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Real exchange rate and employment performance in an open economy☆

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Abstract

The usual neoclassical model of labor supply and employment determination has been based in closed economy models. This paper studies the effect of introducing open economy features on the determinants of equilibrium employment. It derives the long run employment level as a function of the real wage, real interest rate and real exchange rate from a standard open economy optimizing representative agent model. The paper tests the steady state solution of the model using US and UK data and, in order to avoid the Lucas' critique, it tests for the superexogeneity of the interest rate and exchange rate. The evidence shows a significant impact of the real exchange rate, real interest rate, and real wage only for the US, where it is also robust to the Lucas' critique.

Keywords: Labor supply; Interest rate; Real exchange rate; Superexogeneity

JEL classification: D90; J22; E32

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1. Introduction

This paper presents a theoretical and empirical analysis of the intertemporal optimising agent model in which we introduce imported goods and capital flows and hence the effect of the real exchange rate. The employment behaviour derived from these kinds of models lies at the heart of labor market fluctuations, and cyclical fluctuations in employment are one of the leading forces behind the business cycle.[1] The hypothesis gained strength in the literature after the seminal paper of Lucas and Rapping (1969). The main idea is that workers, as rational maximizing agents, compare actual and expected future real wages and adjust their labor supply accordingly. If, due to an increase of the real interest rate, workers expect the future real wage to decrease relatively to the present real wage, they increase their labor supply and vice versa. Given the consumer producer assumption of the model, changes in the interest rate would imply changes in equilibrium employment.

The optimising agent model has been tested exhaustively. Just to quote a few references, the findings of Hall (1980), Abowd and Card (1987), Alogoskoufis (1987a,b), Dutkowsky and Foote (1992), Dutkowsky and Dunsky (1996), Mulligan et al. (1999) and Ziliak and Knieser (1999) support its hypothesis. While Card (1991) in a survey of the microeconometric literature, Altonji (1982), Altonji et al. (2002) and Mankiw et al. (1985) present evidence against the model.

However, the theoretical and empirical work done in this area has been based on closed economy models.[2] This paper is a first attempt to analyse the consequences for employment of setting the intertemporal optimising agent model in an open economy context. We do so by setting up a standard open economy model in which the derived labor supply and employment is a function not only of the real wage and the real interest rate, but also of the real exchange rate. By testing empirically the long run predictions of the model, the paper is able to assess the relevance of the introduction of the real exchange rate. Moreover, it allows us to examine the direct impact of the real exchange rate on employment. As we shall see, the open economy model provides a better specification of the equilibrium employment function. Some papers on the 'new open economy macroeconomics' tradition such as Benigno and Thoenissen (2003) have analysed the impacts of real exchange rates on labor market performance using calibration methods. Others such as Campa and Goldberg (2001), Gourinchas (1999) and Klein et al. (2003) have estimated the impact of the real exchange rate on the US and French labor markets finding significant re-location effects. In this paper, we propose a simple but appealing set up based on the intertemporal optimising agent model that extends the original contribution of Lucas and Rapping (1969) to analyse the possible effects of exchange rates on employment performance.

The paper is structured as follows. Section 2 presents the representative agent model of an open economy, where the equilibrium employment function is derived as a function of the real wage, real interest rate and real exchange rate. Section 3 presents the econometric

[1] See, for instance, Barro and King (1984).

[2] A notable recent exception to this is Hoon and Phelps (2004) who develop a 'structuralist' model of the small open economy.

estimation of this function for the US and the UK economies. The concluding remarks appear in Section 4.

2. The model

The model is an open economy version of the standard intertemporal labor supply model (Turnovsky, 1995). The representative agent derives utility from the consumption of the domestic good (c) and imported good (c^*) and disutility from labor (L). The representative agent produces a single commodity using the stock of capital (K) and labor through a well behaved neoclassical production function $F(K,L)$. He faces increasing installation costs of investment, represented by a convex function $C(I)$ [$C(0)=0$, $C'(I)>0$, $C'(0)=1$]. Finally, the representative agent allocates his savings in foreign bonds (b) that pay an exogenously given world interest rate (i^*). For simplicity there is no government,[3] no labor migration, and no other assets in this economy, such as real money balances.

The optimization problem in a command optimum framework is:[4]

$$\underset{c,c^*,L,I}{\text{Max}} \int_0^{\infty} U(c, c^*, L)\mathrm{e}^{-\theta t}\mathrm{d}t$$

$$\dot{b} = \frac{1}{\sigma}[F(K, L) - c - \sigma c^* + \sigma i^* b - C(I)]$$

$$\dot{K} = I$$

where σ is the relative price of the foreign good in terms of the domestic good, that is, the real exchange rate, and θ stands for the rate of time preference.

The use of continuous time model contrasts with the most commonly used stochastic discrete time models that derive the Euler equations for consumption and labor supply (see, for instance, Dutkowsky and Dunsky, 1996). However, our interest focuses on the long run steady state employment level and not on the short run intertemporal substitution effect, which would capture transitional dynamics. This is because we are concerned with what is the possible impact of inserting the standard intertemporal model in an open economy context rather than analyzing its short run properties and its implications for business cycles.

Let us assume a separable utility function between consumption and labor supply: $U(c, c^*, L) = u(c, c^*) + V(L)$. The solution of this model is straightforward. The steady state equilibrium is given by the following equations

$$I = 0 \tag{1}$$

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[3] From an empirical point of view, by not introducing the government in the model we are implicitly assuming that the variables that determine labor supply are superexogenous. This point will be addressed in Section 3.

[4] There is equivalence between the centralized and decentralized equilibrium as shown in Blanchard and Fischer (1989).

$$\lambda(\theta - i^*) = 0 \tag{2}$$

$$q = \frac{\lambda}{\sigma} \tag{3}$$

$$u_c(c, c^*) = \frac{\lambda}{\sigma} \tag{4}$$

$$u_{c^*}(c, c^*) = \lambda \tag{5}$$

$$F_K(K, L) = \theta \tag{6}$$

$$V'(L) = \frac{-\lambda}{\sigma} F_L(K, L) \tag{7}$$

$$F(K, L) + \sigma i^* b = c + \sigma c^* \tag{8}$$

where λ and q are the shadow prices of net foreign bonds and capital. The system of Eqs. (1)–(8) is clearly block recursive. Eq. (1) determines investment in the steady state. Eq. (2) gives the equilibrium value of λ, which can be assumed constant equal to 1 without loss of generality. In addition, Eq. (2) shows that the rate of time preference is equal to the international interest rate [$\theta = i^*$]. Given $\lambda = 1$, the rest of the system is determined. Eq. (3) gives the equilibrium value of the capital's shadow price (q) as the inverse of the real exchange rate. Eqs. (4) and (5) define the equilibrium values of consumption of the domestic good (c), and imported good (c^*). In the same vein, Eqs. (6) and (7) determine simultaneously the equilibrium values of L and K. Finally, Eq. (8) gives the optimal value of net foreign bonds.

The focus of this article is on the equilibrium level of employment derived from this model. Given the assumption of producer–consumer agents, employment is always on the labor supply curve. The equilibrium level of employment hence emerges from Eqs. (6) and (7). It is easy to see that the labor supply is a function of the real wage (w) (which is given by the marginal productivity of labor, $F_L(K,L)$), the real interest rate (r) (given by the marginal productivity of capital, $F_K(K,L)$, which in equilibrium is equal to the rate of time preference, θ, and the international real interest rate i^*), and of the real exchange rate σ:

$$L = L(w, r, \sigma) \tag{9}$$

The expected behavior of this function is that an increase in the real wage leads to an increase in labor supply and hence employment. In the same fashion, an increase in the real interest rate is associated with an increase in employment, which captures the intertemporal substitution effect in the steady state. The impact of the real exchange rate can be negative or positive.[5] A depreciation of the exchange rate increases the present value of financial wealth accumulated in foreign bonds. This leads to a positive income

[5] Lahiri (1996) presents a model that associates a sustained real appreciation of the domestic currency with an increase in labor supply over time.

effect. Therefore, workers can keep the same level of utility by working fewer hours or they may choose to increase their labor supply to take advantage of the higher value of their income in order to increase future consumption. The ambiguity of the impact of the real exchange rate comes from the functional form of $V(L)$. It is easy to show that this impact will depend on the second derivative of $V(L)$. In our model $V'(L)$ is negative, but $V''(L)$ can be positive or negative.

We can illustrate this by using a specific example of production and disutility functions that allows us to obtain an explicit employment function.[6] Assume that the production function is Cobb–Douglas and the 'labor disutility' function $V(L)$ is of the CES form (or constant relative risk aversion).[7] Hence, we have that

$$F(K,L) = K^{\alpha}L^{1-\alpha}$$

$$V(L) = -\frac{L^{1-\gamma}}{1-\gamma}, \quad \text{for } \gamma \neq 1$$

$$V(L) = \ln(L), \quad \text{for } \gamma = 1$$

where the elasticity of substitution of labor between two periods t and s is equal to $1/\gamma$.

From Eqs. (6) and (7) L and K are determined simultaneously. If we want to obtain the employment function, we first need to obtain the equilibrium level of capital (K^*). This is done by substituting $F_L(K,L)$ for the real wage in (7) and then this value into (6) having first substituted $F_K(K,L)$ for r. Given the functional forms defined above and assuming $\lambda = 1$, we get

$$K^* = \left(\frac{\alpha}{r}\right)^{1/(1-\alpha)}\left(\frac{\sigma}{w}\right)^{1/\gamma} \tag{10}$$

Substituting (10) into (7) and solving for L yields the equilibrium employment function as

$$L^* = \left(\frac{1}{1-\alpha}\right)^{(1/\gamma-\alpha)}\left(\frac{r}{\alpha}\right)^{(\alpha/1-\alpha)(1/\gamma-\alpha)}(w)^{(\alpha/\gamma(\gamma-\alpha))}(\sigma)^{(1/\gamma)} \tag{11}$$

It can be easily seen that employment is a positive function of wages and the interest rate if and only if $\gamma > \alpha$. The condition $\gamma > \alpha$ is a reasonable assumption given that usually $1/\gamma$ is estimated to be less than one. Also, employment is a positive function of σ. Hence, if agents are such that labor disutility behaves as a constant relative risk aversion function, we should expect appreciations of the real exchange rates to reduce employment and vice versa. The relevance and sign of the relationship between labor supply and the exchange rate is thus an empirical question that we address in Section 3.

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[6] Note that these functional forms are not fundamental for the model and are used for exposition. In the empirical application we do not impose any particular functional form for production and labor disutility.

[7] By assuming a CES function, we explicitly impose that $V''(L)$ is positive.

3. Empirical evidence

As already commented above, most of the empirical attempts to capture the intertemporal substitution effect in both consumption and labor supply concentrate on short run effects. This is because of its relevance for real business cycle models. Our interest rests on the long run equilibrium impact of the interest rate (intertemporal effect) and the real exchange rate (openness effect). By doing so, we can identify not only the equilibrium properties of the model, but also the transition properties as captured by an equilibrium correction mechanism. Hence, we estimate a more general model in which the transitional dynamics are data-determined, with a theory-determined steady state solution.

In order to do so, we estimated the general solution (9) for employment. The model was estimated for the US and UK economies using quarterly data ranging from 1972:1 to 2001:4.[8] All the data used for estimation was obtained from the OECD Main Economic Indicators except the interest rates that were obtained from the International Financial Statistics of the IMF. All data has been seasonally adjusted. The choice of the US and UK is based on the fact that the US is a relatively closed economy and the UK can be considered a small open economy, which is in accordance with the setting of the model. Assuming equal preferences, we would expect a larger impact of the real exchange rate on employment in the UK, given that changes in the terms of trade will have a stronger effect on UK households' income vis a vis the rest of the world. The semi-log form of Eq. (9) for estimation purposes is:[9]

$$L_t = \alpha_0 + \alpha_1 \mathrm{RER}_t + \alpha_2 W_t + \alpha_3 R_t + u_t \tag{12}$$

where L_t is the log of employment; RER_t is the log of the real exchange rate; W_t is the log of the real wage rate, and R_t is the real interest rate. Employment is measured for the US as the index of the total number of hours worked in the private sector. For the UK, data on hours worked was only available from the beginning of the 1990s and we had to use an index of the number of employees in the private sector. The RER_t is an index of the effective real exchange rate calculated using trade weights by the OECD (that is, $1/\sigma$). W_t is measured for the US as the index of after-tax total wages and salaries, adjusted by CPI, divided by total hours of work of the employed population. For the UK we used an index of the after tax weekly earnings adjusted by CPI. Finally, R_t is the quarterly nominal interest rate on long term government bonds at date t minus inflation over the next quarter $t+1$ (expected inflation). Other measures of the real interest rate, such as the real yield of the composite index of the NYSE, or FTSE were also used. We also constructed expected inflation as the fitted values of an ARMA model for inflation. The results using these other measures yielded very similar results and we report here only those using the Government Bond and inflation over the next quarter.

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[8] The starting date was determined by data availability. The empirical literature on exchange rates has usually focused on the analysis of the post-Bretton Woods float (1973). However, the data shows enough variability of the real exchange rate before that date.

[9] We can derive this semi-log function from (11) and hence α_3 would be a direct estimation of $1/\gamma$. However, this would depend whether or not the labor disutility function is best represented by a CES.

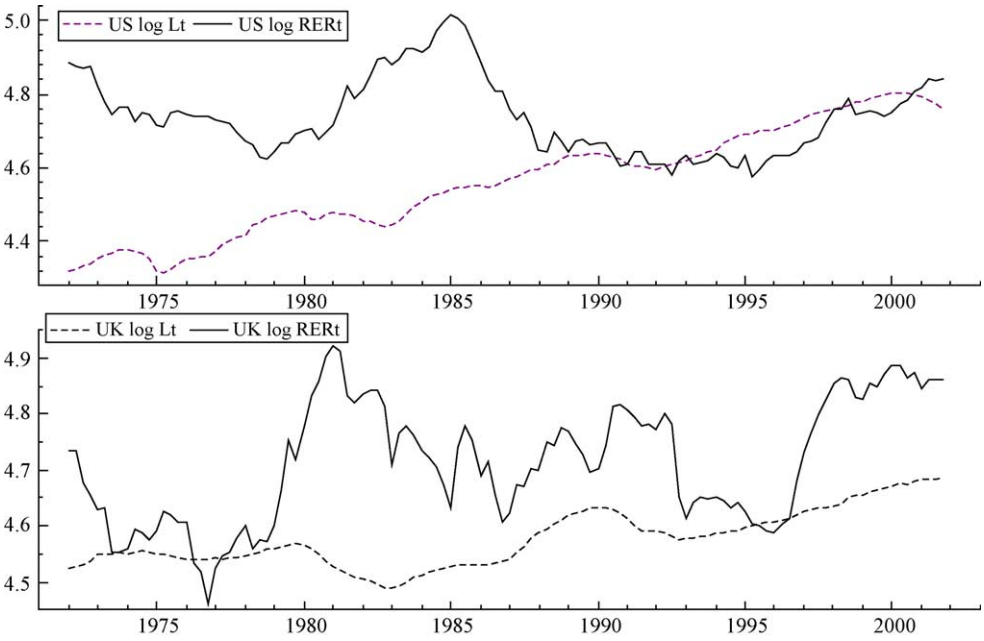

Fig. 1. Employment and the real exchange rate.

Given our focus on the impact of the RER_t on employment, Fig. 1 plots employment and the real exchange rate for both countries. We can see that, although employment shows a clear upward trend, fluctuations of the RER and employment seem to move in opposite directions, although this pattern is less clear for the UK. In both cases employment contracts or stagnates in the first half of the 1980s coinciding with a rapid real appreciation of both currencies due to the oil shock and the reaction of monetary policy during the 'Volcker disinflation' period. Pre-tests for the order of integration of the variables using the ADF, Phillips–Perron and KPSS tests showed that, in all cases, the variables involved have a unit root. For this reason, and in order to allow for dynamics without imposing a priori exogeneity properties, we estimated Eq. (10) as a long run equilibrium correction mechanism (ECM) using Johansen's (1991 and 1992) VAR method. Note also that, since we are testing the steady state solution of the model, our interest is on the long run cointegration vector between the variables involved.

The number of lags was chosen using several criteria. We started with a maximum number of eight lags and analyzed the sensitivity of the cointegration tests and parameter values to a reduction in the number of lags. Also, the Schwarz Bayesian Criteria (SBC) and Akaike Information Criteria (AIC) were used as additional information. Three lag lengths were finally chosen for estimation, i.e. 5, 4 and 3. The results using these lags were remarkably stable and we will report the ones using four lags to avoid under and

Table 1
LR maximum eigenvalue test for the number of cointegration vectors

US		UK		No. of CVs
Statistic	95% Critical value	Statistic	95% Critical value	
28.453	28.270	25.827	28.270	None
18.127	22.040	14.426	22.040	At most 1
11.239	15.870	10.460	15.870	At most 2
2.6737	9.160	6.641	9.160	At most 3

over-parameterisation of the model.[10] Regarding the choice of deterministic trends we chose a model with a constant and no trends in the cointegrating vector. In no case deterministic trends were found to be significant in the cointegration vector. Also, this specification allows for different growth patterns of the variables involved.[11] We also included a set of unconstrained dummy variables to control for outliers and ensure normality in the errors of the underlying VAR.[12]

Tables 1 and 2 present the maximum eigenvalue LR test and the trace LR test for the null hypothesis of r cointegration vectors versus $(r+1)$, respectively. The results show that there is only one cointegration vector between the variables involved for the US. For the UK only the Trace test is able to reject the null of zero cointegration vectors against one. Although the evidence of cointegration for the UK is weaker, we proceed by assuming one cointegration vector for both countries.

The long-run cointegration relations were estimated using three methods in order to check for the robustness of the relationship to different estimation techniques. The methods used were the Maximum Likelihood (ML) method of Johansen (1991), the Fully Modified OLS (FMOLS) method of Phillips and Hansen (1990) and the Dynamic OLS method of Stock and Watson (1993). The last two were chosen because of being single equation methods that correct either parametrically (DOLS) or non-parametrically (FMOLS) for autocorrelation and endogeneity and hence producing more reliable standard errors than OLS. Given the superiority of system methods such as Johansen's ML estimation, the rest of the results will be carried out with the vectors obtained from the ML estimation. The DOLS and FMOLS results are only obtained as a check of robustness to the estimation method.

Table 3 reports the coefficients of the cointegrating vectors and their t-ratios, together with LR or Wald tests of the significance of the inclusion of the RER_t variable. The results for the US show that, in all estimation methods, all the variables included in the labor supply function are significant and have the expected sign. As expected, the real wage has a significant positive impact on employment. Two of the results are of special relevance. First, the real exchange rate enters the employment function with a negative

[10] Insufficient lag length can lead to size distortions and over-parameterisation can lead to a loss of power.
[11] This is also in accordance with the results obtained in the unit roots tests where the variables were found to be random walks with a drift. See Maddala and Kim (1998) for an analysis of these issues.
[12] Inference about cointegration is strongly affected by non-normal errors.

Table 2
LR trace test for the number of cointegration vectors

US		UK		No. of CVs
Statistic	95% Critical value	Statistic	95% Critical value	
58.320	53.480	**64.402**	53.480	None
32.039	34.870	30.741	34.870	At most 1
13.913	20.180	15.736	20.180	At most 2
2.6738	9.160	6.641	9.160	At most 3

Table 3
Cointegration vectors for the labor supply equation

	US			UK		
	ML	FMOLS	DOLS	ML	FMOLS	DOLS
W_t	0.234	0.182	0.183	−0.047	0.220	−0.008
	(11.407)	(17.592)	(34.619)	(0.528)	(5.412)	(−1.739)
R_t	0.233	0.142	0.145	−0.024	−0.005	0.001
	(4.350)	(2.973)	(3.417)	(−4.800)	(−2.967)	(4.067)
RER_t	−0.534	−0.289	−0.218	0.022	0.050	0.006
	(−3.505)	(−3.296)	(−2.973)	(0.319)	(1.058)	(1.360)
Ctant.	−4.090	−3.388	−3.309	4.919	3.457	3.172
	(−3.574)	(−5.745)	(−11.220)	(13.295)	(15.756)	(3.182)
LR RER	6.802	–	10.476	3.032	–	2.122
(*P*-value)	[0.009]		[0.002]	[0.094]		[0.145]
Wald RER	–	7.211	–	–	1.119	–
(*P*-value)		[0.008]			[0.290]	
$\alpha - L_t$	−0.026	−0.033	−0.040	0.041	−0.003	0.023
	(−2.370)	(−2.775)	(−2.337)	(6.123)	(−1.362)	(2.331)

(i) *T*-ratios in parentheses and *P*-values in brackets. (ii) LR RER_t is the Likelihood Ratio test for the significance of entering RER_t in the employment function. (iii) Wald RER_t is the Wald test for the significance of entering RER_t in the employment function. (iv) A Bartlett lag window of length 4 was used for the FMOLS estimation and the truncation lag for the DOLS estimator was also 4.

and significant effect. An appreciation of the real exchange rate leads to a decrease in employment with an elasticity of between −0.5 and −0.2. In light of our previous model this can be interpreted as the real exchange rate appreciation having a positive income effect[13] to which workers respond by reducing hours worked as they can obtain the same utility by working fewer hours (assuming that $V''(L) > 0$). Second, the effect of the interest rate is highly significant. In addition, the positive sign is evidence in favour of the intertemporal substitution hypothesis. Comparing our results with previous studies, our estimates of the employment elasticity with respect to real wages is slightly lower than that obtained by Alogoskoufis (1987b), Dutkowsky and Dunsky (1996), Kimmel and Kniesner (1998) and Mankiw et al. (1985). In all these studies the elasticity varies between 0.26 and

[13] Given that the US is a debtor country, an appreciation of the exchange rate reduces net foreign debt and this increases financial wealth.

1. Regarding the intertemporal effect, the semi-elasticity of employment with respect to the interest rate is in line with those obtained in previous studies.[14] This comparison, however, should be taken with care, since our estimates provide long-run elasticities and refer to employment effects rather than labor supply. In Campa and Goldberg (2001) the employment effect of a real exchange rate shock is found to be negative but quite small, with an elasticity of -0.01. They also find that the shock absorbing effect on wages is higher than in employment. Given our system estimates, the long-run impact of RER_t on wages would be larger than on employment with a faster speed of adjustment. Nevertheless, interaction between wages and employment in a dynamic system framework is not considered in Campa and Goldberg (2001) due to obvious data limitations and hence comparisons cannot be directly carried out.[15]

For the UK, however, the results are not supportive of the theory. The real wage enters negatively in two of the estimation methods. The real interest rate also has a negative impact on employment in the ML and FMOLS estimations. Finally, the real exchange rate appears to have a positive but not significant impact on employment. This confirms the previous result in which we found only weak evidence of a cointegration relation. The results are not directly comparable to those of the US, as the data used is of a different nature. For the UK we use number of employees rather than hours worked and this may substantially affect the results.

Comparing the three estimation methods, we can see that for the US FMOLS and DOLS yield very similar results. The ML method tends to obtain higher elasticities for the three variables. For the UK there is no clear pattern of differentiation between the three methods and the estimated elasticities show large differences, which confirm a lack of robustness in the estimated relation.

In order to show the relevance of the inclusion of the real exchange rate in the determination of employment, we also provide LR and Wald (in the case of FMOLS) statistics for the inclusion of the RER_t variable. In all cases we reject the specification without the real exchange rate at the 99% significance level for the US. Hence, we can argue that the best specification for the employment function is the one including the real exchange rate. For the UK, however, none of the estimations confirm the significance of the RER_t at the 95% significance level. These results, hence, confirm the relevance of the inclusion of open economy features in the basic intertemporal model for the US.

We finally report the adjustment coefficient of the estimated short-run equilibrium correction model (ECM) for each vector obtained. The adjustment of employment to its' long-run equilibrium is given by $\alpha - L_t$. We can observe a slow adjustment coefficient for the US of between 2.6 and 4% per quarter, which would imply an annual adjustment of between 11 and 17% per year. For the UK the adjustment coefficient is positive using the cointegration vector obtained with the ML and DOLS methods and negative but insignificant for the FMOLS method.

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[14] Although, for instance, in Altonji et al. (2002) intertemporal substitution effects are found to be close to zero.

[15] See also Goldberg and Tracy (2001) for further discussion of the impact of RERt shocks on wages and employment in the US.

Table 4
Significance of ECM_{t-1} in marginal equations. F-statistics (P-values)

	US	UK
In conditional model	4.758 [0.032]	22.197 [0.000]
In marginal model for ER_t	2.701 [0.101]	4.782 [0.031]
In marginal model for R_t	0.459 [0.500]	0.870 [0.353]

An important feature to address in this model is that of the Lucas' (1976) critique. If the government wishes to minimize the business cycle by affecting labor supply decisions and hence employment, it may choose to do it by influencing the interest rate or the exchange rate.[16] However, if agents are forward looking, the mere government intervention can affect the way the policy variables enter the model generating variable-dependent parameters. This would make the estimated model useless for policy issues. In a time series context, Davidson et al. (1978) argued that, if *superexogeneity* of the regressors holds, the Lucas critique does not apply. Superexogeneity holds if both the regressors in the conditional model (10) are weakly exogenous, and if the model presents structural invariance.[17] Thus, we carried out an analysis of superexogeneity of RER_t and R_t in the model presented.

In order to test for weak exogeneity we estimated marginal models for both RER_t and R_t. The instrumental variables used in the marginal models for RER_t were a short run real interest rate such as the short term real Treasury Bill rates and real output. The first would account for possible real interest differential effects and the second would capture productivity effects. In the marginal model for R_t we used the investment-output[18] ratio and an indicator of the cycle such as the firms' stock over GDP. In both cases cointegraton was found and we used the same procedure as for the conditional ECM.[19] Following Hendry and Ericsson (1991), if the lagged value of the conditional ECM enters significantly in the conditional equilibrium correction equation but not in the marginal ones, then the regressors considered are weakly exogenous. Table 4 reports the F-statistics for the significance of ECM_{t-1} in each model. The results show that both ER_t and R_t can be considered weakly exogenous with respect to employment for the US and only R_t for the UK.

The test for structural stability follows Engle and Hendry (1993). Their test consists of including the squared residuals of the marginal equations and its lags in the conditional equation. If an F-test of joint significance cannot reject the null of zero coefficients, then we would accept that the effect of both variables is structurally stable and this would point to superexogeneity. We introduced up to five lags of the squared residuals of the marginal

[16] In a small open economy, the interest rate would not be considered as a policy variable. This is not the case for a large economy as the US. In addition, the real wage can hardly be considered a policy variable and, thus, we concentrate on the other two variables. Of course if the nominal wage is indexed to the interest rate, we would have a quite different picture (see, for instance, VanHoose and Waller, 1989).

[17] The results here presented should be taken with caution. Lindé (2000), for example, suggests that the superexogeneity tests are not capable of detecting the relevance of the Lucas' critique in practice in small samples.

[18] Investment is measured as Gross Fixed Capital Investment.

[19] For sake of space the results are not reported here but are available from the authors upon request.

Table 5
Significance of squared errors of marginal model in conditional model

	US	UK
Marginal model for ER_t	0.726 [0.606]	1.366 [0.254]
Marginal model for R_t	0.259 [0.934]	0.692 [0.631]

ECMs in the conditional one, and then reduced the number of lags until we obtained the highest possible significance levels. Table 5 reports the highest values obtained for the *F*-tests. These values show that the squared residuals of the marginal models are jointly insignificant for both countries. Hence, in the case of the US, the results show that we cannot reject the null hypothesis the superexogeneity of both ER_t and R_t. For the case of the UK we can accept superexogeneity of the real interest rate, but not of the real exchange rate as we found it not to be weakly exogenous.

Overall, thus, the empirical results seem to be supportive of the open economy version of the representative agent model only for the US. We have also showed that the model estimated seems to be robust to the Lucas' critique for this country. For the UK, however, we could not find supportive evidence.

4. Concluding remarks

Most of the theoretical and empirical literature on the optimizing intertemporal model of economic fluctuations has been based in closed economy models. This paper studies the implications of this model in an open economy. It presents a standard representative agent open economy model in which the long-run equilibrium employment level is derived as a function of the real wage, real interest rate and real exchange rate. The expected effect of these variables is in line with the neoclassical growth model. Increases in the real wage and real interest rate lead to increases in employment. The impact of the real exchange rate is ambiguous.

We test the steady state (equilibrium) solution of the model using time series data for the US and the UK for the last thirty years. The results are consistent with the model's predictions for the US case. We find positive impacts of real wages and the real interest rate and a negative and significant impact of the real exchange rate. These results are not confirmed for the UK case. In order to avoid the Lucas critique, tests for the superexogeneity of the interest rate and exchange rate are also carried out. Overall, our empirical evidence is supportive of the open economy version of the intertemporal optimization model and robust to the Lucas critique only for the US economy.

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