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ABSTRACT

This paper discusses a dynamic model that is consistent with the main empirical regularities of economic fluctuations in open economies. While other models in this class have relied on non-separable preferences or finite horizons to generate a realistic consumption volatility, we show that there is a simple class of time separable preferences that is consistent with the cyclical volatilities of the components of the national income accounts identity as well as with the countercyclical character of the balance of trade.

Key Words: Business cycles, open economy, trade balance.

J.E.L. Classification: E32, F32.

I. INTRODUCTION

Some of the most surprising features of business cycles are related to variables that link different economies and transmit fluctuations across national borders. The balance of trade, for example, tends to exhibit high cyclical volatility and is one of the few macroeconomic variables that is countercyclical.

In this paper we summarize the main features of business cycles in a small open economy--Portugal--and discuss the extent to which these features can be rationalized on the basis of a simple dynamic stochastic general equilibrium model. This endeavor is related to recent work on real business cycles in open economies (e.g. Mendoza (1991), Backus, Kehoe and Kydland (1992) and Baxter and Crucini (1993)) as well as to the earlier international literature on models based on intertemporal optimization.[1]

The structure of our model is closest to that of the economies studied by Mendoza (1991) and Lundvik (1992) in which there is a single asset that can be traded with the rest of the world, an international bond that yields a real rate of return that is viewed as exogenous by agents in the economy. In order to ensure that the current account follows a trend-stationary process Mendoza (1991) postulates time-non-separable preferences, while Lundvik (1992) assumes that agents have a finite horizon. In contrast, our model features conventional time-separable preferences and is thus a natural extension of closed economy real business cycle models.

The steady state of our economy is consistent with any level of net foreign bond holdings. Countries with higher net foreign asset holdings can afford higher trade deficits which allow them to enjoy higher levels of steady state consumption. This property of the model implies that consumption follows a difference stationary process, as in Hall (1978), even though the shocks that buffet the economy are stationary. The form of momentary utility dictates whether this unit root property is inherited by the

[1]Contributions to the early literature on intertemporal optimization in open economies include Obstfeld (1981), Svensson and Razin (1983), Greenwood (1984), Razin (1984), Persson and Svensson (1985), and Frenkel and Razin (1987). The recent expanding literature on equilibrium models of open economies includes papers by Finn (1990), Cardia (1991), Stockman and Tesar (1990), Reynolds (1992), and Glick and Rogoff (1993).

other components of the national income identity.

In Section II we present the model and describe its steady state properties. Section III studies the short and long run effects of shocks to international transfers, to productivity or to the terms of trade, to the international real interest rate, and to government expenditures. We also discuss two issues that are relevant to the performance of the model: (i) the possibility of dispensing with serially correlated shocks in the version of the model in which there is strong internal persistence; and (ii) the role of preferences in determining the volatility of consumption and the persistence in output.

Section IV summarizes the empirical regularities of business cycles in Portugal for the period 1958-91 and compares them with the implications of our model. A final section reviews the main findings.

II. A DYNAMIC SMALL OPEN ECONOMY MODEL

Our economy is populated by a large number of identical agents who act as price takers in the various markets in which they interact. To simplify the notation we abstract from population growth and represent all variables in per capita terms.

Preferences

Each agent seeks to maximize his expected utility defined over random sequences of consumption (C_t) and leisure ($1-N_t$):

$$U = E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \frac{1}{1-\sigma} [u(C_t, 1-N_t)-1] \right\}, \qquad \sigma > 0, \quad \beta > 0$$

E_0 denotes the expectation based on the information set available at time zero (which includes current and lagged values of all variables).

We will consider two different momentary utility functions. The first was used in Hansen's (1985) divisible labor model and belongs to the class described by King, Plosser and Rebelo (1988) as being consistent with steady state growth when utility depends on raw leisure hours (as opposed to leisure augmented by technical progress). This is the most common preference specification so we will refer to it as "standard preferences":

$$u(C_t, 1-N_t) = [C_t^{v} (1-N_t)^{1-v}]^{1-\sigma} \qquad 0<v<1$$

The second class of momentary utility functions that we will consider was proposed by Greenwood, Hercowitz and Huffman (1988) and has the special property that the elasticity of intertemporal substitution associated with leisure is zero (we will refer to these as GHH preferences):

$$u(C_t, 1-N_t) = [C_t - \psi X_t N_t^{v}]^{1-\sigma} \qquad v>1,\ \psi>0$$

In order for these preferences to be consistent with steady state growth the disutility of work in the market has to increase with the level of technical progress (X_t). This effect can be interpreted as representing technological progress associated with home production activities.

To ensure that utility is finite we assume that $\beta\gamma_X^{v(1-\sigma)} < 1$, in the case of standard preferences, and that $\beta\gamma_X^{1-\sigma} < 1$, in the case of GHH preferences. The symbol γ_X denotes the growth rate of technical progress which, as we will see below, coincides with the steady state growth rate of the economy.

Technology

Production (Y_t) takes place by combining labor (N_t) and capital (K_t) according to a Cobb-Douglas production function:

$$Y_t = A_t K_t^{1-\alpha}(N_t X_t)^{\alpha}$$

The level of output is influenced by productivity disturbances, represented by A_t and by the level of technological progress X_t. We assume that $\log(A_t)$ follows an AR(1) process and that X_t grows at a constant rate:

$$X_{t+1} = \gamma_X X_t, \quad \gamma_X > 1$$

Output can be used for private consumption, for investment (I_t), or for government consumption (G_t). The difference between output and domestic absorption ($C_t + I_t + G_t$) is the trade balance (TB_t).

$$Y_t = C_t + I_t + G_t + TB_t$$

Domestic investment increases the stock of capital which evolves according to:

$$K_{t+1} = \phi(I_t/K_t)K_t + (1-\delta)K_t$$

where δ is the rate of depreciation. The function $\phi(.)$, which we assume to be concave and twice continuously differentiable, represents adjustment costs to investment, as in Lucas and Prescott (1971), Abel and Blanchard (1983) and Hayashi (1982). We follow Baxter and Crucini (1993) in assuming that this function has two properties that guarantee the absence of adjustment costs in the steady state: $\phi(\gamma_X-1+\delta) = \gamma_X-1+\delta$ and $\phi'(\gamma_X-1+\delta) = 1$, where $\gamma_X-1+\delta$ is the steady state investment-capital ratio. This adjustment cost formulation implies that Tobin's q, the ratio of the value of capital to its replacement cost, is $q_t = 1/\phi'(I_t/K_t)$ and is, thus, equal to one in the steady state.

Government Policy

Since the effects of government expenditures are relatively small in this economy we adopt a very simple description of the role played by the government. Government expenditures (G_t) are viewed as exogenous from the standpoint of the private sector and are financed with lump sum taxes.

We will see later that the form of momentary utility determines whether output follows a trend-stationary or a difference-stationary stochastic process. For this reason we have to assume different stochastic processes for the two versions of the model, in order to ensure in each case that the share of government expenditures in GDP is stationary. When preferences are of the GHH form, output is trend stationary, and we assume that $\log(G_t/X_t)$ follows an AR(1) process. When momentary utility has a standard form output follows a random walk and we assume that the stochastic process for government expenditures is: $G_t = S_t^G Y_t$, where S_t^G follows an AR(1) process. In both cases we define S^G as the mean share of government expenditures in output.

International Borrowing and Lending

Agents in this economy can buy and sell foreign bonds in the international capital market. The price of a bond which delivers one unit of consumption in the next period is p_t. The evolution of the level of net holdings of foreign bonds (B_t) is dictated by:

$$p_t B_{t+1} = B_t + TB_t + TRF_t$$

We assume that $\log(p_t)$ follows an AR(1) process. For future reference it is useful to define the international real rate of return: $r_t^* = 1/p_t - 1$.

We need to rule out the possibility of the economy playing a Ponzi game in the international capital markets (these paths allow the representative agent, among other possibilities, to borrow initially an arbitrarily large amount and then to finance interest payments with further borrowing, thereby never repaying the initial debt):

$$\lim_{t\to\infty} E(p_t B_{t+1}) = 0$$

TRF_t represents exogenous net transfers from abroad. To guarantee that the share of transfers in output is stationary we assume that $\log(TRF_t/X_t)$ follows an AR(1) process when preferences are of the GHH form, and that $TRF_t = S_t^{TRF}\, Y_t$, where S_t^{TRF} follows an AR(1) with mean S^{TRF}, when preferences have a standard form. In both cases we define $S^{TRF} = trf_t/y_t$ as the mean share of transfers in output.

We assume that the following restrictions, involving the mean international real rate of return (r^*), hold:

$$[\beta(1+r^*)]^{1/[1-\nu(1-\sigma)]} = \gamma_X, \quad \text{(in the case of standard preferences)}$$

$$[\beta(1+r^*)]^{1/\sigma} = \gamma_X, \quad \text{(in the case of GHH preferences)}$$

To interpret these equations it is useful to abstract from stochastic shocks. These conditions guarantee that the steady state growth rate of consumption would be the same if the economy had no access to international capital markets. Thus we assume that access to the international capital market will be used to smooth consumption over the business cycle but will not change the long run rate of growth of consumption. This assumption is the most natural from two perspectives. First, we know from the work of Becker (1980) that without this assumption a deterministic version of our model has unappealing asymptotic properties: in the long run the economy is either always a net lender (owning asymptotically all of the world's wealth) or a net borrower (with its wealth converging to zero). Second, this assumption would hold in a world composed of identical small open economies such as ours.

Market Structure

As is always the case with this class of models, there are a variety of decentralization schemes that are compatible with the competitive equilibrium under rational expectations that we describe below.[2] One of these structures involves a spot labor market and a stock market. Firms own the capital stock and choose their investment plans and the quantity of labor that they employ in order to maximize their value. Households choose optimally their supply of labor and their savings, which are allocated between foreign bonds which yield a rate of return r_t^*, and equity shares in the representative firm.

We will solve the model by linearizing the equations that characterize the competitive equilibrium around the steady state, thus imposing certainty equivalence. As a consequence, equity in the representative firm and international bonds are perfect substitutes in our approximate solution, and hence yield the same expected rate of return.

The Steady State

The first step in studying the properties of this model is to abstract from the presence of stochastic shocks and describe its deterministic steady state. This serves two purposes: it characterizes the long run features of the economy and it defines the values of the detrended variables around which we will compute an approximate solution to the competitive equilibrium after reinstating the stochastic shocks.

In the steady state all the components of the national income identity grow at rate γ_X. The steady state value of N and of the ratios k/N, c/k and tb/k are characterized by four simple equations in which we use lower case letters to denote variables that have been detrended (e.g. $k_t = K_t/(\gamma_X^t)$):

$$r^* = (1-\alpha)Ak^{-\alpha} N^{\alpha} -\delta \tag{1}$$

[2]See, for example, the discussion in Stokey, Lucas and Prescott (1989, pp. 22-28).

$$Ak^{-\alpha} N^{\alpha} = (c/k) + (\gamma_X\text{-}1+\delta) + Ak^{-\alpha} N^{\alpha}(S^G\text{-}S^{TRF}) + (\gamma_X\text{-}1\text{-}r^*)b/k \quad (2)$$

$$(tb/k) = (\gamma_X\text{-}1\text{-}r^*)(b/k) + S^{TRF} Ak^{-\alpha}N^{\alpha} \quad (3)$$

The first of these equations, which determines the capital-labor ratio, requires that the marginal product of capital be equated to the international real rate of return (recall that there are no adjustment costs in the steady state).

The second and third equation, which determine c/k and tb/k, are the steady state version of the economy's resource constraint and of the foreign asset accumulation equation. The steady state is compatible with any value of b/k: economies with higher net foreign holdings will have a higher steady state trade deficit. This translates into a higher steady state level of (detrended) consumption and, in the case of standard preferences, into a higher level of leisure.

The fourth equation, which determines the number of hours worked by the representative agent, has the same form whether the economy is in the steady state or not. This equation depends on the momentary utility function adopted:

$$N_t = 1 - \frac{c_t(1-\nu)}{\alpha(y_t/N_t)\nu} \qquad \text{(for standard preferences)} \quad (4a)$$

$$N_t = [(\alpha y_t)/(\nu\psi N_t)]^{1/(\nu-1)} \qquad \text{(for GHH preferences)} \quad (4b)$$

Both equations express the familiar requirement that the marginal rate of substitution between consumption and leisure must be equal to the marginal product of labor, $\alpha Y_t/N_t$ (which equals the real wage in the spot labor market). Equation (4b) shows that GHH preferences imply that there is no intertemporal substitution associated with leisure: the number of hours worked at time t is determined solely by the current real wage.

The λ-constant elasticity of labor supply around the steady state implied by standard preferences is $(1\text{-}N)[1\text{-}\nu(1\text{-}\sigma)]/(\sigma N)$. The elasticity of labor supply implied by GHH preferences is $1/(\nu\text{-}1)$.

III. SHORT-RUN AND LONG-RUN DYNAMICS

In the absence of shocks the competitive equilibrium for this economy would consist of deterministic paths for the different variables. But since the economy is stochastic and the shock realizations occur as time goes by, a description of the competitive equilibrium is a set of contingency rules that specify how the variables of interest evolve for every possible configuration of the shocks. This competitive equilibrium is easiest to describe in a recursive fashion, as in Prescott and Mehra (1980). The equilibrium law of motion for the (detrended) capital stock can be expressed as: $k_{t+1} = \Psi(k_t, b_t, \varepsilon_t)$, where ε_t is a vector that contains the current realizations of the four shocks (since these shocks follow AR(1) processes the current realization contain all the relevant information to predict their future values). The law of motion for all other variables of interest can also be written in this form.

Since this model cannot be solved analytically we compute an approximate solution using the method described in King, Plosser and Rebelo (1988), which is a log-linear version of the approximation of the procedure used by Kydland and Prescott (1982). This method produces linear equilibrium laws of motion for all the variables by linearizing the Euler equations that characterize the competitive equilibrium around the steady state and solving numerically the resulting linear system of stochastic difference equations.[3] The properties that we describe below refer to this approximate, linear, solution to the competitive equilibrium.

For reasons that are familiar from the work of Hall (1978), the equilibrium stochastic process for consumption has a unit root. To discuss whether this unit root property is inherited by all the other components of the national income identity it is convenient, to simplify the exposition, to abstract from the presence of adjustment

[3]This type of method has been found to be surprisingly accurate for standard real business cycle models (see Danthine, Donaldson and Mehra (1989) and Christiano (1990)). The accuracy of linear approximations in models with integrated variables, such as ours, is still an open question. Given that in this class of models one often linearizes the model around a steady state to which the economy does not return, it is natural to expect a smaller degree of accuracy.

costs so that equation (1), with time subscripts reinstated, holds at every point of time. This equation implies that the capital-labor ratio and the output-labor ratio follow stationary stochastic processes.

When preferences are of the standard form, equation (4a), in linearized form, implies that the unit root property of consumption is inherited by N_t. Since k_t/N_t and y_t/N_t are stationary, this means that output and the stock of capital follow integrated processes. This non-stationarity extends also to investment and to the balance of trade.

In the case of GHH preferences, equation (4b) implies that labor effort is stationary. This, in turn, implies that output, investment and the stock of capital are also stationary. The only variables that follow unit root processes are consumption, the balance of trade and the level of net foreign asset holdings. The variables $\hat{c}_t$ and $\hat{tb}_t$ are cointegrated; their sum is stationary.[4] Since k_t follows a stationary process while b_t is non-stationary, the law of motion for the capital stock is, in this case, independent of b_t: $k_{t+1} = \Psi(k_t,\varepsilon_t)$.

We will now use various impulse response functions to explore the properties of the model. Unless we mention otherwise, the parameters used to generate these impulse response functions are those described in more detail in the next section.

Can we dispense with persistent shocks?

One often-mentioned shortcoming of most real business cycle models is that they do not generate endogenously enough persistence. To produce the degree of output persistence that we observe in the data these models have to be driven by productivity shocks with very high serial correlation. This lack of internal persistence is often used as motivation for introducing new features into the basic model.

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[4]Throughout the paper we will use $\hat{x}_t$ to denote the percentage deviation of the variable x_t from its steady state level.

Since the version of our model with standard preferences generates very strong endogenous persistence (the stock of capital follows a unit root process) it is worthwhile to inquire whether we can generate realistic business cycles without driving the model with serially correlated shocks.

Figure 1, which depicts the impulse response functions associated with a positive i.i.d. shock to productivity, shows that consumption and labor effort are procyclical but that investment is countercyclical. In period 2 productivity is back to its steady state level but the positive wealth effect of the shock leads to a decline in labor effort. To maintain the parity between domestic and international real interest rates the capital stock must be lower from period 2 on, hence the decline in investment.

The fact that we cannot dispense with serially correlated productivity shocks even though the model has strong internal persistence, suggests that the quest for mechanisms that enhance internal persistence may be misguided.

Why does consumption fluctuate?

A well-know fact about business cycles is that the cyclical volatility of non-durables consumption is roughly two-thirds that of output. This fact is easily rationalized by closed economy real business cycle models but it is more difficult to deal with in small open economy models. As we will see below, the access to international capital markets presents households with additional opportunities to smooth out consumption that tend to make the volatility of consumption very small when preferences are of the standard form.

Figure 2 shows the impulse response of consumption to a technology shock that follows an AR(1) process with serial correlation 0.8 for three alternative specifications of preferences: standard utility with $\sigma=1$, and with $\sigma=2$ and GHH utility with $\sigma=1$.

With standard utility and $\sigma=1$, preferences are separable across consumption and leisure, and the linearized Euler equation for consumption implies that the level of (detrended) consumption must follow a random walk: $E_t \hat{c}_{t+1} = \hat{c}_t$. Figure 2 shows that the response to a productivity shock involves, in this case, a once and for all upward jump in the level of (detrended) consumption. This change in the level of consumption is very small because the income effect of the productivity increase is evenly spread over consumption in all of the remaining periods.

With standard utility and σ=2 preferences are no longer separable between consumption and leisure. For this reason, the response of labor supply to the productivity shock is accompanied by additional movements in consumption. Smoothing the marginal utility of consumption does not imply, in this case, that consumption should be smooth but that movements in consumption should be roughly proportional to movements in the labor supply: $\varepsilon \hat{c}_t = \hat{N}_t$. Below we write the expression for ε (making use of (4a)), together with the formula for the λ-constant elasticity of labor supply, which we denote by ε_N:

$$\varepsilon = \frac{\sigma(c/y)}{\alpha(\sigma-1)} + \frac{1-N}{N(\sigma-1)} \tag{5}$$

$$\varepsilon_N = \frac{1-N}{N} + \frac{(\sigma-1)/\sigma}{\alpha(y/c) + N/(1-N)} \tag{6}$$

A necessary condition for ε>0, so that the correlation of labor hours and consumption is positive, is σ>1. The consumption share in the steady state (c/y) is dictated by b/y, the ratio of net foreign asset holdings to GDP, which will be chosen in our calibration of the model to match the consumption share in output observed in the data. The value of N is also chosen to match the average fraction of time devoted to work in our data sample.

The effect of σ on ε depends on the relative weights of the two components in equation (5). In contrast, the effect of N on ε is unambiguous: high values of N translate into low values of ε. But even if we were willing to choose values of N that are much higher than what empirical studies suggest, this form of preferences cannot be salvaged. High values of N imply values of ε_N close to zero, which prevent the model from displaying fluctuations in labor supply. Since variations in consumption are proportional to variations in labor effort, this does not succeed in generating the consumption variability observed in the data.

Having experimented with a wide range of parameter values we found it impossible to raise the relative volatility of consumption vis-a-vis that of output above 25%.

The third impulse response function in Figure 2 shows that the response of consumption to a productivity shock is much larger with GHH preferences than with standard preferences. To construct this impulse response function we chose ν so that the elasticity of labor supply, $\varepsilon_N = 1/(\nu-1)$ is the same as that in the standard model (ε_N=2), and chose ψ so that the number of hours worked in the steady state also coincides in the two models. This figure shows clearly that GHH preferences can generate consumption volatility of the magnitude observed in the data. The same line of reasoning that we used in the standard model clarifies why this is the case.

Since preferences are not separable across consumption and labor effort, the efficiency conditions of the household problem dictate that $\varepsilon\hat{c}_t$ - $\hat{N}_t$ should be smooth over time. The expression for ε, can be written, making use of (4b), in a very simple form: $\varepsilon = (c/y)/\alpha$. In the case of Portugal, the average consumption share is .71, while the average labor share is .53, implying a value of ε of 1.3. We will see in the next section that when we calibrate the model with standard values for the elasticity of labor supply the model is consistent with the observed relative volatilities of the different macroeconomic variables.

The other two existing dynamic models of small open economies adopt the GHH momentary utility function together with other additional elements: time-non-separability in preferences in the case of Mendoza (1991) and Blanchard (1985)-style finite horizons in the case of Lundvik (1992). We found that these additional elements play a relatively small role in the behavior of their models. The crucial aspect of their formulations that allows them to produce realistic volatilities is the adoption of the GHH momentary utility function.

The main implication of the additional preference structure used by Mendoza and Lundvik is that it makes stationary the three variables that have a unit root in the version of our model with GHH preferences: consumption, the balance of trade and the level of net foreign assets. This stationarity simplifies the numerical computation of the equilibrium but is not necessarily a desirable feature given that the statistical properties of these series are not inconsistent with the presence of unit roots.[5]

The Effects of Shocks to Foreign Transfers

We now consider the response of the model to a temporary *decline* in the level of net foreign transfers, considering both types of preferences in turn.

With standard preferences the negative income effect of a reduction in transfers leads to a decline in consumption and to an increase in labor effort in both the short and the long run. The balance of trade deteriorates initially as agents borrow to smooth out consumption and leisure and follows a path that is roughly the mirror image of the transfer shock trajectory. The long run effect of this shock on the balance of trade is positive: since the economy borrows from abroad in response to this shock, the new steady state has a lower value of B, and hence a higher steady state trade share.

The least obvious effect of a negative transfer shock is an increase in the capital stock. This increase accompanies the rise in labor effort so that the net marginal product of capital continues to coincide with the international real rate of return. The increase in labor effort is also responsible for a long run increase in the level of output.

The persistence properties of the transfer shock matters only for the behavior of the trade balance. The behavior of all other components of the national income identity depends only on the present value of the deviations of transfers from their steady state path.

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[5]Mendoza's discrete state space approach to computing the equilibrium relies on the fact that the support of the distribution of the net foreign asset holdings lies on a bounded set and is, hence, difficult to adapt to cope with the presence of unit roots. The preferences adopted by Mendoza may, however, potentially resolve problems with the solvency constraint that may arise with time-separable formulations.

With GHH preferences the only effect of a negative transfer shock is a permanent drop in consumption accompanied by a permanent increase in the balance of trade. All the other variables remain unaffected.

The Effects of Shocks to Government Expenditures

The effects of a temporary increase in government expenditures are qualitatively similar to those of a temporary decline in transfers.

When preferences take a standard form all variables, with the exception of investment, respond in the same direction to an expenditure increase as they would in a closed economy. In a closed economy investment declines, so that the fall in consumption and leisure can be spread over time. In contrast investment increases in an open economy because the capital stock must accompany the rise in labor effort to ensure the equality between the domestic and the international real rate of return.

As in the case of the transfer shock, the persistence properties of the shock matter only for the behavior of the trade balance. Permanent increases in government expenditure have the same effects as temporary ones provided that both shock trajectories have the same present value. The equivalence between temporary and permanent shocks to government expenditures is a direct consequence of the real interest rate being exogenous, and hence does not hold in two-country models such as those of Ahmed (1987) and Baxter and Crucini (1992).

When preferences are of the GHH form a permanent shock to government expenditures generates solely a permanent decline in consumption; there are no effects on the trade balance or on any other macroeconomic variable. When the shock is transitory the permanent fall in consumption is accompanied by movements in the trade balance which reflect the borrowing or lending associated with intertemporal smoothing.

The Effects of Productivity Shocks

Figure 3 shows the impulse response for a serially correlated shock to productivity or to the terms of trade (since there is a single good in the economy the effects of terms of trade shocks are the same as those of shocks to productivity) for both types of preferences.

We already discussed the dynamics of consumption associated with this type of shock. The labor effort response is by now also familiar: the initial response is similar for both types of utility functions but with standard preferences there is a long run negative effect on the supply of labor.

The most interesting response is that of the balance of trade, which results from two opposing forces. In order to spread the positive income effect of this shock over future periods agents must invest some of the additional income windfall abroad. On the other hand it is worthwhile to borrow initially to increase the domestic capital stock and take advantage of the temporarily high productivity. With standard preferences the equilibrium path for consumption is very smooth and, as a result, the first effect dominates. In contrast, the second effect often dominates when preferences have a GHH form. In fact, we will see in the next section that when preferences are of the GHH the model is consistent with the fact that the trade balance is countercyclical.

The Effects of Shocks to the International Real Interest Rate

Figure 4 depicts the effects of a persistent increase in p_t. With standard preferences the fall in the international real interest rate raises domestic investment and produces a positive income effect that raises consumption.[6] With GHH preferences hours worked increase in tandem with consumption, raising output.

[6]The income effect associated with this shock is positive if $b_t<0$ and ambiguous when $b_t>0$. With positive levels of net foreign assets a decline in the international real rate of return reduces the capital income received from abroad. Even though shifting capital to the home country reduces to some extent this loss, with sufficiently high adjustment costs the overall income effect can be negative.

As one would expect, the variables that are affected the most by variations in the international real interest rate are investment and the trade balance. The magnitude of the response of output, consumption and hours worked is small.

IV. BUSINESS CYCLES IN PORTUGAL: 1958-1991

To evaluate the descriptive power of our simple model and search for the directions in which extensions will be most useful, we calibrate the model using Portuguese data and compare the second moment implications of the model with those of the data.

Table 1 summarizes the point estimates and the standard errors, reported in parenthesis, of the most important second moments of the different macroeconomic variables. All the variables are expressed in per capital terms and (when appropriate) at constant 1977 prices. The data that we used has annual frequency and covers the period from 1958 to 1991.[7]

Our main data source is Santos, Dias and Cunha (1992). The capital stock data is from Santos (1984); the population series is from Nunes, Mata and Valerio (1989). These two series were updated until 1991 with information published in the Bank of Portugal Annual Report. The employment series was constructed by combining series published by the Instituto Nacional de Estatistica.[8]

To characterize the cyclical behavior of the different variables we performed two transformations. First, we computed the logarithm of all the variables with the exception of the trade balance and then removed a smooth trend using the Hodrick-Prescott (1980) filter with a smoothing parameter of 100.

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[7]Quarterly data for Portugal is available only since 1977 and was, for the most part, obtained by interpolating annual data. There exists some long run annual data for a restricted set of variables which we explore in Correia, Neves and Rebelo (1992).

[8]We combined the following INE publications to obtain an employment series: Estatísticas para o Planeamento (1960-70), Inquérito Permanente ao Emprego (1974-82) and Inquérito ao Emprego (1983-92). The data for 1971-73 was obtained by interpolation.

Since the trade balance takes on negative values we expressed it as percentage deviations from the mean using the following local approximation to $\log(tb_t)$: $tb_t/|\text{mean}(tb)| - 1$. Since the mean of the trade balance is negative we used its absolute value ($|\text{mean}(tb)|$) to preserve the sign of the variable. We then proceeded to detrend the variable with the Hodrick-Prescott (1980) filter.

Table 1 shows that the Portuguese cyclical fluctuations conform with the stylized facts of business cycles described by Kydland and Prescott (1992). Consumption, investment, output and employment are positively correlated.[9] All the variables are procyclical (with the exception of the trade balance) and show a remarkably high degree of persistence. Investment is three times more volatile than output, while consumption (which includes purchases of durables) is slightly less volatile than output.

The movements in the balance of trade, which are countercyclical and exhibit high volatility, also conform with the patterns of behavior found in other countries (see e.g. Reynolds (1982) and Dolado, Sebastian and Valdez (1993)).[10]

Figure 5 provides a snapshot of Portuguese business cycles. The first panel shows the evolution of the logarithm of GDP, together with its Hodrick-Prescott trend. The other panels show the evolution of other (detrended) macroeconomic variables together with detrended output.

This Figure shows the four most important shocks to the Portuguese economy: the oil shock of 1973-74, the revolution of April 1974, the marked terms of trade deterioration in 1980, and the second IMF stabilization program in 1983. The first two shocks can be aptly described as exogenous shocks to productivity. It is less

[9]We report statistics for the rate of employment because there is no reliable series for hours worked for Portugal. This is unfortunate since our model captures only variations in labor along the intensive margin and not along the extensive one.

[10]Another way of gauging the volatility of the balance of trade is to compare the standard deviation of the ratio of investment to GDP with the ratio of the balance of trade to GDP (both detrended with the Hodrick-Prescott filter). The cyclical volatility of the balance of trade share is 2.73 while that of the investment share is 1.73.

satisfactory to describe the 1980 and 1983 shocks as exogenous productivity disturbances.

The most important shock to the Portuguese economy in the 1958-1989 period is clearly the revolution that took place in April 1974. This marked the end of the New State regime, a moderate dictatorship instituted by Salazar in 1926 that blended elements of a market economy with a paternalistic government policy that at times interfered with market mechanisms. The revolution initiated a period of great political instability and of poor protection of property rights. Massive nationalization and land expropriation programs were enacted in 1974-75 by a Communist-influenced government.

Parameterizing the Model

The macroeconomic time series available for Portugal are too short to allow us to estimate the model as in Christiano and Eichenbaum (1992), while the scarcity of microeconomic empirical studies makes it difficult to follow closely the calibration procedures of Kydland and Prescott (1982). For this reason we will choose a plausible baseline parameterization and report sensitivity analysis results.

Some of the parameters can be chosen, as usual, on the basis of the long run information contained in the time series. We set $\gamma_X = 1.04$ so that the steady state growth rate of the economy coincides with the average growth rate of per capita output (4%). The value of α is chosen to coincide with the mean share of labor in income (53%). We chose the rate of depreciation, δ, equal to 5%, which is within the range of estimates provided by Santos (1984). The values of S^G was chosen to coincide with the mean share of government expenditures in output (12%).

Portugal has had a chronic trade deficit, at least since 1833. The average value of TB/Y in the period under study was -9%. We set the share of transfers to a value close to zero.[11] These two shares, together with the international real rate of return

[11]Most of the trade deficit was financed by emigrants remittances, which averaged 7.5% of GDP over the same period. It would be, however, erroneous to set the share of foreign transfers to 7.5% because that would imply that these transfers were not interest

allow us to determine the steady state value of B/Y (recall that the model's steady state is compatible with any value of B/Y).

We borrowed our preference parameterization from Greenwood, Hercowitz and Huffman (1988): $\sigma = 2$, $\nu = 1.7$. The value of ψ was chosen, using (4b), to ensure that the fraction of hours worked in the steady state is the same as that in the data (N=0.18, ψ=2.34).[12] We will introduce fairly small adjustment costs by choosing $\xi = 1/30$, which is half of the baseline value used by Baxter and Crucini (1993). Finally, we set A=1, which is simply an irrelevant choice of units.

The steady state share of investment in output is given by the following expression: $I/Y = (1-\alpha)(\gamma_X-1+\delta)/[\delta-1+(\gamma_X^\sigma/\beta)]$. Given values for α, γ_X, δ, σ and ν this expression implies that β must be equal to 0.9718.[13]

We found that the effects of government expenditures, interest rate and transfer shocks were of second order importance when we chose realistic volatilities for these shocks. For this reason we will focus on the model's moment implications when the only shocks to the economy are productivity disturbances.

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sensitive.

[12]We assumed that there are 7×14 hours per week and that the average work week is 40 hours. We chose N to be equal to the employment rate multiplied by 40/(7×14).

[13]This value of β implies an unusually high value for r^*: 11%. If we re-write the investment share expression as $I/Y = (1-\alpha)(\gamma_X-1+\delta)/(r^*+\delta)$ it becomes clear that we need a high value of r^* to match the mean investment share in the data because the capital share, $1-\alpha$, is much higher in Portugal than in the U.S. (.47 versus .33). Instead of postulating this high value for r^* we could have made different assumptions about the value of the adjustment cost function evaluated at the steady state, choosing $\phi(i/k) = a(i/k)$ with $a>1$, instead of $a=1$. This parameterization produces similar results to the ones we report. We did not pursue it because it complicates our steady state equations, making less transparent the simple economic mechanisms at work in the model.

Second Moment Implications

Since there are no series on hours worked for Portugal we cannot follow Prescott's (1986) strategy of computing the Solow residual and use it to estimate the stochastic process associated with technology shocks. For this reason we resorted to the Kydland-Prescott (1982) strategy of choosing the serial correlation and the volatility of the shock so that the model reproduces exactly the serial correlation and the volatility of output. With this goal in mind we set the serial correlation of $\log(A_t)$ equal to 0.56 and its standard deviation equal to 2.29.

Table 2 summarizes the model's implications for the population second moments of the different series detrended with the Hodrick-Prescott (1980) filter. These statistic are well defined, despite the presence of unit roots in the model, in light of the fact that the Hodrick-Prescott filter renders stationary series that are integrated of order up to four (King and Rebelo (1993)).

Given the tentative nature of our model calibration we are mainly interested in determining whether the model is consistent with the empirical regularities that are most closely related to the openness of the economy. These regularities comprise the moderate volatility of consumption and two features of the trade balance: its high volatility and its countercyclical nature.

Table 2 shows that our model is consistent with these features as well as with the slew of empirical regularities that are well known from closed economy work. For our parameterization the volatility of investment is similar to that in the data while the trade balance is less volatile in the model. As the reader familiar with Backus, Kehoe and Kydland (1991) would probably guess, we would need more complex production and accumulation equations to be consistent with the volatility of both the investment and the balance of trade, as well as with the fact that the correlation between the trade balance and lagged output is negative.

Sensitivity Analysis

Table 3 describes the effects of increasing the parameters of our baseline calibration by 5% on the most important second moments. We apply this sensitivity analysis both to the "deep-structural" parameters of the model and to relevant model characteristics that are non-linear functions of these parameters (e.g. the elasticity of labor supply, ε_N).

We report the moments already described in Table 2 for our baseline parameterization, as well as the moments implied by the version of the model with standard preferences calibrated with the same baseline parameters. The latter confirm that with standard preferences the volatility of consumption is very low and that the trade balance is procyclical.

The moments that are most sensitive to changes in the parameters of this economy are measures of the volatility of the balance of trade and of its comovement with output. This partly reflects the fact that the steady state value of tb/y is computed as a residual and hence adjusts to accommodate changes in the steady state values of I/Y, C/Y and in S_G. Changes in the discount factor factor have a large impact on both the volatility and the comovement of the trade balance because it affects the steady state investment share and hence the value of tb/y.

The other parameters that have a strong influence on the correlation between output and the trade balance affect the extent to which investment is going to increase in response to a technology shock, either by affecting the extent to which decreasing returns to capital set in as capital expands (e.g α and ξ) or the degree of permanence of the shock (ρ_A).

V. CONCLUSIONS

Our most striking finding is that the ability of small open economy models to mimic business cycles depends heavily on the form of momentary utility. When we employed the momentary utility that is standard in closed economy real business cycle settings (e.g. Hansen's (1985) divisible labor model) we found that we could not reproduce important features of the business cycle; the volatility of consumption was much lower than suggested by the data, and the balance of trade was procyclical instead of countercyclical.

In contrast, the version of our model that incorporates the momentary utility function proposed by Greenwood, Hercowitz and Huffman (1988), is consistent with the relative variability and comovement patterns found in by the data for the components of the national income accounts identity. Our analysis suggests that it is the adoption of the GHH momentary utility function that is fundamental to the good performance of the models of Mendoza (1987) and Lundvik (1992).[14]

The implications of our analysis for the sources of business cycle fluctuations are similar to those of closed economy models. The model is uncapable of mimicking actual business cycle fluctuations when it is driven solely by shocks to government expenditures or to foreign transfers. Shocks to productivity (or to the terms of trade) are necessary in order to generate empirically recognizable business cycles.

We conclude that the version of our model equipped with the preferences proposed by Greenwood, Hercowitz and Huffman (1988) is as successful in an open economy setting as the standard Hansen (1985) model in a closed economy context. Our simple model is broadly consistent with the most important patterns of comovements, persistence and variability suggested by the data.

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[14]Devereux, Gregory and Smith (1992) argue that the GHH preferences are capable of resolving the "consumption correlation puzzle" stressed by Backus, Kehoe and Kydland (1992). This puzzle consists in the fact that two-country models generally predict that the correlation of consumption between the two countries should be higher than that of output, while the reverse pattern is found in the data.

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TABLE 1

MOMENTS OF MACROECONOMIC VARIABLES
DETRENDED WITH THE HODRICK-PRESCOTT FILTER
(λ=100)

PORTUGUESE DATA: 1958-1991

	Standard Deviation		First Order Serial Correlation	Correlation Between x(t) and y(t+i)		
	sd(x)	sd(x)/sd(y)		-1	0	1
GDP (y)	3.78 (0.78)	1.00	0.62 (0.08)	0.62 (0.08)	1.00 (0.08)	0.62 (0.11)
Private Consumption	3.17 (0.30)	0.84	0.65 (0.05)	0.67 (0.08)	0.66 (0.08)	0.22 (0.15)
Investment	9.41 (1.34)	2.49	0.66 (0.05)	0.55 (0.07)	0.84 (0.04)	0.66 (0.08)
Government Consumption	3.34 (0.37)	0.88	0.34 (0.14)	0.34 (0.13)	0.36 (0.16)	0.10 (0.19)
Exports	9.74 (1.88)	2.58	0.61 (0.08)	0.33 (0.12)	0.72 (0.12)	0.62 (0.10)
Imports	9.78 (0.99)	2.59	0.51 (0.14)	0.57 (0.08)	0.82 (0.10)	0.54 (0.10)
Balance of Trade	32.08 (8.06)	8.49	0.53 (0.10)	-0.48 (0.07)	-0.48 (0.08)	-0.18 (0.17)
Employment	1.05 (0.21)	0.28	0.62 (0.08)	0.74 (0.07)	0.61 (0.06)	0.02 (0.09)
Capital Stock	1.24 (0.15)	0.33	0.79 (0.04)	0.79 (0.06)	0.52 (0.08)	-0.00 (0.11)

TABLE 2

POPULATION MOMENTS IMPLIED BY BASELINE MODEL DETRENDED WITH THE HODRICK-PRESCOTT FILTER (λ=100)

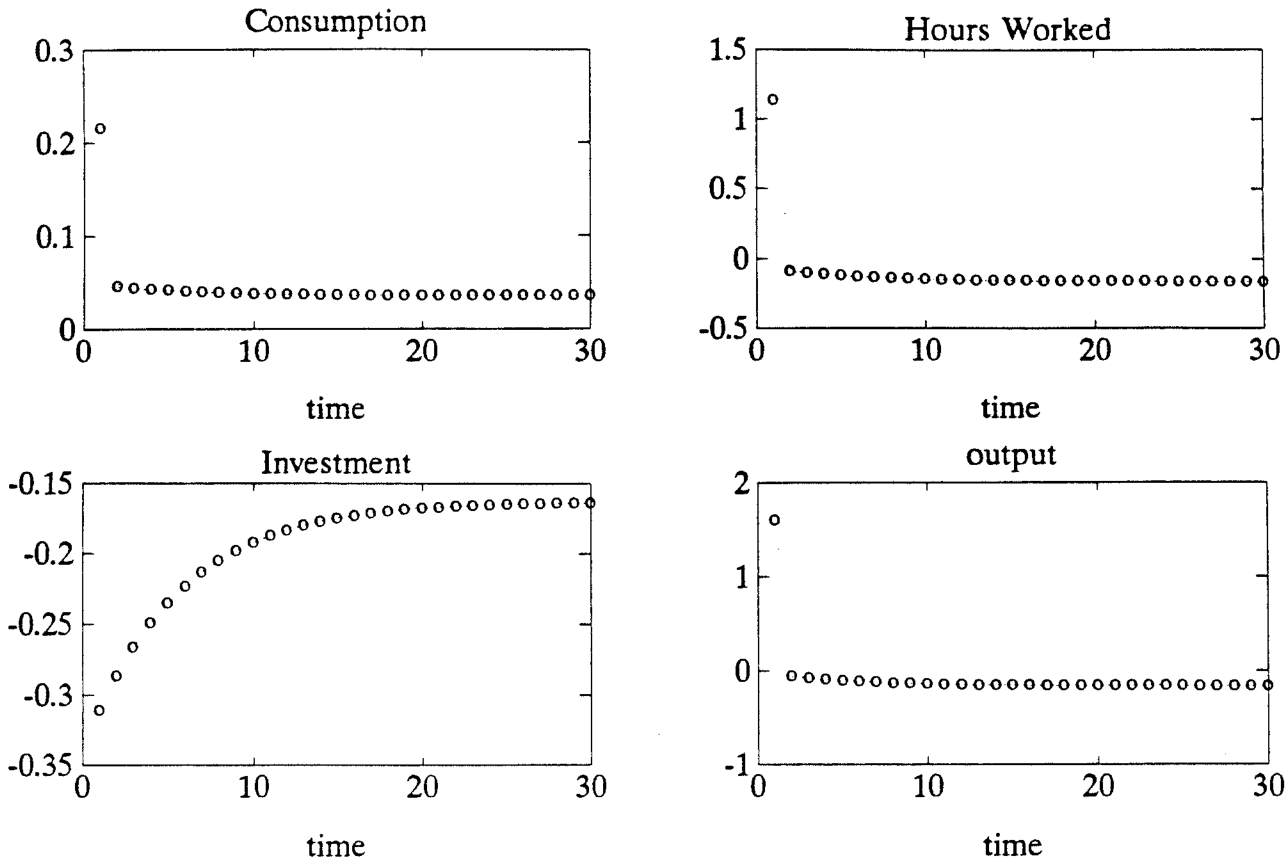
	Standard Deviation		First Order Serial Correlation	Correlation Between x(t) and y(t+i)		
	sd(x)	sd(x)/sd(y)		-1	0	1
GDP (y)	3.78	1.00	0.62	0.62	1.00	0.62
Private Consumption	2.12	0.56	0.63	0.65	0.99	0.58
Investment	9.71	2.57	0.35	0.11	0.81	0.55
Balance of Trade	15.65	4.14	0.49	0.58	-0.13	-0.14
Hours Worked	2.38	0.63	0.62	0.62	1.00	0.62
Wage rate	1.40	0.37	0.62	0.62	1.00	0.62
Capital Stock	1.63	0.43	0.85	0.88	0.50	0.88

TABLE 3

SENSITIVITY ANALYSIS

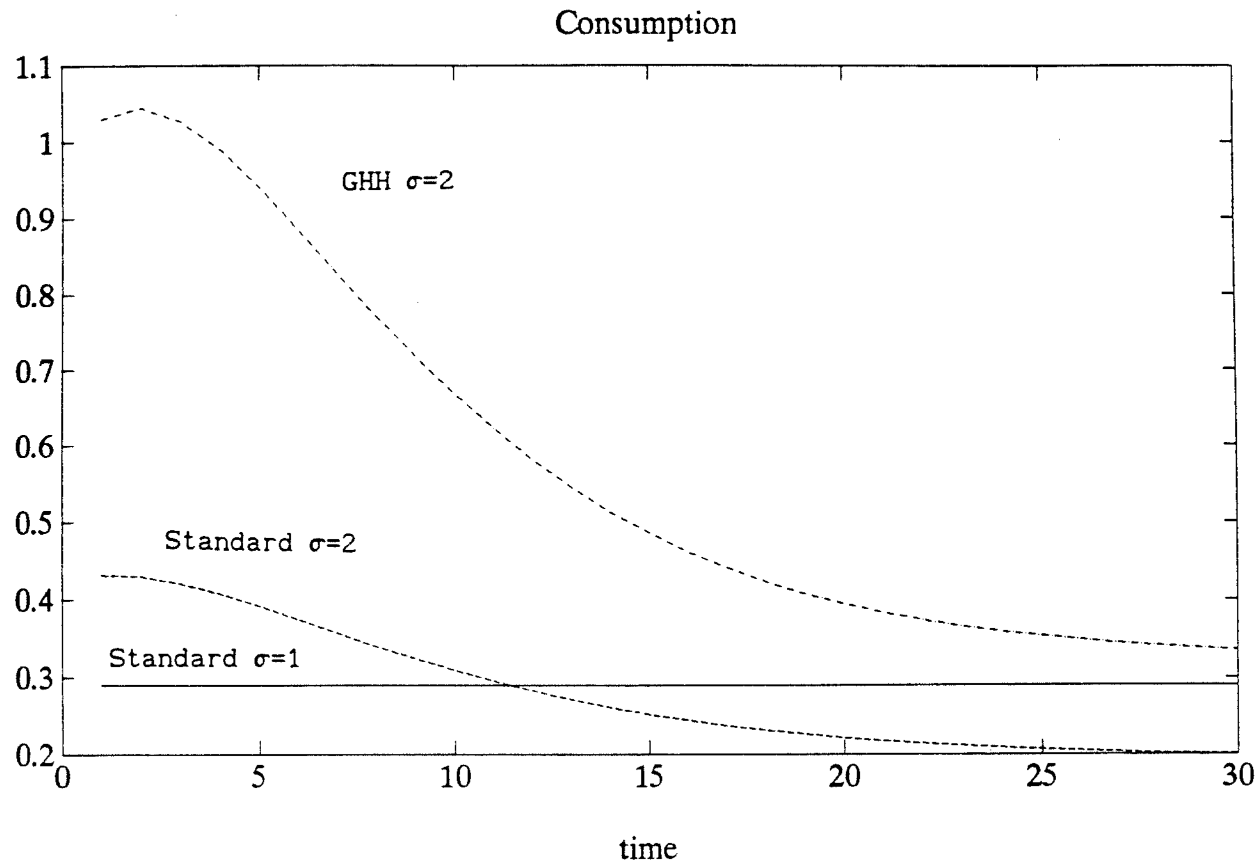
		Relative Volatility (σ_X/σ_Y)			First Order Serial Correlation			Contemporaneous Correlation with Output		
		c_t	i_t	tb_t	c_t	i_t	tb_t	c_t	i_t	tb_t
Baseline Model		0.56	2.57	4.14	0.63	0.35	0.49	0.99	0.81	-0.13
Baseline Model With Standard Preferences		0.18	2.31	6.59	0.66	0.39	0.91	0.90	0.73	0.76
Baseline Model with each of the following parameters increased, alternatively, by 5%	β	0.50	2.07	2.00	0.59	0.36	0.46	1.00	0.85	-0.35
	ν	0.54	2.54	4.04	0.62	0.34	0.51	0.99	0.81	-0.08
	ψ	0.56	2.57	4.14	0.63	0.35	0.49	0.99	0.81	-0.13
	σ	0.56	2.57	4.14	0.63	0.35	0.49	0.99	0.88	-0.13
	α	0.58	2.53	4.53	0.62	0.34	0.51	0.99	0.81	-0.08
	ξ	0.56	2.49	3.91	0.62	0.35	0.51	0.99	0.81	-0.11
	γ_X-1	0.55	2.55	3.98	0.63	0.34	0.48	0.99	0.80	-0.14
	δ	0.56	2.56	4.10	0.63	0.34	0.48	0.99	0.80	-0.13
	ρ_A	0.56	2.70	4.62	0.66	0.37	0.47	0.99	0.79	-0.16
	ε_N	0.56	2.58	4.18	0.63	0.35	0.48	0.99	0.80	-0.15
	N	0.56	2.57	4.14	0.63	0.35	0.49	0.99	0.81	-0.13
	c/y	0.53	2.57	2.97	0.63	0.35	0.49	0.99	0.81	-0.13
	S_G	0.56	2.57	3.89	0.63	0.35	0.48	0.99	0.81	-0.14

Figure 1



Consumption
0.3
0.2
0.1
0
0
10
20
30
time
Hours Worked
1.5
1
0.5
0
-0.5
0
10
20
30
time
Investment
-0.15
-0.2
-0.25
-0.3
-0.35
0
10
20
30
time
output
2
1
0
-1
0
10
20
30
time

Figure 2


Consumption
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
GHH σ=2
Standard σ=2
Standard σ=1
0
5
10
15
20
25
30
time

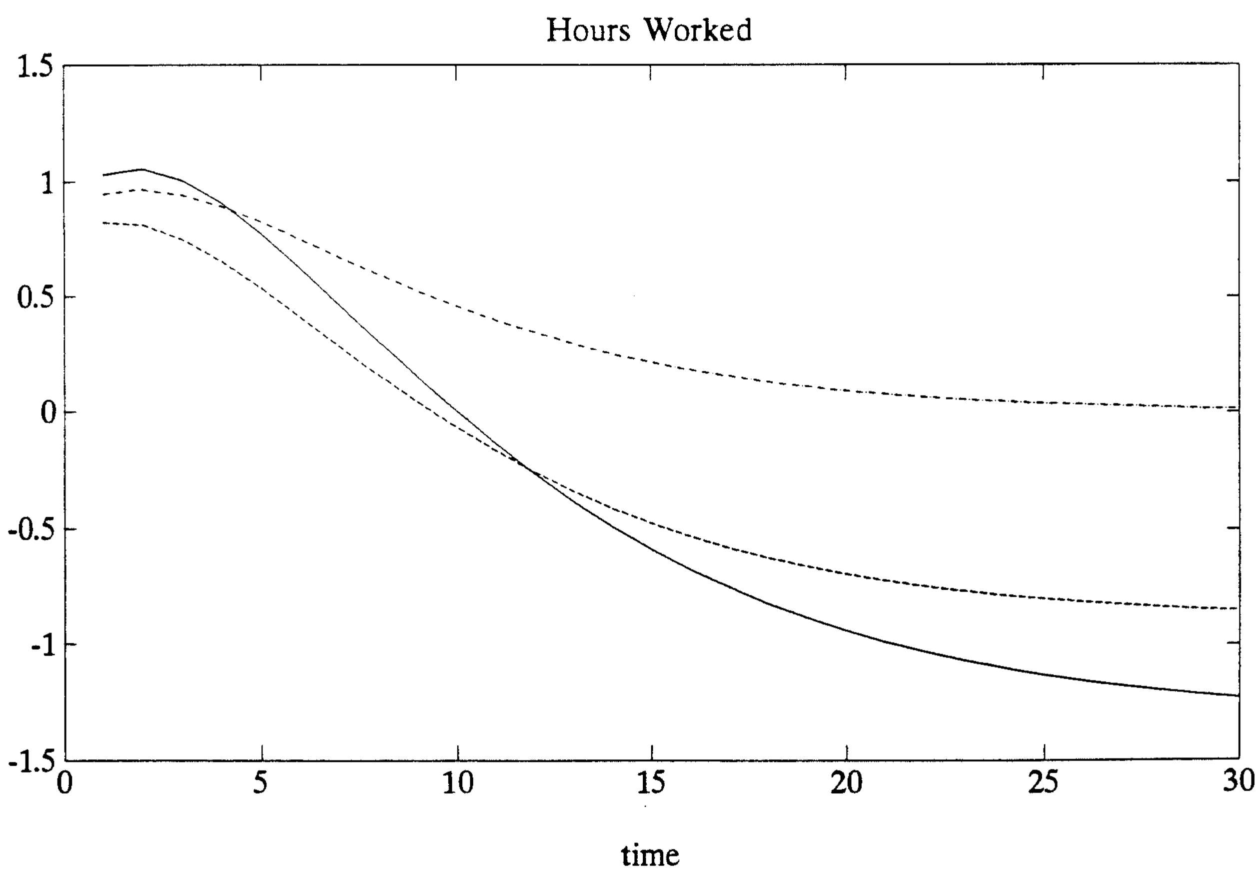
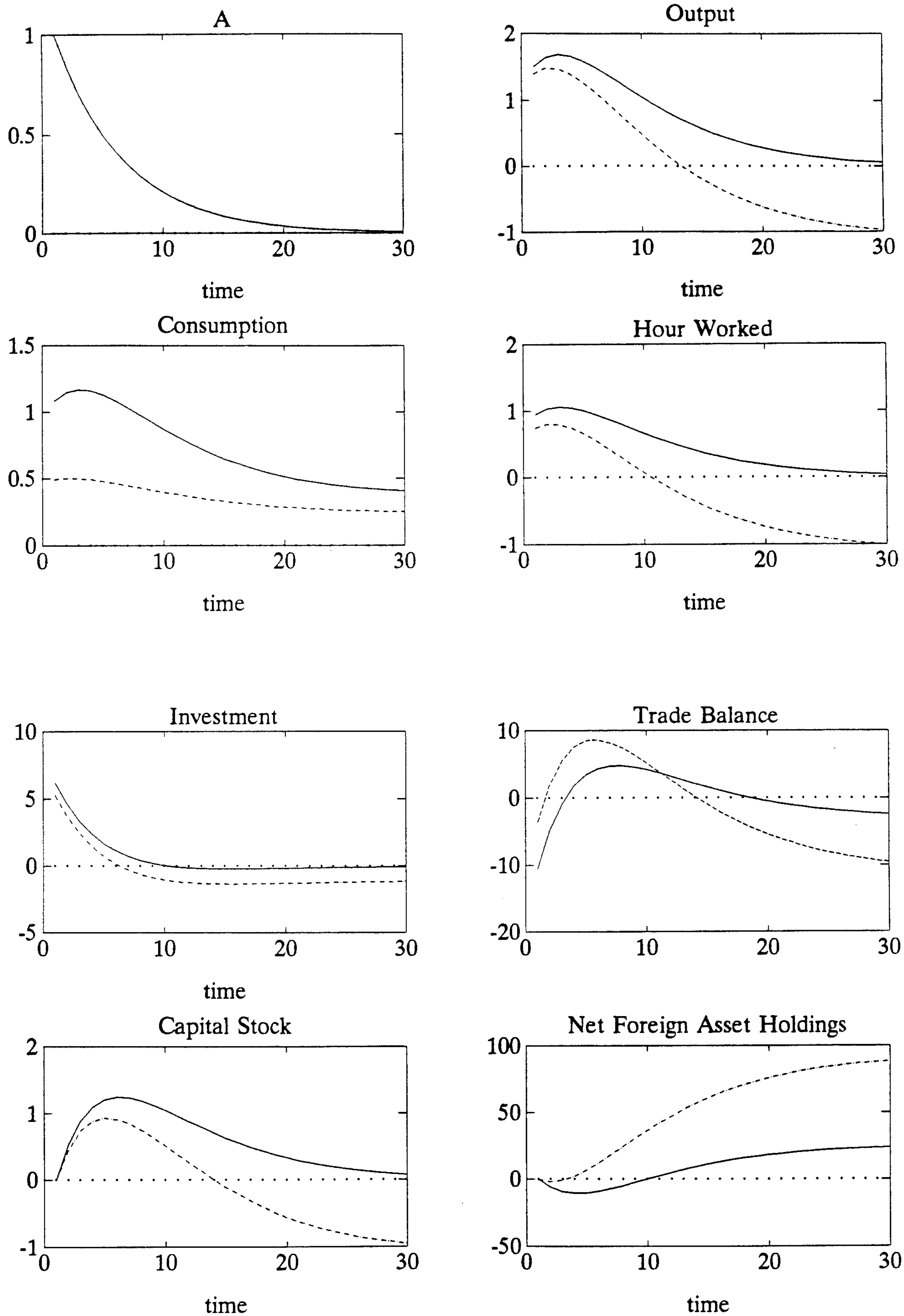

Hours Worked
1.5
1
0.5
0
-0.5
-1
-1.5
0
5
10
15
20
25
30
time

Figure 3



GHH Preferences: ———
Standard Preferences: - - - -

Figure 4

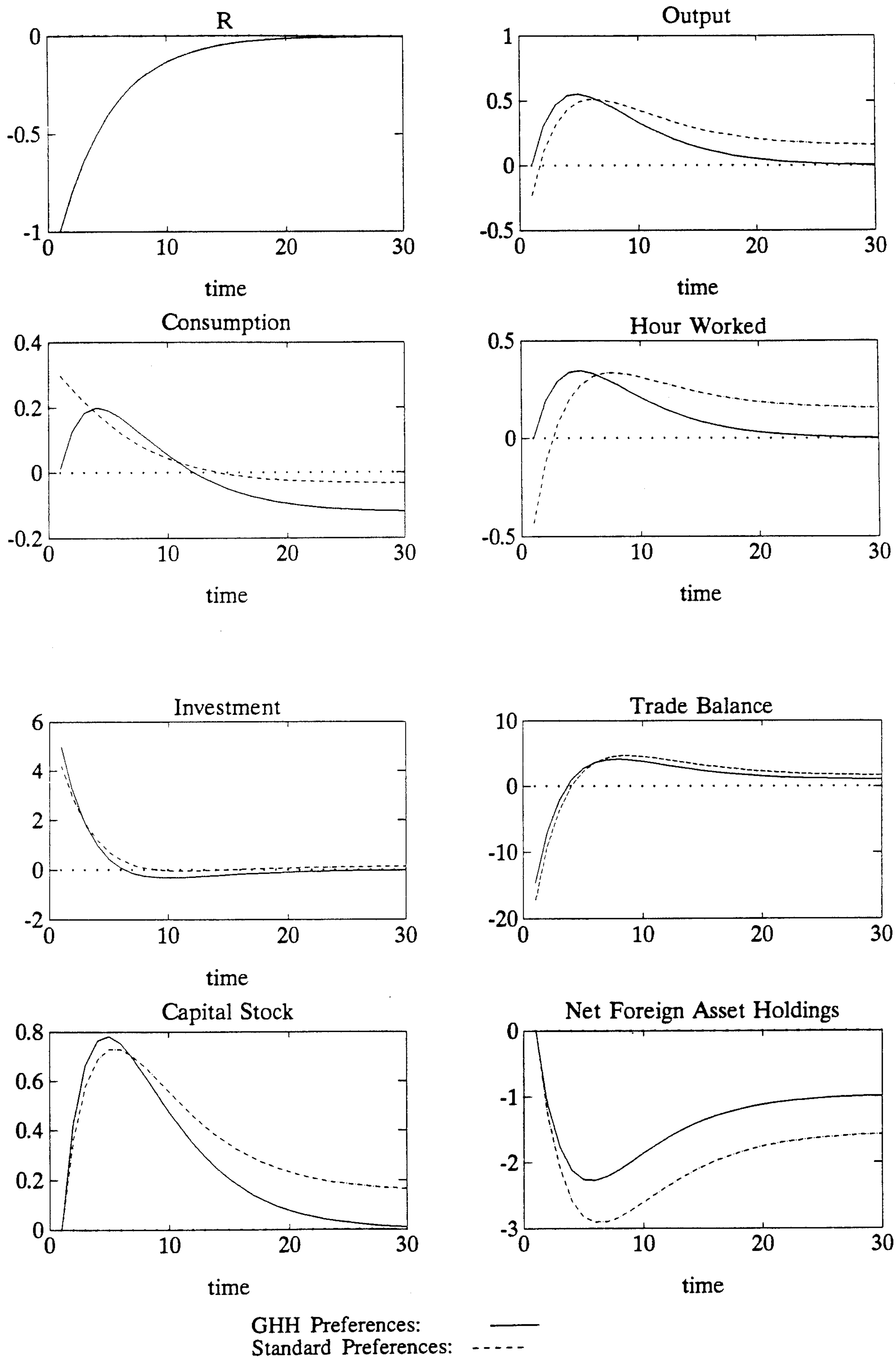
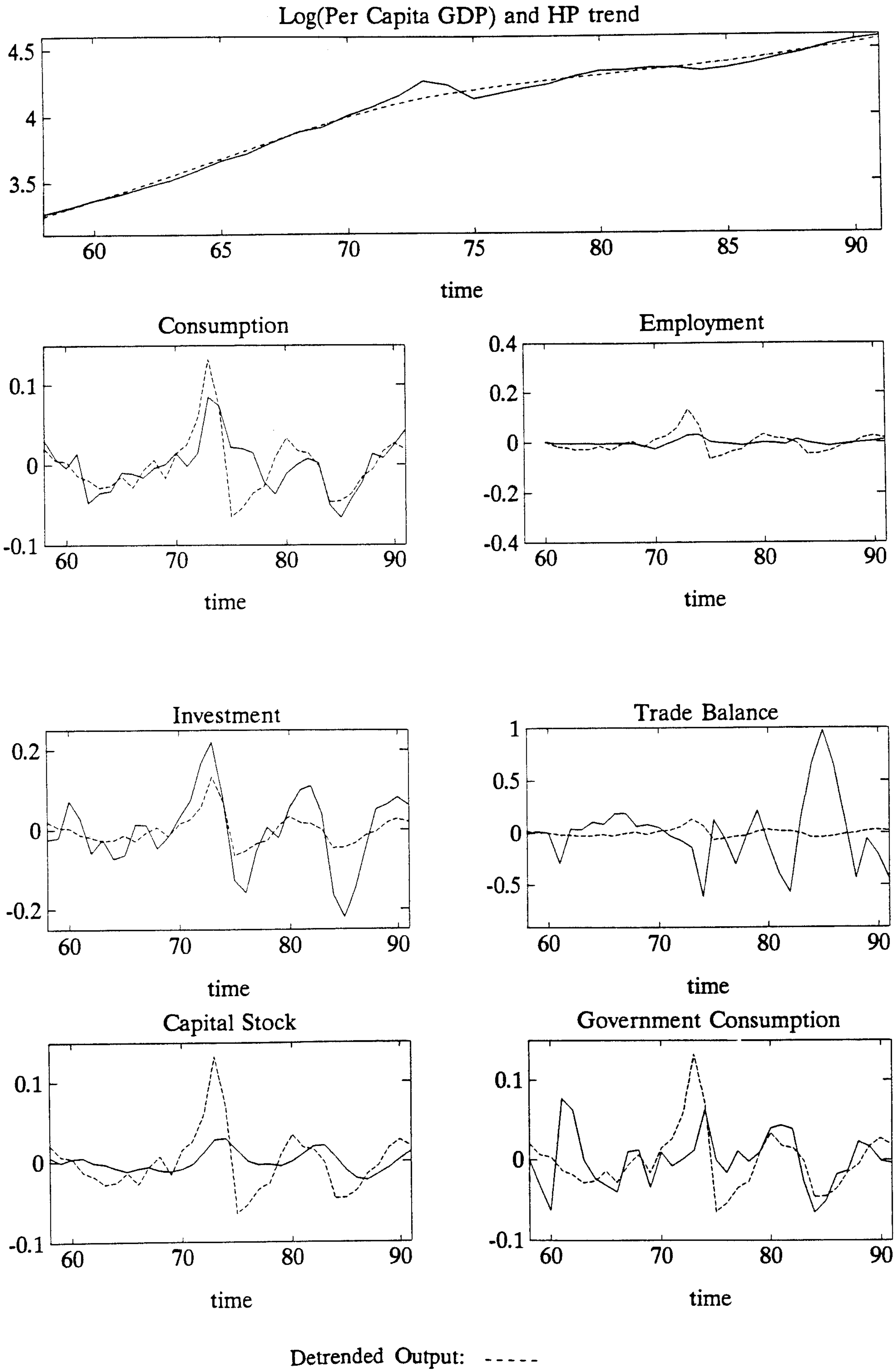

R
Output
Consumption
Hour Worked
Investment
Trade Balance
Capital Stock
Net Foreign Asset Holdings
time
0
-0.5
-1
0.5
1
0.4
0.2
-0.2
6
4
2
-2
10
-10
-20
0.8
0.6
-3
20
30
GHH Preferences:
Standard Preferences:

Figure 5


Log(Per Capita GDP) and HP trend
4.5
4
3.5
60
65
70
75
80
85
90
time
Consumption
0.1
0
-0.1
60
70
80
90
time
Employment
0.4
0.2
0
-0.2
-0.4
60
70
80
90
time
Investment
0.2
0
-0.2
60
70
80
90
time
Trade Balance
1
0.5
0
-0.5
60
70
80
90
time
Capital Stock
0.1
0
-0.1
60
70
80
90
time
Government Consumption
0.1
0
-0.1
60
70
80
90
time
Detrended Output: -----