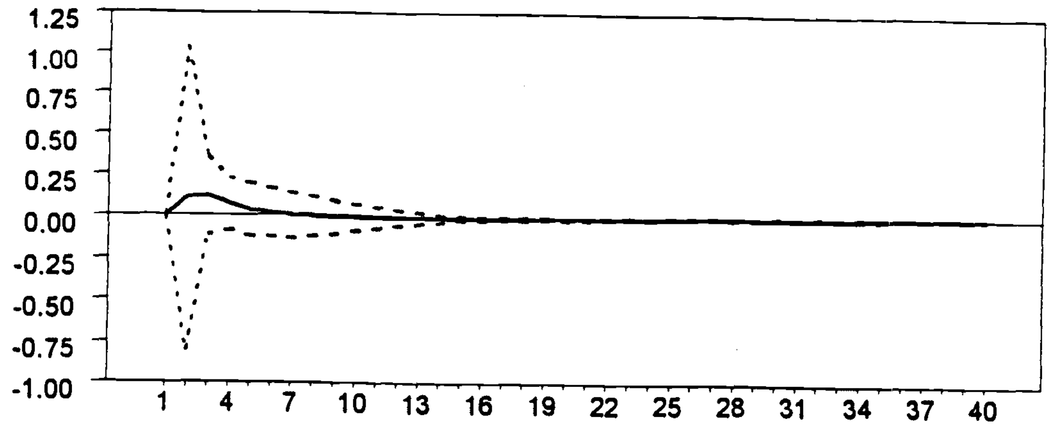


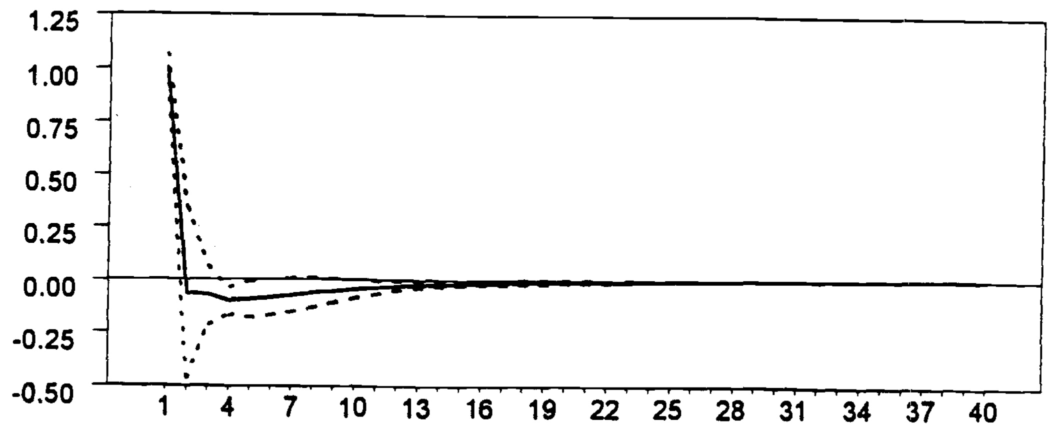
Figure 21B

<u>**Shock To French Short Market Rate.**</u>
<u>**(Ordering German short rate, French short rate, German long Rate).**</u>

<u>**Impulse Response Of German Short Rate.**</u>



<u>**Impulse Response Of French Short Rate.**</u>



<u>**Impulse Response Of German Long Rate.**</u>

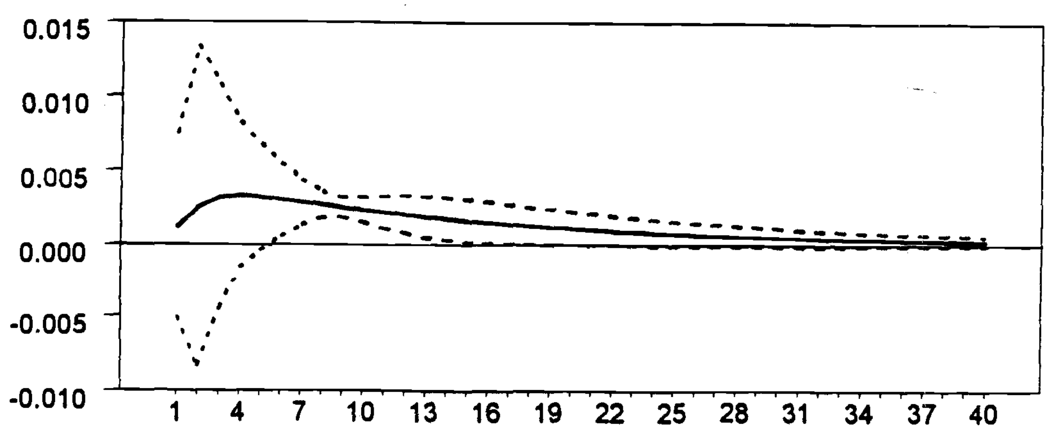
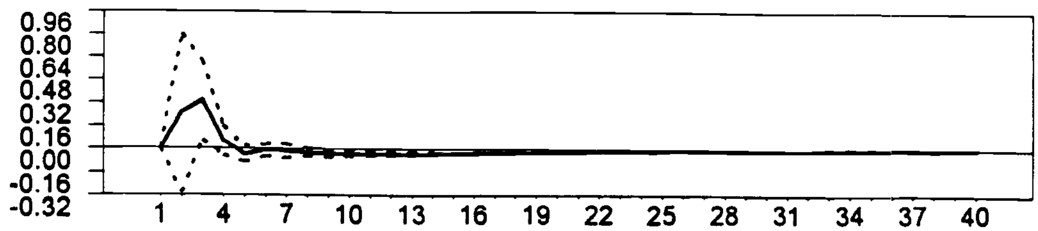


Figure 22

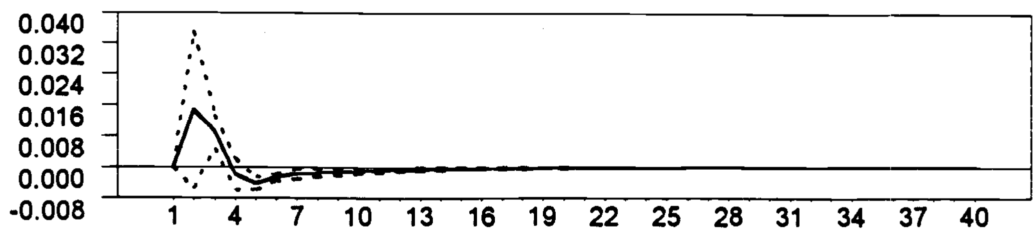
UK / French Market Interest Rate Sytem
(Ordering: UK Economic Fundamentals, UK short Market rate, French short Market rate, UK long Rate) 2 Lags.

(1.) Impulse Responses Of UK Short Market Rate.

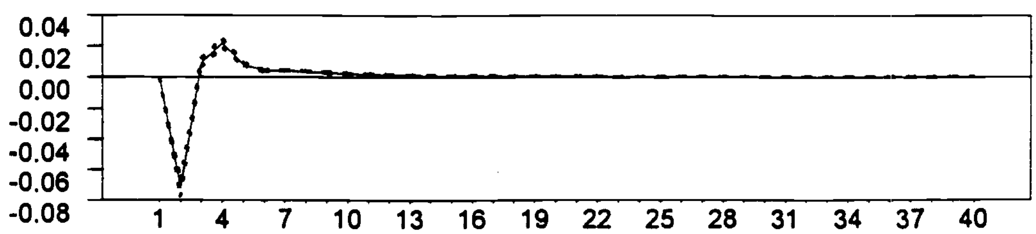
(a.) Shock To French Short Market Rate.



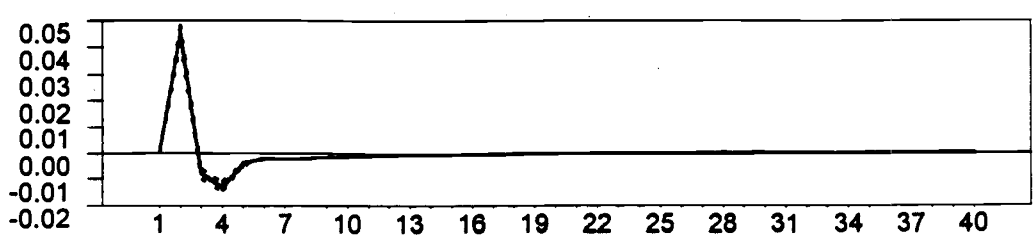
(b.) Shock To UK Output.



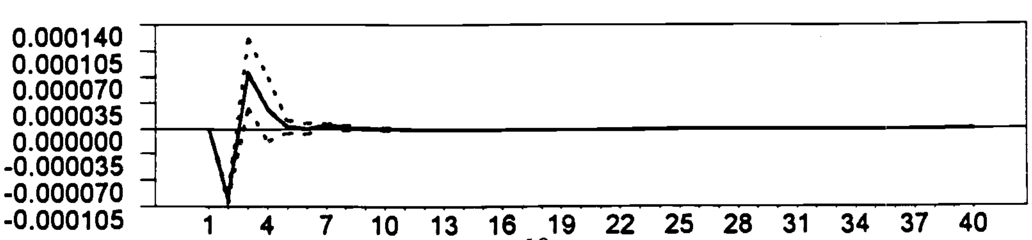
(c.) Shock To UK Money.



(d.) Shock To UK Prices.

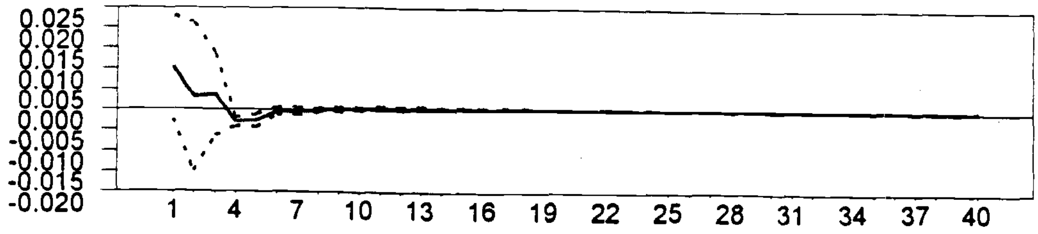


(e.) Shock To UK Short Interest Rate Volatility.

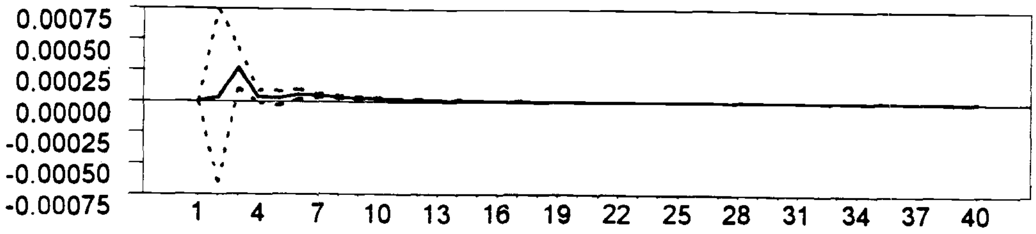


(2.) Impulse Responses Of UK Long Market Rate.

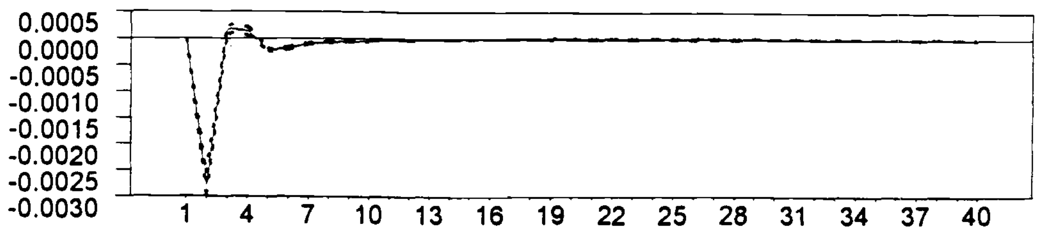
(a.) Shock To French Short Market Rate.



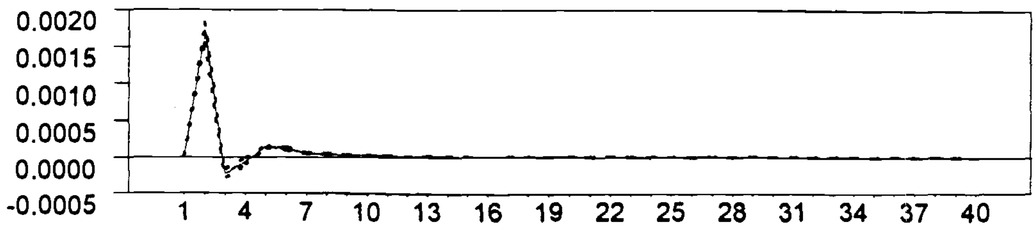
(b.) Shock To UK Output.



(c.) Shock To UK Money.



(d.) Shock To UK Prices.



(e.) Shock To UK Short Interest Rate Volatility.

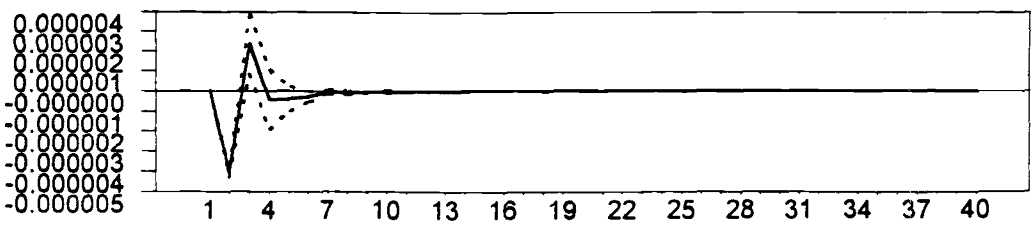
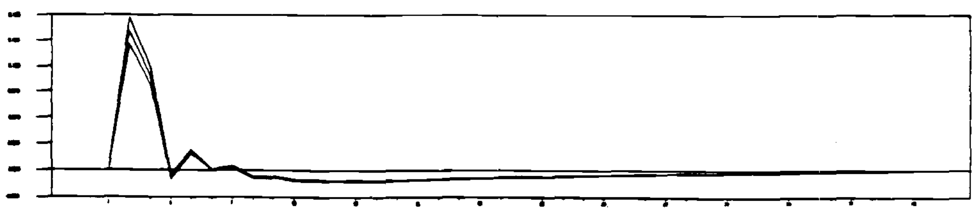


Figure 23

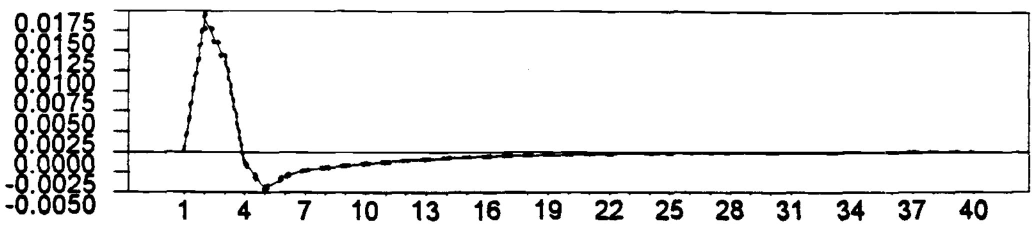
UK / German Market Interest Rate Sytem
(Ordering: UK Economic Fundamentals, UK short Market rate, German short Market rate, UK long Rate) 2 Lags.

(1.) Impulse Responses Of UK Short Market Rate.

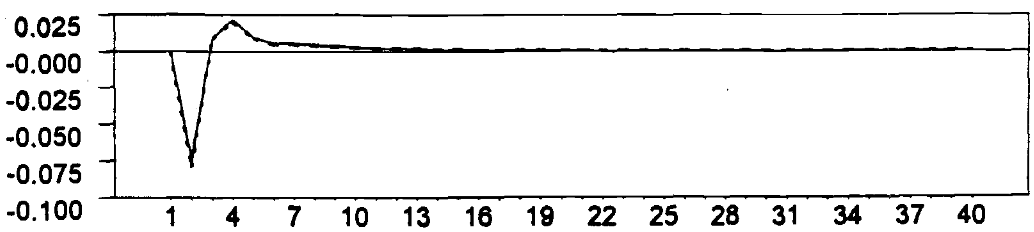
(a.) Shock To German Short Market Rate.



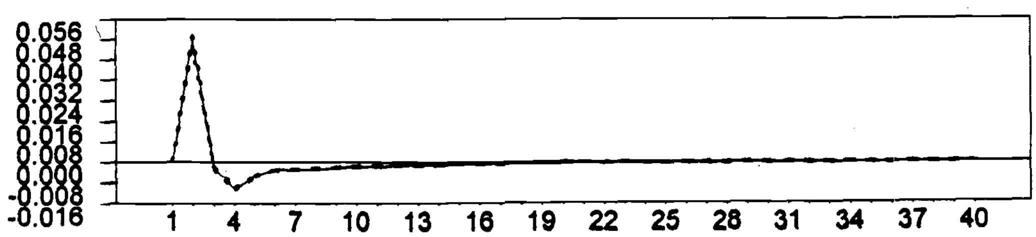
(b.) Shock To UK Output.



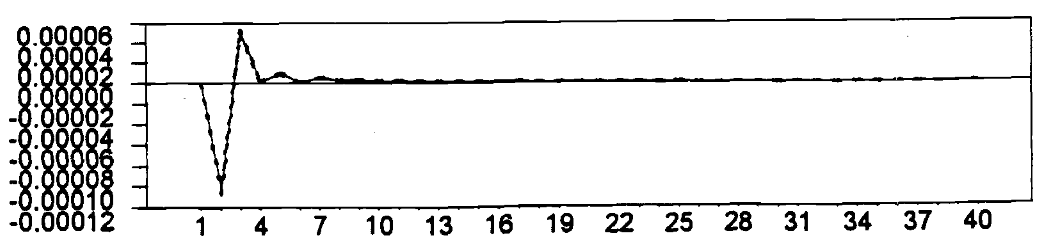
(c.) Shock To UK Money.



(d.) Shock To UK Prices.

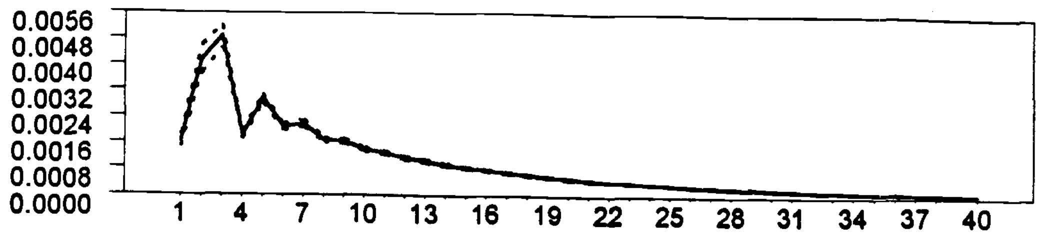


(e.) Shock To UK Short Interest Rate Volatility.

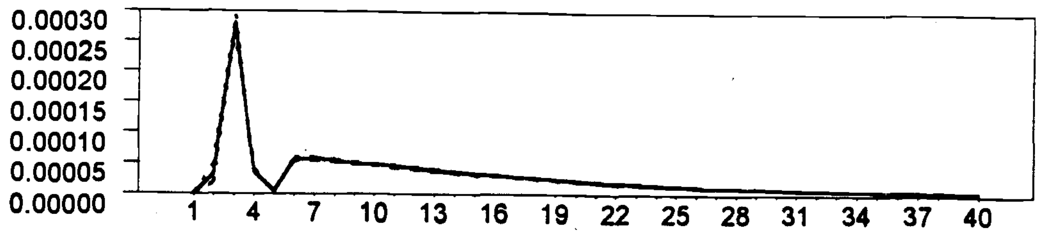


(2.) Impulse Responses Of UK Long Market Rate.

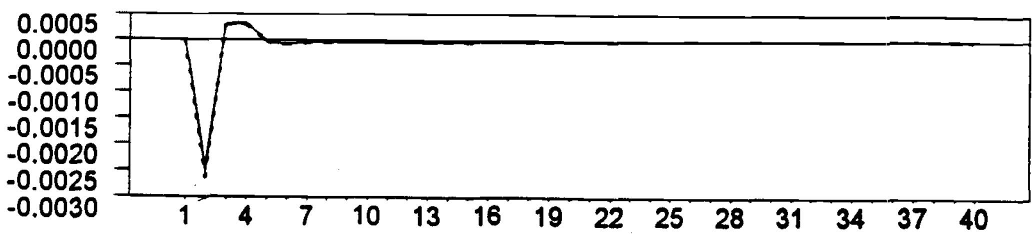
(a.) Shock To German Short Market Rate.



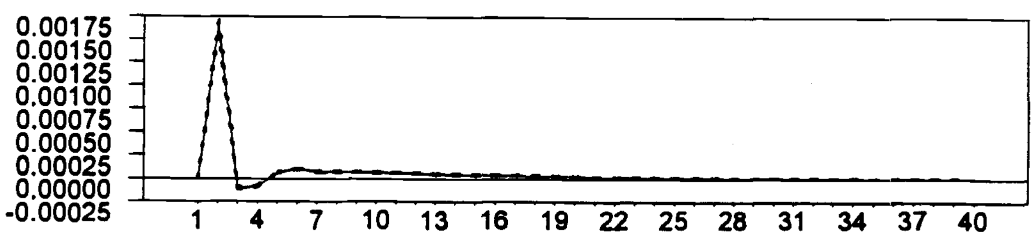
(b.) Shock To UK Output.



(c.) Shock To UK Money.



(d.) Shock To UK Prices.



(e.) Shock To UK Short Interest Rate Volatility.

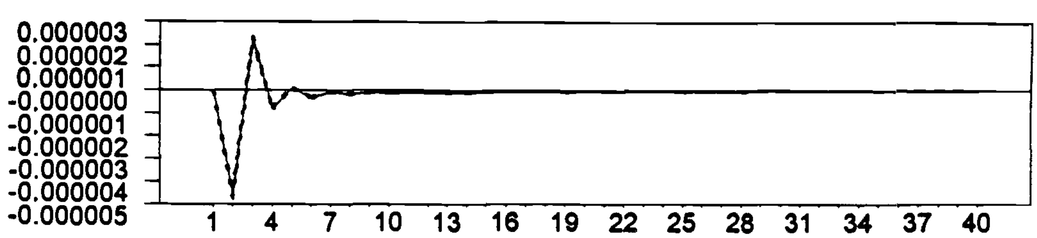
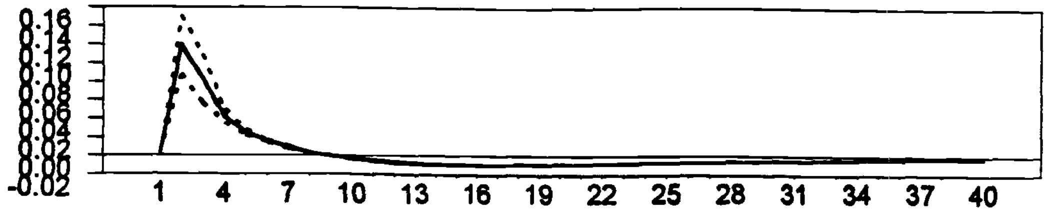


Figure 24

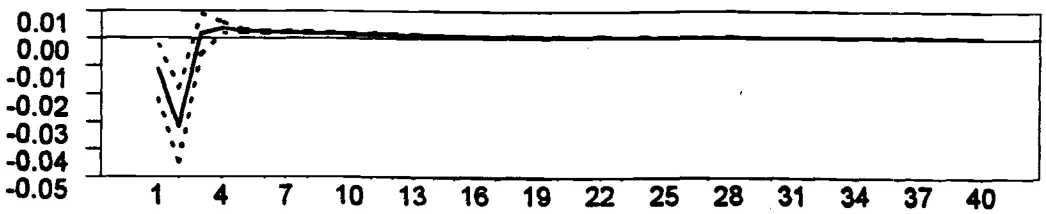
German / French Market Interest Rate Sytem
(Ordering: German Economic Fundamentals, German short Market rate, French short Market rate, German long Rate), 2 Lags.

(1.) Impulse Responses Of German Short Market Rate.

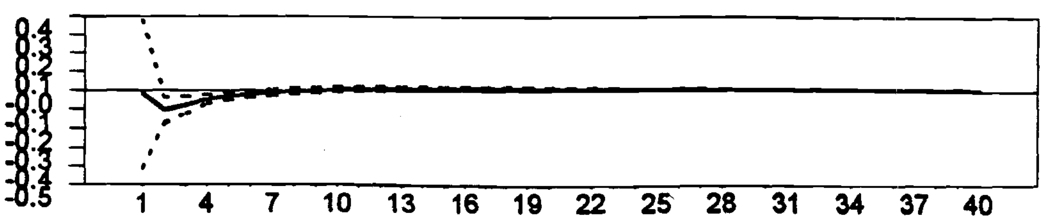
(a.) Shock To French Short Market Rate.



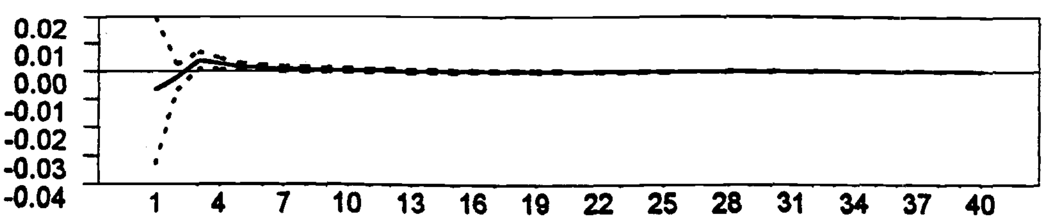
(b.) Shock To German Gold Reserves.



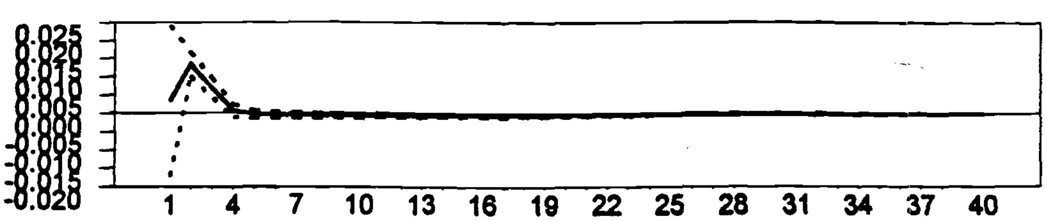
(c.) Shock To German Output.



(d.) Shock To German Money.



(e.) Shock To German Prices.



(f.) Shock To German Short Interest Rate Volatility.

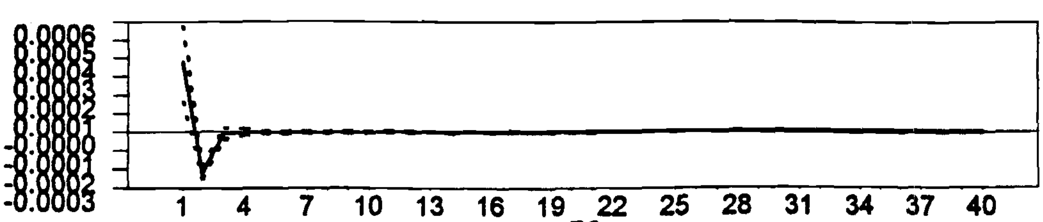
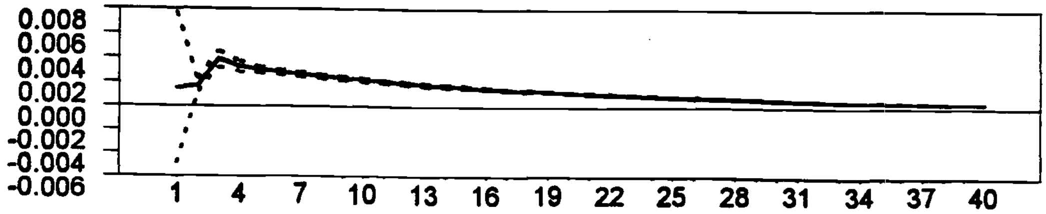


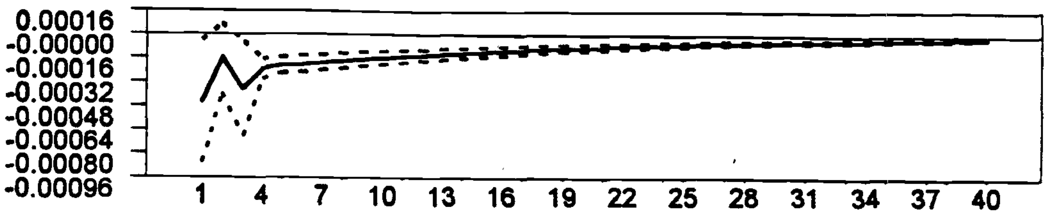
Figure 24 (continued)

(2.) Impulse Responses Of German Long Market Rate.

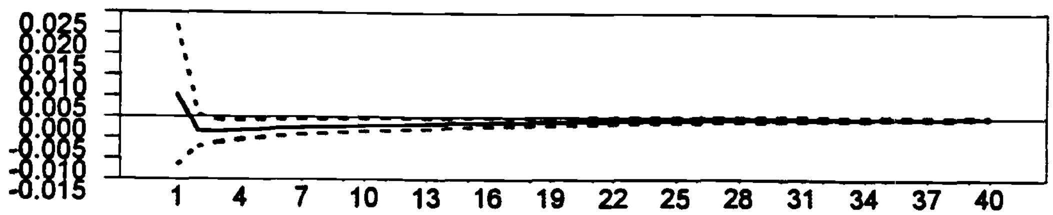
(a.) Shock To French Short Market Rate.



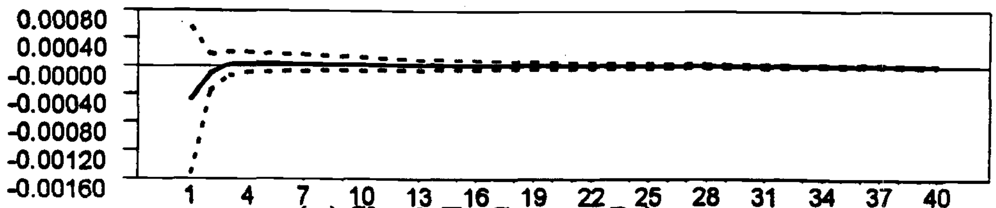
(b.) Shock To German Gold Reserves.



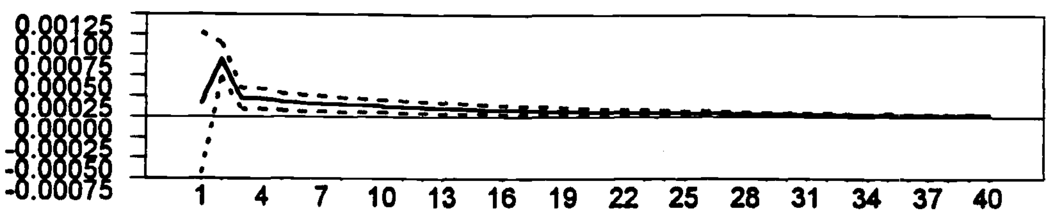
(c.) Shock To German Output.



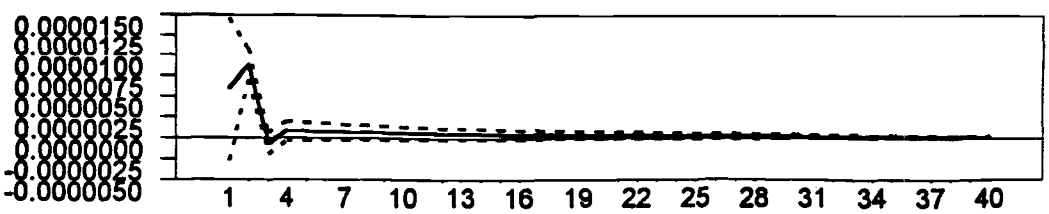
(d.) Shock To German Money.



(e.) Shock To German Prices.



(f.) Shock To German Short Interest Rate Volatility.



DATA APPENDIX A			
DATA TYPE	**FREQ**	**COUNTRY**	**DATA SOURCE(S)**
Bank Discount Rates	M	UK	NBER Series 13013 (1836-1939). Original source :Burdett's Official Intelligence (1894).
		GERMANY	NBER Series 13015 (1876-1939).Original source : Die Reichsbank 1876-1910.
		FRANCE	NBER Series 13014 (1852-1938). Original source : Bulletin de Statistique et de legislation comparee.
Open Market Rates (3 Month Bills)	M	UK	NBER Series 13016 (1880-1914) . Original source : The Economist.
		GERMANY	NBER Series 13018 (1880-1914) . Original sources : Die Reichsbank (1880-1910) and Statistiches jahrbuch fur das deutsche reich (1911-1914).
		FRANCE	NBER Series 13017(1880-1914) . Original sources : USNMC (1889-1908) and The Economist (1880-1888,1908-1914).
Long Term Bond Yield	M	UK	NBER Series 13041 (1840-1938). Original source : Statistical abstract of the United Kingdom.
		GERMANY	NBER Series 13028 (1870-1913) . Original source :Institut of Konjunkturforschung.
		FRANCE	Rentes yield , calculated from 3% Rentes prices detailed in NBER Series 11021 (1874-1914) . Original sources : L'economiste Francais (1874 -1897) and Journal de la societe de statistique de Paris February 1929 (1898-1914).
Spot Exchange Rates	M	UK	NBER Series 14106 (M:£) & 14107 (FR:£) (1877-1914). Original sources : The Economist (1880-1898,1909-1914) and USNMC(1910) (1889-98(monthly data) &1899-1908(weekly data).
		GERMANY	NBER Series 14071 (M:100FR) (1876-1914) .
		FRANCE	Data supplied by Pierre Sicsic, Banque de France. Original source: The Economist, various issues.
Note Circulation	M	UK	Capie and Webber (1985): A monetary history of the United Kingdom 1870-1982.
		GERMANY	Bopp (1953): Reichsbank Operations 1876-1914.
		FRANCE	White (1933): The French international accounts 1880-1913.

Gold Reserves	M	UK	The Economist and USNMC(1910).
		GERMANY	Bopp (1953)
		FRANCE	Data supplied by Pierre Sicsic, Banque de France. Original source: The Economist, various issues.
Wholesale Prices	M	UK	NBER Series 04053 (1885-1935) . Original source : Journal of the royal statistical society vol. 50. Interpolated from export price data (NBER Series 04109) for the period 1880-1884. Original source : Silverman, A.G. Review of economic statistics vol. XII , 3 ,1930.
		GERMANY	NBER Series 04054 (1879-1902 and 1907-1914) . Interpolated from coal price data (NBER Series 04101) for the period 1902-1906.
		FRANCE	Monthly data series interpolated from wheat price data series (NBER Series 04004) for the period 1892-1913.
Industrial Production	M	UK	Monthly data series interpolated from railway receipt data (NBER Series 04053) for the period 1880-1913.
		GERMANY	Monthly data series interpolated from pig iron output data (NBER Series 01134) for the period May 1881-1913.
		FRANCE	Monthly data series interpolated from data on exports of manufactured goods (NBER Series 07011) for the period 1880-1913.
Unemployment	A	UK	Mitchell (1975), pp64-66.
		GERMANY	Mitchell (1975), pp64-66.
		FRANCE	Mitchell (1975), pp64-66.

DATA APPENDIX B			
DATA TYPE	**FREQ**	**COUNTRY**	**TECHNIQUES APPLIED TO DATA SOURCES**
Bank Discount Rates	M	UK GERMANY FRANCE	The data for these variables was only available in a seasonally unadjusted format .It was deseasonalised using the ESMOOTH facility in the RATS software package. The exponential smoothing model selection process selected a model with no trend and a seasonal component that was additive for UK and Germany and multiplicative for France.
Open Market Rates (3 Month Bills)	M	UK GERMANY FRANCE	Market rate data was available in both seasonally unadjusted and seasonally adjusted (by NBER) formats. Where the seasonally unadjusted data was utilised it was deseasonalised using the ESMOOTH facility in RATS. The exponential smoothing model selection process selected a model with no trend and a seasonal component for all 3 countries that was additive.
Long Term Bond Yield	M	UK GERMANY FRANCE	Data for this variable was available in seasonally adjusted and unadjusted form for UK , seasonally unadjusted format for Germany and data was not directly available for France for the whole sample period. A data series had to be created for France by calculating Rentes yields from 3% Rentes price data. The seasonally unadjusted series were utilised and deseasonalised using the ESMOOTH facility in RATS. The exponential smoothing model selection process selected a model with no trend and a seasonal component that was multiplicative for UK and France and a model with a linear trend and an additive seasonal component for Germany.
Spot Exchange Rates	M	UK GERMANY FRANCE	Spot exchange rate data was only available in seasonally unadjusted format for London ,Paris and Berlin , with the exception of the data series for the Berlin rate for the Mark per 100 Francs. In the majority of the work carried out the London rates for the M:£ and the Fr:£ were used along with the Berlin rate for the M:100Fr.
Note Circulation	M	UK GERMANY FRANCE	Only seasonally unadjusted data series were available for this variable for all 3 countries. These data series were deseasonalised using the ESMOOTH facility in RATS. The exponential smoothing model selection process selected a model with an exponential trend for Germany and France and no trend for the UK. The seasonal component was multiplicative for all 3 countries.

Gold Reserves	M	UK GERMANY FRANCE	Only seasonally unadjusted data was available for this variable for all 3 countries. The data was deseasonalised using the ESMOOTH facility in RATS . The exponential smoothing model selection process selected a model with no trend for Germany and the UK , linear trend for France and with an additive seasonal component for all 3 countries.
Wholesale Prices	M	UK GERMANY FRANCE	Data for this variable was not available for any of the study countries for the whole sample period . This necessitated the creation of a wholesale price data series interpolated from other related data series that were available on a monthly basis for the whole or majority of the sample period . In the case of the UK data was unavailable for the period 1880-1884. An interpolated price series was created by regressing the annual wholesale price index on a constant , annual export prices , a time trend and a squared time trend . The coefficient estimates from this regression were then used to calculate a monthly wholesale price index from monthly export price data. For Germany there was no wholesale price data available for the period December 1902 to December 1906. To fill this data gap a wholesale price index was created by regressing the annual wholesale price index on a constant , annual coal prices , a time trend and a squared time trend . Again the coefficient estimates from this regression were used to calculate a monthly wholesale price index from monthly coal price data. In France's case there was no monthly wholesale price index available for the period 1880-1900 . The most comprehensive price data series available was that for wheat prices which was available for the period 1892-1913. The annual wholesale price index was therefore regressed on a constant , annual wheat prices , a time trend and a squared time trend . The coefficient estimates from this regression were then used to create a monthly wholesale price index for the period 1892-1913.
Industrial Production	M	UK GERMANY FRANCE	Industrial production indices were not available on a monthly basis for the whole of the sample period for any of the study countries . Monthly indices had therefore to be interpolated from related data series using similar techniques to those employed in creating monthly wholesale price indices. For the UK a monthly index was interpolated by regressing annual industrial production on a constant , annual railway receipts , a time trend and a squared time trend. Germany's monthly index was interpolated by regressing annual industrial production on a constant , annual pig iron output , a time trend and a squared time trend to produce a monthly index for the period May 1881 to 1913. In the case of France its monthly index was created by regressing annual industrial production on a constant , annual exports of manufactured goods , a time trend and a squared time trend.