NBER WORKING PAPER SERIES

THE INTER-WAR GOLD EXCHANGE STANDARD: CREDIBILITY AND MONETARY INDEPENDENCE

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Working Paper 8429
http://www.nber.org/papers/w8429

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
August 2001

The authors are grateful to an anonymous referee for helpful comments on an earlier draft of the paper and to the ESRC for financial support under grant L120251023. The views expressed herein are those of the authors and not necessarily those of the National Bureau of Economic Research.

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JEL No. F31, G15, N23

ABSTRACT

In this paper we analyze the operation of the inter-war gold exchange standard to see if the evident credibility of the system conferred on participating central banks the ability to pursue independent monetary policies. To answer this question we econometrically analyze two key parity, or arbitrage, conditions, namely uncovered interest rate parity and a yield gap relationship. We find that there were both long- and short-run deviations from the arbitrage conditions. The use to which this policy independence was put is analyzed in the context of a multivariate system, which includes reaction function variables.

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1. Introduction

A number of papers have demonstrated that the Classical gold standard regime represented a highly credible system, despite the fact that participating countries often did not play by the so-called rules of the game (see, for example, Hallwood, MacDonald and Marsh (1997a) and Officer (1997)). The reconciliation of these two apparently conflicting aspects (see Bordo and MacDonald (1997)) appears to lie in the fact that currencies participating in the Classical system were highly credible (in the sense of obeying the predictions of a target zone system (Svennson (1994)) and this allowed them limited scope to deviate from strict adherence to gold standard rules. In contrast, certain key characteristics of the inter-war gold exchange standard would lead one to expect this system to have little credibility and therefore not offer participating countries the freedom to adopt measures which were at variance with the rules of the game. Three key factors may be cited in this regard.

First, the inter-war gold standard had evolved into a gold exchange standard in which member countries held their reserves in gold bullion and (with the exception of the reserve center countries the UK and US and later France) in foreign exchange. This increase in the ratio of central bank liabilities to the gold base increased the fragility of the international monetary system. It also reduced the disciplinary power of gold movements since it increased the possibility of sterilization operations.

Second, the inter-war gold standard was perceived to be subject to a serious gold shortage. This reflected the fall in the real price of gold consequent upon massive worldwide inflation during World War I. The deflation which occurred in the U.S., U.K. and other countries in the early 1920's, was believed not to have been sufficient to restore the real price of gold to the prewar level, hence setting into play deflationary pressure (see Bordo and Eichengreen (1998)).

Third, the inter-war gold exchange standard suffered from a serious maldistribution of gold between debtor and creditor nations. This reflected the Banque de France's pro-gold policies after restoring convertibility in 1926 at an undervalued parity and persistent sterilization of gold inflows by the Federal Reserve.

Finally, in the classical period sterling had played a pivotal role in ensuring that the system worked smoothly by continually altering Bank rate to maintain convertibility. This required that the Bank hold, or have easy access to, sufficient gold reserves. In the inter-war, the U.K., which many observers believe returned to gold parity at an overvalued rate, suffered a persistent balance of payment deficit and a chronic shortage of gold reserves. Sterling's perennial weakness created further tension in the system.

Despite the apparent failings of the inter-war gold standard there is evidence to suggest that it also appeared to be a highly credible system at least up to 1936 when the system began to unravel (Hallwood, MacDonald and Marsh (1997a)).

The purpose of the present paper is to re-examine the inter-war gold standard with the objective of trying to reconcile the apparent credibility of the system, as found in a number of econometric studies, with its very evident failings. Our objective is not to explain the ultimate collapse of the inter- war gold exchange standard (see Eichengreen (1992) and Hallwood, MacDonald and Marsh (1997b)), but rather we focus on the fact that the inter-war system was much more actively managed than the prewar gold standard and this may be sufficient to reconcile the apparently conflicting pieces of information on how the system operated.

Our approach essentially extends the testing framework of Bordo and MacDonald (1997), where the policy independence afforded to central banks operating in a credible system, namely the Classical gold standard, was examined using two key arbitrage conditions. In our previous work we demonstrated that this credibility could have conferred on central banks the ability to pursue independent monetary policies. The emphasis on the word 'could' is designed to stress the fact that before World War I, central banks used their policy tools to influence domestic goals in an episodic manner without guiding principles or well specified objectives. After the war the degree and nature of economic management changed and, in particular, monetary policy became more systematic and was increasingly based on guiding principles. Thus domestic economic stability and objectives other than gold convertibility became specific arguments in a central bank reaction function. The purpose in the present paper is to show not only the possibilities for monetary independence in a credible target zone, but also how central banks used this credibility to adopt independent monetary policies.

The outline of the remainder of the paper is as follows. In the next section we present an historical perspective on the characteristics and operation of the inter-war gold standard. In Section 3 we present our modeling framework which is in the spirit of the traditional reaction function literature, although it has some important distinguishing characteristics. Our econometric methods are presented in Section 4, and a discussion of the construction of the data set is contained in Section 5. The empirical results are presented in Section 6. The final section contains some conclusions.

2. Historical Background: Central Bank Policies and the Interwar Gold Exchange Standard

2.1 The Flaws of the Gold Exchange Standard

Before World War I, most countries of the world adhered to the classical gold standard with its commitment by monetary authorities to convertibility of their currencies at a fixed parity. The gold standard era was also characterized by limited central bank intervention in foreign exchange and money markets, and free mobility of capital. The adherence record and credibility of commitment to gold differed considerably between the clean records of the core countries of the U.K., France, Germany and the U.S. (as well as other Western European countries and British Dominions) on the one hand and peripheral countries on the other.

Even before 1900 a number of peripheral countries (colonial possessions, newly emerging countries such as Japan and Scandinavia) began to convert some of their gold reserves into interest earning assets denominated in sterling and in the other core country currencies (Lindert 1969, Bordo and Eichengreen 1998), so that on the eve of World War I, a gold exchange standard was emerging with foreign exchange reserves constituting about 20 per cent of global international reserves.

The gold standard dissolved during World War I as all major countries, with the exception of the United States, suspended gold convertibility *de facto,* if not *de jure*. The U.S. imposed an embargo on gold exports from 1917 to 1919. After the war, the U.K., and other countries, expressed a strong preference to return to gold at the original parity (Cunliffe 1918). The problem facing all the belligerents wishing to restore convertibility at the original parity, however, was the need to roll back their price levels from the heights that they had scaled during World War I. This proved impossible for Germany, France, Italy (and indeed for a number of other countries) in the face of a greatly altered political reality. Plans for reconstructing the international gold standard were laid at the Genoa Conference of 1922, where the Financial Commission, under British leadership, urged that the world return to a gold exchange standard under which member countries would make their currencies convertible into gold but to use foreign exchange - the currencies of key reserve countries, the U.K. and the US. - as a substitute for gold. The experts also encouraged members to restrict the use of gold as currency, thus establishing a gold bullion standard, and to cooperate when raising or lowering their discount rates to prevent competition for gold. The motivation to economize on gold was a belief that the world would suffer a severe gold shortage in coming decades.

The gold exchange standard was restored worldwide in the period 1924-27, on the basis of the recommendations of Genoa. Central bank statutes typically required a cover ratio for currencies of between 30 and 40 per cent, divided between gold and foreign exchange. Central reserve countries (the U.S. and U.K.) were to hold reserves only in the form of gold.

Germany stabilized its currency following a massive hyperinflation and returned to gold parity at a greatly devalued parity in 1924; Sweden also returned to gold that year. The key event which restored the system was the U.K.'s return to its original gold parity on April 28, 1925. It is widely believed that sterling returned to gold at an overvalued rate of between 5 and 15 per cent depending on the price index used (Keynes 1925, Redmond 1984). The UK was quickly followed by the British Commonwealth and other nations so that by the end of 1928, 35 countries had their currencies officially convertible into gold. Restoration was virtually completed when

France declared de facto convertibility (at a parity which depreciated the franc by 80 per cent) in July 1926. De jure French convertibility occurred in June 1928.

The global gold exchange standard lasted until the UK abandoned it in September 1931. During its six years of existence it suffered serious strains which, it is argued, contributed to the Great Depression. The two strains which have been discussed most in the literature were a systemic disequilibrium and the maldistribution of gold reserves. Many prominent contemporaries (Cassel 1928, Rist 1961) argued that the gold standard was restored at a vastly undervalued real price of gold, since prices after World War I were about 35 to 40 per cent above their pre war level.[2] This gold shortage would either lead to secular deflation or, as foreign exchange reserves were substituted for scarce gold reserves, to the risk of a confidence crisis as external holdings of reserve country liabilities increased relative to their gold reserves (Mylnarski 1929).

The maldistribution of gold reflected two causes: inappropriate parities at the outset of restoration of the gold standard; inappropriate policies by the monetary authorities of key members.

The Gold Exchange standard was established based on incorrect parities. The United Kingdom restored convertibility at an overvalued parity. Consequently she suffered a competitive disadvantage with her trading partners and a chronic balance of payments deficit which forced the Bank of England to continuously follow contradictory monetary policies to maintain gold convertibility. The U.K.'s weak position threatened the stability of one of the key reserve countries and hence the

[2]For arguments and evidence that there was sufficient liquidity in the 1920's to finance the growth of world output and trade see Bordo and Eichengreen (1997). For a recent interpretation of the gold shortage view see Johnson (1998).

system itself. At the same time France restored gold at a vastly overvalued parity. Hence she ran persistent balance of payments surpluses and gold inflows.

This maladjustment involving two key members was greatly aggravated by inappropriate monetary policies pursued by France and the United States. Each nation as well as other countries (Nurkse 1994)[3], consistently sterilized gold inflows which reduced gold reserves available to the rest of the world and enhanced deflationary pressure.

France, following restoration of de jure convertibility in June 1928 and a new central bank law which required the Banque de France to hold a 35 per cent gold reserve ratio on all sight liabilities, and which prevented it from conducting open market operations except under very limited circumstances, began following a pro-gold policy of systematically converting the foreign exchange it had accumulated, following successful stabilization in 1926, into gold. The policy also implied that France's accumulating gold reserves did not lead to proportionate changes in the money supply (Eichengreen 1990, Chapter 5). Indeed, French sterilization policy prevented the normal operation of the gold standard price-specie-flow mechanism (Meltzer 1997, Ch.4).

At the same time as France was absorbing gold from the rest of the world, so was the United States, the world's largest gold holder. The Federal Reserve systematically sterilized gold inflows throughout the 1920s and 30s (Friedman and Schwartz 1963). Consequently the shares of the U.S. and France in the world monetary gold stock increased from 1928 to 1931. Inappropriate international

[3]For example, the German Reichsbank which followed policies to accumulate gold and rebuild the reserve position following the German hyperinflation.

monetary policies by France and the U.S. imposed deflationary pressure on the rest of the world, exacerbating the systemic strains of the gold exchange standard alluded to above. These two fundamental sources of strain were compounded by two other problems. The first was a decline in credibility of the gold standard members compared to that prevailing before World War I. This reflected a change in political fundamentals including the rise of democracy and universal suffrage and the growing power of organized labor. These forces weakened the resolve of monetary authorities to attach primary importance to gold convertibility above domestic policy concerns. Consequently short-term capital flows were no longer stabilizing (Eichengreen 1992).

The second problem was the existence of two competing reserve currencies, sterling and the dollar, that were close substitutes for one another. This heightened the system's fragility by providing easy opportunities for shifting between them.

The gold exchange standard collapsed in the face of the shocks of the Great Depression. Tight monetary policy by the Federal Reserve in 1928 to deflate the stock market boom and France's pro-gold policies precipitated a downturn in the U.S. and the rest of the world in 1929. Subsequent monetary collapse in the U.S. following a series of banking panics transmitted deflationary and contractionary pressures to the rest of the world on the gold standard.

As soon as doubts began to surface about the stability of the reserve currencies, central banks scrambled to liquidate their exchange reserves and replace them with gold. The share of foreign exchange in global central bank reserves plummeted from 37 per cent at the end of 1930 to 13 per cent at the end of 1931 and 11 per cent at the end of 1932 (Nurkse, 1944, Appendix II). The implosion of the foreign-exchange component of the global reserve base exerted strong deflationary pressure on the world economy. Although there was only so much gold to go around, central banks around the world wanted more. To attract it they jacked up interest rates in the face of an unprecedented slump.

2.2 The Role of Central Bank Policies

Within this background of a flawed and strained international monetary system, central bank policy played a big role. As under the prewar gold standard central banks were supposed to follow the 'rules of the game', that is to maintain their fundamental goal of gold convertibility. They were supposed to use their policy tools to speed up adjustments to balance of payments disequilibria. Considerable empirical evidence for the prewar gold standard suggests that most central banks violated the 'rules of the game' in the sense that they did not allow gold flows to influence the domestic money supply (i.e. they engaged in sterilization), and that on occasion they geared their policy tools to domestic economic goals (see Bordo and MacDonald 1997 for a survey of the evidence). Yet the violations were never serious enough to force countries to abandon convertibility. This, it is argued, may be explained by the basic credibility of the prewar gold standard which allowed monetary authorities in the short-run to pursue domestic objectives without inducing capital flight.

In the inter-war regime, faced with a changed and less credible environment, one would expect violations of the rules to be more serious than before World War I. Factors that would suggest that monetary authorities would attach a greater role to goals other than maintaining gold convertibility include: the rising power of organized labor and the movement towards universal suffrage which would force central banks to be concerned over the employment and output consequences of tight monetary policy used to prevent gold outflows (Eichengreen 1992, Simmons 1994); and improved understanding, following advances in economic theory, of the impact of monetary policy on the real economy (Eichengreen 1992). The changed environment would both alter the weights monetary authorities attach to convertibility versus domestic objectives and the credibility that the markets would attach to successful adherence to gold.

The evidence suggests that violations of the rules were at least as serious if not more so, in the inter-war as they were under the gold standard. According to Nurkse's (1944 page 69) famous sign test, the correlations between domestic credit expansion and changes in international reserves were negative 60% of the time for 26 countries from 1922 to 1938.[4]

For the individual core countries in the inter-war period there is important evidence from econometric studies that monetary authorities attached considerable weight to domestic variables in reaction functions and that they engaged in sterilization.

For the U.K., Eichengreen, Grossman and Watson (1985) found that the Bank of England did adjust the discount rate to abnormal increases in unemployment. It also followed an asymmetric policy of raising its discount rate upon losing reserves but not lowering it when gaining reserves. In the case of France, Eichengreen (1990) demonstrates that the Banque de France, constrained by its Central Bank Law of 1928 from following expansionary open market policies, consistently pursued a pro gold policy of sterilizing gold inflows and converting its foreign exchange holdings into gold. For the U.S. Wheelock's (1991, chapter 2) estimation of reaction functions for

[4] These results are quite similar to those found by Bloomfield (1959) for the classical gold standard period 1880-1914 for a smaller sample of countries. The evidence for the individual core

the Federal Reserves policy tools (open market operations and the discount rate) showed that considerable weight was attached to domestic economic stability. The Fed like the Banque de France also systematically sterilized gold inflows. The German Reichsheck, in contrast to the Fed and the Bank of England attached very little weight to domestic objectives in its reaction function from 1924-1931 (Eschweiler and Bordo 1994), but like the Banque de France and the Fed it did follow a pro gold sterilization policy and violated 'the rules of the game'.

Was this experience of persistent violations of the 'rules' sufficient to threaten the stability of the international monetary system, or like the pre-war gold standard did the system possess sufficient credibility to allow the monetary authorities the leeway to pursue domestic goals? In what follows we attempt to provide an answer to this question.

3. Motivation and Modeling Framework.

Since a central component of our work concerns credibility issues, we adopt a target zone framework as our *modus operandi*. In particular, we follow the testing methods of Bordo and MacDonald (1997) who proposed using two key parity conditions to examine the potential for independent monetary in the Classical gold standard period. More specifically, this involves sequentially testing a simple interest parity equation for short term interest rates, an interest parity equation augmented by a term structure relationship, and a system consisting of short and long interest rates and a vector of fundamentals, such as prices, output and gold reserves. In contrast to Bordo and MacDonald (1997), however, the structure of the latter system does not constrain the fundamental variables to have their influence solely through the short-

countries however for the prewar gold standard is mixed on violations of the rules (see Bordo and run dynamics. Rather, the reaction function perspective which we adopt means that the fundamentals feature directly in the long-run equilibrium relationships, and this is justified on the basis of our empirical results. Our approach may therefore be interpreted as in the spirit of the traditional reaction function literature, although it differs significantly from this literature in that we approach the issue from the perspective of a target zone modeling framework.

The starting point of our analysis is the condition of interest rate parity which, under rigidly fixed exchange rates, may be expressed as:

$$i_t = i_t^*, \tag{1}$$

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

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MacDonald (1997)) depending on the country, the methodology used, and the time period.

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 interest 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 maturity period defined for the interest rates.[5] 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:

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

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

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 appreciation relative to c; i.e. $\Delta x_{t+k}^e < 0$.

As Svensson (1994) emphasizes, 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 annualized expected appreciation of 4 per cent per year - a non-trivial number from a monetary policy perspective.

There are, however, important limitations to the extent of any independence. First, if the assumption that Δc_{t+k}^e, is zero is violated and, in particular, if it is endogenously related to Δx_{t+k}^e 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_{t+k}^e, moves in an equal and opposite fashion to Δx_{t+k}^e 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 inter-war 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 (1997a and b) and Officer (1997)). Second, the monetary independence can only be temporary since 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 stabilize 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 six inter-war 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. 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).[6] That is, in the context of an estimated version of equation (6)

$$i_t^s = \alpha + \beta i_t^{s,*} + \nu_t, \tag{6}$$

it would be expected that the error process, ν_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 (6)).

The expected change in the exchange rate within the band does not appear in the cointegrating relationship since on average over the full sample period it will have an expected value of zero. However, the non-zero expected exchange rate change will be captured in the short-run dynamic equations implied by (6). In particular, if the two interest rates defined in (6) are cointegrated then the Granger Representation theorem implies that a dynamic error correction representation of the following form must exist:

$$\Delta i_t^s = -\varphi(i_{t-1}^s - i_{t-1}^{s,*}) + \sum_{i=1}^{p} \kappa_i \Delta i_{t-i}^s + \sum_{i=1}^{p} \gamma_i \Delta i_{t-i}^{s,*} \tag{7}$$

$$\Delta i_t^{s,*} = +\varphi(i_{t-1}^s - i_{t-1}^{s,*}) + \sum_{i=1}^{p} \kappa_i^* \Delta i_{t-i}^s + \sum_{i=1}^{p} \gamma_i^* \Delta i_{t-i}^{s,*} \tag{7′}$$

where the first term on the right hand side of each equation represents the error correction mechanism (ECM) recovered from the cointegration tests on (6) (we have

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

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 adjust 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 (6) 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 behavior 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)):

$$i_t^l = (1-\delta)\sum_{j=0}^{\infty}\delta^j E_t i_{t+j}^s \qquad (8)$$

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

From (8) 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 (8) 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_t^s from both sides of (8) we may obtain:

$$i_t^l - i_t^s = \sum_{j=1}^{\infty} \delta^j E_t \Delta i_{t+j}^s \, . \qquad (8')$$

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

$$\Delta i_t^s = -\varphi(i_{t-1}^s - i_{t-1}^{s,*}) - \delta(i_{t-1}^l - i_{t-1}^s) + \sum_{i=1}^{p} \kappa_i \Delta i_{t-i}^s + \sum_{i=1}^{p} \gamma_i \Delta i_{t-i}^{s,*} + \sum_{i=1}^{p} \mu_i \Delta i_{t-i}^{l,} \, , \qquad (9)$$

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 examining the interrelationships represented in (9), 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 interest rates and some fundamentals which could potentially have been targeted by the authorities. In particular, if we can establish that there is some independence for short term interest rates we may ask: could this independence have been successfully exploited by the policy maker? For example, it is known that, compared to the Classical gold standard period, policy makers pursued much more pro-active macroeconomic policies in the inter-war period. We therefore consider the vector $z_t = [i_t^s, i_t^{s*} i_t^l, y_t, p_t, g_t]'$, where, of variables not previously defined, y_t denotes the logarithm of output, p_t denotes the logarithm of prices and g_t denotes the logarithm of gold reserves. In Bordo and MacDonald's analysis of the Classical gold standard period this vector was manipulated in such a way that only the interest rates enter the long-run equilibrium relationships (as in system 2), while the remaining variables were limited to having only a short-run impact through the dynamics. The justification for this follows on from the prediction of the Svensson model that since interest rates can only differ transitorally across financial centers they can only have a temporary role in absorbing shocks to, say, output or prices. As we shall see below, the empirical results for the inter-war period suggest that the fundamental variables should enter the long-run cointegrating set along with the interest rate terms. We return to this point in Section 6.

4. Econometric Methods.

In interpreting our relationships as equilibrium relationships it seems most natural to estimate them using a cointegration-based approach. Although there are a number of available methods, we propose using the estimator 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)), facilitates testing for the number of significant cointegrating vectors and implementing testable restrictions on the vectors. The latter features seem particularly attractive in the present context since, especially in terms of the largest system knowing how many equilibrium relationships there are and trying to interpret these is important. 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 representation of the form:

$$x_t = \eta + \sum_{i=1}^{p} \Pi_i x_{t-i} + \varepsilon_t \,, \qquad (10)$$

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 (10) may be reparameterised into the vector error correction mechanism (VECM) as:

$$\Delta x_t = \eta + \sum_{i=1}^{p-1} \Phi_i \Delta x_{t-1} - \Pi x_{t-1} + \varepsilon_t \,, \qquad (11)$$

where Δ denotes the first difference operator, Φ_i is an (n x n) coefficient matrix (equal to $-\sum_{j=i+1}^{p} \Pi_j$, Π is an (n x n) 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 Π=αβ′, 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 $\boldsymbol{x_t}$ using the Trace test proposed by Johansen. This statistic is a test of the hypothesis that there are at most r distinct cointegrating vectors:

$$TR = T \sum_{i=r+1}^{N} \ln(1-\hat{\lambda}_i), \qquad (12)$$

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)). Johansen shows that (12) has 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)).

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 response. 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 $\mathbf{x}_t$:

$$\mathbf{x}_t = \eta + \sum_{i=0}^{\infty} \Psi_i \varepsilon_{t-i}, \tag{14}$$

where of terms not previously defined, Ψ_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,

$$\mathbf{x}_t = \sum_{i=0}^{\infty} \theta_i \omega_{t-i} \tag{15}$$

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 factorization, 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 $i \rightarrow \infty$ and $\Sigma_x(h)$ converges to the covariance matrix of $\mathbf{x}_t$ as $h \rightarrow \infty$; 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 factorization.[7]

5. Econometric Results

Our econometric analysis relates to six country pairings, namely the UK against, France, Germany and the US, France relative to Germany and the US and, finally, Germany-US. The longest sample period is for the UK-US combination and runs from May 1925 through to August 1931. Other sample periods are defined in Table 1. The sample periods used in this paper may be deemed rather short for a study which exploits cointegration methods, which are generally thought to be most suited to long time spans of data.[8] However, Granger (1986) has argued that cointegration methods

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

[8] We are grateful to an anonymous referee for making this point.

can be applied to relatively short spans of high frequency data if the concept of equilibrium studied is relevant for such a sample period. Given our motivation in this paper, we believe that this is indeed the case. Furthermore, since cointegration methods have relatively low power to reject the null hypothesis of no cointegration in small samples, our findings (discussed below) of convincing evidence of cointegration for each interest rate pairing would seem to support our use of such methods.

For each of the countries we collected data on a money market short-term interest rates and a (country-specific) single long rate.[9] The non-interest rate data are industrial production, a consumer price index and gold reserves. All data were originally seasonally unadjusted and have been seasonally adjusted using the X11 filter. A complete listing of all variables and their sources is presented in the Data Appendix. As noted earlier, one key assumption underpinning our work concerns the credibility of the inter-war gold standard. Recent literature suggests that the gold exchange standard was credible until 1931 (see Hallwood, MacDonald and Marsh (1996a and b) and Officer (1996)). Therefore we do not test for credibility explicitly in this paper but build upon the earlier results.

Our estimates of the uncovered interest parity condition are presented in Table 1. The Akaike information criterion was used to determine the order of the lag length in the VAR, and the chosen lag length is reported in the second column of the Table. The standardized residuals from the VAR were checked for outliers and appropriate

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[9]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 available 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 short term interest differentials examined in this paper do not contain a significant time-varying risk premium thereby further enhancing their usefulness in the kinds of tests we undertake.

intervention dummies were incorporated to account for these. The dates of the different dummies are reported in the fourth column of the Table. The columns headed LM(1), LM(4) and Normality are portmanteau statistics for residual correlation and normality. In particular, LM(1 and 4) are multivariate Godfrey (1988) LM-type statistics for first and fourth order autocorrelation and NM(6) is a Doornik and Hansen (1994) multivariate normality test. Reported numbers are p-values and indicate, in general, an absence of serial correlation, although there is some evidence of non-normality in all of the systems (the latter seems to be a standard finding in these kinds of systems).

On the basis of the estimated Trace statistics, all of the systems reported in Table 1 produce evidence of one significant cointegrating vector using a 95% significance level. Normalising these significant vectors on the 'home' interest rate we find that the restriction that β=1 cannot be rejected for any of the interest rate pairings (these restrictions tests are reported in the column labeled χ^2, with marginal significance levels in brackets). This result is consistent with the findings of Bordo and MacDonald (1997) for the Classical Gold standard period. However, in contrast to the latter period we note that here all of the constant terms are statistically significant (the estimated coefficients are reported in the column labeled β_0, with standard errors in brackets). For example, the constant in the UK-US relationship is 0.38 suggesting that, on average, UK rates were above US rates by 38 basis points for this period.

The finding of significant constants could perhaps be taken as *prima facie* evidence that the system was non-credible since it implies that on average, over the sample, the domestic rate could differ from the foreign rate. However, if it is non-credibility driving the result this would conflict with the extant empirical tests which focus directly on the credibility of the system (see Hallwood, MacDonald and Marsh (1996a and b) and Officer (1996)). Such tests rely on constructing 95% confidence intervals using interest differentials and the deviation of the exchange rate from the center point of the band. However, in a period, such as the inter-war period, when it was known that central banks were targeting interest rates these 95% intervals may not truly be reflecting the credibility of the system. So it may be that the inter-war system was credible, up to a constant term, and that this credibility was exploited by central banks to pursue the kinds of objectives referred to earlier. Alternatively, the system was non-credible and this was reflected in a constant risk premium. However, the existence of the latter could again have allowed the monetary authorities some leeway in the operation of monetary policy, although this would, of course, be inconsistent with credibility. Given that the independent credibility tests for this period are so clear-cut (see Officer (1997) and Hallwood, MacDonald and Marsh (1997a)), we are inclined towards the view that these significant constants are consistent with a credible system. This is especially so since our sample period is shorter than that used to construct the credibility tests (our sample periods are constrained by the availability of the fundamental series). Indeed, had we had access to a similar number of observations as available for the classical gold standard, the significance of the constants would in all probability have disappeared as, say, a positive constant for one sub-period would eventually have been offset by a negative constant and so on.

As noted in Section 2, the key element in the independence conferred by a target zone relates to the non-zero expected change in the exchange rate in the short-run. A feel for how important this was may be gleaned from the adjustment coefficients – the α's – and the implied half-lives. These are reported in Table 1 in the labeled columns. The results for UK-France and France-Germany are very fast (adjustment is complete in approximately, 4 and 7 months, respectively), while those for UK-Germany and France-Germany are slower, suggesting policy independence of this form of around 4 years. The two remaining systems, France-US and Germany-US are slowest and would seem to be too slow to be consistent with the basic model. However, again this may be a sampling problem. We know, for example, from the recent PPP literature that half-lives are dramatically affected by the sample period (see Rogoff (1995) and MacDonald (1995)). For example, using only data from the recent floating period there is essentially no mean reversion in real exchange rates. However, when around a hundred years of data are used the half-life is a much more reasonable 4 years. Our half-life results, therefore, seem to underscore the conclusion reached above that the inter-war gold standard regime behaved very differently to the Classical system, and this reinforces the point that we made regarding the significant constant terms. We now turn to our trivariate systems to gain a further perspective on these results.

In Table 2 we present our results from estimating system (10), that is, the trivariate systems with two short rates and a single long interest rate. The same intervention dummies used in the bivariate systems are used for the comparable trivariate systems. In each system we find, as expected, two significant cointegrating vectors, although in some instances the second vector is only marginally significant. Furthermore, we are able to interpret these vectors consistently as open interest parity and term structure relationships, and this is evidenced by the fact that the β and γ coefficients are both unity, and the restrictions tests that they are statistically indistinguishable from plus and minus one (reported in the column labeled χ^2) are all statistically insignificant. One particularly interesting feature of these results is that all but one of the systems passed the portmanteau normality test at the 1 per cent level or better. This contrasts with our findings for the simpler systems where non-normality was a persistent problem and suggests, perhaps, that the simplest system is incomplete.

We note again that the constant terms are statistically significant in the majority of open parity conditions in Table 2. Furthermore, in three systems there is evidence that the constant is significant in the yield gap expressions, thereby implying that the pure form of the expectations hypothesis does not hold. These results therefore confirm that in the inter-war period there was a 'long-run' wedge separating short rates across financial centers.

In Figure 1, we present the impulse responses of the home short rates from the various systems reported in Table 2 to, respectively, a standardized one per cent shock in the UK long rate (part a.) and the 'foreign' short rate (part b.). These impulses are designed to capture the dynamic interactions between the short interest rates across countries and the short and long rates within countries, subject to the long-run constraints given in Table 2. The ordering of the variables used for the Choleski decomposition is noted at the top of the figures and we believe this accords with economic intuition. Thus the foreign rate is the most exogenous and the home rate the least exogenous (we also experimented with systems which had the orderings of i^l and i^* reversed, but these produced very similar results and are therefore not reported here). In all cases bar one (iv, part a) these shocks produce an immediate increase in the short rate and in the majority of these the rise is significant. The magnitude of the shocks is similar across the countries. In the case of the UK-US system, for example, the increase in the US short rate produces an immediate 3 basis point increase in the UK short rate which rises to about 8 basis points after 3 months. Although the response is insignificantly different from zero after about 16 months there is still some significant persistence after 16 months. Other interest rate pairings tend to have a similar general profile, although the degree of significance varies. These dynamic profiles indicate that the credibility of the inter-war gold standard conferred on participating countries the ability to have interest rate dynamics which were deviant from those in the foreign country.

Our evidence so far seems to indicate two things. First there was a 'long-run' wedge separating interest rates across financial centers. Second there were different adjustment speeds towards these wedge-adjusted equilibria, with adjustment being fastest for UK-France and France-Germany and slowest for France-US and Germany-US. We interpret the significant wedges as reflecting the fact that in the inter-war period monetary policy became more systematic and was increasingly based on guiding principles. However, it is our contention that it was the credibility bestowed on central banks by participating in the gold standard which facilitated the independence of monetary policies during the period. Our third system is designed to shed further light on the independence of monetary policy during the period by explicitly introducing the kinds of variables likely to be the target of monetary policy.

As noted in Section 3, our third system is defined by the vector:

$$z_t = [i_t^s, i_t^{s*} i_t^l, y_t, p_t, g_t]'$$

The results from systems 1 and 2 suggest that there was a 'long-run' wedge between interest rates in different financial centers for our sample period. It is therefore possible that the authorities could have exploited this wedge in order to pursue standard counter-cyclical objectives which differed, on average, from their partners over the sample period. Therefore, in contrast to Bordo and MacDonald (1987) the fundamental variables here enter the long-run relationship, rather than being restricted solely to having a short-run influence. Our estimates are therefore more in the spirit of the traditional reaction function literature, discussed in section 2. However, in contrast to much of that literature the econometric framework here explicitly recognises both the potential non-stationarity of the variables and also any long-run cointegrating relationships. As we demonstrated, in the system with three interest rates there may be up to two cointegrating relationships, comprising the two interest rate parity conditions. However, since system 3 has an additional three variables, each of which is potentially non-stationary, there may be up to two more cointegrating vectors in this more general system.

The rank of each system 3 is reported in Table 3. It is clear that the addition of the extra fundamental variables has changed the long-run properties, since there are now either three or four significant vectors, depending on the particular country combination. The existence of multiple cointegrating vectors in any system can prove problematic in the sense that it is unclear which vector, say, represents the intervention function. Often in such a situation a researcher will simply focus on the first eigenvector, or the one which has coefficients which correspond most closely with a given set of priors. Here, however, we attempt to interpret all of the vectors using the structure we have already introduced. In particular, our general system contains the two short rates and long rate refereed to above and, additionally, the variables relating to intervention. As in the trivariate systems we interpret the first two vectors as the open interest parity relationship and the term structure relationship, respectively, while any other significant vectors are interpreted as relating to intervention. More formally, and following Johansen and Juselius (1994), we attempted to estimated fully specified systems of the form $\beta = \{H\phi_1, H\phi_2, H\phi_3, H\phi_4\}$ (for a four vector system). We consider the results for the UK-French system for illustrative purposes.

In the UK-French system, reported in Table 3a, we have, in addition to the two parity conditions, a long-run relationship between the short rate, output and gold, and a further relationship between the short rate, prices and output. The signs on these variables seem correct in terms of a standard macro-model: output is positively associated with the interest rate in both cases and gold and the price level are negatively related. We note that all of the freely estimated coefficients are statistically significant in terms of the reported standard errors. Note that the restrictions imposed on the cointegrating space of the UK-France system are accepted at the 5 per cent level. Other systems may be interpreted in a similar way, although the fact that the data generating processes differ across countries means that the form of the restricted vectors are not always the same and, indeed, when they are the same wrongly signed coefficients sometimes appear. However, across all of the systems the vast majority of coefficients are plausibly signed and significant and also the restrictions go through at the 1 per cent level or better in each case. We interpret the finding that the fundamentals are significant in the long-run relationships as consistent with our finding of significant constant terms in the interest rate systems. Having established the existence of sensible long-run relationships for each of our system 3 combinations we now use an impulse response analysis to gauge the interactions of the variables.

In figures 2 to 7 we report the impulse responses for our complete systems. These figures show the response of the home short rate, the rate assumed to be the target rate of the home central bank, to standardized one per cent shocks of all the other variables. Consider first the UK-French system. The profiles of the UK short rate in response to the French short rate and the UK long rate are similar to those contained in system 2. For example, the UK short rate rises by 30 basis points in response to a shock to the French rate and then oscillates between positive and negative values, becoming insignificantly different from zero by around 20 months. The initial response of the short rate to the long rate is negative here (although insignificant), but the dynamic profile of the rate is very similar to that for system 2, returning to zero after 20 months. The UK short rate clearly also has a shock absorber role with respect to the three 'fundamental', or reaction function, variables. For example, its participation in a target zone system allows the UK rate to accommodate a positive income shock by having its short-term rate below the corresponding short term French rate. It takes approximately 30 months for the UK short rate to return to the non interest rate fundamentals.

The impression of domestic interest rates acting as a shock absorber with respect to changes in fundamentals is confirmed in the other systems contained in Figures 3 to 7. For example, in the two other pairings containing the French short rate (Figures 5 and 6) adjustment of the home rate back to equilibrium occurs after about one year. In the case of the French-German system, there would appear to be more significant deviations of the home short rate than in the French-US system. In the two remaining pairings containing the UK short rate (Figures 3 and 4), adjustment back to equilibrium is approximately the same as in the UK-French system, namely about two years. Perhaps the greater ability of the UK rate to deviate from the foreign rate reflects the continuing importance of the UK as a financial center in the inter-war despite the transference of hegemony to to the US in long term lending (Bordo, Edelstein and Rockoff (1999) document the shift in the importance of the UK as a financial center, in the Classical gold standard period, to the US in the inter-war period). Again the shock absorber role of the UK short rate is evident .

7. Summary and Conclusion.

Recently a number of studies have indicated that, despite all its evident failings, the inter-war gold standard appeared to represent a highly credible fixed exchange rate regime. Svensson (1994) has argued that the existence of such a regime should confer on the participating countries some flexibility in the use of their monetary policy. In particular, they should be able to exploit the credibility to pursue objectives like interest rate smoothing and some (albeit limited) counter-cyclical policies. In this paper we have attempted to quantify econometrically the extent to which countries could engage in interest rate policies which were at variance with their partners. Our approach involved exploiting an uncovered interest parity relationship and a simple term structure relationship between long and short interest rates. Although we confirm that the slope coefficient in a cointegrating regression of a domestic interest rate on its trading partner is insignificantly different from unity for all combinations, the included constant term is always significantly different from zero. This contrasts with the findings of Bordo and MacDonald (1997) for the Classical gold standard period, where such constants were always insignificant. Here we have argued that the existence of such significant constants does not necessarily conflict with the interpretation of the inter-war gold standard as a credible target zone regime, since it may simply be a function of the limited observations available. However, the existence of a significant wedge between interest rates implies that countries could, on average, have pursued interest rate policies which were at variance with those in their trading partners, and we believe that this is consistent with the fact that domestic economic stabilisation objectives became important arguments in central bank's reaction functions during the period.

To further gauge the extent of monetary independence for the inter-war gold exchange standard we jointly modeled the parity conditions with a set of fundamental variables suggested by the reaction function literature. In contrast to much of that literature, however, we explicitly recognize the non-stationary nature of these variables and model the levels relationships using cointegration methods, while the dynamic interactions are captured using dynamic vector error correction models. The cointegration results produced evidence of statistically significant long-run relationships over-and-above those contained in the parity conditions considered on their own. Additionally, the signs on the relationship between the interest rates and fundamentals seemed appealing from a theoretical perspective. The dynamic systems produced further evidence that short-term interest rates in the inter-war period could have been used to engage in independent monetary policies, either in terms of interest rates being able to move to absorb shocks to variables like output, gold reserves and prices, or by the authorities deliberately manipulating interest rates to influence these kind of variables. Our findings therefore reinforce those of Bordo and MacDonald (1997) who noted the importance of the institutional aspects of the gold standard regime in creating a credible international monetary system.

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Table 1: Cointegration tests of UIP.

$$i_t=\beta_0+\beta_1 i_t^*+\varepsilon_t$$

System	Lags	Sample	Dummies	β_0	β_1	Trace	χ^2	α	Half Life	LM(1)	LM(4)	Normality
UK-France	8	1927(8) to 1931	1927(11)	1.207 (0.11)	1.00 (0.00)	20.60 0.67	1.59 (0.21)	-0.26 (2.63)	2.3	3.13 (0.54)	3.52 (0.54)	32.76 (0.00)
UK-Germany	12	1926(2) to 1931(6)	1929(11) 1930(2) 1930(3)	1.814 (0.07)	1.00 (0.00)	26.89 0.52	1.18 (0.28)	-0.03 (0.33)	23	1.27 (0.87)	12.42 (0.01)	28.13 (0.00)
UK-US	12	1925(5) to 1931(8)	1929(11) 1930(2) 1930(3)	0.378 (0.16)	1.00 (0.00)	36.25 4.39	0.72 (0.40)	-0.03 (1.19)	23	2.75 (0.60)	0.41 (0.98)	33.68 (0.00)
France-Germany	12	1927(2) to 1931(6)	___	-3.265 (0.02)	1.00 (0.00)	59.93 16.56	4.96 (0.03)	-0.18 (6.43)	3.45	7.60 (0.11)	3.31 (0.51)	17.05 (0.00)
France-US	6	1927(2) to 1933(1)	1929(3) 1929(10)	-1.308 (0.00)	1.00 (0.28)	33.87 4.36	2.71 (0.10)	-0.006 (0.72)	69	3.63 (0.46)	2.18 (0.70)	71.22 (0.00)
Germany-US	12	1926(2) to 1931(6)	___	0.714 (0.14)	1.00 (0.00)	23.38 10.42	0.00 (0.99)	-0.01 (0.16)	69	3.51 (0.48)	13.195 (0.01)	10.63 (0.03)

Table Two. Cointegration Tests of UIP and Term Structure.

$$i_t=\alpha+\beta i^*_t+\gamma i_{L,t}+\varepsilon_t$$

System	Lags	Sample Period	Intervention Dummies	i_t	α	β	γ	χ^2	Trace	Autocorrelation Tests LM(1)	LM(4)	Normality
UK-France	8	1927(2)	1927(11)	1.000	1.203	1.000	0	0.00	36.63	3.550	7.812	4.712
Short Rates,		to			(0.092)			(0.97)	17.24	(0.94)	(0.55)	(0.58)
UK Long Rate.		1931(6)		0.156	3.837	0	1.000		6.28			
					(0.095)							
UK-Germany	8	1926(2)	1929(11)	1.000	-1.255	1.000	0	3.67	76.63	13.173	4.844	17.245
Short Rates,		to	1930(2)		(0.209)			(0.06)	18.22	(0.15)	(0.85)	(0.01)
UK Long Rate.		1931(4)	1930(3)	0.050	4.301	0	1.000		2.57			
				(0.004)	(0.017)							
UK-US	12	1925(5)	1928(12)	1.000	-0.533	1.000	0		52.28	13.553	11.766	10.062
Short Rates,		to	1929(3)		(0.179)				24.04	(0.14)	(0.23)	(0.12)
UK Long Rate.		1931(6)		0.150	3.890	0	1.000		3.57			
				(0.015)	(0.063)							
France-Germany	8	1927(2)		1.000	-0.525	1.000	0	0.03	47.06	20.492	6.209	13.599
Short Rates,		to			(0.532)			(0.86)	21.12	(0.02)	(0.72)	(0.03)
France Long Rate.		1931(6)		0.183	5.372	0	1.000		6.98			
				(0.191)	(0.710)							
France-US	8	1927(2)	1929(3)	1.000	-0.992	1.000	0	1.07	47.19	18.695	4.637	35.286
Short Rates,		to	1929(10)		(0.322)			(0.30)	21.38	(0.03)	(0.86)	(0.00)
France Long Rate.		1932(11)		0.347	3.073	0	1.000		8.27			
				(0.130)	(0.309)							
US-Germany	8	1926(2)		1.000	-0.783	1.000	0	6.86	47.36	5.574	11.414	17.505
Short Rates,		to			(0.293)			(0.01)	25.36	(0.78)	(0.25)	(0.01)
US Long Rate.		1931(6)		0.055	3.100	0	1.000		8.89			
				(0.013)	(0.070)							

Table 3a Long-run Estimates for System 3

System	Lags	Sample Period	Intervention Dummies	i_t	α	β	γ	δ	η	ϕ	$\chi^2_{(5)}$	Trace		Autocorrelation		Normality
													L-B	LM(1)	LM(4)	
UK - French	6	1927 (2)	1927 (11)	1.000	1.734	1.000	0	0	0	0	7.78	304.91	497.7	28.969	36.700	26.218
Short Rates,		to			(0.150)						(0.05)	187.63	(0.00)	(0.79)	(0.44)	(0.01)
UK Long		1931 (6)		-0.190	5.490	0	1.000	0	0	0		86.28				
Rate,				(0.002)	(0.030)							30.81				
UK				0	31.045	0	0	0	-7.853	2.149		12.51				
Fundamental					(0.949)				(0.186)	(0.050)		2.15				
				0	39.063	0	0	2.644	-9.042							
					(0.914)			(0.083)	(0.189)							
UK - German	6	1926(2)		1.000	-1.955	1.000	0	0	0	0	6.30	265.91	525.6	46.550	39.999	20.971
Short Rates,		to			(0.106)						(0.18)	156.33	(0.00)	(0.11)	(0.30)	(0.05)
UK Long		1931(4)		1.000	463.79	0	0	0	0	92.793		111.48				
Rate,					(17.375)					(3.450)		67.77				
UK				0.051	4.286	0	1.000	0	0	0		30.97				
Fundamental				(0.003)	(0.016)							11.23				
				1.000	-58.907	0	0	17.206	1.940	0						
					(4.518)			(1.198)	(0.232)							
UK - US	6	1925(5)		1.000	-0.481	1.000	0	0	0	0	11.19	147.04	559.4	49.774	19.580	7.990
Short Rates,		to			(0.318)						(0.08)	90.02	(0.00)	(0.06)	(0.99)	(0.79)
UK Long		1931(6)		1.017	0	0	1.000	0	0	0		58.59				
Rate,				(0.008)								36.87				
UK				1.000	0	0	0	0	0	0.891		17.98				
Fundamental										(0.008)		7.51				
				1.000	5.636	0	0	-0.301	-0.045	0						
					(0.353)			(0.091)	(0.022)							

Table 3b Long-Run estimates for System 3

System	Lags	Sample Period	Interventio n Dummies	i_t	α	β	γ	δ	η	ϕ	$\chi^2_{(5)}$	Trace	Autocorrelation			Normaliy
													L-B	LM(1)	LM(4)	
French -	4	1927(2)	1927(11)	1.000	17.050	1.000	0	0	0	0	6.77	186.52	418.6	47.026	25.539	44.300
German		to	1928(3)		(2.106)						(0.24)	114.86	(0.00)	(0.10)	(0.90)	(0.00)
Short Rates,		1931(4)	1928(6)	-0.083	19.263	0	1.000	0	0	0		58.68				
France Long				(0.125)	(1.591)							26.03				
Rate,				1.000	275.64	0	0	-56.093	2.175	4.039		7.30				
France					(25.107)			(3.986)	(2.056)	(0.427)		2.07				
Fundamental																
French - US	4	1927(2)	1928(6)	1.000	0.545	1.000	0	0	0	0	8.04	131.54	542.1	47.601	69.967	90.509
Short Rates,		to			(0.620)						(0.15)	84.60	(0.00)	(0.09)	(0.00)	(0.00)
French Long		1932(11)		0.490	3.011	0	1.000	0	0	0		56.77				
Rate,				(0.092)	(0.253)							29.49				
French				1.000	32.079	0	0	-12.818	10.505	0.062		6.80				
Fundamental					(6.960)			(1.593)	(0.875)	(0.078)		0.07				
US - German	2	1926(2)	1928(12)	1.000	-0.452	1.000	0	0	0	0	12.95	151.21	603.6	26.902	50.563	33.947
Short Rates,		to	1929(3)		(0.208)						(0.04)	92.40	(0.00)	(0.86)	(0.05)	(0.00)
US Long Rate		1931(4)		0.576	0	0	1.000	0	0	0		57.18				
US				(0.014)								30.69				
Fundamental				1.000	0	0	0	0	0	0.747		18.07				
										(0.019)		6.79				
				1.000	4.124	0	0	-0.501	1.079							
					(0.471)			(0.110)	(0.036)							

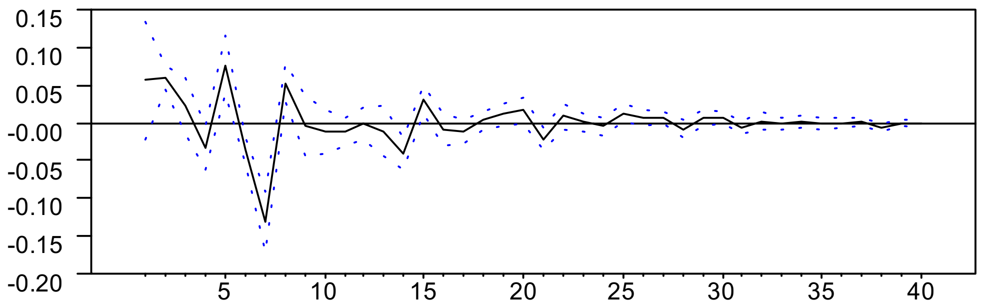
Figure 1

Impulse Responses for $i_t = \alpha + \beta i^*_t + \gamma i_{L,t} + \varepsilon_t$.

Ordering: i^*_t, $i_{L,t}$,i_t.

System 1. UK-France Short Rates, UK Long Rate.

(a.) Response of UK Short Rate to shock in UK Long Rate.



(b) Response of UK Short Rate to shock in French Short Rate.

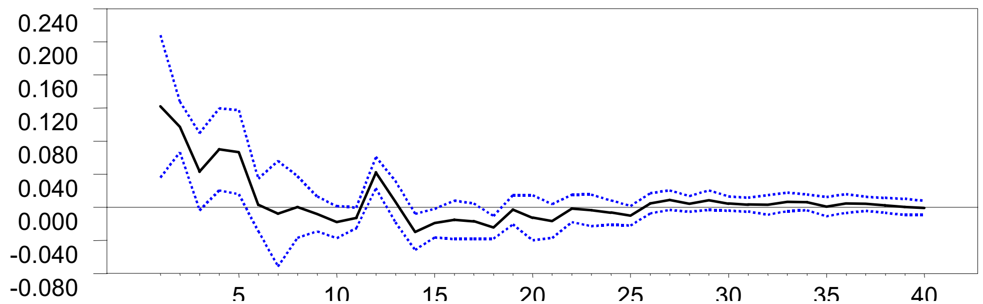
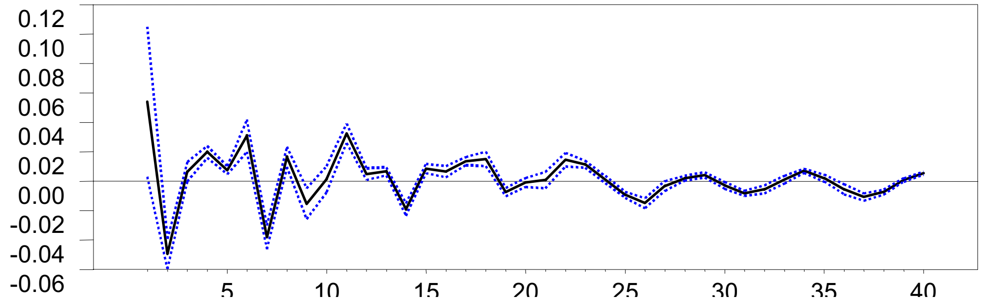


Figure 1 Contd.

System 2. UK-Germany Short Rates, UK Long Rate.

(a.) Response of UK Short Rate to shock in UK Long Rate.



(b) Response of UK Short Rate to shock in German Short Rate.

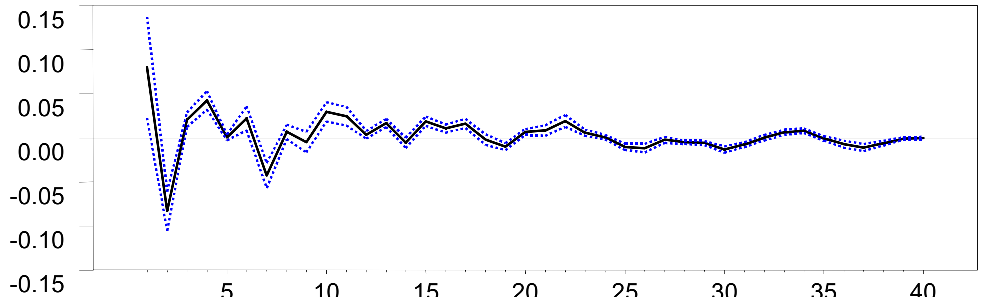
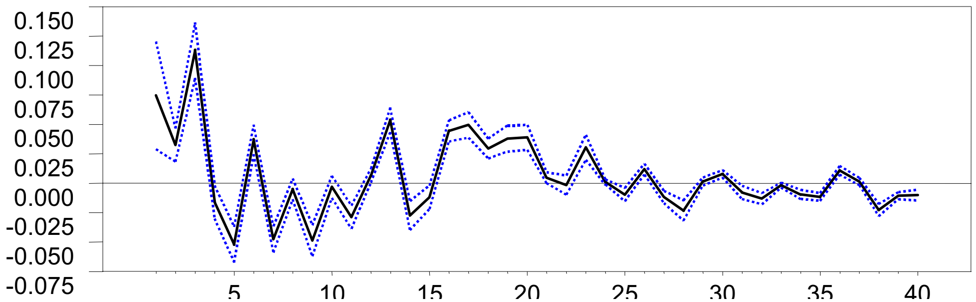


Figure 1 Contd.

System 3. UK-US Short Rates, UK Long Rate.

(a.) Response of UK Short Rate to shock in UK Long Rate



(b.) Response of UK Short Rate to shock in US Short Rate

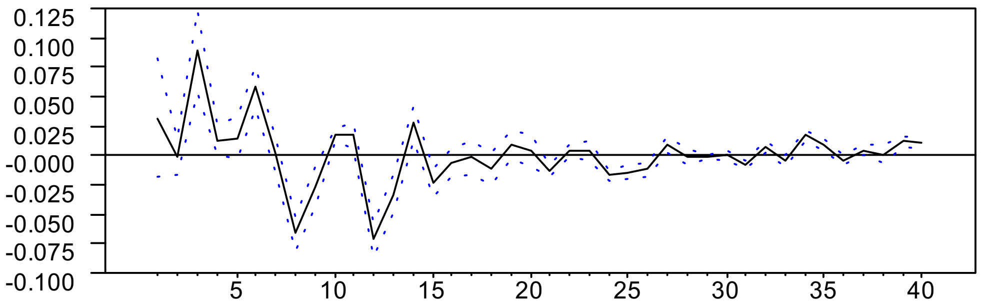
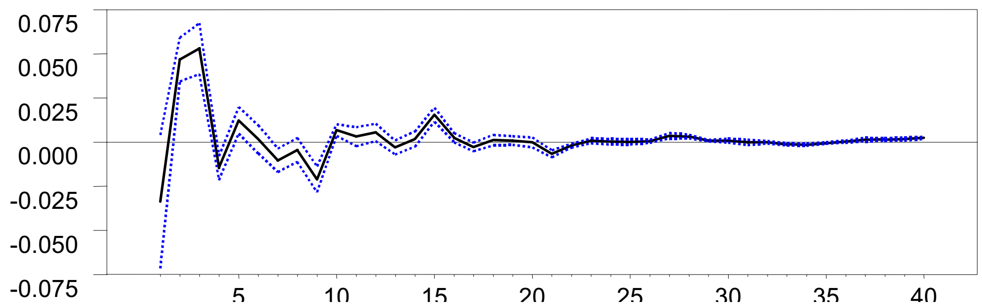


Figure 1 Contd.

System 4. France-Germany Short Rates, France Long Rate.

(a.) Response of French Short Rate to shock in French Long Rate



(b.) Response of French Short Rate to shock in German Long Rate

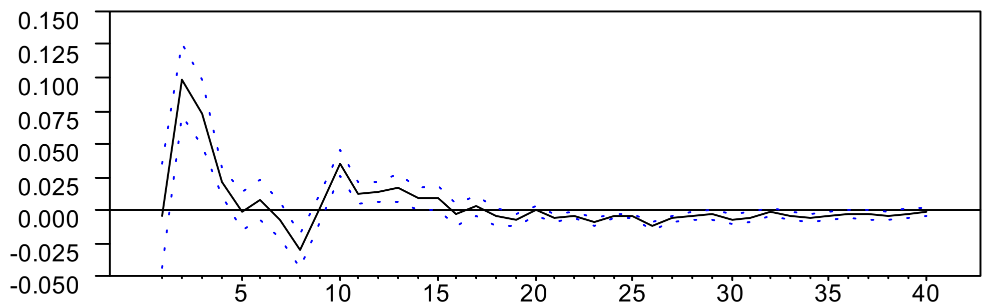
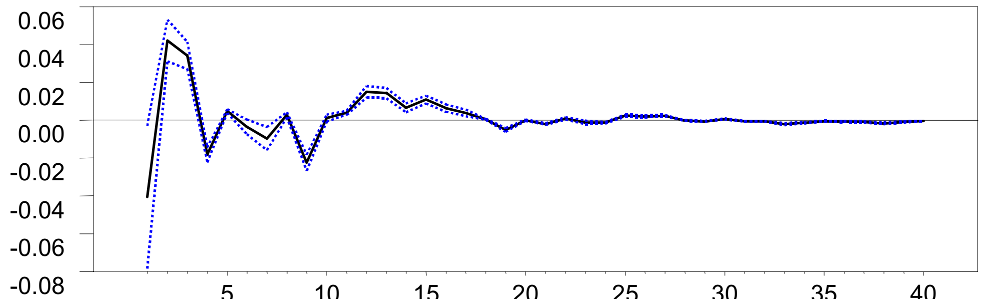


Figure 1 Contd.

System 5. France-US Short Rates, France Long Rate.

(a.) Response of French Short Rate to shock in French Long Rate



(b.) Response of French Short Rate to shock in US Short Rate

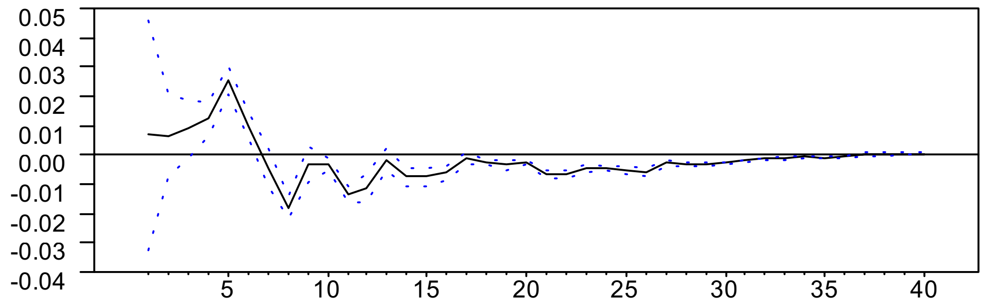
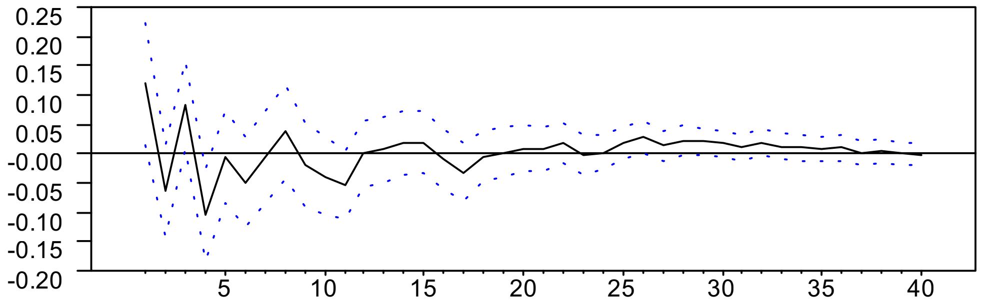


Figure 1 Contd.

System 6. US-German Short Rates, US Long Rate.

(a.) Response of US Short Rate to shock in US Long Rate



(b.) Response of US Short Rate to shock in German Short Rate

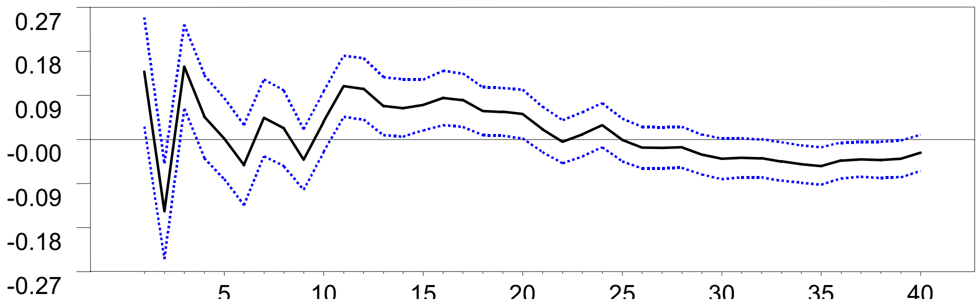


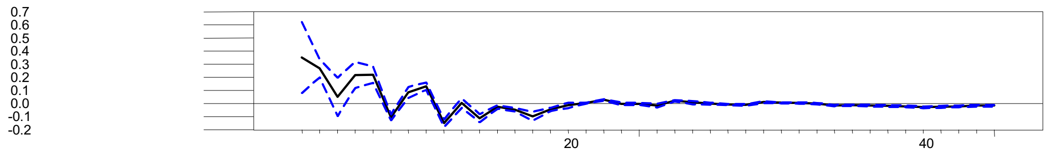
Figure 2

Impulse Responses for $i_t = \alpha + \beta\, i^*_t + \gamma\, i_{L,t} + \delta\, Prices_t + \eta\, Output_t + \phi\, Gold_t + \varepsilon_t$

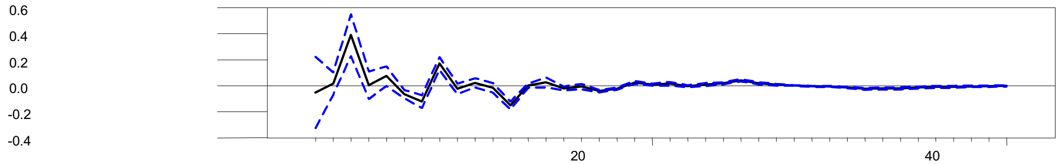
Ordering: Prices, Output, Gold Reserves, $i_{L,t}$, i^*_t, i_t.

UK-French Short Rates, UK Long Rate, UK Prices, Output and Gold Reserves.

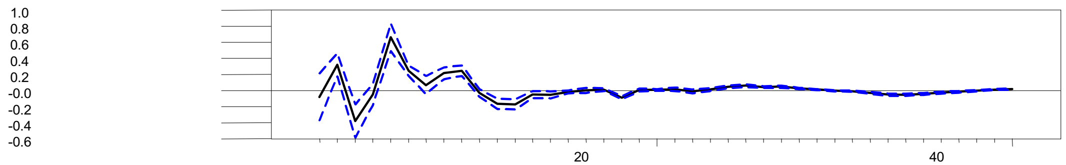
(a.) Response of UK Short Rate to Shock in French Short Rate.



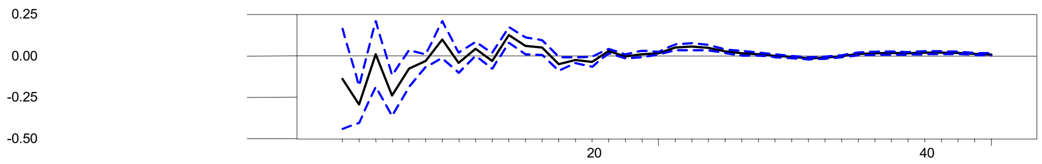
(b.) Response of UK Short Rate to Shock in UK Long Rate.



(c.) Response of UK Short Rate to Shock in UK Gold Reserves.



(d.) Response of UK Short Rate to Shock in UK Output.



(e.) Response of UK Short Rate to Shock in UK Prices.

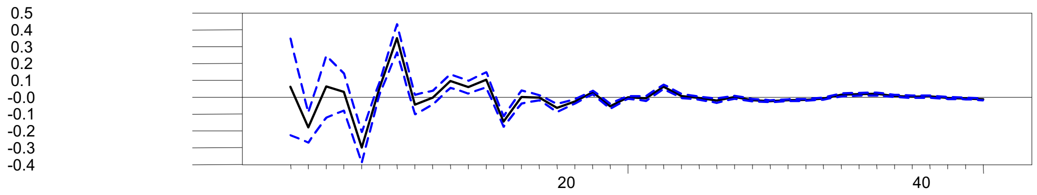


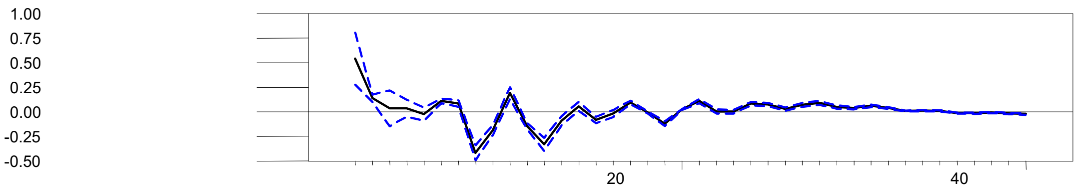
Figure 3

Impulse Responses for $\boldsymbol{i_t = \alpha + \beta i^*_t + \gamma i_{L,t} + \delta Prices_t + \eta Output_t + \phi Gold_t + \varepsilon_t}$

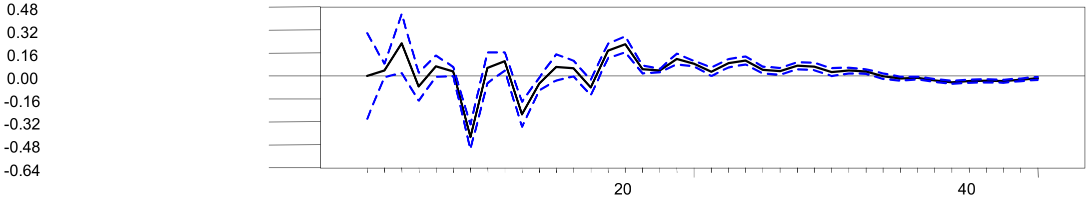
Ordering: Prices, Output, Gold Reserves, $i_{L,t}$, i^*_t, i_t.

UK-US Short Rates, UK Long Rate, UK Prices, Output and Gold Reserves.

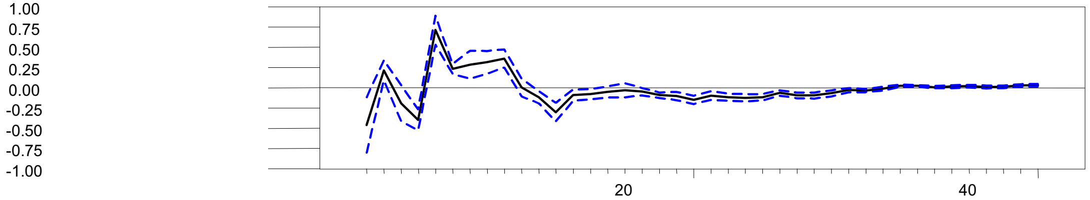
(b.) Response of UK Short Rate to Shock in US Short Rate.



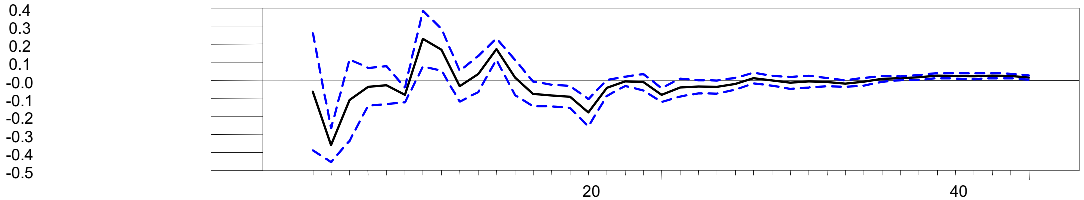
Response of UK Short Rate to Shock in UK Long Rate.



(c.) Response of UK Short Rate to Shock in UK Gold Reserves.



Response of UK Short Rate to Shock in UK Output.



Response of UK Short Rate to Shock in UK Prices.

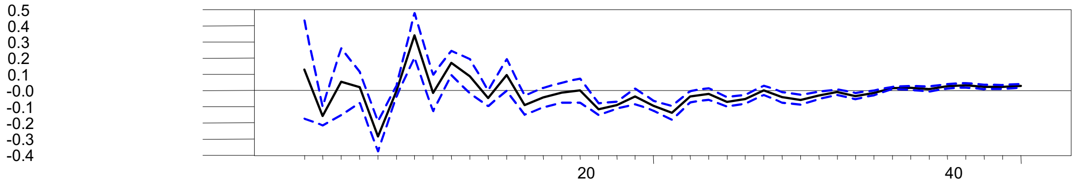


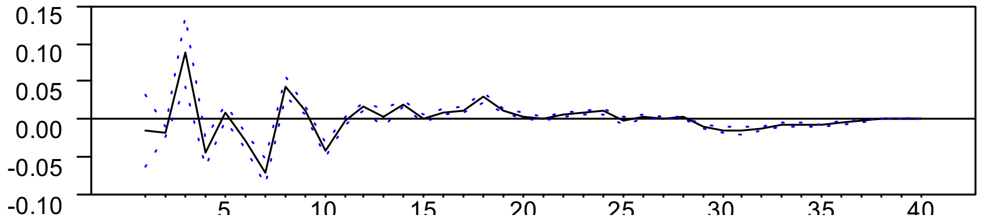
Figure 4

Impulse Responses for $i_t = \alpha + \beta\, i^*_t + \gamma\, i_{L,t} + \delta\, Prices_t + \eta\, Output_t + \phi\, Gold_t + \varepsilon_t$

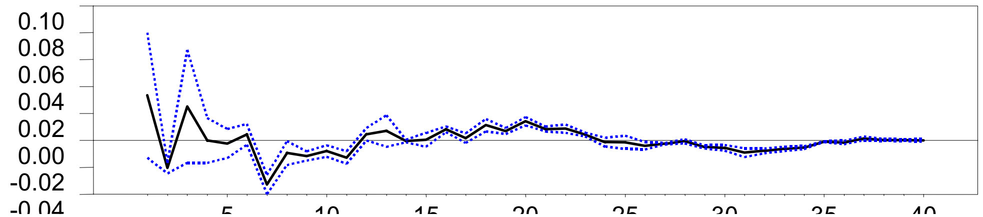
Ordering: Prices, Output, Gold Reserves, $i_{L,t}$, i^*_t, i_t.

UK-German Short Rates, UK Long Rate, UK Prices, Output and Gold Reserves.

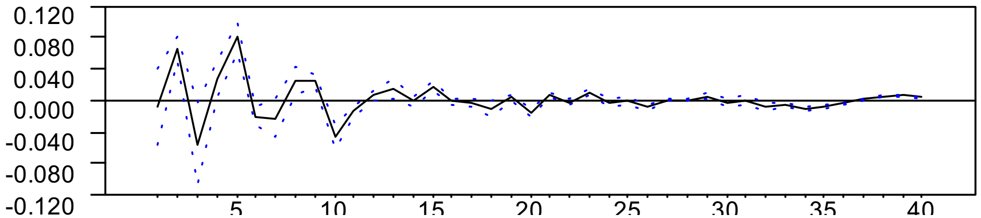
(a.) Response of UK Short Rate to Shock in German Short Rate.



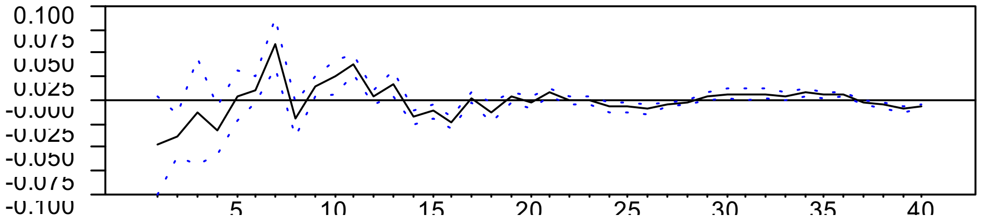
(b.) Response of UK Short Rate to Shock in UK Long Rate.



(c.) Response of UK Short Rate to Shock in UK Gold Reserves.



(d.) Response of UK Short Rate to Shock in UK Output.



(e.) Response of UK Short Rate to Shock in UK Prices.

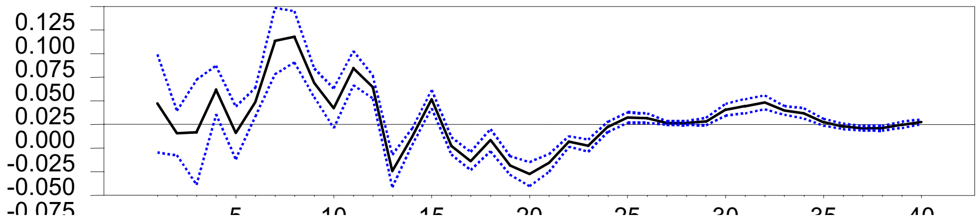
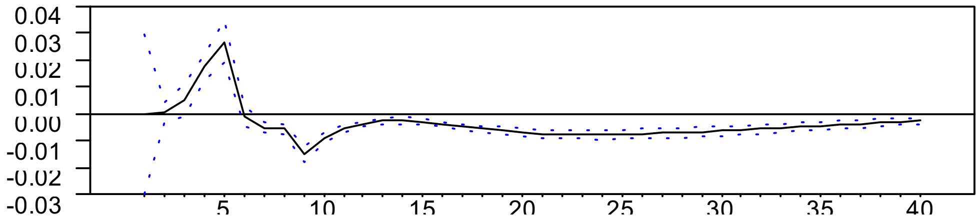


Figure 5

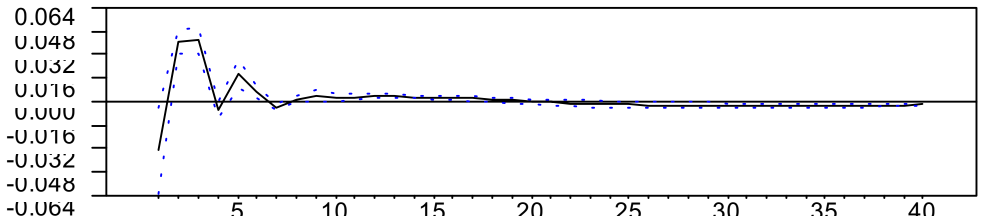
Impulse Responses for $\boldsymbol{i_t = \alpha + \beta i^*_t + \gamma i_{L,t} + \delta Prices_t + \eta Output_t + \phi Gold_t + \varepsilon_t}$

Ordering: Prices, Output, Gold Reserves, $i_{L,t}$, i^*_t, i_t.
System 9 French-US Short Rates, French Long Rate, French Prices, Output and Gold Reserves.

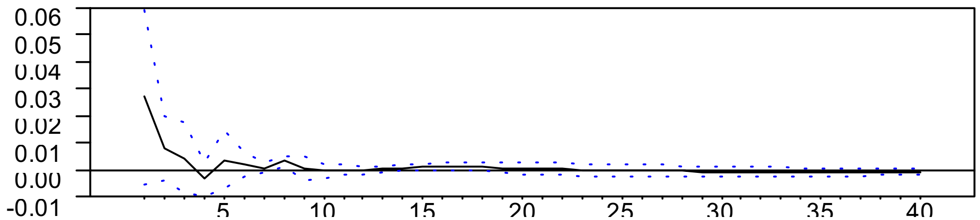
(a.) Response of French Short Rate to Shock in US Short Rate.



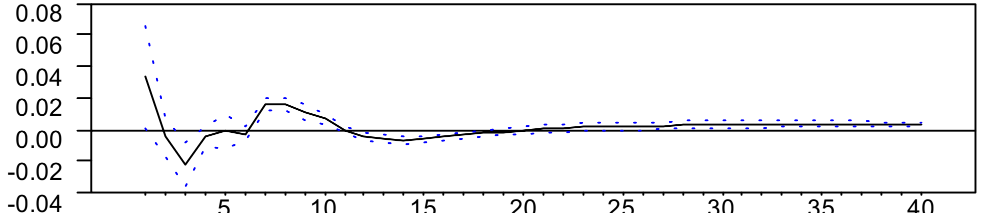
(b.) Response of French Short Rate to Shock in French Long Rate.



(c.) Response of French Short Rate to Shock in French Gold Reserves.



(d.) Response of French Short Rate to Shock in French Output.



(e.) Response of French Short Rate to Shock in French Prices.

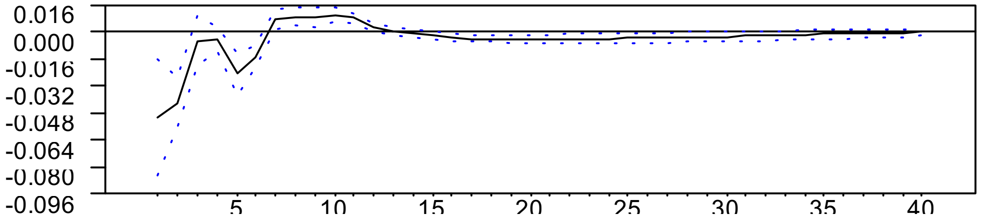
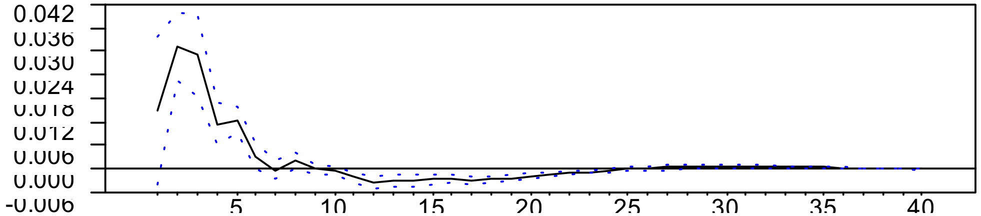


Figure 6

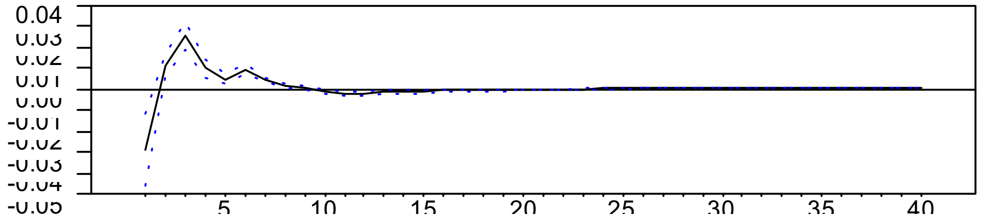
Impulse Responses for $i_t = \alpha + \beta\, i^*_t + \gamma\, i_{L,t} + \delta\, Prices_t + \eta\, Output_t + \phi\, Gold_t + \varepsilon_t$

Ordering: Prices, Output, Gold Reserves, $i_{L,t}$, $i^*_{t,}$ i_t.
French-German Short Rates, French Long Rate, French Prices, Output and Gold Reserves.

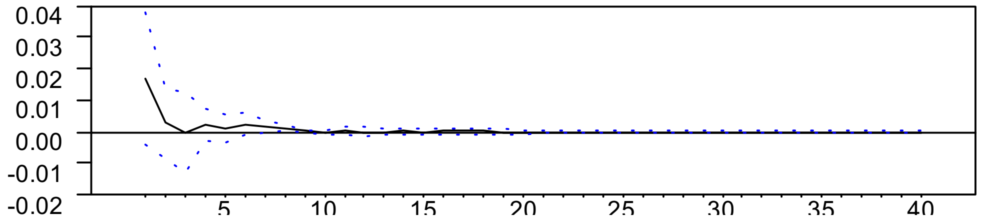
(a.) Response of French Short Rate to Shock in German Short Rate.



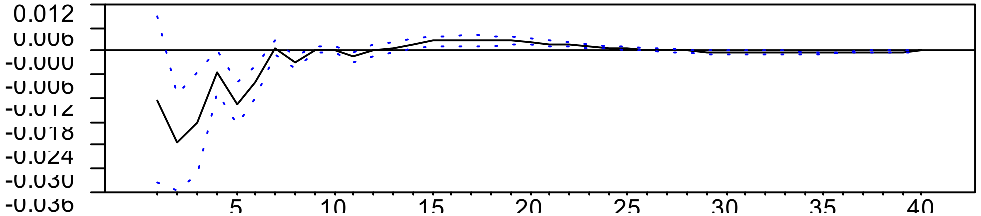
(b.) Response of French Short Rate to Shock in French Long Rate.



(c.) Response of French Short Rate to Shock in French Gold Reserves.



(d.) Response of French Short Rate to Shock in French Output.



(e.) Response of French Short Rate to Shock in French Prices.

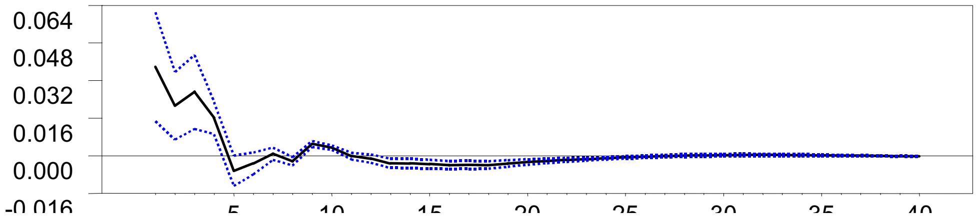


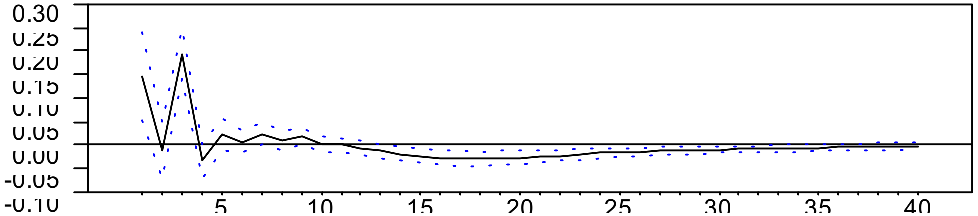
Figure 7

Impulse Responses for $\boldsymbol{i_t = \alpha + \beta i^*_t + \gamma i_{L,t} + \delta Prices_t + \eta Output_t + \phi Gold_t + \varepsilon_t}$

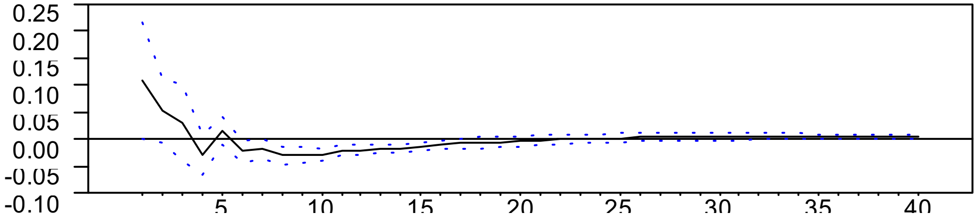
Ordering: Prices, Output, Gold Reserves, i^*_t, $i_{L,t}$, i_t.

US-German Short Rates, US Long Rate, US Prices, Output and Gold Reserves.

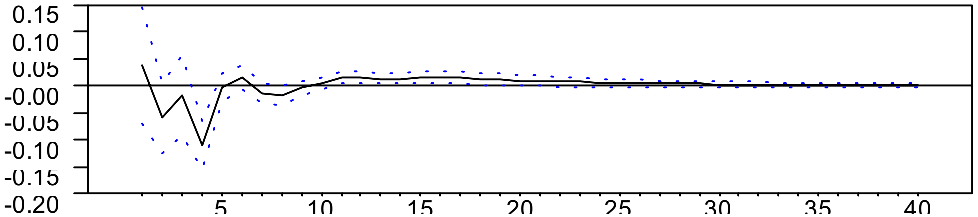
(a.) Response of US Short Rate to Shock in German Short Rate.



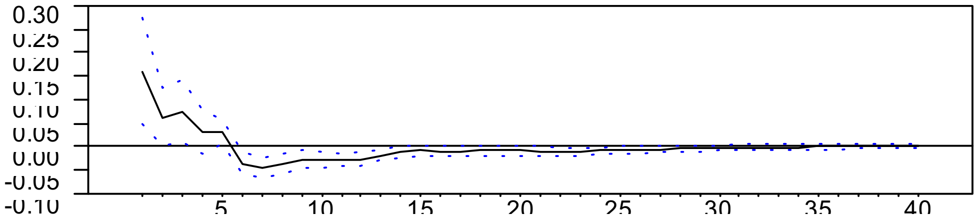
(b.) Response of US Short Rate to Shock in US Long Rate.



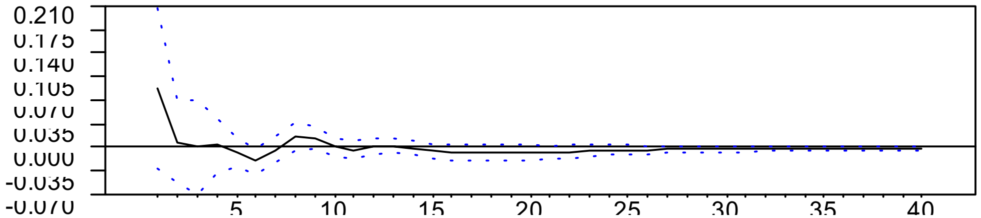
(c.) Response of US Short Rate to Shock in US Gold Reserves.



(d.) Response of US Short Rate to Shock in US Output.



(e.) Response of US Short Rate to Shock in US Prices.



DATA APPENDIX

DATA TYPE	FREQ.	COUNTRY	DATA SOURCE
Short –term interest rate	M	UK	NBER Series 13016 (SU/SA)
		France	NBER Series 13017 (SU/SA)
		Germany	NBER Series 13018 (SU/SA)
		US	NBER Series 13001 (SU/SA)
Long-term bond rate	M	UK	NBER Series 13041 (SU/SA)
		France	NBER Series 11021 (SU)
		Germany	NBER Series 13028 and 11020
		US	NBER Series 13033 (SU/SA)
Gold Reserves	M	UK }	
		France }	
		Germany }	
		US	NBER Series 14062 (SU)
Retail Prices	M	UK	Capie & Webber (1985) (SU)
		France	NBER Series 04073 (SU) (1919-8/1939)
		Germany	International Abstract of Economic Statistics.
		US	NBER Series 04128 (SU/SA*)

Industrial Production	M	UK	NBER Series 01133A
		France	NBER Series 01004B (1919-38 (SA) and 1928-39 (SU)
		Germany	NBER Series 01004A (SU) (only covers 1925-8/39)
		US	NBER Series 01002
Money Supply	M	UK	Capie & Webber (1985) (SU) M1
		France	Paitat & Lutfalla (SU/SA) M2
		Germany	NBER Series 14098
		US	NBER Series 14175 (SU/SA) M1