

ARE THERE ANY SPECIAL FEATURES IN THE SPANISH BUSINESS CYCLE?

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In this paper we analyze the empirical performance for the Spanish economy of a standard real business cycle model. To this purpose, we define a set of measurements consistent with the structure of our model economy and we evaluate both the long-run and business cycle properties of this reference data set. We solve the model alternatively with divisible and indivisible labor and, in each case, with and without government consumption. We set the values of the structural parameters by combining calibration and estimation (GMM) techniques, and its implications on the results are evaluated. When we introduce indivisibilities in labor supply and government consumption the model's empirical performance is improved. In this respect, our results do not differ substantially from those obtained for the US economy. However, the model fails to explain the cyclical behavior of private consumption in the Spanish economy. (JEL E32, E37)

1. Introduction

In this paper we evaluate the empirical performance for the Spanish economy of a standard real-business-cycle (RBC) model. The RBC approach has produced important advances in the investigation of the

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aggregate fluctuations associated with the business cycle. However, there is a small number of applications of the RBC methodology to the analysis of the fluctuations of the Spanish economy.¹ One of the main reasons underlying this circumstance is the lack of appropriate data. In fact, only recently National Accounts have been available on a quarterly basis. Moreover, the additional data sources, which are generally needed to round off the selection of parameter values, often lack an adequate homogeneity.² Consequently, the first objective of this paper is to build an appropriate data set for the Spanish economy to fulfill the basic measurement requirements of RBC exercises.

Not only the lack of reliable data justifies the absence of RBC models for the Spanish economy. One of the most recurrent arguments amongst the (Spanish) detractors of the RBC approach can be stated in terms of its inappropriateness to the study of the labor-market fluctuations in economies with high unemployment. Another argument typically arises when discussing the role of the government sector in OECD economies other than the US. These two reasons lead us to choose as our standard RBC benchmark the specification proposed by Christiano and Eichenbaum (1992). Undoubtedly, as a variant of Hansen (1985) and Rogerson's (1988) indivisible labor model, Christiano and Eichenbaum's (1992) constitutes one of the most significant advances in the study of the key labor-market features in the RBC tradition. These authors modify the indivisible labor model by allowing government consumption shocks to influence labor-market dynamics. Their empirical results indicate that this change improves the predictions of the model throughout its labor-market dimension and, in particular, with respect to the observed weak correlation between hours worked and wages, the so-called Dunlop-Tarshis observation.

Of course, in the last seven years much progress has been made on the labor-market dimension of business cycle models, often through departures from the assumption of perfectly competitive labor markets.³

¹Some exceptions are Dolado et al. (1993), Licandro et al. (1996) and Ortega (1994).

²In this respect, recent works by Carbajo and García-Perea (1988), Estrada and Sebastián (1993) and García Perea (1991), amongst others, are extremely valuable.

³See for example Andolfatto (1996), Beaudry and DiNardo (1995), Boldrin and

However, none of these contributions belongs to the mainstream of the RBC research program. We would like to see whether the main conclusions of Christiano and Eichenbaum's (1992) RBC models hold when parameter values are chosen to fit the Spanish data.

Thus, the motivation of this paper is twofold: *i*) following Christiano (1987) and Cooley and Prescott (1995), to define a set of measurements of the Spanish economy consistent with the type of models under consideration, and *ii*) to evaluate the validity of the main conclusions of the RBC models on Spanish data, in particular in one of their most critical dimensions: labor-market fluctuations. This will allow us to achieve a better characterization of both the cyclical properties and the long-run features of the Spanish economy. Also, we will be able to provide a set of results that can be useful for future research. This research should involve both extensions of the models and improvements in the data set.

As has been stated above, the specification of a stochastic dynamic general equilibrium model we adopt is the one proposed by Christiano and Eichenbaum (1992). This specification incorporates: *i*) the divisible and indivisible labor hypothesis, and *ii*) either the presence or absence of the government sector. The indivisible labor model in Rogerson (1988) and Hansen (1985) assumes that individuals either work a fixed number of hours or they do not work at all. If the individuals can choose the probability of working, then it is possible to widen the set of choices in such a way that the economy behaves as if there were no indivisibilities. This gives rise to fluctuations in aggregate employment relatively more important than variations in the labor productivity since the marginal disutility of an extra unit of individuals at work is constant and independent of the number of individuals who work. Christiano and Eichenbaum (1992), building upon Hansen (1985), argue that the observed weak correlation between hours worked and productivity suggests that technology shocks cannot be the only impulse behind aggregate fluctuations. The rationale for this is that, with technology shocks, movements in equilibrium wages and hours are mainly due to movements along the labor sup-

Horvath (1995), Danthine and Donaldson (1990) and (1995), Fairise and Langot (1994) and Gali (1996).

ply curve, which results in a high positive correlation between these two variables. Consequently, when innovations in government expenditures are incorporated into the analysis the empirical performance of the model is improved.

This is not the only contribution in Christiano and Eichenbaum (1992) though. In addition, their work represents one of the first implementations of Hansen's (1982) Generalized Method of Moments (GMM) to the formal estimation of RBC models. We will pursue this methodology in our application to the Spanish economy. This means that we evaluate the conformity of the models with the data and we estimate the structural parameters of the model in order to have a metric to measure and test the model's implications. Our main motivation to incorporate the estimation and evaluation procedure comes from practical reasons: to perform comparisons not only with the results for the US economy but also with comparable results for the French economy reported in Fève and Langot (1994).⁴ As emphasized by Kydland and Prescott (1991) the evaluation of a model relies on the economic theory underlying it and not on any statistical measure of the discrepancy between the model and the data. Consequently, our strategy does not particularly stress the validation procedure; rather, it tries to take advantage of nearly ten years of GMM estimation to obtain additional insights into the performance of the models. Thus, we consider it useful to compare the parameter selection procedure used under calibration techniques with the GMM estimation of the structural parameters.⁵

It is important to stress that RBC models integrate the study of aggregate fluctuations within the framework of growth theory. Thus, before proceeding with the analysis it is important to evaluate whether the observations are consistent with the assumption of balanced growth. We find that hours worked exhibit a marked downward trend until the middle of the eighties and that the capital-output ratio has

⁴Tentative comparisons with results in Correia et al. (1995) and Kollintzas and Vassilatos (1996), for Portugal and Greece respectively, may be possible.

⁵This argument is in line with part of the discussion in Canova and Ortega (1996). Increasingly, researchers are combining calibration and estimation techniques to analyze business cycles, for instance when developing the SMM approach as in Hairault et al. (1996).

a slight upward trend. It is for this reason that we will restrict the sample period to 1976:1-1994:4. This sample approximates the long-run properties of the Spanish economy better than the whole sample.

Our main results suggest that the empirical behavior for Spanish data of the standard RBC models under consideration does not differ substantially from that for the US economy. All the models do well at matching output volatility and the volatility of investment relative to output. Also, when labor indivisibilities and innovations in government expenditures are incorporated into the analysis the empirical performance of the model with respect to the labor-market variables is somewhat improved. This might be taken as some evidence with respect to the fact that, in terms of aggregate fluctuations at least, different economies behave in a similar way regardless of the level of unemployment, and only deviations of employment have relevant effects on the cyclical properties of the economy. This opens the question of what is the role played by unemployment in the transmission of aggregate fluctuations.

As reported by Dolado et al. (1993), Spanish private consumption is more volatile than GDP, which contradicts the life-cycle hypothesis. They measure private consumption as the consumption of durable and non durable goods. The substitution of consumer durables by an estimation of the flow of services derived from them partially answers this puzzle, by reducing private consumption volatility below GDP volatility. Moreover, our proposed measure for production is more volatile than GDP, but the relative volatility of private consumption remains high. In any case, the models analyzed in this paper are not able to reproduce the high volatility of our measure of private consumption in Spain relative to our measure of production. This means basically that a lot of work remains to be done in order to explain what we would call the Dolado-et-al puzzle. Moreover, from the results in Christiano and Eichenbaum (1992) we know that labor indivisibilities and government consumption shocks are not enough to account for the Dunlop-Tarshis observation. Only when they incorporate measurement error in hours worked into the analysis the puzzle is resolved. Given that we do not have a reliable measure of hours worked, we leave for future research the exploration of this

feature of the model.

The paper is organized as follows. Section 2 describes the model and its alternative specifications. In Section 3 we analyze the main implications of our measurements of aggregate variables for the stylized facts of the Spanish economy. Section 4 discusses calibration and estimation. In Section 5 we report the main results and Section 6 concludes and evaluates the plausibility of some extensions. Appendix 1 contains the description of the data and the procedures used to construct our reference data set.

2. The economy

As our benchmark RBC model we adopt Christiano and Eichenbaum's (1992) specification. This includes a version of the stochastic growth model with divisible labor and a version of Hansen's (1985) indivisible labor growth model. In both cases government consumption may be incorporated into the analysis as described below.

The economy is inhabited by a large number of infinitely lived households that we normalize to one. As is standard in growth and business cycle models, the decentralized competitive equilibrium can be characterized by the solution of a planning problem. The planner chooses the representative household's stochastic sequences of consumption and leisure to maximize

$$E_0 \sum_{t=0}^{\infty} \beta^t [\ln(C_t^s) + \theta V(N - n_t)], \quad [1]$$

where β represents the discount factor, C_t^s are per-capita consumption services, n_t per-capita hours worked, N is the individual endowment of productive time, and θ is a positive parameter which represents the household's preferences for leisure. In the reference case $V(N - n_t) = \ln(N - n_t)$. Alternatively, if we assume that households' utility functions are linear in leisure then $V(N - n_t) = N - n_t$, as in Hansen (1985). This specification is consistent with the existence of indivisibilities in the labor supply.⁶ Notice that an appropriate manipulation implies that $\theta(N - n_t) = \theta N(1 - \pi_t) + \theta(N - l)\pi_t$, where

⁶If households' utility functions are separable across consumption and leisure, Rogerson (1988) shows that a market structure in which agents choose the prob-

$\pi_t = n_t/l$ represents the probability of finding a job with a fixed number l of quarterly hours.

Consumption services incorporate both per-capita private consumption C_t and per-capita government consumption G_t according to the function

$$C_t^s = C_t + \eta G_t, \quad [2]$$

where η is either 0 or 1. It is assumed that G_t is a stochastic process beyond the planner's control. When $\eta = 1$, private and public consumption are perfect substitutes. In this case, for any sequence of public consumption individuals may adjust private consumption in order to follow the same optimal path for total consumption. The equilibrium of this economy is formally the same as the one for an economy without government. Government consumption is incorporated into the analysis when $\eta = 0$, implying that public consumption has no effects on individual utility (it is a pure loss of resources). Crowding-out effects coming from stochastic government spending should affect the equilibrium path. In particular, they should help to explain the Dunlop-Tarshis puzzle, since shocks to government consumption move the labor supply curve, allowing for countercyclical responses of employment and wages.

We will assume that per-capita aggregate output at time t , Y_t , depends on per-capita capital stock, K_t , and per-capita hours worked, n_t , through a Cobb-Douglas production function of the form

$$Y_t = K_t^{(1-\alpha)} (n_t X_t)^\alpha, \quad [3]$$

where $0 < \alpha < 1$ and X_t represents the state of technology which evolves according to

$$X_t = X_{t-1} \exp\{\gamma + v_t\}. \quad [4]$$

The technology shock v_t is supposed to follow an *i.i.d.* process with zero mean and standard deviation σ_v , and γ is a positive constant which represents the expected growth rate.

ability of being at work some fixed number of hours instead of hours worked guarantees a Pareto optimal allocation of consumption and leisure.

The aggregate resource constraint is given by

$$C_t + G_t + K_{t+1} - (1 - \delta) K_t \leq Y_t. \quad [5]$$

Given the definition of the state of technology and to keep the balanced growth properties of the model we assume that G_t evolves according to

$$G_t = X_t g_t, \quad [6]$$

where g_t follows the law of motion

$$\ln(g_t) = (1 - \rho) \ln(\bar{g}) + \rho \ln(g_{t-1}) + \epsilon_t. \quad [7]$$

$\ln(\bar{g})$ is the mean of the stationary component of government consumption, $\ln(g_t)$, $0 < \rho < 1$, and ϵ_t is the innovation to $\ln(g_t)$ which is assumed to follow an *i.i.d.* process with zero mean and standard deviation σ_ϵ .

The planner chooses $\{Y_t, C_t, K_{t+1}, n_t : t \geq 0\}$ to maximize [1] subject to [2] - [7] given K_0, X_{-1} and g_{-1} .

Finally, it is convenient to obtain a stationary representation of this social planning problem by normalizing with respect to the state of technology, X_t . To this end we define the following detrended variables:

$$c_t = \ln(C_t/X_t), k_{t+1} = \ln(K_{t+1}/X_t), \text{ and } y_t = \ln(Y_t/X_t).$$

Note that g_t , and n_t are stationary.⁷

3. Consistent measurements and stylized facts

Business cycle theory aims at improving our understanding of the cyclical behavior of actual economies. The empirical evaluation of the capability of different models to reproduce the type of aggregate fluctuations associated with the business cycle requires the set of measurements describing the actual economy to be consistent with the features of the model economy.

The National Accounts of the Spanish Economy (Contabilidad Nacional de España; NA henceforth and NAq for the quarterly version)

⁷Unless otherwise indicated, lower case letters denote stationary variables.

are somewhat inconsistent in their treatment of consumer durables and this has some effects on the measures of output, consumption and investment.⁸ More precisely, the NA data include consumption of durable goods as part of private consumption. However, the flow of services from these goods lasts for more than one period so that purchases of consumer durables should be computed as investment. Consequently, capital stock data have to match the definition of investment, and the corresponding flow of services from the stock of consumer durables has to be imputed as part of measured output. In addition, in this paper we restrict ourselves to closed economy models so that we have to construct consistent measures of output and the components of demand. In particular, Christiano (1987) and Cooley and Prescott (1995) have proposed alternative definitions of measurements consistent with closed economy models. These two approaches differ in their treatment of the balance of trade. Cooley and Prescott (1995) include net exports in the measure of investment, whereas Christiano (1987) excludes the foreign sector from the definition of output. We choose to keep our definition of variables closer to Christiano's (1987) proposal in order to make comparisons more straightforward.⁹

We discuss below the main ingredients of our reference data set and we evaluate its implications on the stylized facts of the Spanish economy.

3.1. The data

Following Christiano (1987), we define a set of measurements for the capital stock, employment, output and the components of demand. All series are quarterly for the period 1970:1-1994:4 and they were transformed to per capita terms using a measure of the labor force. See Appendix 1 for details.

The capital stock, denoted by K_t , includes public and private cap-

⁸Cooley and Prescott (1995) discussed in detail the imperfections of the National Income and Product Accounts (NIPA) of the US. These imperfections are present in the Contabilidad Nacional de España.

⁹Christiano (1988) and several subsequent papers use Christiano's (1987) measures.

ital, residential structures and a measure of the stock of consumer durables. The time series of hours worked we consider, H_t , corresponds to hours worked by employed-person times the number of employed population and it is in per-capita terms.

Private consumption, C_t was measured as quarterly real expenditure in nondurables and services, plus an imputed flow of services from the stock of consumer durables. Gross Investment, I_t , is the result of adding up the investment on fixed capital series and the series of expenditure in durable goods. We have not included inventory investment in our measure of gross investment, since in future work we expect to include this variable explicitly into the analysis. Government consumption, which we denote G_t , is the government consumption from the NAq divided by our measure of population. Finally, output per capita is the result of adding up the three previous components: $Y_t = C_t + I_t + G_t$. The main difference between our measure of output and the corresponding GDP measure in the NAq is that we exclude net exports and inventory investment and we include the imputed flow of services of the stock of consumer durables. We would have liked to include a measure of the flow of services generated for the stock of public capital. Unfortunately a quarterly series for public investment is not available.

3.2. *Stylized facts*

A first and extensive description of the cyclical regularities of the Spanish economy was carried out by Dolado et al. (1993), using quarterly National Accounts (NAq) data. Our interest here is to briefly discuss some stylized facts relevant to our study. In particular, from the conclusions outlined by Dolado et al. (1993), we want to highlight the following: (a) the low volatility of Spanish output when compared with output volatility in other industrialized economies, (b) in a seeming contradiction with the life-cycle hypothesis, consumption is more volatile than output, and (c) net exports are countercyclical.

Table 1 reports some moments of interest for the original NAq data set in the 1970:1 1994:4 period.¹⁰ Table 2 reports the results with

¹⁰The trend component of the series is obtained by the use of the Hodrick-

TABLE 1
Second-moment properties of HP-filtered data.

		National Accounts Data Period 1970:1 1994:4						
Variable	Relative Volatility	Cross-correlations of GDP with						
		x(t-3)	x(t-2)	x(t-1)	x(t)	x(t+1)	x(t+2)	x(t+3)
x								
GDP	1.00	.60	.80	.94	1.00	.94	.80	.60
Private cons.	1.07	.53	.69	.78	.79	.70	.57	.42
Govt' cons.	0.94	.06	.21	.34	.41	.45	.45	.44
Fixed Inv't'	3.85	.58	.74	.84	.87	.80	.68	.52
NX/ GDP	1.03	-.27	-.39	-.46	-.47	-.44	-.39	-.35

National Accounts quarterly data for the period 1970:1 1994:4. All variables are in real terms. For the net exports over GDP ratio, XN/PIB, the reported value is absolute volatility (%). All variables are in logs except XN/PIB. Output volatility is 1.16%.

our reference data set. The use of one or the other set of measurements is not innocuous and has some relevant effects on the moments of the cyclical component of the Spanish economy's aggregate variables. In particular, when we move from NAq data to the reference data set there is an important increase in output volatility (from 1.16% to 1.46%), mainly as a result of the exclusion of net exports which are negatively correlated with GDP. As a consequence of the previous result, the relative volatility of the demand components decreases significantly. Moreover, the substitution of the consumption of consumer durables by an estimate of the flow of services of the corresponding stock results in a smoothing of the consumption se-

Prescott filter (HP), with the usual value of the smoothing parameter for quarterly data, i.e. $\lambda = 1600$. For comparison purposes, note that the sample period in Dolado et al. (1993) is 1970:1-1991:4. The sample we are able to use includes the last recession, which results in a slight increase in the volatility of all the series, and particularly in GDP.

TABLE 2
Second-moment properties of HP-filtered data.

		Reference data set Period 1970:1 1994:4						
Variable	Relative Volatility	Cross-correlations of output with						
x		x(t-3)	x(t-2)	x(t-1)	x(t)	x(t+1)	x(t+2)	x(t+3)
Output	1.00	.57	.76	.93	1.00	.93	.76	.59
Private cons.	0.69	.35	.52	.71	.78	.70	.57	.48
Govt' cons.	0.78	.05	.21	.34	.44	.49	.48	.45
Fixed Inv't	2.58	.61	.75	.86	.90	.84	.70	.51

Reference quarterly data set for the period 1970:1 1994:4. All variables are in logs and real terms. All variables are in per capita terms. Output volatility is 1.46%.

ries. This element further contributes to the decrease of the relative volatility of consumption. It can be seen that with the NAq data consumption is more volatile than production (the relative volatility is 1.07%), whereas in our reference data set the relative volatility of consumption is 0.69. However, the correlations of the components of output with GDP are not substantially modified.

Finally, it is important to evaluate whether the aggregate data of the Spanish economy during the period 1970:1-1994:4 are consistent with the required balanced growth assumptions. In this respect it is important to notice that hours worked exhibit a marked downward trend until the middle of the eighties. This is explained by an important reduction in the number of hours per worker during the seventies and, to a lesser extent, by a decrease in the employment rate in the eighties. The capital-output ratio exhibits some trend at the beginning of the sample. It can be argued that the unit root resulting from a stationarity test of the series is spurious though. More precisely, we find that the capital-output ratio admits a change of mean around the second quarter of 1975. However, once the usual tests are performed, the hypothesis that the capital-output ratio is stationary

with a change of mean is only acceptable up to a 10% significance level. When testing this hypothesis on the output series (both on GDP and on our measure of output) and the capital series we find some evidence in favor of a segmented mean at 1975:2. This finding is consistent with the results reported in Andrés et al. (1990 p.103) and Bajo-Rubio and Sosvilla (1994 p.114) from annual data.

For all these reasons, it is clear that the Spanish economy does not fulfill the balanced growth assumptions over the whole sample. We accept as a compromise solution that data from 1976:1 to 1994:4 might represent the long run properties of the Spanish economy better than the entire sample. As we will see when discussing our empirical results, this selection turns out to be particularly appropriate for the capital-output ratio, the output growth rate and the labor share, which are key elements of the model. Moreover, as can be checked by comparing Tables 2 and 6, second moment properties are very similar in both samples. However, as noted in Section 5, only some of the dimensions of the restricted sample are fully consistent with the balanced growth assumptions.

4. Calibration and estimation

In this section we perform three tasks: *a)* we calibrate the model economy to obtain point estimates of the underlying parameters, *b)* we use a version of Hansen's (1982) generalized method-of-moments (GMM) to take into account parameter and sample uncertainty, and *iii)* we test from a statistical point of view the plausibility of the model's implications.

It should be noticed that the labor share, α , and the discount factor, β , cannot be set independently. In this dimension, calibration implies taking α from data and obtaining β from the Euler condition at the steady state, whereas under a standard GMM approach the procedure consists of fixing β to estimate α . To have consistent parameters coming from these two alternative methodologies, we set the value of the discount factor β obtained from the calibration in order to obtain our GMM estimation of α .

TABLE 3
Calibrated parameter values.

Individual's time endowments	(1)	N	1369
Subjective discount rate	(3)	β	0.9891
Preference for leisure	(3)	θ	
Without Government			
Divisible labor			2.0684
Indivisible labor			0.0021
With Government			
Divisible Labor			2.4895
Indivisible Labor			0.0026
Labor share	(1)	α	0.6529
Average depreciation	(2)	δ	0.0222
Growth rate	(2)	γ	0.0037
Standard deviation for tech. shock	(4)	σ_v	0.0126
Government consumption share	(2)	g/y	0.1280
Correlation coef. for Govt' spending	(4)	ρ	0.9510
Standard deviation for Govt' shock	(4)	σ_ϵ	0.0112
Calibration criteria: (1) External information, (2) sample averages (3) steady state, and (4) stochastic properties.			

4.1. Calibration

To calibrate the model economy we follow the methods described in Cooley and Prescott (1995): parameter values are chosen so that the model economy produces values for the stationary variables which match the corresponding averages of actual data. This principle is based on the assumption that the Spanish economy is moving around its balanced growth path, which implies that stationary variables move around the observed averages. To this end we use the set of measurements discussed in Section 3.1 for the period 1976:1-1994:4.

Table 3 reports the calibrated parameter values. Following Christiano and Eichenbaum (1992) we fixed the individual's productive time endowment, N , to 1369 hours per quarter.

To calibrate the labor share, α , we have corrected the NA data in order to take into account that a) a share of revenues corresponding to self-employed workers, imputed as capital revenues in the NA,

should be registered as labor revenues¹¹ and b) an estimated flow of services of consumer durables is included as capital revenues. The labor share obtained after this correction is $\alpha = 0.6529$.

All other parameters were chosen so that the balanced growth path conditions hold for the average data for the period 1976:1-1994:4. That is, the share on output of government expenditures, the quarterly growth rate, the depreciation rate, the capital labor ratio and the per-capita worked hours were set at their average values. Given all these values, we have solved the non-stochastic stationary conditions of each model in order to calibrate the subjective discount factor β and the labor disutility parameter θ .

To complete the calibration, the parameters corresponding to both the technological and government expenditure stochastic processes have to be set. The Solow residual measure is derived from equation [3]

$$\ln(X_t) = [\ln(Y_t) - (1 - \alpha) \ln(K_t) - \alpha \ln(n_t)] / \alpha. \quad [8]$$

The stochastic process for $\ln(X_t)$ is difference-stationary and in accordance with equation [4] the innovations of this process should be taken as a measure of the sequence of technology shocks of the Spanish economy.

Given X_t , the stationary component of the government expenditures is solved and the corresponding parameters are estimated using equation [7].

4.2. *Econometric method*

In this section we briefly describe both the estimation procedure and the methods to evaluate the model's implications. As noted above, we focus on GMM estimation as implemented for RBC models by Christiano and Eichenbaum (1992).

¹¹As we point out in Appendix 1, following Bentolila and Blanchard (1990) we use the adjustment made by *European Economy* (1994). The corresponding calculation of the labor share is in annual terms.

Estimation

The criterion for choosing parameters is setting to zero the discrepancy between certain model and data first and second moments. To this end, we use some moment restrictions implied by the model.

In particular, from the model presented in Section 2, we consider the following vector of parameters

$$\psi_1 = \{\theta, \alpha, \delta, \gamma, \sigma_v, \bar{g}, \rho, \sigma_\epsilon\}. \quad [9]$$

Parameters β and N are not estimated: β is set to imply a 4.5% annual subjective discount rate¹² and N is fixed at 1369 hours per quarter. Parameter η is set to one or zero alternatively.

In addition, we are interested in a set ψ_2 of second-order moments of the cyclical component of the data:

$$\psi_2 = \{\sigma_c/\sigma_y, \sigma_i/\sigma_y, \sigma_g/\sigma_y, \sigma_n/\sigma_y, \sigma_n/\sigma_{y/n}, \sigma_y\}, \quad [10]$$

where σ_z is the standard deviation of the cyclical component (logged and HP-detrended) of the variable z with $z = \{y^{hp}, c^{hp}, i^{hp}, g^{hp}, n^{hp}, (y/n)^{hp}\}$, (y/n) being average labor productivity.

The combined parameter vector $\psi = (\psi_1, \psi_2)$ can be estimated through moment conditions of the form¹³

$$E\{f([Z_t, z_t]', \psi)\} = 0, \quad [11]$$

where $Z_t = \{Y_t, C_t, I_t, G_t, n_t, K_t\}$. Thus, the entire parameter vector ψ is estimated by GMM.

A GMM estimator of ψ can be obtained by minimizing a quadratic form in the sample moments, i.e. choose $\hat{\psi} = (\hat{\psi}_1, \hat{\psi}_2)$ to minimize

$$J_T = g_T(\hat{\psi})' W_T g_T(\hat{\psi}), \quad [12]$$

¹²Which roughly corresponds to our calibration result.

¹³See Appendix 2 for a detailed presentation of the orthogonality conditions.

	Without government ($\eta = 1$)				With government ($\eta = 0$)			
	Divisible labor		Indivisible labor		Divisible labor		Indivisible labor	
	Exactly identified	Over identified	Exactly identified	Over identified	Exactly identified	Over identified	Exactly identified	Over identified
θ	2.1271 (.0364)	2.2078 (.0377)	0.0022 (.0000)	0.0022 (.0000)	2.6179 (.0512)	2.6025 (.0514)	0.0027 (.0000)	0.0027 (.0000)
α	0.6506 (.0059)	0.6569 (.0057)	0.6507 (.0059)	0.6570 (.0057)	0.6602 (.0065)	0.6633 (.0063)	0.6601 (.0065)	0.6634 (.0063)
δ	0.0222 (.0003)	0.0219 (.0003)	0.0222 (.0003)	0.0219 (.0003)	0.0222 (.0003)	0.0220 (.0003)	0.0222 (.0003)	0.0220 (.0003)
γ	0.0037 (.0009)	0.0035 (.0009)	0.0037 (.0009)	0.0035 (.0009)	0.0037 (.0009)	0.0034 (.0009)	0.0037 (.0009)	0.0034 (.0009)
σ_v	0.0131 (.0012)	0.0086 (.0009)	0.0131 (.0012)	0.0086 (.0009)	0.0130 (.0012)	0.0085 (.0009)	0.0130 (.0012)	0.0085 (.0009)
\bar{g}	174.66 (7.482)	166.50 (7.870)	174.54 (7.496)	166.45 (8.033)	165.90 (7.233)	160.96 (7.021)	166.00 (7.273)	160.74 (7.004)
ρ	0.9506 (.0226)	0.9588 (.0251)	0.9507 (.0226)	0.9601 (.0252)	0.9499 (.0229)	0.9467 (.0250)	0.9499 (.0229)	0.9466 (.0252)
σ_ϵ	0.0110 (.0012)	0.0058 (.0006)	0.0110 (.0012)	0.0059 (.0006)	0.0109 (.0012)	0.0058 (.0006)	0.0109 (.0012)	0.0058 (.0006)
J	...	14.242 [.002]	...	14.235 [.002]	...	14.089 [.002]	...	14.083 [.002]

All of the statistics for the models are averages, across 100 simulated data sets, each with 75 observations. Numbers in parentheses are the standard deviations across data sets.

Under the null hypothesis that the model moments and the data moments are equal, $\mathcal{W} \sim \chi^2(l)$. The degrees of freedom, l , are equal to the number of restrictions to be tested.

5. Empirical results

In this section we discuss our empirical results for the four models under consideration. As can be seen from Tables 3 and 4 (under the exactly identified heading) nearly all the calibrated parameters are in the confidence intervals of the estimated parameters. This is particularly true for the labor share α and, consequently, for the variance of the technology shock σ_v .¹⁷

Table 4 also displays our parameter estimates for all the models when

¹⁷Notice that the labor share is not in the data set utilized for the GMM estimation. However, an appropriate choice of β in the estimation stage is crucial to obtain a value for α consistent with the labor share data.

we impose the orthogonality between the innovation in the technology shocks and the innovation in the government spending shocks. A first test of the model consists of imposing the overidentifying restriction $E(\nu_t \epsilon_t) = 0$ by using Hansen's (1982) J -statistic. As can be expected from the previous literature on this issue, the overidentified system is rejected at less than the 0.5% significance level. However, given our reference data set and the specification for the shocks processes, the point estimates of the model's parameters do not move to inadmissible values.¹⁸

Table 5 reports the implications of our point estimates for some first-moment properties of the models under consideration. First, our estimate of ψ_1 implies steady state ratios that lie in the confidence interval of the corresponding empirical averages. This is particularly true for the capital-output ratio, which is the only ratio explicitly included in the orthogonality conditions. Secondly, as discussed in Section 3.2, the capital stock at the beginning of the sample grows at a higher rate than output and hours worked evolve with a marked downward trend. For these reasons, the growth rate of capital is greater than the growth rate of output¹⁹ and the growth rate of hours is different from zero. Indeed, the unconditional growth rate of capital in the models correspond to the growth rate of output and the unconditional growth rate of hours is zero. However, the growth rates of the data exhibit a high variability and the short length of the sample does not allow a proper evaluation of whether the Spanish economy is on its balanced growth path.

Tables 6 and 7 present a selection of second-moment properties for the HP-filtered data corresponding to simulations of the calibrated

¹⁸This findings call for the investigation of the economic reasons underlying the non-exogeneity of the Solow residual for the Spanish economy. Indeed, the non-exogeneity of the Solow residual has been extensively discussed in the literature, for instance in Burnside et al. (1993).

¹⁹The rate of growth of capital depends crucially on the depreciation rate, which is far from being correctly measured. In particular, obsolescence is not considered in the standard measurements of the capital stock, even if it could have played a crucial role in the Spanish accumulation process during the seventies. A better measurement of the depreciation rate would be necessary to evaluate if, during the seventies, the Spanish economy was on the balanced growth path or it was converging to the balanced growth path.

TABLE 5
First moment properties for the reference data set.

		Estimated economies Period 76:1 94:3			
Moments	data	Without government ($\eta = 1$)		With government ($\eta = 0$)	
		Divisible labor	Indivisible labor	Divisible labor	Indivisible labor
C_t^p/Y_t	0.612 (.023)	0.623 (.008)	0.622 (.008)	0.627 (.007)	0.626 (.007)
G_t/Y_t	0.128 (.015)	0.133 (.003)	0.134 (.003)	0.135 (.002)	0.136 (.002)
I_t/Y_t	0.260 (.019)	0.245 (.007)	0.245 (.007)	0.238 (.007)	0.238 (.007)
K_{t+1}/Y_t	9.445 (.456)	9.506 (.175)	9.505 (.174)	9.247 (.179)	9.248 (.176)
n_t	403.0 (43.8)	394.6 (2.53)	390.4 (3.83)	392.5 (3.09)	388.5 (4.46)
$\Delta \ln C_t^p$	0.0033 (.006)	0.0037 (.001)	0.0037 (.001)	0.0037 (.001)	0.0037 (.001)
$\Delta \ln K_t$	0.0059 (.005)	0.0037 (.001)	0.0037 (.001)	0.0037 (.001)	0.0037 (.001)
$\Delta \ln G_t$	0.0091 (.007)	0.0037 (.001)	0.0037 (.001)	0.0037 (.001)	0.0037 (.001)
$\Delta \ln Y_t$	0.0037 (.008)	0.0037 (.001)	0.0037 (.001)	0.0037 (.001)	0.0037 (.001)
$\Delta \ln n_t$	-0.0051 (.010)	0.0000 (.000)	0.0000 (.000)	0.0000 (.000)	0.0000 (.000)

All of the statistics for the models are averages, across 100 simulated data sets, each with 75 observations. Numbers in parentheses are the standard deviations across data sets.

economies and the estimated economies, respectively. As can be seen by comparing both tables, the cyclical behavior of the artificial economies is quite similar, irrespective of the methodology underlying the selection of parameter values. This is an expected result given how close the corresponding sets of parameter values are. Consequently, we will concentrate the analysis on the estimated economies, since this allows to have a metric for the distance between simulated and observed second moments, and to perform comparisons with previous results for other economies.

A first result is that all the models perform poorly at matching the volatility of consumption relative to output. As has been stated in

TABLE 6
Second moment properties for HP filtered data.

Calibrated economies Period 76:1 94:3					
Moments	data	Without government ($\eta = 1$)		With government ($\eta = 0$)	
		Divisible labor	Indivisible labor	Divisible labor	Indivisible labor
σ_c/σ_y	0.695	0.491 (.050)	0.466 (.046)	0.500 (.027)	0.473 (.025)
σ_i/σ_y	2.508	2.422 (.026)	2.555 (.029)	2.268 (.057)	2.424 (.046)
σ_n/σ_y	0.936	0.326 (.005)	0.505 (.008)	0.384 (.018)	0.571 (.023)
$\sigma_n/\sigma_{y/n}$	1.329	0.475 (.013)	0.972 (.040)	0.602 (.044)	1.212 (.106)
σ_g/σ_y	0.694	1.635 (.240)	1.397 (.205)	1.569 (.212)	1.322 (.171)
σ_y	0.0155	0.0129 (.002)	0.0151 (.002)	0.0135 (.002)	0.0160 (.002)
$corr(y/n, n)$	-0.283	0.950 (.017)	0.905 (.030)	0.905 (.039)	0.835 (.052)

All of the statistics for the models are averages, across 100 simulated data sets, each with 75 observations. Numbers in parentheses are the standard deviations across data sets.

Section 3, private consumption is highly volatile in the Spanish economy. An improvement in the empirical performance of the model along this dimension may need either an alternative specification of the households' preferences or some specification of liquidity constraints.

All the models do reasonably well at matching the estimated values of the relative volatility of investment, σ_i/σ_y , and the volatility of output, σ_y . However, the different models do not behave so well at matching the relative volatility of hours worked. Even though incorporating both indivisibilities in labor supply and government consumption seems to improve the empirical performance of the model along this dimension, all the models are strongly rejected. Nonetheless, it can be seen that incorporating these two features into the analysis results in a substantial improvement of the model with respect to the volatility of hours relative to the volatility of the average productivity of labor. When labor is indivisible, the marginal disu-

TABLE 7
Second moment properties for HP filtered data.

		Estimated economies Period 76:1 94:3			
Moments	data	Without government ($\eta = 1$)		With government ($\eta = 0$)	
		Divisible labor	Indivisible labor	Divisible labor	Indivisible labor
σ_c/σ_y	0.695	0.483 (.007) [0.00]	0.460 (.005) [0.00]	0.500 (.004) [0.00]	0.474 (.003) [0.00]
σ_i/σ_y	2.508	2.414 (.043) [.476]	2.543 (.050) [.780]	2.295 (.044) [.112]	2.456 (.052) [.700]
σ_n/σ_y	0.936	0.330 (.002) [0.00]	0.505 (.002) [0.00]	0.387 (.006) [0.00]	0.570 (.007) [0.00]
$\sigma_n/\sigma_{y/n}$	1.329	0.484 (.005) [0.00]	0.975 (.007) [.023]	0.610 (.012) [0.00]	1.208 (.020) [.446]
σ_g/σ_y	0.694	1.594 (.051) [0.00]	1.365 (.045) [0.00]	1.500 (.048) [0.00]	1.265 (.041) [0.00]
σ_y	0.0155	0.0135 (.001) [.224]	0.0157 (.001) [.833]	0.0142 (.001) [.474]	0.0168 (.002) [.422]
$corr(y/n, n)$	-0.283	0.950 (.017)	0.906 (.030)	0.903 (.033)	0.835 (.051)

All of the statistics for the models are averages, across 100 simulated data sets, each with 75 observations. Numbers in parentheses are the standard errors of the discrepancy between the statistic and its associated sample value. p-values for the \mathcal{W} statistics are in brackets.

tivity of an extra unit of individuals at work is constant and independent of the number of individuals working. Then, the adjustment of employment to aggregate shocks, and in particular in response to changes in the real wage, is greater.

As expected, all the models fail dramatically at approximating the observed correlation between hours and productivity. The incorporation of government shocks and labor indivisibilities into the analysis improves the performance of the model along this dimension. In any case, results are far from being satisfactory at matching the empirical behavior of employment and productivity. Clearly, the volatility of

TABLE 8
Measure of the amplification of shocks for HP-filtered data.

Moments	<i>Without government</i> ($\eta = 1$)		<i>With government</i> ($\eta = 0$)	
	<i>Divisible</i> <i>labor</i>	<i>Indivisible</i> <i>labor</i>	<i>Divisible</i> <i>labor</i>	<i>Indivisible</i> <i>labor</i>
σ_s	0.0163	0.0163	0.0161	0.0162
σ_c/σ_y	0.8283	0.9667	0.8784	1.0403

government spending cannot compensate for the effect of technology shocks.

Christiano and Eichenbaum (1992) evaluate the impact of classical measurement error in hours worked on their empirical results. They find that measurement error in hours worked is capable by itself of explaining an important part of the observed empirical behavior of the labor-market variables of the US economy. Indeed, our reference measure of hours worked displays the same objections as its US economy counterpart.²⁰ However, we did not find an alternative measure of hours that could allow us to replicate the analysis in Christiano and Eichenbaum (1992).

A common critique of RBC models is that they do not incorporate internal propagation mechanisms of aggregate fluctuations. Thus, the explanation of fluctuations that these models provide depends upon the properties of the stochastic processes governing the shocks. Table 8 reports the ability of the different models to account for output volatility through a measure of the amplification of shocks associated with each model: σ_y/σ_s , where σ_s is the standard deviation of the HP-detrended state of technology X_t . In terms of our measure of the amplification of shocks, we find that indivisibilities in the labor supply have a greater impact on output volatility than government consumption. In all cases it turns out that the model lacks substantial propagation mechanisms, even though labor indivisibilities contribute slightly to the amplification of shocks.

²⁰That is, apart from the strict measurement error, the measure of hours worked considered is restricted to the industrial sector.

6. Conclusions and extensions

In this paper we analyze the cyclical patterns of the Spanish economy from a real business cycle (RBC) perspective. We follow Christiano and Eichenbaum (1992), who incorporate: *i*) the divisible and indivisible labor hypothesis *ii*) the possibility of introducing shocks to government consumption. To be able to evaluate the empirical performance of the model we define a set of measurements for the aggregate variables of the Spanish economy. We analyze the main implications of our measurements on the stylized facts, and contrast them with those derived from the National Accounts.

Even though we have some doubts about the quality of the data, in particular concerning the capital stock, we have found that the Spanish economy is not necessarily on a balanced growth path over the whole sample period. Thus, in order to apply the standard business cycle methodology, we have worked with a shorter sample on which the balanced growth assumptions are more likely to hold. An alternative approach would require new methodological developments which are beyond the scope of this paper.

Our main finding is that incorporating into the analysis both labor indivisibilities and aggregate demand shocks arising from stochastic changes in government spending contributes to the explanation of the stylized facts of the Spanish economy. In this sense, we consider Christiano and Eichenbaum's (1992) RBC model as a good benchmark to evaluate alternative models of the cyclical behavior of the Spanish economy. In addition, our results suggest some extensions that should be undertaken in future research. At any rate, we think that some important elements from standard RBC theory should remain in the analysis.

A first extension relates to the assumption of an open economy. Undoubtedly the main disadvantage of the type of models we consider in this article are closed economy models. This represents an important restriction for the analysis of the fluctuations of the Spanish economy, in particular because of the exclusion of the cyclical behavior of net exports. Indeed, it can be expected that modelling the Spanish econ-

omy as an open economy is more important than in the US case. In this respect, Correia et al. (1995) propose an extension of the RBC framework to an open economy when investigating the aggregate fluctuations of the Portuguese economy. Their results are consistent not only with the observed volatilities of the components of demand but also with the countercyclical behavior of the balance of trade. More recently, Kollintzas and Vassilatos (1996) design a stochastic general equilibrium model for Greece in which both international capital markets and the role of public sector are explicitly incorporated into the analysis with appealing results. Indeed, these two countries are thought to have similarities with the Spanish economy so that useful insights can be gained from them.

Secondly, the models presented in this paper hardly reproduce consumption volatility, which is more volatile in Spain than in the US. An improvement in the empirical performance of the model along this dimension should require incorporating into the analysis some form of limited smoothing of consumption. This feature can arise from alternative specification of preferences or from the introduction of liquidity constraints. In particular, this second strategy should increase the dependency of consumption on output, and as a consequence increase the relative volatility of consumption with respect to output.

Third, alternative specifications of the labor market should help us to improve the performance of the model in relation to the Dunlop-Tarshis puzzle. In particular, it could allow us to understand the possible role of unemployment on the stochastic behavior of the Spanish hours worked and labor productivity. In addition, it remains an open question to evaluate the impact of measurement error in hours worked, particularly on aggregate labor-market fluctuations. This would require an alternative measure of hours worked.

An additional question is whether the underutilization of productive factors can have played a special role in the propagation of aggregate fluctuations in the Spanish economy. Indeed, the underutilization of factors seems to be a common feature in most of the OECD countries. However, it is possible that this circumstance can have particular relevance for the Spanish economy. Licandro et al. (1996) propose a

stochastic general equilibrium model that incorporates optimal factor underutilization. On the one hand, their findings suggest that some specifications of labor hoarding can contribute to explain the dramatic decrease in hours worked during the seventies and up to the middle of the eighties. On the other hand, they show that the propagation mechanism associated with both capital underutilization and capital maintenance activities substantially modify the propagation of aggregate fluctuations. Alternative and more appealing specifications for the US have been proposed by Cooley et al. (1995) and Fagnart et al. (1996).

Finally, our findings point to the need to investigate the economic reasons underlying the non exogeneity of the Solow residual for the Spanish economy. The introduction of factor utilization or some alternative specification of the labor market should help in this direction, since the Solow residual might be endogenous under these assumptions.

Appendix 1: Data sources

A1.1. Stocks and flows

In this section we discuss how we obtain our measure for K_t and the way in which we compute the imputed flow of services from the stock of consumer durables.

Capital stock

The quarterly capital stock series, K_t^* , results from the corresponding updating, to 1986 pesetas, of the annual one constructed by Corrales and Taguas (1990).²¹ Starting with the 1969 capital stock number as initial value, and given the quarterly data on gross fixed investment (Formación Bruta de Capital Fijo) from the NAQ, I_t^* , we build a quarterly aggregate capital stock series by assuming a constant depreciation rate. This depreciation rate results from regressing Corrales and Taguas annual data, which we denote with a superindex ct ,

$$K_t^{ct} - I_t^{ct} = (1 - \delta^*) K_{t-1}^{ct},$$

²¹This series is constructed using the permanent inventories method on the basis of public and private capital data, and residential structures. Depreciation rates are constant for each of these three items, but the depreciation rate on total capital changes over time due to a composition effect.

for the period 1970-1988. The resulting annual estimate for the parameter $(1 - \delta^*)$ is 0.937. We find that $K_t^{ct} - 0.937K_{t-1}^{ct}$ is close to I_t^{ct} : on average $100 \times |K_t^{ct} - 0.93687K_{t-1}^{ct} - I_t^{ct}|/|I_t^{ct}|$ is 0.46 in the period 1970-88.

Stock of durable goods

One of the most important differences between our reference data set and the NAq data is the treatment of durable goods. The durable and non-durable goods series we use correspond to the decomposition of the private consumption series discussed in Estrada and Sebastián (1993). To generate a quarterly series for the stock of durable goods, denoted by S_t^d , we assume a constant annual depreciation rate $\delta^d = .21$. We pick this value from Cooley and Prescott (1995). To set an initial value for the stock of durable goods S_0^d we make use of the balanced growth assumption. Thus, on average data has to verify the following condition:

$$\frac{S^d}{K^*} = \frac{C^d}{I^*} \times \frac{g + \delta^*}{g + \delta_d^d},$$

where S^d and K^* are the average values of the stock series of durables and capital, respectively, C^d and I^* are the average values for the durable consumption series and the gross investment series in the NAq, g is the average growth rate of real GDP and δ^* and δ_d^d are the corresponding depreciation rates. The averages have been computed over the period 1970:1-1994:4.

Reference data on capital

The measure that we finally adopt as our quarterly reference data on capital stock per-capita, denoted by K_t , includes public and private capital, residential structures and durable goods. It is defined by $K_t = (K_t^* + S_t^d)/P_t$ and it depends on the initial values for both stocks, K_0^* and S_0^d , the constant depreciation rates δ^* and δ^d , and the corresponding flow series I_t^* and C_t^d . P_t is our measure of population, discussed below.

Flow of services from the stock of consumer durables

National Accounts report payments of wage-earners. This figure has to be corrected to have a proper approximation of the capital share in output. To this end, and following Bentolila and Blanchard (1990), we accept the correction from *European Economy* (1994), which consists of adjusting the labor share in output, α_t , by the ratio of self-employed to total employment in the Spanish economy. Then, taking this figure and following Cooley and Prescott (1995), we evaluate private capital income as $Y_{kp} = (1 - \alpha_p) \times PIB$. With this measure of capital income, and the private capital stock K_p (which is aggregate capital minus public capital) we estimate the average quarterly return on private capital from $i = (Y_{kp} - CCF)/K_p$, where CCF is the

National Accounts' measure of depreciation. We have computed both the capital income and the average rate of return from annual data since the *European Economy* (1994) figure is annual and we do not have quarterly data on private investment.

In a second stage we compute the quarterly flow of services of the stock of consumer durables, $Y_t^d = (i + \delta_d/4)S_t^d$. For this purpose we assume for the stock of consumer durables the same average real return we have computed for the rest of private capital and we use our measure of the average depreciation of this stock.

A1.2. Employment and population

The series for the labor-force, employed-population and wage-earners are those constructed by García-Perea (1991) (homogenized and updated). To convert all the aggregate variables to per capita terms we have used the labor-force series as our measure of population, P_t . We made this selection for convenience since a homogeneous series of working-age population is not available for the period 1970:1-1994:4.

As in Christiano (1987), we adjusted our employment measures by sex and age groups, to capture the potential effects that changes in the structure of human capital can have on labor productivity. For this purpose we weighted, with constant weights for each period t , every population age-sex group by an approximation of labor productivity obtained from the Encuesta Piloto sobre Ganancias y Subempleo (EPGS-INE, 1991, a specific earnings Survey) which is part of the Encuesta de Población Activa (EPA, Labor Force Survey). This survey reports a measure of average annual gross earnings for age-sex groups in employed population. Even though the information contained in the survey is not very satisfactory, Jimeno and Toharia (1993) find some evidence with respect to the fact that the results in the EPGS are in line of those in the Encuesta sobre Conciencia y Biografía de Clase (Working Status Survey) and that the relative earnings amongst the different groups under consideration have stayed roughly constant in the recent period. Table A1 summarizes the weights. The one corresponding to men aged between 35 and 45 is normalized to one in our measure of human capital.

To obtain an approximation of the participation of each age-sex group in the labor force we use the non-homogenized data and we apply the same proportions to our homogenized data of the labor force. The corresponding percentages are applied to both the employment and wage earners series as well. The final series for labor force, employed and wage-earners were seasonally adjusted through X-11 ARIMA.

TABLE A1
Weights for the adjustment of employment and population data.

Age groups	Men	Women
16-24	0.54	0.53
25-34	0.78	0.76
35-44	1.00	0.74
45-54	0.86	0.57
55-64	0.84	0.63

Hours worked

Hours worked per employed person result from the homogenization of the monthly series per worker of the Encuesta de Salarios (Wage Survey) for the period 1963:1-1987:4 as discussed in Carbaajo and García-Perea (1987). To obtain data for the last seven years we use the corresponding series in the Dirección General de Previsión y Coyuntura (DGPC) data base of the Ministerio de Economía y Hacienda. The latter series has been adjusted to correct for the impact of the methodological change introduced in the Wage Survey after the first quarter of 1989. More precisely, the adjustment affects every third quarter throughout the period 1981-1988.²²

Finally, it is worthwhile to notice that the original data for hours worked in the Wage Survey refer exclusively to workers, which means basically work-force. To have a measure of total hours worked in terms of the whole employed population, we approximate the hours worked by non-wage-earners (na) from the data in the Encuesta de Población Activa (EPA, Labor Force Survey) on hours worked by employed-person (oc) and wage-earner (as) according to

$$h_{oc}^{EPA} = t_a h_{as}^{EPA} + (1 - t_a) h_{na},$$

where t_a is the rate of wage-earners over employed. Then, average hours per employed are

$$h_{oc} = t_a h_{as}^{ES} + (1 - t_a) h_{as}^{ES} \frac{h_{na}}{h_{as}^{EPA}}.$$

Consequently, the final series of hours worked we consider is h_{oc} , on a quar-

²²For extensive details the reader can check the DGPC data base. The reason that explains the decline in the third quarters is that the workers enjoying their holidays were not under proper consideration in the Survey before 1988.

terly basis, times the number of employed population and in per capita terms.²³

A1.3. Output and components of demand

Our measures for output and the components of demand are as follows:

Private consumption was measured as quarterly real expenditure in non-durables and services, plus the imputed flow of services from the stock of consumer durables. Private consumption per capita, which we denote by C_t , is the result of dividing private consumption by our measure of population.

Gross Investment is the result of adding the investment on fixed capital series (FBCF) and the series of expenditure in durable goods. Our measure of per capita gross fixed investment, which we denote I_t , is then $I_t = (I_t^* + C_t^d)/P_t$, where P_t represents our measure of population. We have not included inventory investment in gross investment, since we expect in future work to include this variable into the analysis.

Per capita government consumption, which we denote G_t , is the government consumption from the NAQ divided by our measure of population.

Output per capita, is the result of adding up the three previous components: $Y_t = C_t + I_t + G_t$.

Appendix 2: Orthogonality conditions

We follow Christiano and Eichenbaum (1992) in defining the moment conditions underlying our estimator of the combined parameter vector $\psi = (\psi_1, \psi_2)$.

The social planner's first-order necessary conditions for hours worked and capital accumulation are respectively

$$E \{ \theta - \alpha (Y_t/n_t) / [C_t V'(N - n_t)] \} = 0,$$

$$E \{ 1 - \beta [(1 - \alpha) (Y_{t+1}/K_{t+1}) + 1 - \delta] C_t/C_{t+1} \} = 0,$$

from which parameters θ and α are estimated. Parameter δ is estimated from the law of motion for the capital stock:

$$E \{ \delta - [1 - (K_{t+1} - I_t)/K_t] \} = 0.$$

²³Note that the quarterly data on hours worked supplied by the EPA refer to weekly hours (per employed and wage-earner) and began in 1976:3. Then, the weights we use to approximate average hours per employed and month (h_{oc}) are: *i*) for the period 1970:1 1976:2, the average of h_{na}/h_{as}^{EPA} for the period 1976:3 1994:4, and *ii*) for the period 1976:3 1994:4 the ratio h_{na}/h_{as}^{EPA} quarter by quarter.

The parameters describing the state of technology, γ and σ_v , are estimated by imposing the following restrictions:

$$E \{ \Delta \ln(Y_t) - \gamma \} = 0,$$

$$E \{ (\Delta \ln(X_t) - \gamma)^2 - \sigma_v^2 \} = 0,$$

and the parameters describing the law of motion of government consumption, \bar{g} , ρ and σ_ϵ , are obtained from:

$$E \{ \ln(g_t) - (1 - \rho) \ln(\bar{g}) - \rho \ln(g_{t-1}) \} = 0,$$

$$E \{ [\ln(g_t) - (1 - \rho) \ln(\bar{g}) - \rho \ln(g_{t-1})] g_{t-1} \} = 0,$$

$$E \left\{ [\ln(g_t) - (1 - \rho) \ln(\bar{g}) - \rho \ln(g_{t-1})]^2 - \sigma_\epsilon^2 \right\} = 0.$$

The second-order moments must verify:

$$E \left\{ (y_t^{hp})^2 - \sigma_y^2 \right\} = 0,$$

$$E \left\{ (y_t^{hp})^2 (\sigma_c/\sigma_y)^2 - (c_t^{hp})^2 \right\} = 0,$$

$$E \left\{ (y_t^{hp})^2 (\sigma_i/\sigma_y)^2 - (i_t^{hp})^2 \right\} = 0,$$

$$E \left\{ (y_t^{hp})^2 (\sigma_g/\sigma_y)^2 - (g_t^{hp})^2 \right\} = 0,$$

$$E \left\{ (y_t^{hp})^2 (\sigma_n/\sigma_y)^2 - (n_t^{hp})^2 \right\} = 0,$$

$$E \left\{ ((y/n)_t^{hp})^2 (\sigma_n/\sigma_{(y/n)})^2 - (n_t^{hp})^2 \right\} = 0.$$

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Resumen

En este artículo se analiza el comportamiento empírico de un modelo básico de ciclos reales con datos de la economía española. Para ello, se define un conjunto de medidas de las variables agregadas de la economía española y se evalúan las propiedades de largo plazo y cíclicas que se derivan de este conjunto de datos de referencia. El modelo se resuelve alternativamente bajo las hipótesis de trabajo divisible e indivisible y, en cada caso, se incorpora el consumo del sector público. En la selección de los valores de los parámetros estructurales se combinan técnicas de calibración y de estimación (GMM), y se evalúan sus implicaciones sobre los resultados. La incorporación de indivisibilidades en la oferta de trabajo y del consumo del sector público mejora el comportamiento empírico del modelo. En este sentido, los resultados no difieren sustancialmente de los obtenidos para los EE.UU. Sin embargo, la explicación del comportamiento cíclico del consumo privado en la economía española es insuficiente.