FUNDAMENTALS OF THE US AND THE UK INTEREST RATES UNDER THE RATIONAL EXPECTATION SCHEME

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A B S T R A C T

This paper presents a macro-econometric model for medium- and long-term nominal interest rates and the empirical results obtained with US and UK data. The explanatory equation for nominal interest rates is derived from the equilibrium condition of the savings market and takes real, financial and foreign aspects into account. Expected values of the inflation rate appear as regressors and, assuming rational expectations, two alternative models are obtained and estimated by the generalized method of moments.

The empirical results for the US support: a) the strong influence of the inflation rate on the nominal interest rate (although the Fisher hypothesis is not completely fulfilled), b) the importance of the growth rate of the real GDP in the interest-rate determination, and c) the fulfilment of the Ricardian hypothesis. The UK nominal interest rate follows the US nominal interest rate.

Keywords: rational expectations, gmm estimation, limited- and full-information models, reduced and structural forms, error-correction model.

JEL Classification: C32, E43.

1 INTRODUCTION

The modelling of interest rates has been attempted from many di®erent approaches, and various explanatory variables have been proposed to try and explain their evolution. Contrasting empirical conclusions have also been arrived at, depending, not only on the frequency with which the necessary data is compiled (monthly, quarterly, or annualy), but also on the type of interest rates that are modelled (long- or short-term), as well as on the sort of expectations scheme that is adopted. A proper modelling of interest rates and of expectations seems, therefore, to be of vital importance.

The ¯rst concern of this paper is the proposal of a global and theoretical framework in which to explain the evolution of middle- and long-term nominal interest rates, with a special focus on the modelling of expectations and on the in°uence of certain variables like government de¯cit and foreign interest rates.

The theoretical framework used in this paper to determine interest rates is a sort of IS-LM-BP approach in which interest rates are considered equilibrium price from a global point of view, taking real and ¯nancial aspects, both national and foreign, into account, as well as the inter-dependence that exists between the markets. Most interest-rate models, however, are based on an only market focus, and consider interest rates as the equilibrium price that equates supply and demand in that particular market.

Assuming rational expectations for the expected in°ation rates appearing in the explanatory equation for interest rates, we shall develope two alternatives. This generating mechanism for expectations has been the most widely used and is, in fact, still in vogue in the most recent literature. If expectations are rational, both of these alternatives are valid.

The second concern of this paper is to achieve an empirical modelling for the US and UK interest rates, assuming rational expectations, to thus be able to study the performance of the model and compare its main results with those obtained by other authors.

The paper is organised as follows. In the following section, we present the theoretical model. Sections 3 and 4 are devoted to the empirical models for the US and the UK interest rates respectively. Section 5 summarizes the main results and conclusions. Finally, the de¯nitions, sources and stationarity of the variables employed are made available in an appendix.

2 THE THEORETICAL MODEL

From a macroeconomic standpoint, there exist two basic models of interest-rate determination, namely: the savings market focus, which concentrates on the real aspects of the economy, and the financial approach, which includes the money market focus and the credit market focus. Foreign facts can be studied within any of the before approaches, although the credit market focus is the more suitable to try and explain their influence, as well as the influence of the government deficit, on domestic interest rates. An alternative focus to study the linkages between budget deficits and interest rates is the loanable funds model[1], which considers the term structure of interest rates explicitly.

In the present research, we consider the eclectic approach proposed in Mauleón (1991) to arrive at a model that enables us to gauge all of the possible effects that could influence medium- and long-term interest rates. The approach combines the real aspects of the savings market focus, the financial aspects of the credit market approach and the possible foreign influences, and is equivalent to the well-known IS-LM-BP approach proposed by Dornbusch-Fischer substituting the LM with the demand for credit.

Following the global focus, the identity between supply and demand for savings, which is the equilibrium condition of the savings market focus, is equivalent to equating supply and demand for credit. We consider the accounting identity between total savings (or savings supply) and investment (or savings demand) to be a more suitable starting point, as decisions on savings and investment are based mainly on medium- and long-term considerations and depend on real interest rates:

$$S_t = I_t \qquad (2.1)$$

Raymond and Mauleón (1997) use this same equilibrium condition, following the savings market approach, to explain the real facts that influence long-term nominal interest rates.

In equilibrium, the real rates of return (i.e., the nominal interest rates minus the corresponding expected inflation rates) tend to converge internationally. Recall that the uncovered interest parity (the equilibrium condition

[1] See, for instance, Correia-Nunes and Stemitsiotis (1995).

of the international credit market under imperfect foresight), together with the purchasing power parity (PPP, which holds with perfect arbitrage in the goods market), implies the equalization of the expected real interest rates (the real interest rate parity)[2].

We shall now specify a behavioral equation for saving and for investment during a given period t. The sum of government, private and foreign savings depends, positively, on the difference between the national nominal interest rate of the long-term government bond (B_t) and the foreign nominal interest rate (FB_t); negatively, on the difference between the expected domestic inflation rate (EI_{t+1}) and the expected foreign inflation rate (FEI_{t+1}); positively, on the real volume of activity measured by the real gross domestic product ($RGDP_t$); positively, on the real money of the economy (RM_t); and, also positively, on the real claims on government (RC_t), allowing us to test the Ricardian equivalence theorem or full crowding-out effect. Note that the nominal interest rates and the expected inflation rates are considered, rather than the real interest rates.

$$S_t = a_0 + a_1 B_t - a_2 FB_t - a_3 EI_{t+1} + a_4 FEI_{t+1} + a_5 RGDP_t + a_6 RM_t + a_7 RC_t + u_{1t} \quad (2.2)$$

This equation is similar to that of Raymond and Mauleón (1997), with two basic differences: the effect of the real money is included and the effect of the tax pressure is omitted. It must be remembered that a global approach is being employed here, so that financial aspects are also considered, and that the relevant variable is not the after-tax interest rate, but rather, the real interest rate.

Regarding the demand for savings, we have the government demand, measured by the real claims on government (RC_t), and the private and foreign demand as well. The latter depends on the domestic nominal interest rate (B_t) negatively, and, positively, on the share yield (SY_t), on the expected domestic inflation rate (EI_{t+1}), on the real gross domestic product ($RGDP_t$), and on the real money (RM_t).

$$I_t = RC_t + b_0 - b_1 B_t + b_2 SY_t + b_3 EI_{t+1} + b_4 RGDP_t + b_5 RM_t + u_{2t} \quad (2.3)$$

[2] Wu and Chen (1998) provide empirical evidence in favour of the real interest rate parity. In their work, the stationarity of real interest differentials is examined with three different panel unit-root tests.

This type of investment equation has been used before by Raymond and Mauleón (1997). According to Tobin's q scheme, investment increases when the ratio between the market value of assets and their replacement cost, q, is greater than one. On the one hand, the market value of assets increases when the real interest rate decreases, and when the real gross domestic product, the real money and the share yield increase. On the other hand, the replacement cost decreases when the real interest rate decreases and the share yield increases (when the growth rate of share prices increases, securing financial support is easier and cheaper for firms).

The yield of long-term bonds (an interest-bearing financial asset) and industrial shares (a stock market security) are considered in this equation, disregarding for the yield of currencies by the Walras Law.

The introduction of the share yield is also pursued by the loanable funds model proposed by Knot (1995). In the investment expression of that model, the real rate of return on the stock market, together with the interest rate, proxy for the present discounted value of future profits, which determines the shadow price of capital.

Note that only the first period ahead of the expected inflation rate is considered in equations (2.2) and (2.3) for the sake of simplicity. Its generalization to further periods is quite straightforward. Likewise, some lags on the other explanatory variables can also be included in the two equations.

Substituting these behavioral equations in the previous identity between supply and demand for savings, yields, by re-arranging the terms, an expression for the nominal interest rate. This new equation expresses the nominal interest rate as a function of the foreign interest rates, of the national and foreign expected inflation rates, of the real gross domestic product, of the real money, of the real claims on government and of the national share yield.

$$B_t = c_0 + c_1 FB_t + c_2 SY_t + c_3 EI_{t+1} - c_4 FEI_{t+1} + c_5 RGDP_t - c_6 RM_t + c_7 RC_t + u_{3t} \quad (2.4)$$

Considering the nominal rates and the expected inflation rates, instead of the real interest rates, allows us to test the Fisher hypothesis or the full translation of changes in inflation rates to nominal interest rates.

Regarding expectations, rational agents form their expectations in a way that is consistent with the model. The inflation rate for period t+k (I_{t+k}) is equal to its expected value (EI_{t+k}) plus a white noise random error (ε_{t+k}).

$$I_{t+k} = EI_{t+k} + \varepsilon_{t+k} \qquad (2.5)$$

And the t+k in°ation rate expected by rational agents at time t is the conditional expectation for the t+k in°ation rate, based on the relevant information set available to agents at time t-1 (IS_{t-1}), for any $k \in N$,

$$EI_{t+k} = E(I_{t+k}/IS_{t-1}) \qquad (2.6)$$

or, following equation (2.5), the observed in°ation rate minus the unexpected error.

$$EI_{t+k} = I_{t+k} - \varepsilon_{t+k} \qquad (2.7)$$

Two alternatives shall be developed within the rational expectations generating mechanism. They obviously work, regardless of the expected variable.

The ¯rst alternative consists of substituting the future expected in°ation with the corresponding observed value minus a random error, according to equation (2.7). In this case, the model has a single equation (that of the nominal interest rate), and can be de¯ned as a limited-information model insofar as other structural-form equations still remain unspeci¯ed.

The second alternative is to model the variables whose expected values are required. In the in°ation rate equation, we shall consider its lags, the growth rate of nominal money (following Friedman monetary view), and the growth rates of the unit labor cost and of the exchange rate (taking the ¯rm's mark-up into account). For the sake of simplicity, the model for the money's growth rate will be an autoregressive one. So, all the structural-form equations of the simultaneous-equation system shall be completely speci¯ed and utilized, de¯ning a full-information model. The additional information should give rise to estimators for the parameters of the interest rate equation, which are asymptotically more e±cient than those derived from the limited-information model.

Substituting the expected values of the interest rate equation with the expressions provided by the rest of the equations of the model, a new equation shall be obtained for the nominal interest rate. This new equation, together with the others, de¯nes the reduced form of the model. If the model is identi¯ed, the estimators of the structural-form parameters can be recovered from the estimators of the reduced-form parameters.

3 THE U.S. EMPIRICAL MODEL

The two afore-mentioned alternatives have been considered within the rational expectations scheme. The ¯rst one substitutes the future expected in°ation with the future observed in°ation minus a random error. After deleting the non-signi¯cant explanatory variables, the resulting dynamic equation relates the long-term nominal interest rate to its ¯rst lag, to the ¯rst period ahead of the US in°ation rate, to the US real money at time t and t-1, and to the US real gross domestic product for period t and t-1. The non-signi¯cance of the foreign nominal interest rate and the foreign expected in°ation rates is a reasonable result, considering the choice of the UK rates as the foreign rates.

$$\begin{aligned} usab_t \;=\; & c_1 usab_{t-1} + c_2 usair_{t+1} + c_3 usarm_t + c_4 usarm_{t-1} + c_5 usargdp_t + \\ & c_6 usargdp_{t-1} + v_t \end{aligned} \qquad (3.1)$$

Since the error term of the model is correlated with the regressors and with itself over time, this US bond equation, which de¯nes the limited-information model, is estimated by the generalized method of moments (GMM) using all the predetermined and weakly exogenous variables of the full-information model de¯ned below as instruments. The outcome is presented in table 1.

TABLE 1. GMM estimation of the limited-information model for the US.

Parameter	Estimate	Error	t-statistic	p-value
c_1	0.915795	0.028538	32.0904	0
c_2	0.333471	0.147645	2.25859	0.024
c_3	-13.0706	4.63002	-2.8230	0.005
c_4	14.1544	4.30727	3.28615	0.001
c_5	42.5846	7.77777	5.47517	0
c_6	-43.0308	7.82038	-5.50238	0

Notes: Standard Errors computed from heteroscedastic-consistent matrix (Robust-White) also robust to autocorrelation (NMA= 1, Kernel=Bartlett). E'HH'E (the objective function for the gmm estimation, evaluated from the solution) = 0.117045. Test of overidentifying restrictions = 11.2363 [0.260]. Degrees of freedom = 9. Number of Observations = 96. Current sample: 1974:1 to 1997:4.

The second alternative consists of modelling the observed inflation rate to obtain an expression for the expected inflation rate. The US inflation rate depends on its first three lags and on the money growth rate for t and t-2, after deleting non-significant variables.

$$usair_t = b_1 usair_{t-1} + b_2 usair_{t-2} + b_3 usair_{t-3} + b_4 usamg_t + b_5 usamg_{t-2} + v_{2t} \quad (3.2)$$

On substituting the expected inflation rates in the interest rate equation with the corresponding expression, expected values of the money growth rate also appear. The money growth rate depends on a constant and on its first two seasonal lags.

$$usamg_t = d_0 + d_1 usamg_{t-4} + d_2 usamg_{t-8} + v_{3t} \quad (3.3)$$

Equations (3.1), (3.2) and (3.3) define the structural form of the model. By substituting the expected inflation in the interest rate equation with the corresponding expression, we obtain a new simultaneous system of three equations (the reduced form of the model) and cross-equation restrictions involving the parameters of both the structural and reduced forms.

$$\begin{aligned} usab_t = \; & c_1 usab_{t-1} + a_1 usair_{t-1} + a_2 usair_{t-2} + a_3 usair_{t-3} + a_4 usamg_{t-1} + \\ & a_5 usamg_{t-2} + a_6 usamg_{t-3} + a_7 usamg_{t-4} + a_8 usamg_{t-7} + \\ & a_9 usamg_{t-8} + c_3 usarm_t + c_4 usarm_{t-1} + c_5 usargdp_t + \\ & c_6 usargdp_{t-1} + v_{1t} \end{aligned} \quad (3.4)$$

$$usair_t = b_1 usair_{t-1} + b_2 usair_{t-2} + b_3 usair_{t-3} + b_4 usamg_t + b_5 usamg_{t-2} + v_{2t} \quad (3.5)$$

$$usamg_t = d_0 + d_1 usamg_{t-4} + d_2 usamg_{t-8} + v_{3t} \quad (3.6)$$

subject to the coefficient restrictions

$$
\begin{aligned}
a_0 &= c_2 b_4 d_0 (b_1 + 1) \\
a_1 &= c_2 (b_1^2 + b_2) \\
a_2 &= c_2 (b_1 b_2 + b_3) \\
a_3 &= c_2 b_1 b_3 \\
a_4 &= c_2 b_5 \\
a_5 &= c_2 b_1 b_5 \\
a_6 &= c_2 b_4 d_1 \\
a_7 &= c_2 b_1 b_4 d_1 \\
a_8 &= c_2 b_4 d_2 \\
a_9 &= c_2 b_1 b_4 d_2
\end{aligned}
$$

In this overidentified system, the current US nominal interest rate, inflation rate and money growth rate are endogenous variables, the real GDP and real money for period t and t-1 are weakly exogenous, and the rest of the variables are predetermined, according to Engle, Hendry and Richard (1983).

The simultaneous GMM estimation of the equations (3.4), (3.5) and (3.6), without imposing the cross-equation coefficient restrictions, yields some non-significant variables. When the constraints on the coefficients of the reduced form are imposed, all the variables are relevant, apart from the constant term in the explanatory equation for the money growth rate. Anyway, this variable is included in the full-information model seeing that its estimated coefficient is far from cero (0.261022). Table 2 gives the estimation results.

TABLE 2. GMM estimation of the full-information model for the US, subject to the relevant coe±cient restrictions.

Parameter	Estimate	Error	t-statistic	p-value
c_2	0.543614	0.210159	2.58668	0.010
b_1	0.668072	0.077792	8.58788	0
b_4	-0.074790	0.026013	-2.87507	0.004
d_2	0.293155	0.069094	4.24283	0
d_1	0.528325	0.097155	5.43795	0
b_5	0.114436	0.019211	5.95694	0
b_3	0.476263	0.069619	6.84095	0
b_2	-0.201521	0.093211	-2.16199	0.031
d_0	0.261022	0.205400	1.27080	0.204
c_1	0.862884	0.037334	23.1128	0
c_3	-14.9560	4.06622	-3.67810	0
c_4	17.1340	3.46308	4.94762	0
c_5	54.6471	8.22270	6.64588	0
c_6	-55.5339	8.42291	-6.59319	0

Notes: Standard Errors computed from heteroscedastic-consistent matrix (Robust-White) also robust to autocorrelation (NMA= 1, Kernel=Bartlett). E'HH'E = 0.119815. Test of overidentifying restrictions = 11.5022 [0.320]. Degrees of freedom = 10. Number of Observations = 96. Current sample: 1974:1 to 1997:4.

The GMM estimation of the full-information model (table 2) is more e±cient, at least asymptotically, if the additional information about the behaviour of the in°ation rate and the money growth rate is correct. Nevertheless, the GMM estimation of the limited-information model (table 1) is more robust and cold be more e±cient from the ¯nite sample point of view.

The real claims on the US government and the US share yield turn out to be non-signi¯cant in the two models estimated. According to the theoretical model developed in the previous section, the non-signi¯cance of the real claims means that the US private sector fully compensates for the prodigality of the government, which implies the ful¯lment of the Ricardian equivalence theorem or a complete crowding-out e®ect. The non-signi¯cance of the share yield could be due to the fact that the nominal interest rate in°uence the share yield and no the other way around, or to the fact that, despite of being mutually related, at the end, real variables are the ones in°uencing the two ¯nancial variables.

Also note that the estimated coe±cients of the real money for period t and for period t-1 are very close in absolute value, but with di®erent sign. And the same happens with the estimated coe±cients of the real GDP for period t and for period t-1. We accept that the explanatory variables are the increment of the real money and the increment of the real GDP. Inasmuch as the two variables are expressed in logarithms, the corresponding explantory variables are the growth rate of the real money and the growth rate of the real GDP.

Finally, seeing that the estimated coe±cient for the ¯rst lag of the US bond shows a good deal of persistence, we check whether it is equal to one. In table 3, the GMM estimation of the full-information model in its error-correction form concludes that the lagged estimated disturbances, whose coe±cients are f, g and h, are signi¯cant. The model has therefore been correctly speci¯ed and estimated in levels. Of course, the same conclusion is obtained for the limited-information model.

TABLE 3. Levels or increments? GMM estimation of the full-information model for the US in an error-correction form.

Parameter	Estimate	Error	t-statistic	p-value
c_2	1.22890	0.275600	4.45898	0
b_1	0.563774	0.113291	4.97635	0
b_4	-0.083066	0.021727	-3.82312	0
d_2	0.402492	0.055863	7.20494	0
d_1	0.392731	0.068445	5.73794	0
b_5	0.108920	0.015572	6.99442	0
b_3	0.518209	0.100460	5.15834	0
b_2	-0.197420	0.070157	-2.81398	0.005
c_1	1.21625	0.279640	4.34934	0
c_3	-12.5986	5.61936	-2.24200	0.025
c_4	11.8020	7.71779	1.52919	0.126
c_5	62.6905	8.22302	7.62378	0
c_6	-49.1443	12.5431	-3.91805	0
f	-1.27053	0.265272	-4.78954	0
g	-0.925197	0.168913	-5.47735	0
h	-0.850648	0.087983	-9.66833	0

Notes: Standard Errors computed from heteroscedastic-consistent matrix (Robust-White) also robust to autocorrelation (NMA= 2, Kernel=Bartlett). E'HH'E = 0.0929244. Test of overidentifying restrictions = 8.82782 [0.638]. Degrees of freedom = 11. Number of Observations = 95. Current sample: 1974:2 to 1997:4.

In equilibrium, assuming that the real money and the real GDP grow at the same rate, the nominal interest rate is given by equation (3.7), if we estimate the limited-information model, or by equation (3.8), if we estimate the full-information model.

$$usab_t = 0.764614\, usair_t + 1.044146 \cdot usargdp_t \qquad (3.7)$$

$$usab_t = 0.716657\, usair_t + 1.03423 \cdot usargdp_t \qquad (3.8)$$

Even though the Fisher hypothesis is not completely fulfilled, the estimated coefficient of the inflation rate is quite high in equilibrium. On the one hand, this means that financial markets are rather efficient (economic agents are relatively well-informed and transaction costs are not very high), and that economic agents take real interest rates into account when deciding, which supports the choice of the theoretical approach used to develope the model. On the other hand, the result point out the importance of the inflation rate to control the nominal interest rate.

Equations (3.7) and (3.8) also show that, if we assume that the Fisher hypothesis is completely fulfilled, changes in the growth rate of the real GDP fully translate to changes in the real interest rate, which means that, in equilibrium, the real interest rate is completely determined by the growth rate of the real GDP.

4 THE U.K. EMPIRICAL MODEL

Substituting the observed inflation minus a random error for the expected inflation and estimating by GMM, the UK nominal interest rate can accurately be explained by its first lag, by a constant term, by the current US nominal interest rate, by the second period ahead of the US expected inflation rate, and by the UK share yield. Now, the foreign rate is that of the US and is significant as expected: the US nominal interest rate influences the

UK nominal interest rate, but not the other way around. And, surprisingly, the UK nominal interest rate depends on the US in°ation rate, rather than on the UK in°ation rate.

$$ukb_t = c_0 + c_1 ukb_{t-1} + c_2 usab_t + c_3 usair_{t+2} + c_4 uksy_t + w_t \qquad (4.1)$$

This equation de¯nes the limited-information model and is estimated by GMM with the proper instruments, which are all the predetermined and weakly exogenous variables of the full-information model de¯ned below. The outcome is available in table 4.

TABLE 4. GMM estimation of the limited-information model for the UK.

Parameter	Estimate	Error	t-statistic	p-value
c_0	1.25273	0.300341	4.17101	0
c_1	0.628363	0.049417	12.7155	0
c_2	0.235022	0.042255	5.56196	0
c_3	0.573386	0.119495	4.79839	0
c_4	-0.024644	0.00743686	-3.31374	0.001

Notes: Standard Errors computed from heteroscedastic-consistent matrix (Robust-White) also robust to autocorrelation (NMA= 1, Kernel=Bartlett). E'HH'E = 0.0606136. Test of overidentifying restrictions = 5.7583 [0.764]. Degrees of freedom = 9. Number of Observations = 95. Current sample: 1974:1 to 1997:3.

We already know that the US in°ation rate depends on its ¯rst three lags, and on the money growth for period t and t-2,

$$usair_t = b_1 usair_{t-1} + b_2 usair_{t-2} + b_3 usair_{t-3} + b_4 usamg_t + b_5 usamg_{t-2} + v_{2t} \qquad (4.2)$$

and that the US money growth depends on a constant and on its ¯rst two seasonal lags,

$$usamg_t = d_0 + d_1 usamg_{t-4} + d_2 usamg_{t-8} + v_{3t} \qquad (4.3)$$

Therefore, the full-information model is the following overidentified linear simultaneous-equation system:

$$
\begin{aligned}
ukb_t = \; & c_0 + c_1 ukb_{t-1} + c_2 usab_t + a_1 usair_{t-1} + a_2 usair_{t-2} + a_3 usair_{t-3} + \\
& a_4 usamg_{t-1} + a_5 usamg_{t-2} + a_6 usamg_{t-3} + a_7 usamg_{t-4} + \\
& a_8 usamg_{t-6} + a_9 usamg_{t-7} + a_{10} usamg_{t-8} + c_4 uksy_t + w_{1t} \qquad (4.4)
\end{aligned}
$$

$$
usair_t = b_1 usair_{t-1} + b_2 usair_{t-2} + b_3 usair_{t-3} + b_4 usamg_t + b_5 usamg_{t-2} + v_{2t} \qquad (4.5)
$$

$$
usamg_t = d_0 + d_1 usamg_{t-4} + d_2 usamg_{t-8} + v_{3t} \qquad (4.6)
$$

subject to

$$
\begin{aligned}
a_0 &= c_0 + c_3 d_0 (b_4 (b_1^2 + b_1 + b_2 + 1) + b_5) \\
a_1 &= c_3 (b_1 (b_1^2 + 2b_2) + b_3) \\
a_2 &= c_3 (b_1 (b_1 b_2 + b_3) + b_2^2) \\
a_3 &= c_3 b_3 (b_1^2 + b_2) \\
a_4 &= c_3 b_1 b_5 \\
a_5 &= c_3 (b_5 (b_1^2 + b_2) + b_4 d_1) \\
a_6 &= c_3 b_1 b_4 d_1 \\
a_7 &= c_3 (b_4 d_1 (b_1^2 + b_2) + b_5 d_1) \\
a_8 &= c_3 b_4 d_2 \\
a_9 &= c_3 b_1 b_4 d_2 \\
a_{10} &= c_3 (b_4 d_2 (b_1^2 + b_2) + b_5 d_2)
\end{aligned}
$$

The current UK interest rate, US inflation rate and US money growth rate are endogenous variables. The US interest rate and the UK share yield are weakly exogenous in the system, and the rest of the variables are predetermined.

The simultaneous GMM estimation of equations (4.4), (4.5) and (4.6), without imposing any constraint on the coefficients, yields some non-significant variables. Imposing the coe±cient restrictions, only the second lag on the US in°ation rate is not signi¯cant. The estimation results are in table 5.

TABLE 5. GMM estimation of the full-information model for the UK, subject to the relevant coe±cient restrictions.

Parameter	Estimate	Error	t-statistic	p-value
c_3	0.587956	0.155984	3.76934	0
b_1	0.730737	0.073925	9.88488	0
b_4	-0.083886	0.030927	-2.71236	0.007
d_2	0.274895	0.076225	3.60636	0
b_2	-0.081891	0.096961	-0.844574	0.398
b_5	0.114788	0.026180	4.38449	0
d_1	0.328833	0.096752	3.39871	0.001
b_3	0.274962	0.068242	4.02923	0
c_0	1.34363	0.348793	3.85222	0
d_0	0.602151	0.189127	3.18385	0.001
c_1	0.617964	0.059303	10.4204	0
c_2	0.237595	0.041604	5.71087	0
c_4	-0.028109	0.007947	-3.53711	0

Notes: Standard Errors computed from heteroscedastic-consistent matrix (Robust-White) also robust to autocorrelation (NMA= 1, Kernel=Bartlett). E'HH'E = 0.0886118. Test of overidentifying restrictions = 8.41812 [0.588]. Degrees of freedom = 10. Number of Observations = 95. Current sample: 1974:1 to 1997:3.

The outcome of the GMM estimation of the full-information model (table 5) is close to the outcome of the GMM estimation of the limited-information model (table 4).

The noticeable importance of the foreign e®ects becomes apparent from the dependence of the UK nominal interest rate on the US nominal interest rate and on the US in°ationary expectations. UK in°ation rates do not a®ect the UK nominal interest rate, and the dependence of the UK nominal interest rate on the US in°ation rate is positive as if the US in°ation rate proxy for the national in°ation rate. A bad measurement of the market expectations, together with the strong in°uence of the US variables, could be the responsible for these results.

The yield of the UK bond decreases 2.46% (table 4) or 2.81% (table 5) when the UK share yield increases, showing a modest trade-off between the two financial assets. This result, that can be interpreted as a portfolio reallocation in the short term, is a spurious correlation in equilibrium because the influence of the share yield on the interest rate should be positive and bigger.

As in the case of the US explanatory models, the non-significance of the UK real claims is indicative of a full crowding-out effect.

Finally, note that the estimated coefficient of the lagged national interest rate is far away from unity in both the limited-information model and the full-information model, denoting less persistence than in the case of US.

In the dynamic equilibrium, disregarding for the share yield and taking into account the annual effect of the foreign (US) inflation rate and real GDP on the foreign nominal interest rate calculated in the previous section, the UK nominal interest rate follows the US nominal interest rate, whether we start from the limited-information model or we start from the full-information model.

$$ukb_t = 3.37083 + 0.869256\, usair_t + 0.660315 \cdot usargdp_t \tag{4.7}$$

$$ukb_t = 3.51702 + 0.830454\, usair_t + 0.643206 \cdot usargdp_t \tag{4.8}$$

Now, the estimated coefficient of the inflation rate is higher than before in equilibrium. And, assuming that the Fisher hypothesis is completely fulfilled, about the 65% of the change in the growth rate of the real GDP moves to the real interest rate.

5 CONCLUDING REMARKS

In this paper, we propose a rational-expectation model to explain the fundamentals of medium- and long-term nominal interest rates, and show the empirical results obtained with US and UK data.

Following a global approach that focuses on real, financial and foreign facts, interest rates are thought to be determined by equilibrium in the savings market. On substituting the behavioral equations for saving and for investment in the accounting identity between supply and demand for savings, and on solving for nominal interest rates, expected values of the inflation rate appear as regressors. Assuming rational expectations, which is the most widely used expectations generating mechanism, two valid alternatives are possible: either substituting the expected values with the observed ones minus a white noise random error, or modelling the inflation rate to provide an expression for its expected values. The GMM estimation of the two resulting models, based on these two alternatives, has produced similar outcomes.

If expectations are rational, the US nominal interest rate is mainly driven by its first lag, by the expected inflation rate for period t+1, and by the growth rates of the real money and the real GDP. The UK nominal interest rate depends on a constant term, on the lagged UK nominal interest rate, on the US nominal interest rate, and, surprisingly, on the US expected inflation rate for period t+2.

Some results confirm the findings of other authors: the non-strict fulfillment of the Fisher hypothesis, the influence of both national and foreign aspects, and thus the less than expected international integration of financial markets. Other results find less empirical support in the literature: the fulfillment of the Ricardian hypothesis and the stationarity of the series used.

The existence of non-rational agents in the market, together with the strong influence of foreign (US) facts in the case of the UK, could explain the striking empirical results obtained for the UK nominal interest rates. Further research on interest-rate models for the US and the UK with heterogeneous economic agents in the market is now in progress.

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APPENDIX: DEFINITIONS, SOURCES AND STATIONARITY OF THE USED VARIABLES

The empirical work has been performed with quarterly IMF and OECD series from the "International Statistical Yearbook 1998. Data Service & Information GMBH."

usab stands for the three-year government bond yield for the US, percent per annum, averages, IMF, Wash., and ukb is the five-year government bond yield for the UK, percent per annum, averages, IMF, Wash.

usair and ukir are the US and the UK growth rates of consumer prices (the US and the UK inflation rates), derived from the respective US and UK consumer prices, index no., base year 1990, averages, IMF, Wash.

usamg and ukmg are growth rates of M3 (money plus quasimoney) for the US and the UK, which are expressed in billions of US $ and in millions of pounds sterling respectively, stocks, IMF, Wash.

usasy and uksy are growth rates of the US and the UK industrial share prices respectively, index no., averages, IMF, Wash.

usamrg and ukmrg stand for the US and the UK market rate of change, US dollar per pounds sterling and pounds sterling per US dollar respectively, averages, IMF, Wash.

usaulcg is the growth rate of the US unit labor cost, s.a., 1990=100, USALAB-OECD STAT., Paris., and ukulcg is the growth rate of the UK unit labor cost, s.a., 1990=100, GBRNSO-OECD STAT., Paris.

usarc is the logarithm of real claims on US government, calculated from net claims on central government (in billions of US $, stocks, IMF, Wash.) divided by the US consumer prices, and ukrc is the logarithm of real claims on UK government, calculated from claims on government (in millions of pounds sterling, stocks, IMF, Wash.) divided by the UK consumer prices.

usarm is the logarithm of real money for the US and ukrm is the logarithm of real money for the UK, both calculated from M3 divided by consumer prices.

usargdp and ukrgdp are logarithms of the US and the UK real gross domestic products, which are expressed in billions of US $ and in billions of pounds sterling respectively, base year 1990, averages, constant prices, seasonally adjusted, IMF, Wash.

Finally, looking at the autocorrelation and partial autocorrelation functions of the time series de¯ned above, we decide to discuss the existence of a unit root in the AR(1) process of usab, ukb, usarc, ukrc, usarm, ukrm, usargdp, and ukrgdp.

A large literature on unit root tests has appeared since the paper of Dickey and Fuller (1979). Several empirical studies show that standard unit root tests, including those allowing for error autocorrelation, fail to reject the null hypothesis of a unit root for many economic series.

In the case of the quarterly real gross domestic product, there exists evidence that the seasonal adjustment induces higher persistence and ¯rst order autocorrelation, reducing the power of the conventional unit root tests[3].

On the other hand, recent studies provide evidence that conventional unit root tests are not very powerful against relevant alternatives. In this line, Kwiatkowski, Phillips, Schmidt and Shin (1992) propose a test of the null hypothesis of stationarity to complement tests of the null hypothesis of a unit root. However, their empirical results show that this procedure does not solve the problem for all macroeconomic series.

The simulation study of Pantula, Gonz¶lez-Farias, and Fuller (1994) shows that tests based on the OLS estimator are the less powerful, and that tests based on the Weighted Symmetric (WS) estimator and the unconditional maximum likelihood estimator are the more powerful to test the unit-root hypothesis in AR processes. Since the WS test has more power than the Dickey-Fuller (DF) test and is easier to compute than tests based on ML estimators, we conduct the Dickey-Fuller and Weighted Symmetric tests.

In the Weighted Symmetric test for a pth-order AR process, the residual from the regression of the variable on the constant/trend variables is used as Y in a weighted double-length regression[4]: in the ¯rst half, Y is regressed on Y(-1) and lags of Y-Y(-1) with weights (t-1)/T; in the second half, Y is regressed on Y(+1) and leads of Y-Y(+1) with weights 1-(t-1)/T.

[3] See Ghysels (1990).

[4] See Pantula, Gonz¶lez-Farias, and Fuller (1994) for further details.

The p-values of the Weighted Symmetric and Dickey-Fuller integration tests performed without assuming the presence of a trend or constant are presented in table 6. The table also shows the p-values of the augmented WS and DF tests and, in brackets, the number of augmenting lags chosen by the program to control for additional serial correlation[5]. The null of a unit root in the eight time series analyzed is rejected with the WS and AWS tests, meanwhile is accepted with the DF and ADF tests.

Recall that, for the US nominal interest rate, the unit root is also rejected in the model presented in section 3, and that the estimated coe±cient of the lagged UK nominal interest rate is far away from one in the model presented in section 4. Besides, the existence of a unit root in a time series implies that the variable under study has in¯nite variance, which makes no economic sense in the case of the nominal interest rate.

Following the results of the more powerful tests (WS and AWS) and taking into account the before arguments, our conclusion is that all the US and UK variables are stationary, despite of the results of the DF and ADF tests for the nominal interest rate, for the real claims, for the real money and for the real GDP.

[5] The program chooses the minimum of the optimal lag length and 10, where the optimal lag length is the order selected by the Akaike information criterion (AIC) plus 2, as described in Pantula et al. (1994).

TABLE 6. Summary of unit root tests.

p-values	WS AWS	DF ADF
usab	0 0 (5)	0:46847 0:45032 (5)
ukb	0 0 (4)	0:29353 0:34321 (4)
usarc	0 0 (10)	0:90469 0:93202 (10)
ukrc	0 0 (5)	0:53171 0:50350 (5)
usarm	0 0 (10)	0:99962 0:95446 (10)
ukrm	0 0 (6)	0:99751 0:98691 (2)
usargdp	0 0 (3)	1 1 (3)
ukrgdp	0 0 (5)	1 0:99897 (5)

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