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5 A Competitive Theory of Fluctuations and the Feasibility and Desirability of Stabilization Policy

Finn Kydland and Edward C. Prescott

Introduction

Can fiscal policy be used to stabilize the economy? In this essay we first develop an equilibrium theory of fluctuations consistent with the observed persistence of unemployment and then address this question within the framework of that theory. We conclude that fiscal policy rules, which alter relative prices facing firms and households, can and have had important effects upon the stability of the economy. Some rules increase fluctuations and others smooth out the business cycle. In choosing among rules the criterion used is the cost-benefit measure of neoclassical public finance, which has been applied to numerous problems involving important effects of government policies upon resource allocation.[1] Our conclusion is that tax rates should remain constant or nearly constant over the cycle with the budget being balanced on average. This does not minimize fluctuations but does minimize the deadweight burden of financing government expenditures.

Need for Rules

At this point we emphasize that the choice is from a set of fiscal policy *rules*. Only if businesses and households have a basis for forming expectations of future policies do they have well-defined decision problems, a prerequisite for the application of modern public finance theory. Only

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1. See for example Feldstein 1974 for his analysis of the effects of the Social Security System upon capital accumulation.

then is the behavior of the economic agents econometrically predictable. This is just the point made by Lucas (1976) in his critique of current econometric policy evaluation and will not be dwelt upon here. We emphasize that the fixed-rule procedure we advocate does not necessarily imply constant values or constant growth rates of the policy instruments. Feedback rules with the tax parameters varying systematically with economic conditions are considered. A policy rule, however, is needed before one can predict what equilibrium process will govern the economy.

The policy problem considered is that of choosing from a set of fiscal policy rules for setting tax rates and levels of government spending. Rather than characterizing the rule that is best in the cost-benefit sense of modern public finance, principles are sought for the design of policy rules that do well in terms of this criterion. This is done for three reasons. First, the policy that is best, relative to the specified objective, may be very complicated and not explainable to the public. This negates its usefulness, for the democratic policy selection process is not well suited to making subtle second- and third-best distinctions. Second, the determination of optimal policy requires precise estimation of the parameters of preferences and technology, and these estimates are not available and probably not obtainable. Third, the optimal policy will almost surely be time inconsistent, as we have previously shown (Kydland and Prescott 1977). Even for deterministic dynamic optimal taxation problems, if one again solves the optimization problem subsequent to the initial period, taking as given decisions already made, the resulting optimal plan for the remainder of the planning horizon is inconsistent with the initially optimal plan. Besides invalidating the principle of selecting the action which is best given the current situation, a principle needed to justify discretionary policy, the computation of the optimal taxation programming problem when there is uncertainty is beyond our current capabilities. This time inconsistency does not arise because of a conflict between social and private objectives except insofar as people value consumption of public goods and prefer not to pay taxes. The problem is present even if the social objective is the welfare of the representative individual.[2]

2. Calvo (1977), in a very interesting paper, has demonstrated the time inconsistency of an optimal monetary policy. Since inflation can be viewed as a tax on liquidity, his is an optimal taxation analysis. The authors (1978*a*) have explored further the problems of computing optimal policy. Bellman's principle of optimality was shown to hold if policy is constrained to rationalize *past* decisions of private agents. In that paper the standard optimal taxation problem is extended to dynamic environments.

Need for a Theory Consistent with Facts

A prerequisite for the application of neoclassical public finance is an equilibrium theory, that is, a specification of preferences and technology which rationalizes choices of the economic actors. The puzzle of the business cycle is why output does not vary smoothly over time but rather fluctuates about trend. In the postwar period some of these deviations of measured output from trend have exceeded 5% of trend output. The rate of capital accumulation, in particular the production of producer and consumer durables, is highly correlated with output (all variables are measured as percentage deviation from trend); however, the percentage fluctuations are of much greater amplitude. Fluctuations in labor supplied are also positively and strongly correlated with output and have amplitudes comparable with those of real output. An equilibrium theory must explain these well-known facts about the comovements of these aggregate economic time series.

A second set of observations that confronts a theory of business fluctuations is the persistence of deviations of output from trend. Indeed, these persistent deviations have been taken by many as an argument against the use of equilibrium models with rational expectations to explain business cycle phenomena. Modigliani (1977, p. 6), in his presidential address, states: "But the most glaring flaw of MREH (Macro rational expectations hypothesis) is its inconsistency with the evidence: if it were valid, deviations of unemployment from the natural rate would be small and transitory—in which case *The General Theory* would not have been written and neither would this paper."

An indication of this persistence can be obtained by regressing the detrended log of real output on itself lagged one period and on the lagged rate of change. The estimated equation from quarterly data for the 1947–77 period is

$$y_t = \underset{(.026)}{.909} y_{t-1} + \underset{(.082)}{.477} (y_{t-1} - y_{t-2}).$$

$$S.E. = .00011 \quad R^2 = .908$$

This second-order difference equation is stable with largest eigen-value .75. Given this fact and that there are 120 observations, large sample theory should provide nearly valid inference.

For this difference equation the expected deviation from trend this period is a function not only of last period's deviation but also of the rate of change in the deviation. This latter dependency, which we label momentum, results in the response to an innovation not being greatest in the initial period but rather increasing to a peak in a period subsequent to the innovation before subsiding (see fig. 5.1).

Additional evidence for persistence and momentum is the research of Barro (1977, 1978). He finds that the effects of unanticipated monetary shocks upon output initially increased before dampening. Sims's (1979) estimates of response functions of real output to innovations in the vector autoregressive process display a similar pattern.

The Monetary Shock Theory

Lucas (1972) developed an equilibrium business cycle theory with monetary shocks to explain the negative correlation of output and the consumption of leisure or non-market-produced goods and services. Monetary shocks confound relative price shifts resulting in correlated supply errors in a decentralized economy. Crucial to this theory is the intertemporal substitutability of leisure, which implies that temporary changes in expected real wages have important effects upon labor supply even though permanent changes have little or even slightly negative effects. We find the theory that monetary shocks have important effects on real aggregates appealing and the evidence supportive. But we think shocks to technology and fiscal policy shocks, which affect relative prices, are also important in triggering economic fluctuations. The following analysis of the deterministic equilibrium growth model suggests that variations in factors affecting the equilibrium rate of capital accumulation could give rise to fluctuations in investment of the magnitude observed in the postwar period. We emphasize that this analysis is not a substitute for a rational expectations theory with shocks, which is de-

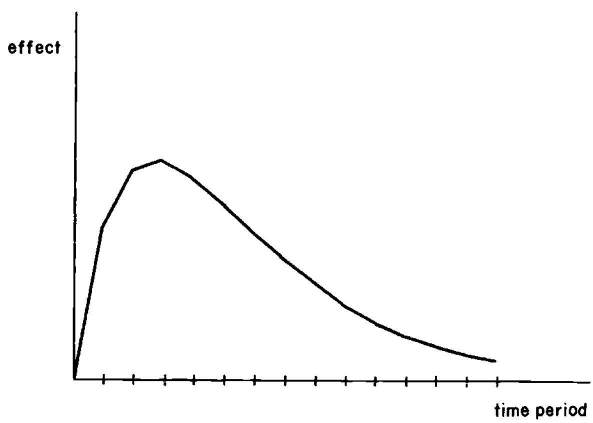

Fig. 5.1 Effect of shock occurring in period 1

veloped subsequently. Rather, it is a simple exercise to bring to bear prior knowledge about preferences and technology to determine whether such factors should be ruled out as a *quantitatively* important source of fluctuations.

Quantitative Importance of Real and Policy Shocks

Policies that affect the relative price of capital goods, leisure, and consumption have important effects upon the stationary capital stock. Abstracting from growth, as our concern is with deviations from trend, the stationary capital stock k^s satisfies

$$(1-\theta)\, f_k(k^s,n^s) = q(\delta+\rho),$$

where θ is the corporate tax rate, f_k the marginal product of capital, n^s the stationary labor supply, q the effective price of new capital, δ the exponential depreciation rate of capital, and ρ the subjective time discount rate.

The effective price of capital is related to fiscal policy parameters and the inflation rate as follows:

$$q = 1 - \tau - \frac{\theta\,\psi}{\psi+\pi+\rho},$$

where τ is the investment tax credit rate, ψ the capital consumption allowance rate allowed for tax purposes, and π the inflation rate.

This is the standard rental price analysis of Jorgenson except for the last term, which is the present value of reductions in future tax liabilities and is obtained by summing the present value of capital consumption allowances t periods hence,

$$\frac{\psi(1-\psi)^t}{(1+\rho+\pi)^{t+1}},$$

from t equal zero to infinity and multiplying by the corporate tax rate θ.

For purposes of obtaining order of magnitude estimates of effects of policy parameters upon stationary capital stock, we assume a Cobb-Douglas production function with capital's exponent being .25. If the time period is a year, the initially assumed values for the other parameters are $\rho = .05$, $\psi = .10$, $\delta = .10$, $\pi = 0$, and $\tau = 0$. We also assume that changes in the policy parameters have a negligible effect upon the stationary labor supply. This is not an unreasonable approximation given the small change in per person labor supply that has occurred over the last forty years, a period in which there was a large increase in the real wage.

With these assumptions the effect of a 10% investment tax credit is to increase the stationary capital stock by 20%. Because a 10% investment tax credit was introduced in the early sixties and the depreciation schedule accelerated (ψ increased), the rapid rate of capital accumulation over much of that decade is no surprise. More surprising, at least to us, is the large effect that changes in the anticipated future inflation rates have upon the capital stock. A change in the average inflation rate from zero to 7% more than offsets the effect of a 10% investment tax credit, at least for the assumed parameter values. The increase in the average inflation rate that occurred in the seventies may be the principal cause of the low rates of capital accumulation in recent years.

This structure considers only plant and equipment in the corporate sector. This stock is only a fraction of the physical capital stock and is approximately three-quarters of annual GNP for the American economy. Other components of the capital stock comparable in size are inventories, housing stock, stock of consumer durables, and the public capital stock. Considering all of these components, the reproducible capital–annual output ratio is about 3 for the American economy.[3] A shock to technology, such as the increase in the price of imported oil that occurred in the early seventies, might reduce our production possibilities set by 2.5% and therefore stationary capital stock by 10% of annual GNP.[4]

This stationary point analysis indicates that policy and technology shocks have effects upon the stationary capital stocks of the order of 10% of annual GNP. Depending upon the rate of adjustment along the equilibrium path, these shocks might or might not have effects comparable in magnitude to observed fluctuations. To address this issue of speed of adjustment, additional assumptions about preferences are necessary. We assume that the utility function of the representative household can be approximated in the neighborhood of the stationary point by

$$\sum_{t=0}^{\infty} (1+\rho)^{-t} \{\ln c_t + 2 \ln (1 - n_t)\}.$$

We also assume that the production relationships are

$$f(k_t, n_t) = k_t^{1/4} n_t^{3/4}$$

and

$$c_t + k_{t+1} \leq f(k_t, n_t) + (1 - \delta)k_t.$$

The rest point values for this growth model are $k^s = .6132$, $n^s = .3103$, $c^s = .3066$, and stationary GNP $= .3679$.

3. These numbers were taken from *The Statistical Abstract of the United States* (1976), table 695, p. 428.

4. We are assuming stationary capital–output ratio of three, a Cobb-Douglas production function with coefficient of capital equal ¼, and a 2.5% reduction in the multiplicative factor of the production function.

We substitute $f(k_t,n_t) + (1 - \delta)k_t - k_{t+1}$ for c_t in the utility function and make the quadratic approximation about the stationary values. We find that for this approximate problem the equilibrium law governing the capital stock is

$$k_{t+1} - k^s = .7544(k_t - k^s).$$

This solution to the approximate problem is the first-order Taylor series approximation at k^s to the equilibrium rule for the growth problem being considered.

The stationary capital–annual output ratio for the growth problem is 1.7, and the rate of adjustment of capital to the stationary value is almost 25% per year. That is, in three years more than half the gap between current and stationary capital stock is closed along an equilibrium growth path. If capital is 10% below its stationary value, labor supply is about 2.1% above its stationary value, output 1% below its stationary value, gross investment 2.4% of stationary output above its value, and consumption 4.1% below its value. These numbers are not consistent with the observed correlations: other features must be introduced before we have an explanation of fluctuations. These numbers do indicate that capital-theoretic elements cannot be ruled out as a quantitatively important source of economic fluctuations.

A Theory of Economic Fluctuations

Ours is a competitive theory which combines the Lucas (1972) monetary shock model with the model of capital accumulation in an environment with shocks to technology.[5] We choose the infinitely lived family rather than the overlapping generation abstraction because it facilitates bringing to bear prior knowledge and is easier to analyze. Such structures with a single capital good do give rise to the observed comovements of economic aggregates and persistence of deviations of output from trend when plausible parameters are assumed. For the examples considered, however, momentum for the equilibrium process governing real output was not obtained. Possibly introducing information diffusion, a feature of Lucas's (1975) extension of his business cycle theory, is the way to obtain momentum. We think a more plausible explanation is that more than a single period is required to build a new capital good. The work by Jorgenson (1963, 1971) and recent estimates by Hall (1977) suggest that there are long lags from the time when changes in its determinants call for an increase in the capital stock until the time when the new capital starts yielding services.

5. See Brock 1978 for the theory laid out in detail or Prescott and Mehra 1978, where recursive methods are used. Black (1978) has argued that real factors can explain aggregate fluctuations.

Supposing that the process of designing, ordering, and installing capital can be described by a fixed distribution of lags, Hall (1977) found the *average* lag to be about two years. Evidence of a different kind is reported by Mayer (1960). On the basis of a survey he found that the average lag (weighted by the size of the project) between the decision to undertake an investment project and the completion of it was twenty-one months. To this must be added any lag that occurs between the arrival of information and the decision to carry out the investment. If anything, this estimate is likely to be an underestimate of the actual lag during a period of general expansion. If most firms decide to expand almost simultaneously, delivery lags are likely to be substantially longer than would be the case if investments were evenly spread out over time. It should also be noted that lags are generally longer for larger projects.

Once a project is begun, the cost will be distributed over the period of time it takes for it to become productive. According to Mayer, the construction period for a typical plant is fifteen months. During the time period of half a year or so before start of construction, plans are drawn, financing is arranged, and the first significant orders are placed before construction can begin. There was, of course, a lot of variation in lead times. For example, in his sample of completed plants, 20% required ten months or more from start of drawing of plans to start of construction. These findings, which are probably low estimates for periods of generally high capital accumulation, suggest that only a small fraction of additions to capital stock that are decided on in a given year show up as investment expenditures in the same year. Most of the expenditures will be incurred during the next year, with a not insignificant fraction being left over for the subsequent year.

To our knowledge, the first analysis incorporating this feature within a dynamic equilibrium framework was done by the authors (1977). The typical firm in a competitive industry was assumed to make investment plans in period t on the basis of the state of the economy at that time, the investment tax credit, and expectations about future prices. Part of the expenditures were incurred in the same period and the rest in period $t + 1$. The new capital stock was assumed to become productive in period $t + 2$. Expectations were rational in the sense that, when aggregated across firms, the investment behavior did indeed lead to the distribution of future prices on which individual decisions were based. In that model the propagation of random demand shocks or changes in the tax rate was fairly slow.

In this paper we present an abstraction in which durables play the role of capital, although they were assumed, directly or indirectly, to enter the consumer's utility function. Thus, durables as a proportion of total output are thought of as being roughly equivalent in magnitude to the sum of consumer and producer durables. In general, suppose additions to the stock of durables planned in period $t - L$ do not produce services before period $t + 1$, as expressed by the equation

$$(1) \qquad d_{i,t+1} = (1 - \delta_d)d_{it} + s_{iLt},$$

where d_{it} is the stock of durables held by individual i at the beginning of period t, s_{iLt} is the plan made in period $t - L$ for an addition to the stock of durables, and $0 < \delta_d < 1$ is a depreciation rate. The expenditures, however, are distributed with a fraction ϕ_0 in the planning period $t - L$, a fraction ϕ_1 in period $t - L + 1$, and so on. Total investment expenditures in period t are then

$$(2) \qquad z_{it} = \sum_{j=0}^{L} \phi_j s_{ijt},$$

where $\sum_{j=0}^{L} \phi_j = 1$. On the basis of empirical evidence, it seems reasonable that L would be at least two years, that ϕ_0 would be relatively small, and that ϕ_1 would be at least 0.5.

Lucas and Rapping (1969) and Ghez and Becker (1975) found ample evidence that leisure time in one period is a good substitute for leisure time in another period. This suggests that intertemporal substitution is an important feature of people's preferences. Greater intertemporal substitutability can be modeled by introducing a quasi-capital element in the utility function which measures how much workers have worked in the past, with relatively more weight on the more recent past, say given by

$$(3) \qquad a_{i,t+1} = (1 - \delta_a)a_{it} + n_{it},$$

where n_t is hours worked in period t, and δ_a is a depreciation rate. Both a_t and n_t enter the current-period utility function. The higher the value of a_t in a given period, the more utility is derived from leisure in that period. This model is consistent with the observation that labor supply is elastic with respect to transitory changes in the real wage rate, but inelastic with respect to permanent changes.

In this economy we have a large number of people who have identical preferences. Each maximizes expected discounted utility

$$\sum_t \beta^t u(c_{it}, d_{it}, n_{it}, a_{it}), \; 0 < \beta < 1,$$

where c_{it} is consumption of nondurables. This is not a time-separable utility function because a_{it} is a function of previously supplied labor. But it is determined recursively, a property which is needed to insure that resulting equilibrium decision rules are stationary.

We assume that the function u is such that after using the budget constraint to eliminate c_{it}, the resulting function can be approximated by a quadratic function over the range of fluctuations. Resulting equilibrium decision rules are then linear, as required for most econometric time series analyses, and the equilibrium is computable.

For the examples presented here we do not permit loans among individuals. The consumer has a store of value, namely capital, so our somewhat arbitrary exclusion of this market should not significantly affect our conclusions. Some preliminary results (see Kydland and Prescott 1978*b*) support this conjecture and we would be very surprised if the inclusion of a consumer bond market would alter any conclusions. With these apologetic statements the consumer is faced with the sequence of budget constraints:

$$c_{it} = \lambda_{it} n_{it} - z_{it} \tag{4}$$

indexed by t where λ_{it} is his real wage. Another set of constraints he faces is:

$$s_{i,k,t+1} = s_{i,k-1,t} \text{ for } k = 1, \ldots, L. \tag{5}$$

The number of new projects initiated k periods prior to next period will be the number of projects initiated $k - 1$ periods prior to the current period.

We do not assume a standard production function with capital, labor and a technology shock parameter because of the computation problems that would result. Rather we assume that the sum of consumption and gross investment is constrained by the sum of individuals' outputs, $\lambda_{it} n_{it}$. The curvature of our (indirect) utility function, we think, captures the substitutability of capital for labor in the production process.

The exogenous stochastic elements giving rise to fluctuations are shocks to productivity. We assume the individual λ's are distributed about an economy wide mean Λ_t, which is subject to change over time. More explicitly, we assume Λ_t is subject to a first-order autoregressive process:

$$\Lambda_{t+1} = \rho \Lambda_t + \mu + \xi_{t+1}$$

$$\lambda_{it} = \Lambda_t + \epsilon_{it} \text{ for all } i.$$

The ϵ_{it} are distributed independently over individuals and for simplicity over time as well. By the law of large numbers, the average ϵ_{it} over the continuum of individuals is zero with probability 1. In addition, the disturbances ξ and ϵ are normally distributed with means of zero and variances $\sigma^2{}_\xi$ and $\sigma^2{}_\epsilon$.

In order to simplify subsequent analysis we represent the relationships as

$$\lambda_{ti} = \Lambda^e{}_t + \xi_t + \epsilon_{it}, \tag{6}$$

where

$$\Lambda^e_{t+1} = \rho\Lambda^e_t + \rho\xi_t + \mu. \tag{7}$$

The Λ^e_t is the expected real wage at time t conditional upon observations with index less than t.

Using the convention of letting capital letters denote the aggregate or per capita quantities of the corresponding individual variables, we can write

$$A_{t+1} = (1 - \delta_a)A_t + N_t, \tag{8}$$

$$D_{t+1} = (1 - \delta_a)D_t + S_{Lt}, \text{ and} \tag{9}$$

$$Z_t = \sum_{j=0}^{L} \phi_j S_{jt}.$$

Some might question whether the real wage does move procyclically as the theory requires if there is to be persistence and momentum. First, if the elasticity of labor supply with respect to cyclical variations in the real wage is high, only small fluctuations in the real wage, say a percent or two, are needed to explain the observed fluctuations in employment. Measurement errors could very well introduce a *cyclical* bias in the measurement of the real wage of this magnitude. In boom periods a given worker may be assigned to a job which is higher on the internal job ladder and has higher pay, and being less experienced, he will cost the firm more per unit of effective labor service in the boom period.[6] Another potential source of cyclical measurement bias is that, with the implicit employment contract, payments are not perfectly associated over time with labor services supplied. Thus, we do not consider it damaging to our theory that there is little evidence of procyclical movement of the real wage.

The theory presented assumes a single capital good. Generalization to multiple capital goods with different time periods required for construction (i.e., different L's) and different distributed resource allocations (i.e., different sets of ϕ_j's) is straightforward. Such generalizations were not attempted because, besides significantly increasing the costs of computing the fixed-point problem that must be solved to determine the competitive equilibrium, they were not needed to explain persistence of shocks nor did we see any reason why policy conclusions would be at all sensitive to the simplification.

In our model so far we have measured the wage rate in terms of the price of output (durables or nondurables). An important extension is to allow for monetary shocks. The individual observes only his own nominal wage rate (or the wage rate on his "island") before making the decision

6. See Reder 1962 for a further discussion.

on how much to work in period t. From the observed nominal wage rate, say w_{it}, and knowledge of variances of shocks, he can infer only with error his own real wage rate, λ_{it}, and the economywide real wage, Λ_t.

To be specific, assume that

$$w_{it} = \lambda_{it} + \eta_t, \tag{10}$$

where η_t is due to monetary shocks and is assumed to be normally distributed with mean zero and variance σ^2_η. The worker will want to supply more labor when his real wage is high relative to what he can expect to earn in the future, of which the economywide real wage rate is an indication. He will therefore try to infer λ_{it} and Λ_t from the observation of w_{it}. Given the assumptions above, the conditional expectations are

$$E(\Lambda_t \mid w_{it}) = (1 - \psi_1)\, \Lambda^e{}_t + \psi_1 w_{it},$$

where $\psi_1 = \sigma^2{}_\xi / (\sigma^2{}_\xi + \sigma^2{}_\epsilon + \sigma^2{}_\eta)$, and

$$E(\lambda_{it} \mid w_{it}) = (1 - \psi_2)\, \Lambda^e{}_t + \psi_2 w_{it},$$

where $\psi_2 = (\sigma^2{}_\xi + \sigma^2{}_\epsilon)/(\sigma^2{}_\xi + \sigma^2{}_\epsilon + \sigma^2{}_\eta)$. It is instructive to write these conditional expectations in a different form:

$$E(\Lambda_t \mid w_{it}) = \Lambda^e{}_t + \psi_1(\epsilon_{it} + \eta_t + \xi_t) \tag{11}$$

$$E(\lambda_{it} \mid w_{it}) = \lambda_{it} - (1 - \psi_2)\, (\xi_t + \epsilon_{it}) + \psi_2 \eta_t. \tag{12}$$

Of course, some of the variables on the right-hand sides of the last two equations are not observable.

In this setup, if the agent observes a change in w_{it}, he does not know how much of it is due to the monetary shock (η_t), to the economywide productivity shock (ξ_t), or to the difference between his own and the average productivity (ϵ_{it}). His knowledge of relative variances for the three shocks, however, allows him to form conditional expectations. Having decided how much labor to supply, he subsequently observes his real income. If it is, say, higher than anticipated, optimal behavior is to allocate a larger proportion of his income to durables, yielding services in future periods, than he would have otherwise.

Definition of Equilibrium

An individual at a point in time is characterized by his state variable vector $y_t \equiv (d_t, a_t, s_{1t}, \ldots, s_{Lt})$ and wage w_t. The subscripts i are omitted because individuals with the same (y_t, w_t)-pair are indistinguishable and consequently choose the same decision vector, (c_t, s_{0t}, n_t), in that period. The vector y_t was selected to summarize all relevant aspects of past decisions upon current and future decisions.

The state of the economy is the distribution of the y_t over the implicitly assumed continuum of individuals plus $\Lambda^e{}_t$. For our structure only the first moment of this distribution matters in the sense that equilibrium values of aggregate economic variables and prices are a function of the population averages only. The convention of using the corresponding capital letter to denote a variable's population average is adopted in the subsequent discussion. The economywide state is the pair (Y,Λ^e). A second important feature of our structure—that it is recursive—results in time invariant, or stationary, equilibrium laws of motion for the economy, as is required for the application of standard econometric time series analysis. Equilibrium prices and aggregate variables are a function of the economy state variable while optimal individual decisions are functions of both individual and economy state variables. Equilibrium requires that the individual decision rules imply the aggregate relationships, that expectations are rational, and that markets clear. We now make this more explicit.

Let value function $v(y,w,Y,\Lambda^e)$ be the (equilibrium) expected discounted utility for an individual with initial state (y,w) if the initial economy state is (Y,Λ^e). Primes denote the value of a variable in the subsequent period. By Bellman's principle of optimality, this value function must satisfy the following functional equation:

$$v(y,w,Y,\Lambda^e) = \max_{n} E\,\{\max_{c,s_0}\,[u(c,d,a,n)$$

$$+ \beta\, E\, v(y',w',Y',\Lambda^{e\prime})] \mid w,\Lambda^e\}$$

subject to constraints (1)–(5). In the above, the first expectation is conditional on his observed nominal wage w. The maximization with respect to n is outside the expectation because the labor supply decision is on the basis of the nominal wage prior to deducing the value of the nominal shock. At the time of the consumption-savings decision, realized real wage, nominal shock, and therefore economywide average real wage as well are known.

The one variable whose distribution is not yet well defined is Y'. A (linear) law of motion $Y' = F(Y,\Lambda^e,\xi,\eta)$, where ξ and η are the economywide real and nominal shocks, is assumed. Given function F, the decision problem of the household is well defined, and there are resulting (linear) optimal decision rules for individuals:

$$n = n^e(y,w,Y,\Lambda^e)$$

$$c = c(y,n,Y,\Lambda^e,\epsilon,\eta,\xi).$$

$$s_0 = s_0(y,n,Y,\Lambda^e,\epsilon,\eta,\xi).$$

Equations (6) and (10)are used to obtain labor supply as a function of individual and economywide states and the three shocks or

$$n = n(y,Y,\Lambda^e,\epsilon,\eta,\xi).$$

Averaging variables (note that average ϵ is 0 because ϵ is independent across individuals), one obtains (N,C,S_0) as a linear function of (Y,Λ^e,η,ξ), which along with (8) and (9) can be used to obtain Y' as a function of (Y,Λ^e,η,ξ). For equilibrium, this implied law of motion must equal the assumed law of motion F.

Our method of determining an equilibrium is to use backward induction to solve for the first-period equilibrium decision rules and law of motion for finite-period problems. As the horizon increased, in all cases, these equilibrium first-period decision rules converged. This limiting rule is a solution to the infinite-horizon equilibrium problem and is computable.

Except for the monetary shocks, our abstraction is very much a Robinson Crusoe economy. This we consider a virtue, for, other things being equal, we prefer a simple easily understood explanation to a complicated one. For public finance applications, the introduction of a government debt state variable and a market for government bonds is necessary. This extension is conceptually straightforward but within our computability requirement a nontrivial extension. This is the subject of current research, and we are optimistic that the technical problems can be solved.

Some Results

The theory is not complete until the parameters of preferences and technology and the variances of the shocks are specified. One approach would be to estimate the parameters using, say, maximum likelihood techniques. But since this is impractical given current computational methods and existing computers, an alternative approach was adopted. We simply specified what we think are reasonable values for the parameters and then varied some of the parameters to see if the results were sensitive to the specified value.

The parameters of technology, that is the coefficients of the distribution of investment expenditures, are $\phi_0 = \phi_1 = 0.3$ and $\phi_2 = 0.4$. We think the evidence previously cited provided strong prior support for a pattern not too unlike this one, and we do not think results should be very sensitive to the values assumed for the ϕ_i, provided a significant fraction of the expenditures occurred in each of the periods. We did find that momentum was not obtained when investment projects initiated during this period became part of the productive capital stock during the subsequent period. It would have been of some interest to vary these parameters, but, given the sizable cost of each example, resources were best allocated to varying the shock variances, about which our prior knowledge is weak. The parameters of the preference were selected so that stationary values of the variables would be consistent with the data and "long-run" labor supply inelastic. We did some sensitivity analysis with respect to these parameters and found the results varied little.[7]

Our first example assumes no monetary shocks ($\sigma^2_\eta = 0$) and highly persistent real shocks ($\rho = .9999$).

Figure 5.2 shows that the effect of a shock on labor supply and production of durables peaks two periods subsequent to the shock and then approaches a limit with some fluctuation. In the case of employment, the new limit is essentially zero. We have taken after-shock productivity to be one, so that aggregate output and employment are comparable in magnitude. We see that, although purchases of durables represent roughly one-third of total output, their degree of fluctuation is comparable with that of total output. The shape of the curve for employment looks very much like the one derived in figure 5.1 from the estimated relation. In this example we have not assumed any cost of adjustment of changing employment from one period to another, as is emphasized in some of Sargent's work. Such an assumption can easily be incorporated in our framework as well and would have made the curve for employment (and output) even more similar to the estimated one.

This example illustrates the effects of permanent real shocks to the economy without any monetary shocks or imperfect information. The results were not sensitive at all to the choice of parameters of preferences. The most important feature of our model in producing this kind of persistence and momentum is the distributed lag. As we have argued earlier, there is strong a priori information on this lag, and this evidence

7. The values of the parameters can be obtained from the authors. For technical details see Kydland and Prescott 1978*b*.

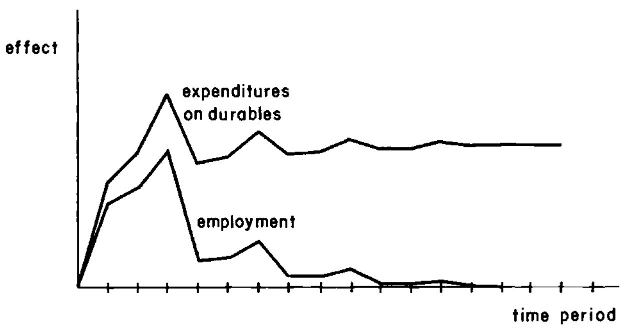

Fig. 5.2 Effect of permanent real shock occurring in period 1

has been incorporated in our model. In conclusion, this example shows substantial persistence and momentum as a result of a permanent innovation to technology.

We next determined the equilibrium process when there were monetary shocks ($\sigma^2_\eta \neq 0$) but no real shocks ($\sigma^2_\xi = 0$). The results obtained correspond to those of Lucas (1975) in his equilibrium model of the business cycle with capital accumulation. There was no momentum, and the effect of the shock was offset in subsequent periods. A similar result was obtained when there were transitory real shocks only ($\sigma^2_\eta = 0$ and $\rho = 0$). The only important difference was that with positive real shocks agents rationally supplied more labor services and accumulated more capital in and for a period subsequent to the period of the shock, whereas with positive monetary shocks agents were tricked into supplying more labor services and initiating more investment projects than were optimal.

When there are simultaneously both transitory real and monetary shocks, however, greater persistence and some momentum result. This point is illustrated in figure 5.3, which depicts the response to an innovation in the productivity process. The effect on employment is larger in the third period than in the first. There is then a negative effect reflecting partly a reduction in purchases of durables (since the steady state has not changed) and partly the increased value of leisure resulting from the increased labor supplied in the previous period. This response is consistent with the argument that monetary shocks can be used to delay a recession but not to avoid it. Offsetting real shocks with monetary shocks results in a more severe recession at a later time.

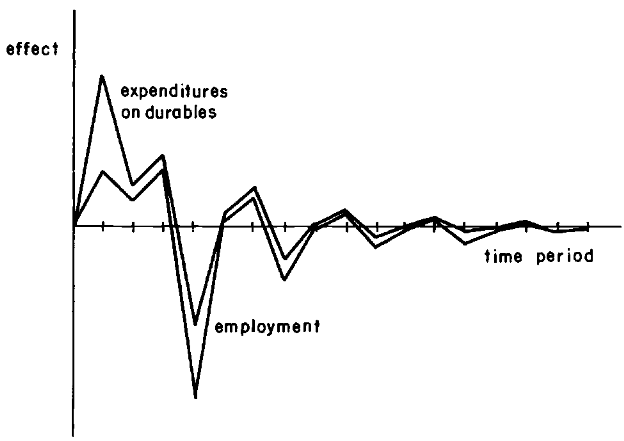

Fig. 5.3 Effect of transitory real shock occurring in period 1

Policy Implications

Most would agree that some fluctuations in output and employment are not a social problem and may even be socially desirable. For example, seasonal fluctuations, which are of the same order of magnitude as postwar business cycle fluctuations, generally are not considered to be a matter of great social concern. Indeed, the most widely reported and watched time series are all seasonally adjusted. Most would also agree that the 6% average difference in seasonally unadjusted output between the fourth and first quarters could be eliminated by providing a modest wage subsidy in the first quarter and wage tax in the fourth to induce an intertemporal substitution of labor supplied, but that this should not be done.

What differentiates fluctuations resulting from seasonal factors from those arising as the result of shocks to the technology of production and exchange? The answer sometimes given is that the seasonal components are predictable, whereas shocks, by definition, are not. The implication of competitive theory under uncertainty, and therefore the implication of our theory, is that this argument is flawed. It is true that with anticipated events adjustment can occur prior as well as subsequent to the event although for a shock there can be no prior adjustment. This does not invalidate the first theorem of welfare economics, that, in the absence of externalities, competitive equilibria, including those of the dynamic stochastic variety, are Pareto optimal.[8] Consequently, in the absence of a public sector, the policy implication of our theory of fluctuations is that the cost of stabilizing the economy exceeds the benefits in the cost-benefit sense advocated by Phelps (1972). It also follows that the monetary authorities should behave as predictably as possible. This would not eliminate monetary shocks but would reduce them and result in the improved performance of the economy.

Once a public sector is introduced into a competitive model, one can no longer rely upon the first theorem of welfare economics to answer the desirability of stabilization policy question. Rather one must apply modern public finance and the theory of efficient taxation.[9] Assuming that sufficiently precise estimates of the parameters are available, our theory predicts that greater stability could be achieved by an appropriate cyclical manipulation of tax rates than if a noncyclical tax rate policy

8. A few other weak conditions are needed for this result. For example, if there is nonsatiation, convex preferences, and the individuals' consumption possibility sets are convex, the result follows (Debreu 1954, theorem 1).

9. We found Sandmo's 1976 survey a good introduction to the optimal taxation literature. Diamond and McFadden 1974, Diamond and Mirrlees 1971, and Harberger 1964 were also useful.

were pursued. To achieve the greater stability, the tax rates must be adjusted in response to shocks so that more labor is supplied in states in which employment would otherwise be below average and less in states in which it would be above. For example, temporary investment tax credits reduce the cost of future consumption in terms of current leisure inducing an increase in current labor supplied. Similarly a temporary wage tax affects the relative costs of current and future leisure resulting in intertemporal substitutions.

The issue then is whether the gains from manipulating tax rates cyclically to achieve greater stability exceed the costs. The answer to this question is no and follows from the well-known principle of public finance (Ramsey 1927), that the loss in consumer surplus per dollar collected from taxing a commodity is greater the more elastic is its demand. Capital goods produced in different periods that are close in time are close substitutes as are both market-produced and non-market-produced goods in adjacent periods. The elasticity of demand for a product with close substitutes is high. Thus varying tax rates over time to induce a particular state-contingent intertemporal reallocation of labor supplied is inconsistent with efficient taxation, at least to a first approximation. Cyclical variations in tax rates add to the burden of financing society's demands for public goods and income redistributions.

Summary

The principle for fiscal policy that emerges from this exercise in neoclassical public finance is that tax rates should not respond, at least not much, to aggregate economic fluctuations. These are just the principles laid down by Friedman (1948) thirty years ago. His conclusions, however, were based in large part upon ignorance of the timing and magnitude of the effects of various policy actions. With our analysis, these conclusions follow even if the structure of the economy is well understood and the consequences of alternative stabilization policy rules are econometrically predictable. We did not determine the rule with the best operating characteristics for a particular estimated structure, as Taylor (1979*a*) did. This was unnecessary because the conclusion follows from well-known principles of modern public finance.

The issue was addressed within a competitive equilibrium framework which requires maximizing behavior and market clearing. Part of the maximizing assumption is the efficient use of information or, equivalently, rational expectations. Equilibrium also requires that the set of markets assumed be sufficiently rich that it is not in the mutual interest of economic agents to organize additional markets. We argued that the persistence of deviations of output from trend can be explained within the equilibrium framework by requiring multiple periods to build new capital goods. Considerable persistence of the effects of monetary, fiscal, and technological shocks and momentum characterize the equilibrium behavior of our models, which incorporate this factor as part of the technology.

The implication of this equilibrium analysis is that the economy, like a single-commodity market, can be stabilized but like the commodity market, the costs of stabilization exceed the benefits. Cyclical variations in tax rates, whether they increase or decrease fluctuations, increase the burden of taxation.

Comment Martin Feldstein

There are many things that I like about the Kydland and Prescott paper, particularly the authors' attempt to link modern public finance analysis with current macroeconomic theory. But I remain unconvinced by their discussion of the equilibrium business cycle and I do not think that they have presented a new case for restricting fluctuations in tax rates for either stabilization or revenue reasons.

Let me begin with the part I like best: the authors' use of a more general description of the role of fiscal effects than is typical in macroeconomic analyses. Instead of limiting their analysis of fiscal policy to variations in lump sum taxes or government spending, Kydland and Prescott recognize the importance of tax rules that change relative prices. In particular, I agree very strongly with their emphasis that the effect of inflation on real depreciation has been one of the most significant fiscal effects on the economy in the 1970s. Larry Summers and I recently estimated that the use of "original cost depreciation" for tax purposes without any adjustment for inflation caused taxable profits of U.S. corporations in 1977 to be overstated by $40 billion or 39% (Feldstein and Summers, 1978*b*). Because of the rise in the inflation rate during the past decade, the effective tax rate on real corporate profits rose from 54% in 1967 to 66% in 1977 despite a series of statutory changes designed to reduce the tax rate. Although I have analyzed some of the long-run implications of the depreciation effect in papers with Summers (Feldstein and Summers 1978*a*) and with Green and Sheshinski (1978), the Kydland and Prescott paper is the first that I know that emphasizes the way in which changes in the rate of inflation can cause cyclical instability.

I have only one small quarrel with their analysis of this issue. There is no doubt that the introduction of the investment tax credit in the 1960s and the effect of inflation on real depreciation in the 1970s would have major effects on the desired capital stock if the relevant discount rate remained unchanged, that is, if these changes in the effective tax rate on capital income were fully shifted. But this *conditional* statement is very different from asserting that these tax changes would actually increase the capital stock. If the supply of private saving is inelastic, the induced increases in the demand for industrial capital can be satisfied only at the expense of residential construction and government demand. The net effect of this substitution on employment is surely not unambiguous.

But this is a question about their analysis and not about the historical facts. Let us accept, as historically accurate, the following sequence of events described by the authors: (1) Accelerated depreciation in the 1960s and then the adverse effects of the original cost depreciation in the inflationary 1970s caused changes in the desired capital stock. (2) These changes in desired capital caused the actual capital stock to adjust with a distributed lag of investment. (3) This pattern of capital stock adjustment caused fluctuations in output and employment.

The key question is: *How should the change in employment be interpreted?* There are three quite different possibilities and each has different implications about the rest of the analysis.

Kydland and Prescott regard any change in employment as an equilibrium intertemporal substitution of leisure in the manner of the original Lucas and Rapping paper. An alternative interpretation is the Friedman-Phelps view, namely, that increases in nominal wages fooled workers into accepting jobs with a lower real wage than they otherwise would have accepted. Finally, there is the traditional Keynesian view that in the early 1960s there was a temporary disequilibrium—that is, short-run involuntary unemployment—and that the increase in aggregate demand permitted the unemployed to find jobs; according to this Keynesian view, the reverse process of creating disequilibrium unemployment occurred in the mid-1970s.

Although Kydland and Prescott present a consistent model interpreting the facts in the first framework, they provide no evidence or logic to make this first interpretation more plausible than either of the other two or than some combination of all three. While I believe in the intertemporal substitution of leisure in some circumstances (e.g., that social security induces earlier retirement and might cause more work during preretirement years), I doubt the relevance of intertemporal substitution to unemployment fluctuations. I certainly do not think it is the sole explanation. I remain to be convinced that there is any persuasive evidence, let alone the "ample evidence" to which Kydland and Prescott refer.

The authors' characterization of unemployment is important in another context. In the paper they raise a general methodological issue by asserting the applicability of public finance efficiency arguments to the analysis of stabilization policy. That position is correct only if all cyclical instability in employment represents *equilibrium* intertemporal substitution of leisure. More generally, if there is a temporary disequilibrium (i.e., short-run involuntary unemployment) or if workers are temporarily "fooled" by changes in nominal magnitudes, the conditions required for the application of traditional welfare analysis are not satisfied. With disequilibrium unemployment, the observed prices are not market-clearing ones and certainly do not measure the marginal evaluations of the private agents. If workers are being "fooled," the observed prices may clear the market, but the workers' actual marginal rates of substitution between goods and leisure equal what they (falsely) believe to be the real wage rates rather than the observed real wage rates.

In practice, the authors do not try to apply the traditional welfare argument to stabilization policy. Instead, they use it to analyze the appropriate mix of fluctuations in debt and in taxes in response to exogenously determined changes in government spending. The use of traditional welfare economics in this context is quite appropriate since unemployment as such is irrelevant. But I find their argument for fluctuations in borrowing rather than in tax rates far from compelling. It rests on the assertion that current labor supply is very sensitive to small differences between the current real wage rate and the future real wage rate. It requires that individuals can distinguish permanent tax rate changes from temporary ones and can adjust their labor supply accordingly. Moreover, the analysis in the paper appears to assume a fixed capital stock so that variation in debt only affects consumptions and not changes in capital or production. Let me emphasize that I do not disagree with the authors' conclusion about the appropriate fluctuations in debt and taxes. But I think a more complete analysis is required to make a convincing case.

Let me return now to the authors' key conclusion that "tax and investment credit rates should not be varied in an effort to stabilize the economy." This conclusion follows directly from their view that all employment fluctuations represent equilibrium intertemporal substitution of leisure. If there are costs of adjustment, asymmetries of information, or other reasons why observed fluctuations in unemployment represent temporary disequilibrium, there is a potential role for good macroeconomic policy. The choice among fiscal and monetary instruments depends on issues of timing and of the mix of demands to be affected. The government's limited ability to forecast the future course of the economy and the effects of different stabilization policies is to me still the main reason for limiting policy activism.

Comment Robert E. Hall

Given its very strong premises, the paper by Kydland and Prescott reaches a sharp conclusion—minimization of the deadweight loss of fiscal programs requires equalization of tax rates over the present and the future. When new information arrives, tax rates should move in tandem. Temporary fiscal moves are never planned, though they may happen unexpectedly. The paper is the application of a very general proposition about optimal planning when the present and future instruments enter the objective function symmetrically. Other applications can be made to consumption, where the rational consumer never plans a temporary adjustment of consumption, and to the dividend policy of the firm.

The provocative issue raised by this paper is the relevance of the general principle—that is, whether it is true that the deadweight loss of present and future fiscal moves are symmetrical on the margin. The case made for the application of the principle in the paper rests on the equilibrium interpretation of aggregate fluctuations—cyclical changes in employment represent movements along an aggregate supply function for labor. The premise of the paper is that the cyclical labor supply schedule reflects the true valuation of workers' time. That valuation is not very sensitive to the amount of work done, on the margin, because peope have valuable alternative activities. A recession is just a spell when the financial reward for work is low and other activities become attractive. This contrasts strikingly with the Keynesian view that there is a strong externality operating in a recession: the marginal value of labor's time drops far below the marginal product of labor, and genuine involuntary unemployment results. Under the Keynesian view, the premise of the paper is quite wrong and something like a temporary investment subsidy to offset a recession makes good economic sense.

In its most carefully stated form, for example, in this paper, the equilibrium theory of business cycles interprets the observed combination of interest rates, current and expected future wages, and level of employment as a point on an intertemporal labor supply function. Employment will be low when the current reward to labor is low relative to its discounted future value. Kydland and Prescott continue the tradition of emphasizing fluctuations of the real wage as the most important ingredient in this calculation, though it has been pointed out by several authors that movements in interest rates could be the principal source of changes in the optimal intertemporal labor supply plan of the worker.

Testing of the equilibrium–labor supply hypothesis has been no better than rudimentary. Its proponents have cited some fragmentary evidence on the intertemporal substitutability of alternative uses of time. Its many critics have generally asserted that the hypothesis is too foolish to be taken seriously (for example, Robert Solow in his paper for this conference) or that it was refuted by simple evidence. It has often been said that the equilibrium theory predicts that quits should rise in a recession, so the theory must be wrong because quits actually fall.

My own view is that the equilibrium theory deserves a serious examination and that it is not self-evident that it is completely wrong or completely right. With respect to the long-standing and basic criticism that the theory makes all cyclical movements in labor supply "voluntary," one of the branches of modern theory of labor contracts suggest a possible answer—under labor contracts, workers cede to employers the right to determine the level of employment subject to prescribed rules about compensation. If the rules respect the value of the worker's time, then it could both be true that employers make unilateral employment decisions and that the observed movements are along the true labor supply function.

This line of argument only weakens one of the elements of the case against the equilibrium theory. The real task of the proponents of the theory is to show that the intertemporal substitutability is high enough to explain observed cycles. The evidence on this point is mixed. What we seem to have learned from the various negative income tax experiments, for example, is fairly weak substitution toward nonwork activities under temporary reductions of wages in the order of 50%. But contract theory may help explain the weakness of that response, since contracts have not been written to take account of the appropriate adjustment of employment in response to an experimental temporary tax. All I can say at this stage is that much more thought and work is needed.

Comment John B. Taylor*

In their paper Kydland and Prescott present a novel technique for answering an old macroeconomic question: Can fiscal policy be used to stabilize the economy? The technique combines "equilibrium business cycle modelling" with modern tools of public finance and contrasts sharply with the conventional techniques—such as econometric model simulation—now commonly used to answer such questions. Although the technique confronts some difficult modelling and computational problems, it offers a promising alternative to the more traditional methods of quantitative policy evaluation.

The first stage of the Kydland-Prescott policy evaluation method is the development of an equilibrium business cycle model which displays the major empirical regularities of macroeconomic fluctuations. For example,

*A grant from the National Science Foundation is gratefully acknowledged.

they model *contemporaneous* correlations between the major aggregates by assuming limited information about aggregate disturbances in local markets. More difficult however, is modelling *serial* correlations which characterize business cycles. Kydland and Prescott summarize these intemporal correlations in terms of an estimated second-order stochastic difference equation in the linearly detrended log of real GNP (y_t):

$$y_t = 1.4y_{t-1} - .5y_{t-2} + \epsilon_t. \qquad (1)$$

This can be written equivalently as a distributed lag in the shock ϵ_t. That is,

$$y_t = \sum_{i=0}^{\infty} \psi_i \epsilon_{t-i} \qquad (2)$$

where $\psi_0 = 1$ and the ψ_i weights first increase before starting to decline toward the neighborhood of zero.[10] The primary explanation given by Kydland and Prescott for this "humped" pattern is the delay between actual expenditures and planned expenditures for many components of GNP. For example, investment expenditures are a distributed lag of investment plans, and empirically this lag is "humped"; hence output should also have a humped lag distribution similar to the observed ψ_i values in equation (2).

Although this type of investment behavior will indeed produce the desired correlation pattern, I feel it has two basic difficulties as a central mechanism for generating output persistence in this model. First, in order for such a mechanism to qualify as an essential propagator of business cycle fluctuations, the impulse variables (in this case investment plans) should be serially uncorrelated. If the impulse variables themselves are serially correlated, then another propagation mechanism is necessary to explain this persistence. In fact, investment plans do appear to be highly correlated serially. For example, capital appropriations and construction permits, which are rough proxies of expenditure plans, have high serial correlation properties. Moreover, this correlation is very similar to that of investment expenditures.[11] Since the expenditure–planning lag hypothesis does not explain these fluctuations, it is insufficient as a mechanism to generate business cycle movements without other sources of persistence.

A second difficulty is related to the "parameter variation" problem emphasized by Robert Lucas. As stated by Kydland and Prescott, avoid-

10. Many such empirical regularities are presented in Hodrick and Prescott 1978, where alternative detrending methods are also examined.

11. Many variables which are representative of expenditure plans, such as permit authorizations, are thought to be leading indicators of actual expenditures. As leading indicators, they tend to have serial correlation properties which are similar to expenditures, but are slightly out of phase.

ing policy-induced shifts in parameters is a major motivation for developing models like the one they propose here as an alternative to conventional econometric models. Yet, the expenditure–planning lag emphasized by Kydland and Prescott is not derived explicitly from a maximizing model and, hence, in principle is subject to such policy-induced shifts. Moreover, one might expect such shifts in the expenditure–planning lag mechanism to be important in practice. For example, construction of previously planned projects might be accelerated in anticipation of higher costs—perhaps induced by a policy change. If the effect of policy on this acceleration is not accounted for, then a wrong—and possibly destabilizing—policy might be used. While all existing econometric models are subject to this same problem, I emphasize it here because one of the main reasons for using these techniques is to avoid such problems.

A number of other explanations of the pattern of serial correlation summarized in (2) have been proposed by business cycle researchers. The flexible accelerator mechanism will generate such correlation for suitable parameter values, and attempts have been made to develop this mechanism in a simple rational expectations model (see Pashigian 1969). Another explanation comes from some of my own research on staggered contracts with rational expectations (see Taylor 1979*a*). Serial persistence patterns similar to (2) may be due to short-lived wage and price rigidities which cause purely random shocks to accumulate for a number of periods before their effect diminishes toward zero. A review of U.S. data suggests that contracts about one year in duration may be sufficient to generate business cycle persistence similar to what has been observed during the postwar period. One advantage of this alternative type of rational expectations model is that it also generates a persistence of inflation. In fact a good argument can be made that the persistence of inflation is at least as big a theoretical challenge to rational expectations theorists as the persistence of output or employment fluctuations: if policymakers form expectations rationally and the world behaves according to the market-clearing rational expectations model described by Kydland and Prescott, then there is no explanation for the inflation-supporting aggregate demand policies which we have observed during much of the postwar period. The inflation-output trade-offs evident in contract models provide at least a partial explanation.

With the exceptions noted above, Kydland and Prescott build their equilibrium business cycle model upon the assumption of utility maximization. That is, they posit a representative household utility function which depends on consumption, leisure, and government expenditures, and they assume that households maximize this utility function subject to budget constraints. An important and welcome feature of their policy analysis is the use of this same utility function to evaluate fiscal stabilization policy. No additional policy criterion function—such as a quadratic loss in output and inflation fluctuations—is needed for the analysis. Since the maximized value of the household utility functions depends on the parameters of government decision rules, the welfare effects of policy can be evaluated directly by examining the improvement or deterioration of individual utilities as policy changes.

In principle, such an approach is preferable to the more standard procedure of postulating a simple aggregate policy criterion which is only indirectly related to individual welfare. But the indirect approach has practical advantages. There are many reasons why macroeconomic policy should aim to reduce the size of output and price fluctuations—simply maintaining a stable and relatively certain environment for private decision making is one reason. Such reasons have not, however, been formally linked to a basic household utility function analysis. Apparently a fairly complex and complete model must be developed to formalize such a link. Until this development, a simple aggregate criterion may serve well as a first approximation.[12]

Using this model and this procedure for evaluating policy, Kydland and Prescott conclude their analysis by examining whether taxes or borrowing should be used to finance temporary government expenditures. They find the model indicates that it is better to finance temporary expenditures (such as wars) by bond finance, leaving more lasting expenditures to tax finance. Intuitively, this result is due to the assumption that labor supply and the demand for durables are very elastic in the short run, but not in the long run. If so, then the Ramsey inverse elasticity rule—lower taxes on high elasticity items—suggests the resulting debt finance mix. It is reassuring that the formal techniques give answers which correspond to this intuitive finding.

This result, which is the main conclusion of the policy analysis, certainly has important implications for fiscal stabilization policy. For example, it gives a rationale for stability of tax rates and hence for including the major tax instruments of fiscal policy in aggregate criterion functions—policy variables are usually included for pure computational reasons and to prevent the embarrassment of instrument instability. It is not clear, however, why this result is particularly relevant to the central question of the paper. An analysis of other fiscal policy issues, such as the usefulness of the automatic stabilizers, might have been more helpful. Nevertheless, developing and applying an equilibrium business cycle model to a central problem of public finance represents an important and unique contribution to the problem of policy evaluation in a rational expectations setting.

12. An example of the potential empirical advantages of such a criterion is given in a rational expectations setting by Taylor (1979).

General Discussion

In response to the comment by Taylor that the lag weights in his equation (2) would themselves change with policy rules, Prescott suggested that the weights were dependent on technology and would thus be policy invariant. He also remarked that procyclical movement of the real wage was needed for persistence effects, even though real wage movements need not be large.

On the persistence issue raised by Taylor, Robert Barro commented that it was difficult to reconcile the behavior of prices with that of real output and unemployment. Disequilibrium or contracting models imply a pattern of price persistence that matches the pattern of output and unemployment persistence.

Edmund Phelps suggested that the terms "equilibrium" and "disequilibrium" were being used in confusing ways. Markets might well clear even with disequilibrium; he defined equilibrium as an evolution of events in which expectations were borne out—and this did not require or imply that demand equaled supply in every market.

Robert Hall preferred a definition of equilibrium as a situation where people think they have no further opportunity to make themselves better off, and where the basic efficiency conditions are met.

Phelps also voiced concern about the time inconsistency of optimal policy. Time inconsistency implies that if generation "zero" conducts policy based on a utilitarian or other social welfare function, then subsequent generations would find it desirable to deviate from the policy that had previously been optimal. He did not see why the use of rules would solve this problem—since the later generations would still be better off if they broke the rules.

Charles Nelson noted that stability required the sum of the coefficients in the Kydland-Prescott autoregressive equation for output to be less than unity. If the stochastic process for output were unstable, parameter estimates might still tend to indicate stationarity even though it did not obtain; he was thus worried about how close the Kydland-Prescott equation was to instability. William Poole did not see any persuasive reason for technological change and relative price shifts to occur over time in such a way that per capita income should return to trend.

Alan Blinder commented on Hall's remarks on testing the degree of intertemporal substitution of leisure that it might be useful to examine the evidence from temporary tax cuts, such as that of 1968. Robert Solow pointed out that the intertemporal substitution of leisure mechanism implied that the demand for leisure complements, such as ski equipment, color TV sets, should be countercyclical. This could easily be tested.

Robert Weintraub picked up on the argument that high real interest rates would induce an increase in the labor supply in the current period and suggested that people should answer unemployment surveys by saying "I'm waiting for real interest rates to rise." He was similarly bemused by the fact that Barro's paper explained the behavior of prices using the nominal interest rate: now he could agree with those who blamed inflation on high interest rates.

Frank Morris commented that the policy prescription of Kydland and Prescott had been followed by Lyndon Johnson, who refused to change tax rates during the Vietnam intervention: it was good to know that policy had then been optimal.

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