Order Number 9304651

Policy and cycles

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City University of New York, 1992

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by

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A dissertation submitted to the Graduate Faculty in Economics in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York

1992

This manuscript has been read and accepted for the Graduate Faculty in Economics in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

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Abstract

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A General Equilibrium model of a simple economy was developed. The model has two decision makers: A representative household and a government. The impact of anticipated exogenously chosen policy variables on the households' choices and resulting prices is computed. The derived dynamic equilibrium for prices and quantities replicates the fundamental facts about the evolution of macroeconomic variables over the business cycle. We also demonstrate that if the governments' demand for goods and labor fluctuates over time; stability of the economy requires the policymaker to impose an exogenously chosen time-sequence of a choice variable or a price upon the household.

Acknowledgements

I wish to thank my parents Govind and Vimal Dashputre. Their support, material and moral, has been invaluable during my graduate education. I cherish their faith in me. I wish to thank my wife Mona Dashputre for the sacrifices she endured while I worked on the dissertation. My deep gratitude goes to Professor Michael Grossman for giving me the opportunity to pursue a graduate education in Economics. Professor Salih Neftci exposed me to the frontiers of research in Macroeconomics. This thesis was motivated by his lectures. I thank him for all that he has taught me.

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Introduction

Macroeconomic theorists have spent the last decade trying to develope a sound methodology to study the evolution of aggragate economic variables. This is a seemingly peculiar excercise, for a subject has been seriously studied at least since time of David Ricardo. Post-depression theory, begining with Keynes, was motivated by the crucial need to understand the impact of government policy on the evolution of the major macroeconomic variables such as consumption, investment, employment, and prices of labor and credit. Typically, real variables were posited to depend on, among other things, the inflation rate, taxes, and the governments' demand for credit, labor, and goods. The structure of the hypothesized relationship was based on econometric studies. Friedman's consumption function (1957) or Jorgensen's investment function (1965) are examples of this approach.

There are two principal objections to this methodology. It posits behavior of private decision-makers which often does not have microfoundations- contradict behavior implied by the constrained optimization problem typically faced by private agents. Secondly, it implies that private agents do not form rational expectations about government policies.

The lack of microfoundations in macroeconomic analysis was demonstrated by Lucas-Rapping (1969). The inconsistency involved the posited labor supply function in growth theory versus short-run employment theory. In growth analysis, the population growth rate is assumed to be exogenous. And labor supply is an inelastic function of the real wage. In Keynsian-type business cycle theories, labor supply was assumed to be infinitely elastic at a rigid money wage. The second objection was based on the application of Muth's (1961) insight of rational expectations to macroeconomics.

The fundamental statement was was made by Lucas (1976)- "... given that the structure of an econometric model consists of optimal decision rules of economic agents, and that optimal decision rules vary systematically with changes in the structure of series relevant to the decision maker, it follows that any change in policy will systematically alter the structure of econometric models."

The decision rules supposed of private choices must be of a reduced form with respect to policy variables.

An early application of the Lucas Econometric Critique was made by Sargent (1969). Sargent illustrated a variety of econometric issues exposed by the critique by applying the pricinciple that private choices will change when agents' constraints change to the problem of investment under uncertainty.

The first explicit macroeconomic model satisfying the Lucas critique and one defining the representative agents problem within the context of constrained otimization was developed by Kydland and Presscott (1982). The representative agent's decision rules were based on the principles of constrained optimization. The agent had access to a production function. He derived utility from consumption and leisure. He faced budget and time-allocation constraints. Contemporaneous with the Kydland-Presscott construct, Long and Plosser (1983) developed a model based on the same methodology.

In the two models, a general equilibrium was computed for the scenario in which the production technology was altered by a autoregressive random process. The models demonstrated that the private agent responds to such shocks by altering his intertemporal plans. This adjustments bring about changes in the agents' consumption, employment, and investment plans which replicate the joint time series behavior of post-war economic data. The framework used by Kydland-Presscott and Long-Plosser is commonly referred to as real business cycle theories. This thesis is motivated by two concerns about real business cycle theories. They generate deviations from the stationary state by exclusively shocking the production possibilities. And they are not designed to explicitly study the impact of policy variables on the choices made by private agents. Thus, while they overcome the Lucas econometric critique; real business cycle models lose the ability to explain the impact of government policy on the economy. The inability to explicitly examine the impact of policy on aggragate variables is a major drawback, as perhaphs the most important function of Macroeconomics is to understand the explicit connection between such things as money supply, deficits, tax rates and variables like consumption, investment, employment, and relative prices.

A general equilibrium model capable of serving this pricincipal function of macroeconomic analysis must be capable of incorporating the impact of policy variables on the constraints and production possibilities confronted by private agents. It must also be equipped to study the impact of fluctuations in policies on private choices. Designing and simulating such a model under alternative government policies is the motivation of this thesis.

A model with government demand

The economy has two decision-makers: The government and the representative household. Let the subscript t index time. The government purchases labor (L_{gt}) and units of the single good produced in the economy (G_t) from the household. It funds these purchases by imposing a nominal lump-sum tax (T_t) on the household. I am not interested in studying the impact of expectational errors on private choices. Therefore I assume that policy variables $\{L_{gt}, G_t, T_t\}_{t=0}^{\infty}$ are announced at t=0 and faithfully executed.

$$P_t G_t + W_t L_{gt} = T_t, \qquad (1.0)$$

where (P_t) and (W_t) are, respectively, the prices of the good and labor.

The household seeks to maximize a time separable, constant returns to scale utility function in leisure (Z_t) and consumption (C_t) represented by

$$U = \sum_{t=0}^{T} \rho^t [\alpha \ln Z_t + (1-\alpha) \ln C_t]. \qquad (1.1)$$

ρ is the rate of time preference. The household has access to a single constant returns to scale production function of the form

$$Y_t = L_{t-1}^{\phi} I_{t-1}^{1-\phi}, \qquad (1.2)$$

where (Y_t) is the output of the good in period t, (L_{t-1}) and (I_{t-1}) are, respectively, the amount of labor and investment employed in production in period t-1. Each periods output has to be allocated across consumption, investment, and sales to the government:

$$Y_t = C_t + I_t + G_t. \qquad (1.3)$$

The fixed amount time available each period is allocated across leisure, and work in production and for the government:

$$H = Z_t + L_t + L_{gt}. \qquad (1.4)$$

The assumed value of H is 2,190- equal to the number of hours in 3 months. Thus this can be thought of as a quarterly model.

The solution

Equations (1.0)-(1.4) yields the Lagrangian:

$$\begin{aligned} \text{Max } L = \sum_{t=0}^{T} \rho^t \{&\alpha \ln Z_t + (1-\alpha)\ln C_t \\ &+ \lambda_t [P_t (L_{t-1}^{\phi} I_{t-1}^{1-\phi} - C_t - I_t) + \\ &\quad W_t (H - Z_t - L_t) - T_t]\}. \end{aligned} \qquad (2.0)$$

The efficiency conditions are:

$$\frac{\delta L}{\delta Z_t} : \frac{\alpha}{Z_t} = \lambda_t W_t, \qquad (2.1)$$

$$\frac{\delta L}{\delta C_t} : \frac{1-\alpha}{C_t} = \lambda_t P_t, \tag{2.2}$$

$$\frac{\delta L}{\delta L_t} : \rho \lambda_{t+1} P_{t+1} \phi L_t^{\phi-1} I_t^{1-\phi} = \lambda_t W_t, \tag{2.3}$$

$$\frac{\delta L}{\delta I_t} : \rho \lambda_{t+1} P_{t+1} (1-\phi) L_t^{\phi} I_t^{-\phi} = \lambda_t P_t. \tag{2.4}$$

The equilibrium values of endogenous variables and prices will be computed using the efficiency conditions, the budget constraint (1.3), the time constraint (1.4), and the money constraint (1.0). Imagine that for $t = T,\ldots,\infty$ the economy remains at the stationary state. The stationary values of the policy variables- $\{T_t, G_t, L_{gt}\}$ - are respectively assumed to be 100, 50, 50. We want to study the impact on choice variables and prices of changes in the policy variables. Policy variables will thus be chosen in deviation from their stationary values for t = 1, ..., T-1. Given this scenario, the economy permanently (from $t = T,\ldots,\infty$) reverts to the stationary state. Once the stationary state is computed, it becomes the terminal condition for the problem from t = 0,..., T-1.

The stationary-state

Equation 2.4 yields

$$W = \left[\frac{1}{\rho\phi^{\phi}(1-\phi)^{(1-\phi)}} \right]^{\frac{1}{1-\phi}} P,$$

$$\equiv \Delta_0 P. \tag{3.0}$$

Equations 1.0 and 3.0 yield

$$P = \frac{T}{\Delta_0 L_g + G}. \tag{3.1}$$

Equations 3.0 and 3.1 yield

$$W = \frac{\Delta_{0t} T}{\Delta_{0t} L_g + G}. \tag{3.2}$$

Equation 1.2 yields

$$L = \left(\frac{1-\phi}{\phi} \frac{W}{P} \right)^{\phi} L + \frac{1-\alpha}{\alpha} \frac{\left(\frac{W}{P} \right)^{\phi}}{\left(\frac{1-\phi}{\phi} \right)^{1-\phi}} + \frac{G}{\left(\frac{(1-\phi)W}{\phi P} \right)^{1-\phi}} \tag{3.3}$$

$$\equiv \Delta_1 L + \Delta_2 Z + \Delta_3 G, \tag{3.3}$$

or

$$L = \frac{\Delta_2}{1-\Delta_1} Z + \frac{\Delta_3}{1-\Delta_1} G. \tag{3.4}$$

Equations 1.4 and 3.4 yield

$$Z = \frac{H - L_g - \frac{\Delta_3}{1-\Delta_1} G}{1 + \frac{\Delta_2}{1-\Delta_1}}. \tag{3.5}$$

Equations 2.3 and 2.4 yield

$$I = \frac{(1-\phi)WL}{\phi P}. \tag{3.6}$$

Equations 2.1 and 2.5 yield

$$C = \frac{(1-\alpha)WZ}{\alpha P}. \tag{3.7}$$

Stationary state results

The computed stationary state yields the terminal conditions for the problem from t = 0, ..., T-1. By assumption $\rho = .99$. Since leisure typically consumes two-thirds of the time, α is assumed to equal .666. Since about three-fourths of the GNP is wages, ϕ is assumed to equal .75. The computed values of the choice variables are- Z = 1362.15, C = 317.5, L = 777.85, and I = 120.87.

Solution for t = 0, ..., T-1

Equations from 2.1 and 2.3 yield

$$Z_t = \frac{\alpha C_{t+1} L_t}{\rho\phi(1-\alpha)(C_{t+1} + I_{t+1} + G_{t+1})}. \tag{4.1}$$

Equations 1.4 and 4.1 yield

$$L_t = \frac{H - L_{gt}}{1 + \frac{\alpha}{\rho\phi(1-\alpha)} \frac{C_{t+1}}{C_{t+1} + I_{t+1} + G_{t+1}}}. \tag{4.2}$$

Equation 1.0 yields

$$P_t = \frac{T_t - W_t L_{gt}}{G_t}. \tag{4.3}$$

Dividing equation 2.3 by equation 2.4 yields

$$I_t = \frac{(1-\phi) W_t L_t}{\phi P_t}. \tag{4.4}$$

Equations 2.2, 2.4, and 4.4 yield

$$C_t = \frac{C_{t+1} W_t L_t}{\rho\phi(C_{t+1} + I_{t+1} + G_{t+1}) P_t}. \tag{4.5}$$

Finally, equations 1.2, 1.3, and 4.4 yield

$$W_t = \left(\frac{\phi}{1-\phi}\right)(C_{t+1} + I_{t+1} + G_{t+1})^{\frac{1}{1-\phi}} L_t^{\frac{1}{\phi-1}} P_t. \tag{4.6}$$

Simulation Results

The model was simulated for 50 periods, i.e.- T-1 = 50. The first experiment was to compute the behavior of choice variables $\{Z_t, C_t, L_t, I_t\}$ and prices given a constant inflation rate of 1% per period. The inflation rate was generated by increasing the nominal tax by 1% per period. Predictably, output prices and wages increased by 1% per period. Values of choice variables did not change. The next experiment was to compute the behavior of choices and prices given a constant inflation rate of -1%. Output prices and wages declined at 1% per period. Values of choice variables did not change. This is surprising. During deflations (depressions) units of consumption and production inputs decline substantially. A crucial reason for this is that the nominal return on credit nears zero, while the marginal product of capital increases. Moreover, intertemporal efficiencies are distorted during periods of decline in the price level. I speculate that the model displays stability during a simulated deflation because there does not exist a credit market. Thus the normal relationship between the nominal return on credit and the marginal product of capital is not captured. All choices strictly depend on relative prices. The model sustains the proposition of the neutrality of money. Namely, anticipated changes in money supply leave the values of real variables unaltered; and consequently relative prices remain constant.

The model was then simulated to study the impact of changes in real government demand- $\{L_{gt}, G_t\}_{t=1}^{T-1}$. Any tested deviation in $\{L_{gt}, G_t\}_{t=1}^{T-1}$ from their stationary values induces the model to degenerate into insolubility. See charts for the results of a simulation in which the only induced change was for the government to increase its demand for labor $\{L_{gt}\}$ by .1 units per period for t = 26, ..., 50. The minor change in the government's demand for labor induces a large increase in the relative price of labor. Since the nominal price level $\{T_t\}_{t=0}^{T-1}$ is fixed, the nominal (and relative) price of output falls. This simultaneously induces large increses in desired consumption and investment. We tried to find a feasible level of Taxes to support the increase in the government's demand for level. However the needed increase reached completely implausible levels.

I think the failure of the model to study the impact of changes in real government demands is quite instructive. I claim that if real policy variables $\{L_{gt}, G_t\}$ deviate from their stationary values, or more generally fluctuate, then the stability of the economy requires the government to impose upon the representative household the time-value of a choice variable, output price, or wage.

This is indeed done in practice. Conventionally, the monetary authority targets the nominal interest rate. The inflation rate is determined in equilibrium.

Therefore, the real interest rate is imposed upon private agents. I will impose a time-sequence of outputs upon the representative agent. The economic policy which accomplishes this is a marginal tax rate of 100% on output exceeding the targeted output.

A model with exogenously chosen output

Since the government is going to impose a time-sequence of outputs on the representative agent; solutions for the choice variables and prices are recast. The Solutions will be derived using the original efficiency conditions and constraints.

Equations 2.3 and 2.4 yield

$$I_t = \frac{(1-\phi)W_t L_t}{\phi P_t}. \tag{5.1}$$

Equations 2.2, 2.4, and 5.1 yield

$$C_t = \frac{C_{t+1} W_t L_t}{\rho\phi(1-\phi)Y_{t+1} P_t}. \tag{5.2}$$

Equations 2.1 and 2.3 yield

$$Z_t = \frac{\alpha C_{t+1} L_t}{\rho\phi(1-\alpha)Y_{t+1}}. \tag{5.3}$$

Equations 5.3 and 1.4 yield

$$L_t = \frac{H - L_{gt}}{1 + \dfrac{\alpha C_{t+1}}{\rho\phi(1-\alpha)Y_{t+1}}}. \tag{5.4}$$

Equations 1.3, 5.1, and 5.2 yield

$$W_t = P_t \frac{Y_t - G_t}{L_t \left\{ \dfrac{1-\phi}{\phi} + \dfrac{1}{\rho\phi(1-\phi)} + \dfrac{C_{t+1}}{Y_{t+1}} \right\}},$$

$$\equiv P_t \Omega_t. \tag{5.5}$$

Finally, equations 1.0 and 5.5 yield

$$P_t = \frac{T_t}{G_t + \Omega_t L_{gt}}. \tag{5.6}$$

Simulations

A host of simulations were done on this model. We studied the impact of a constant 1% per period inflation on endogenous variables and prices. Values of the choice variables were invariant to the inflation rate. Nominal prices grew at 1% per quarter. The impact of a constant 1% deflation was to leave real variables unchanged, while deflating prices at the rate of 1% per period. The second class of simulations involved alternatively varying the governments demand for $\{L_{gt}, G_t\}$ while leaving the exogenously chosen level of output constant. We also experimented with shifting output from labor demand to good demand.

For example, in a simulation the government's demand for the consumption good was increased above the stationary level and then decresed. Contemporaneous with it, consumption and leisure declined. While investment remained virtually unchanged, workhours increased considerably.

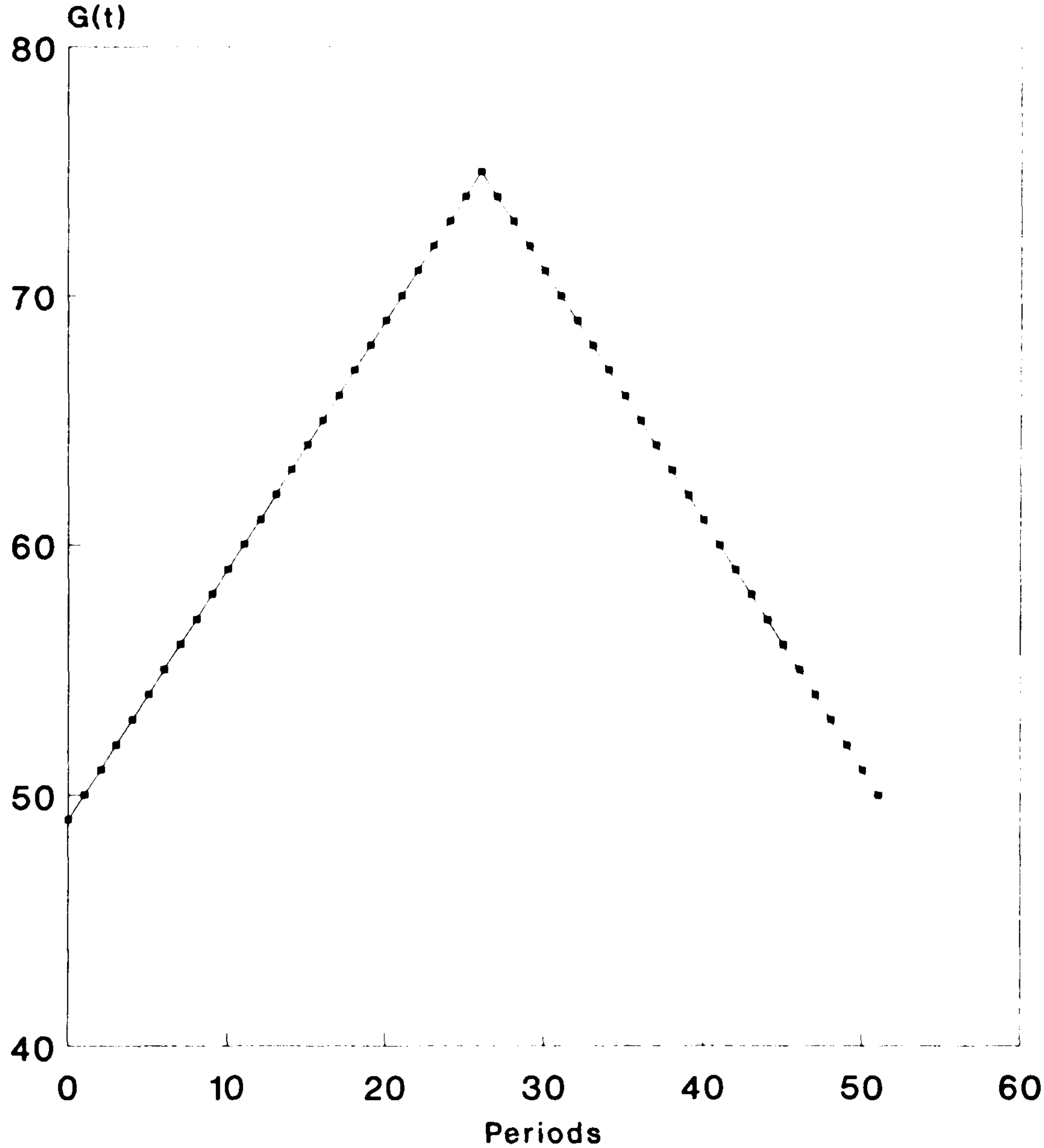
The most interesting simulation involved varying government demand for goods and contemoraneously changing output level by an amount arbitrarily greater than the change in government demand. Consumption, investment, and work hours were procyclical- positively correlated with shifts in output. Leisure was countercyclical. The relative price of the consumption good was positively correlated with government demand. These charactersitics resemble the pricincipal stylized facts about macroeconomic variables. Detailed results of these simulations are at the end of this section.

Summary

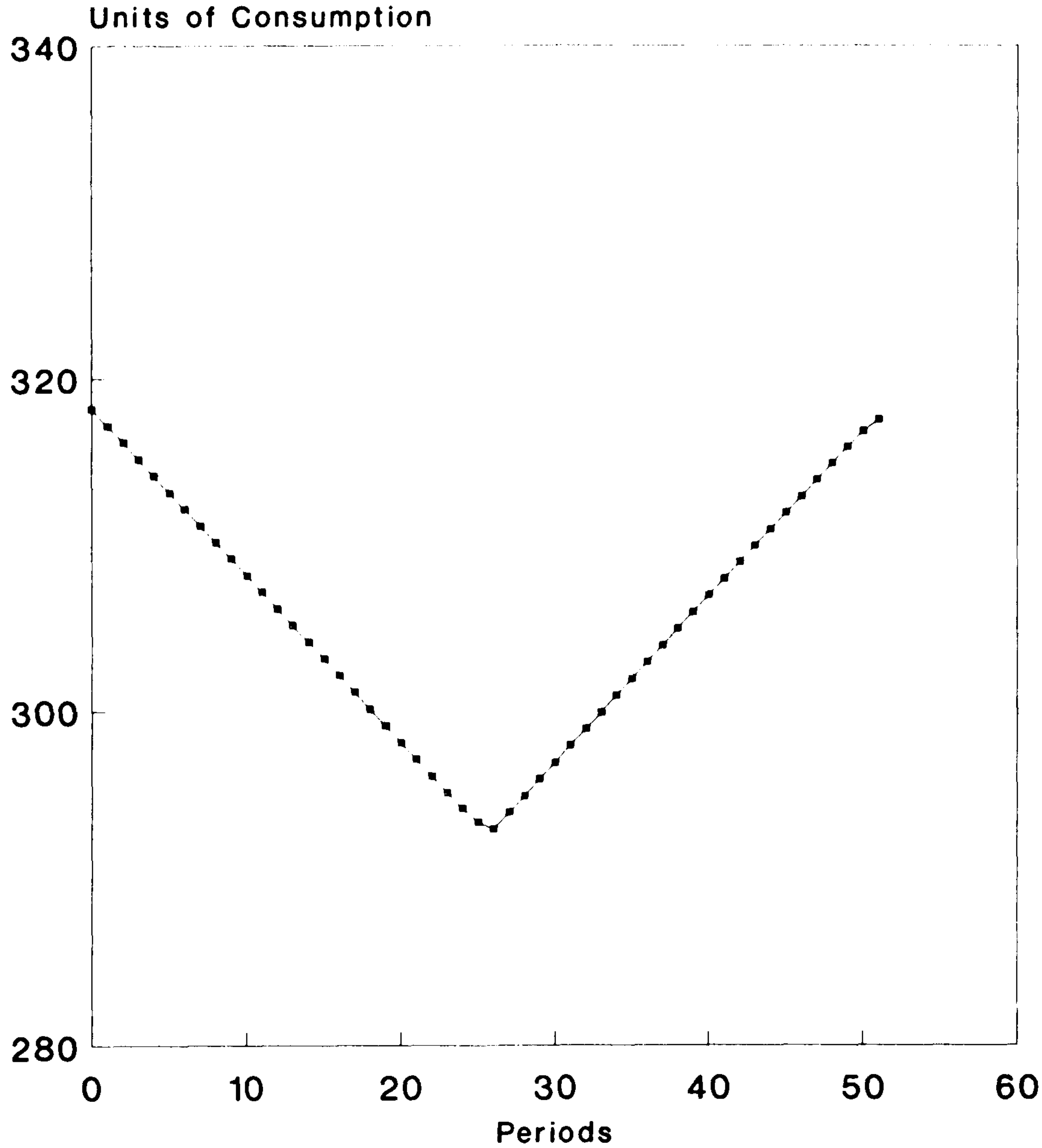
This thesis makes three contributions. It developed a general equilibrium framework for explicitly studying the consequences of government policy on the evolution of macroeconomic variables. It demonstrated that that evolution is affected by anticipated changes in policies. Most surprising of all, it illustrated that if the government's demand for real variables fluctuates, it must impose upon the representative household the time-sequence of a choice variable or a price.

Since a targeted nominal interest rate is the most frequent chosen policy, the model should be extended to include a credit market. This requires having three decision agents: The household, a representative firm, and the government. The household derives utility from leisure and consumption. It sells labor to the firm and to the government. And it lends to the firm and the government as a means of deferring consumption. The firm seeks to maximize the present discounted value of future profits. It has access to a production technology- the output from which it sells to the household, the government, and reinvests in future production. In this model the government will have one of two variables it can manipulate: The output level of the consumption good or, having access to credit, the nominal interest rate.

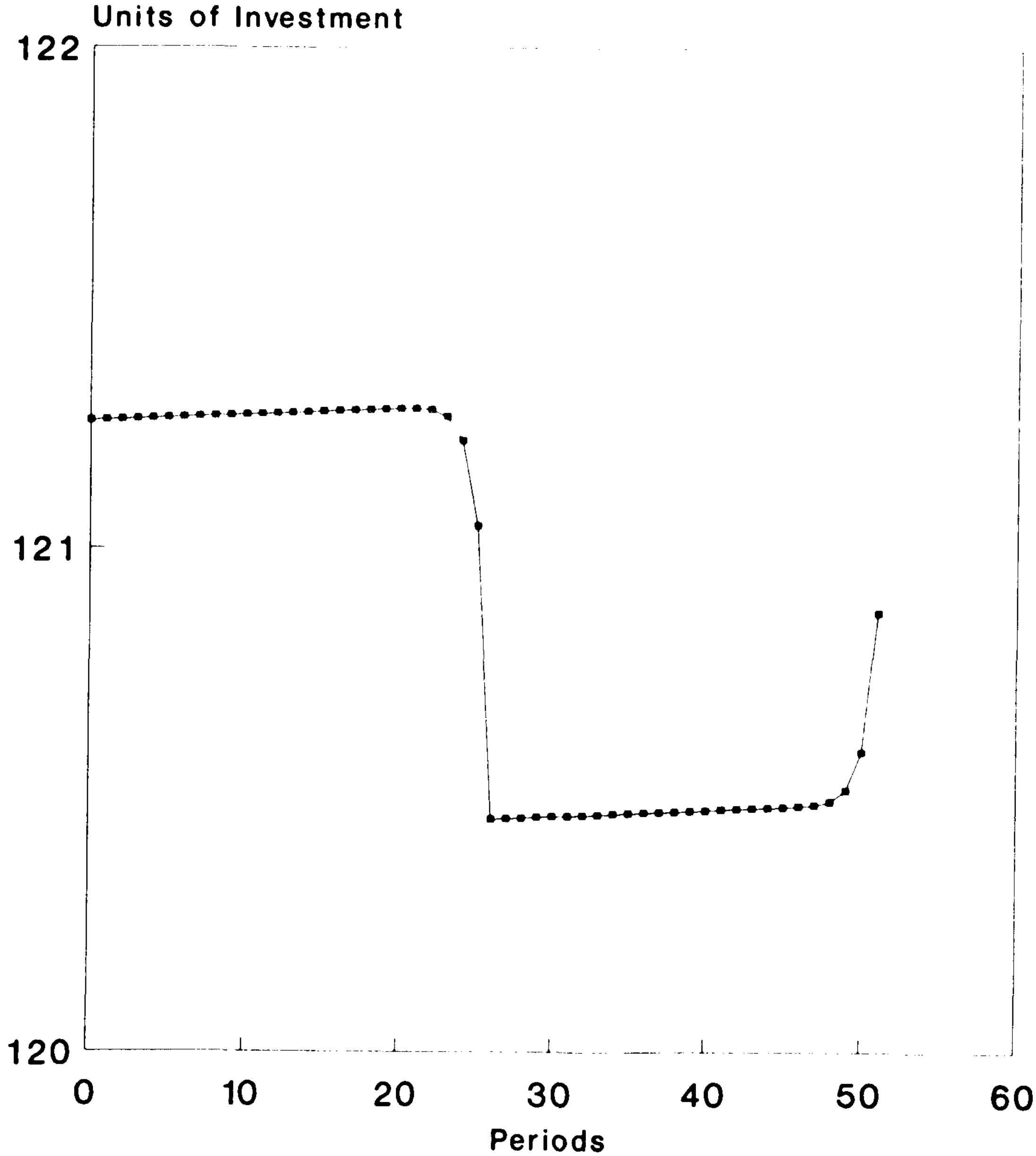
G(t) Conditional on Exogenously Chosen Output
Chart 1



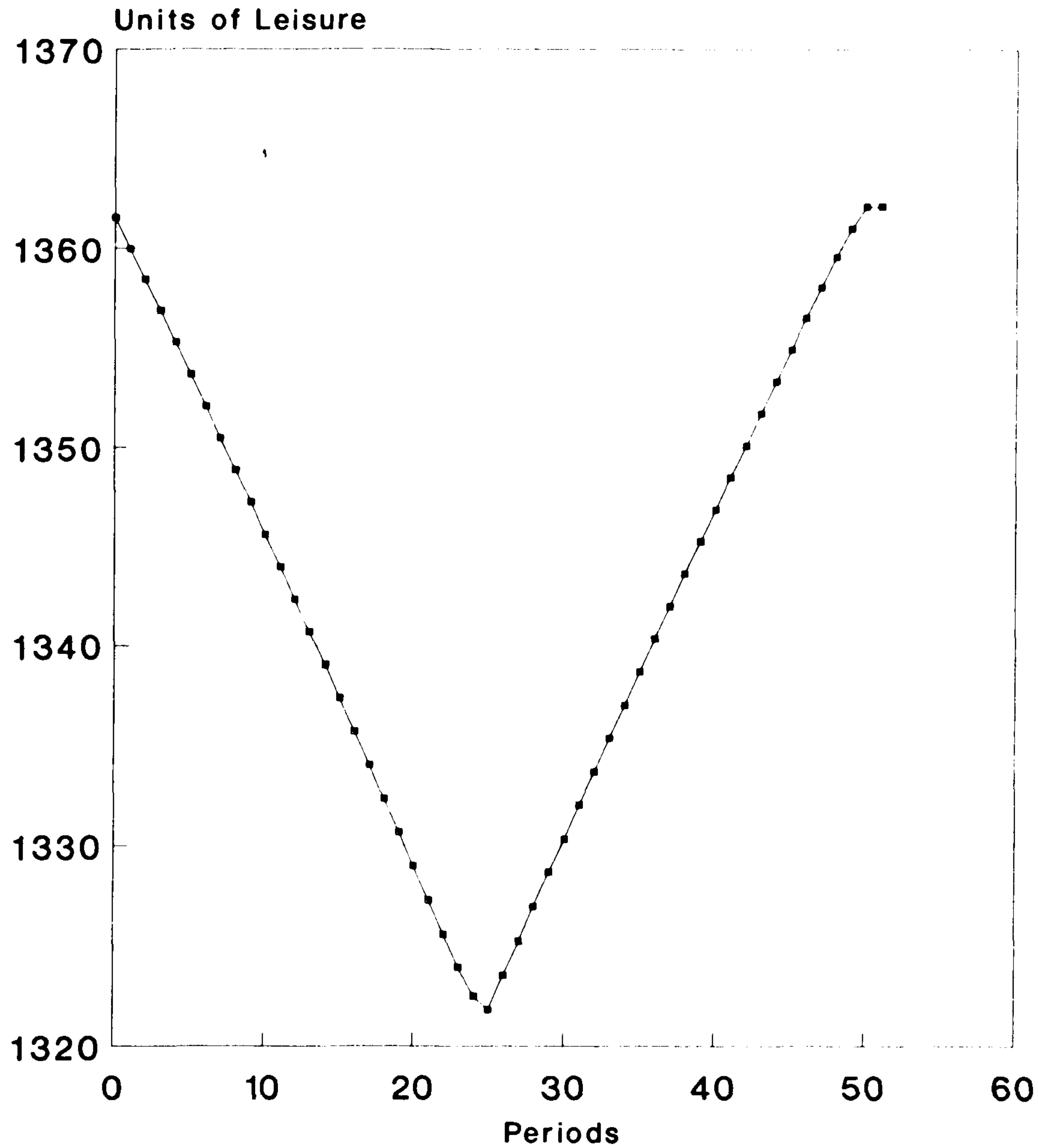
Consumption Conditional on
Exogenously Chosen Output
Chart 2



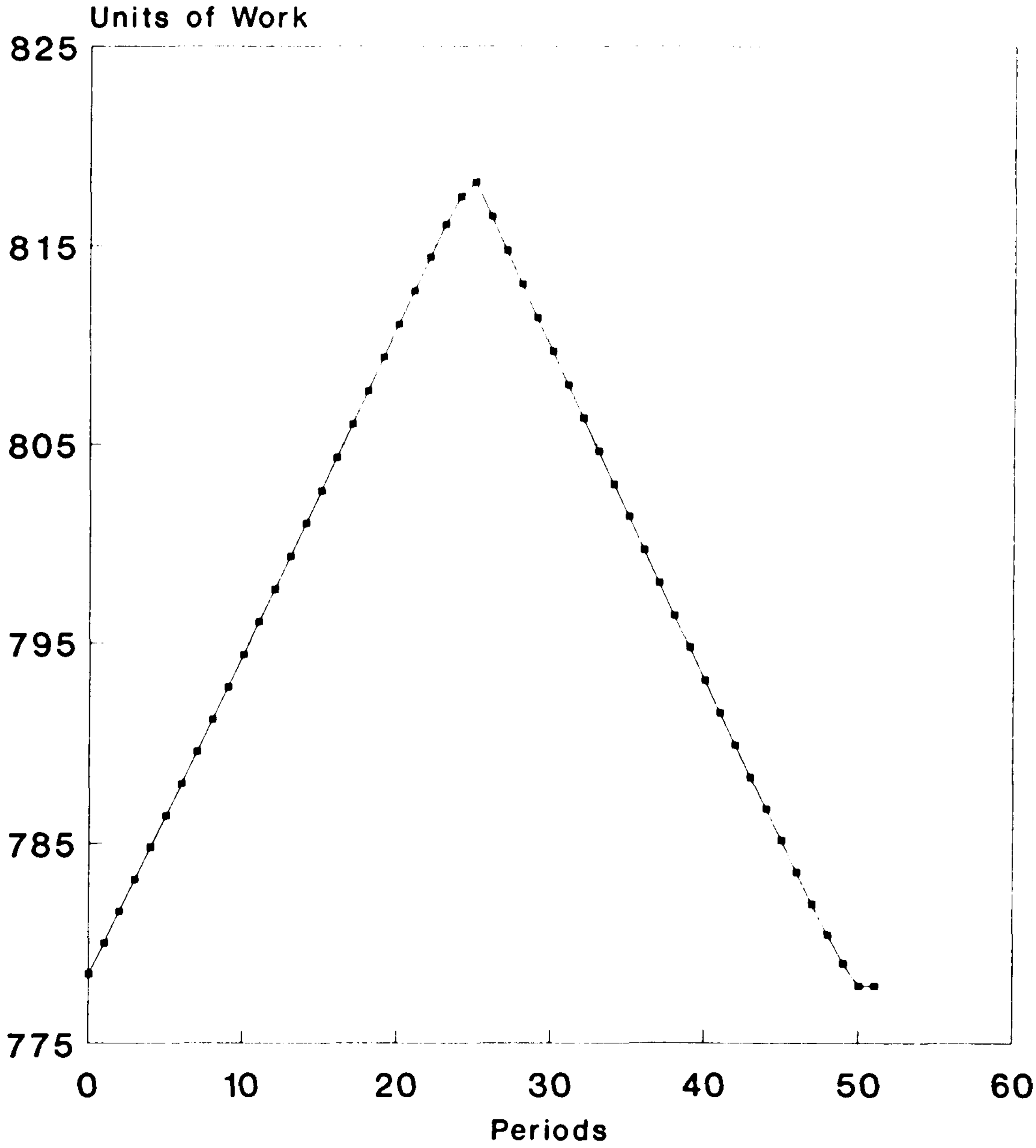
Investment Conditional on Exogenously Chosen Output
Chart 3



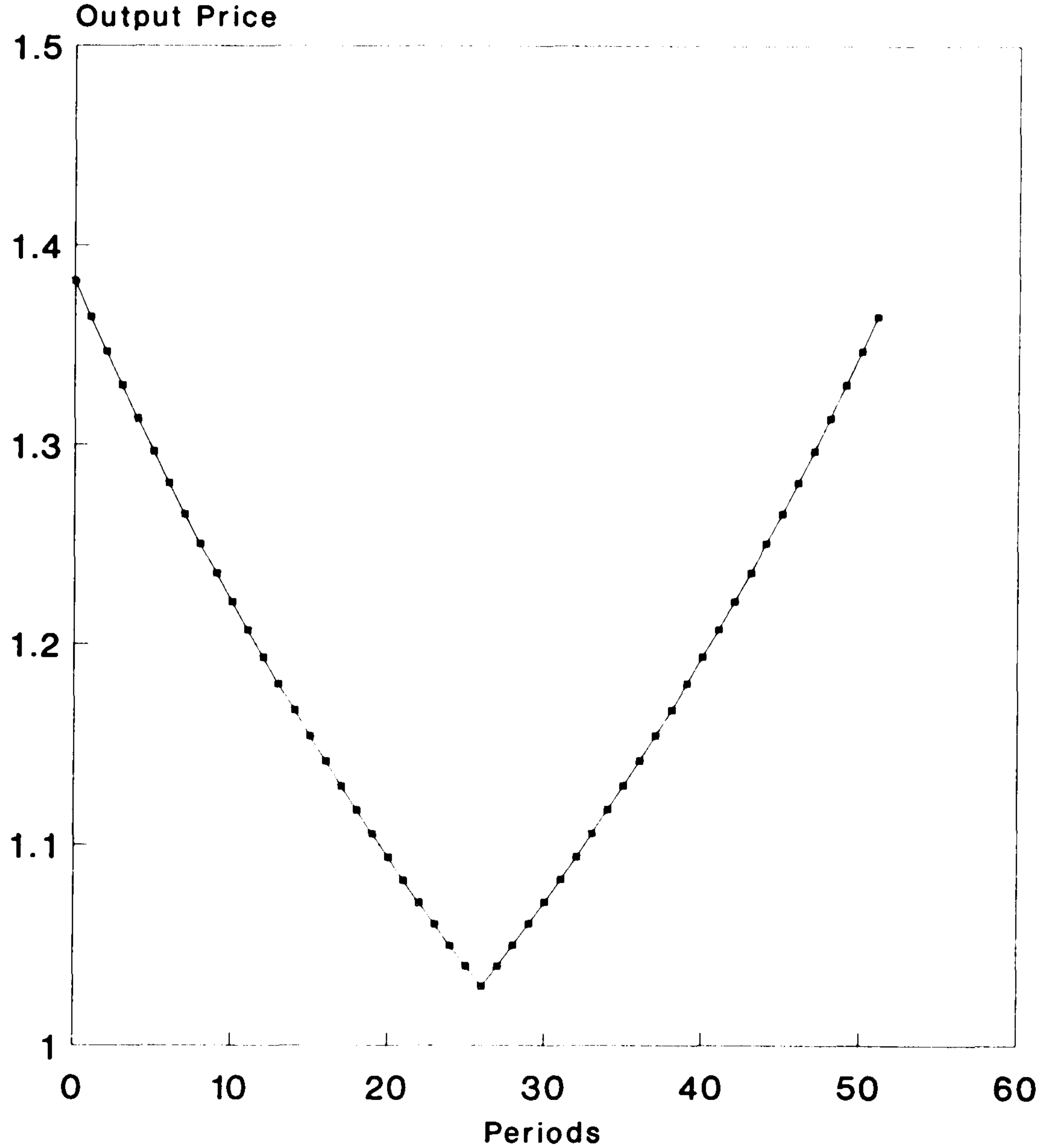
Leisure Conditional on Exogenously Chosen Output
Chart 4



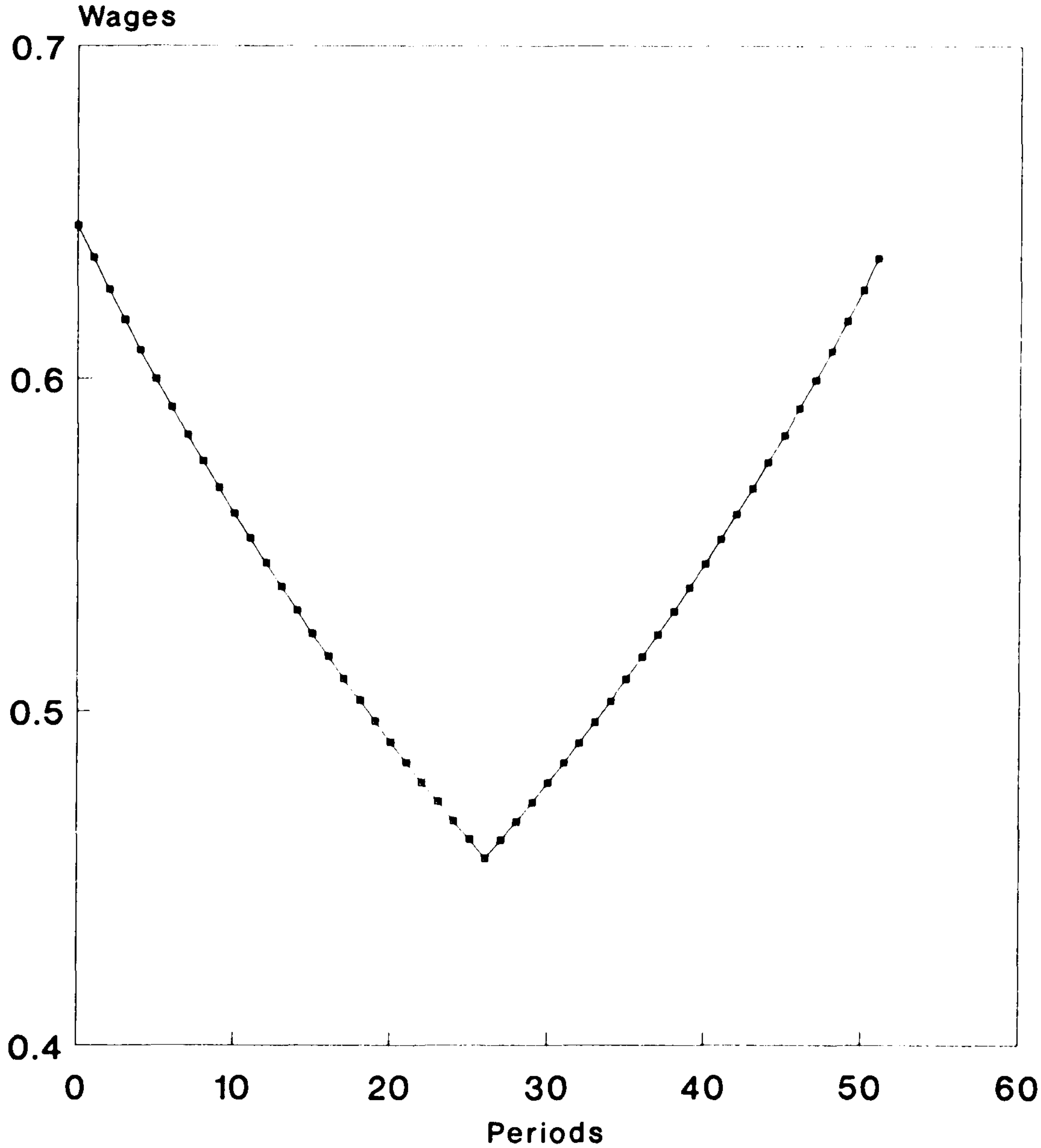
Work Hours Conditional on Exogenously Chosen Output
Chart 5



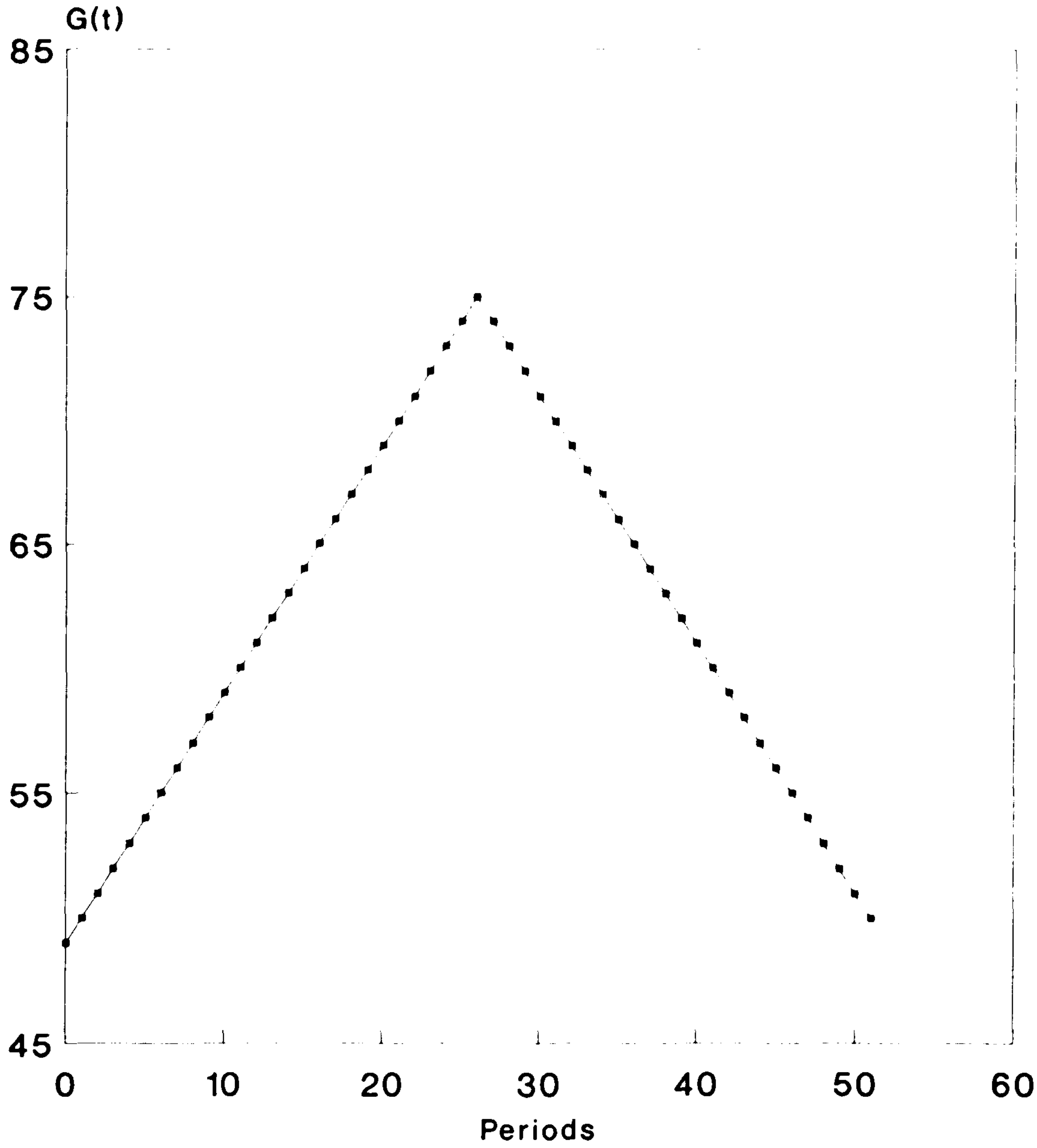
Output Price Conditional on
Exogenously Chosen Output
Chart 6



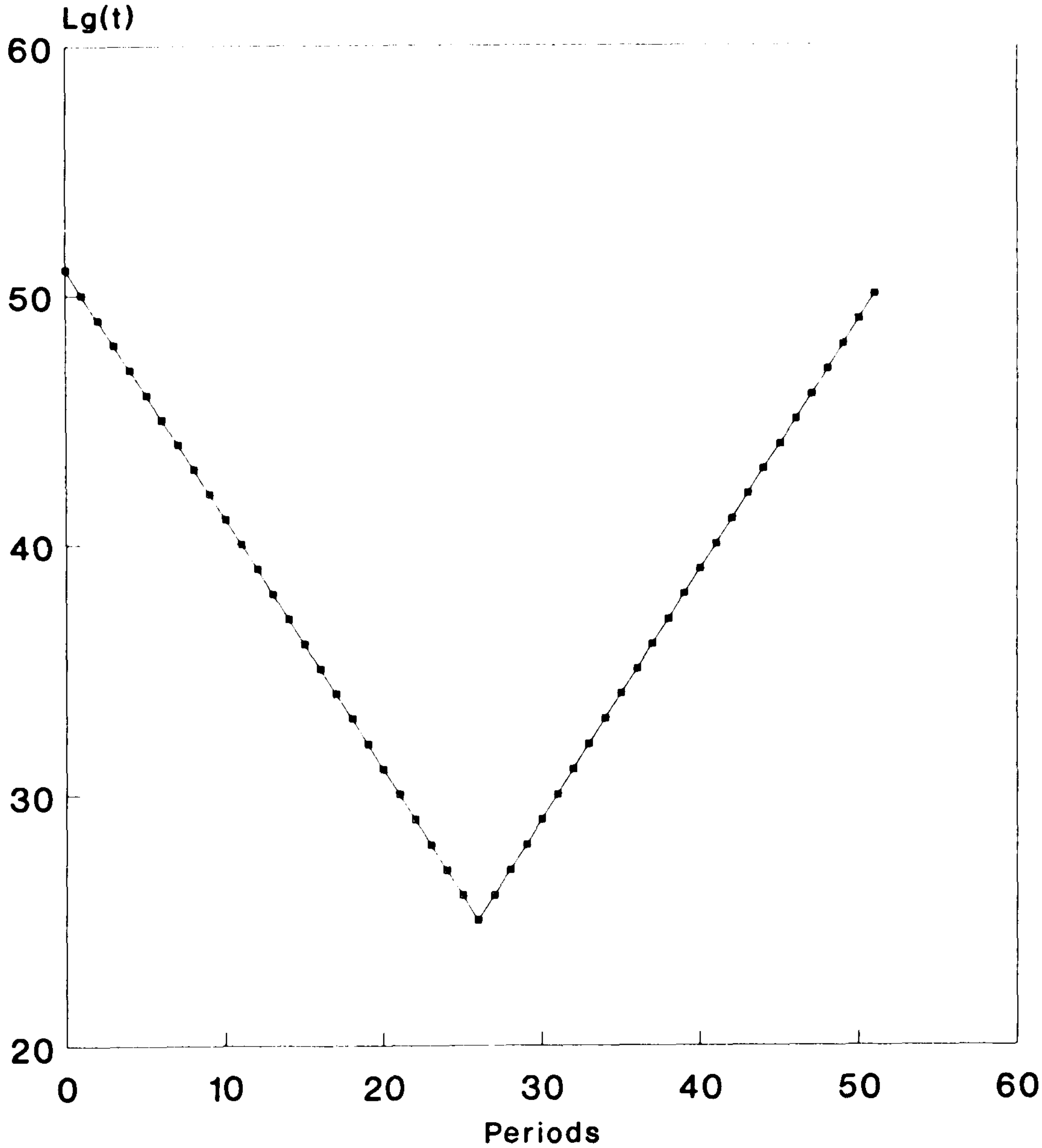
Wages Conditional on Exogenously Chosen Output
Chart 7



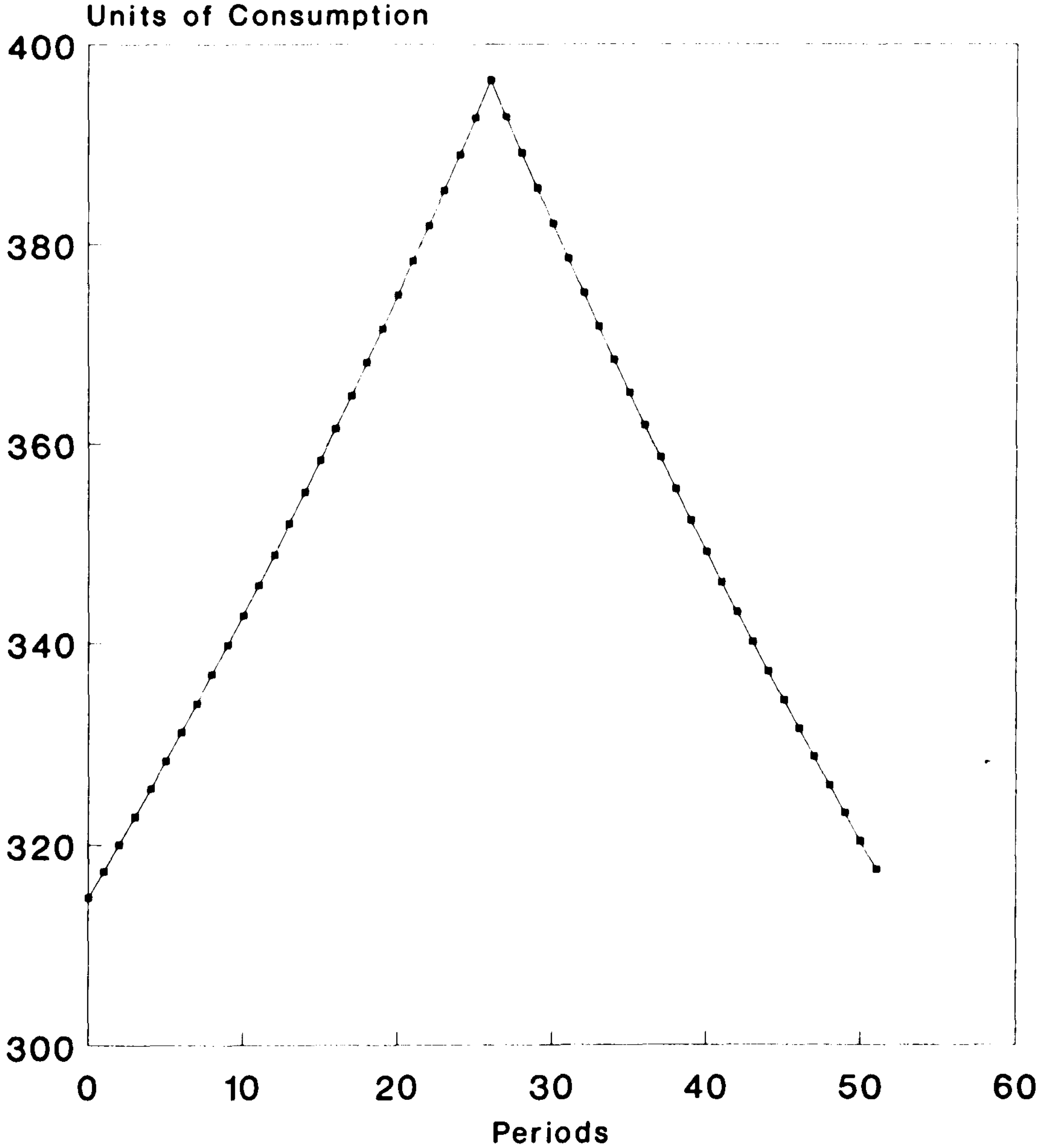
G(t) Conditional on
Exogenously Variable Output
Chart 8



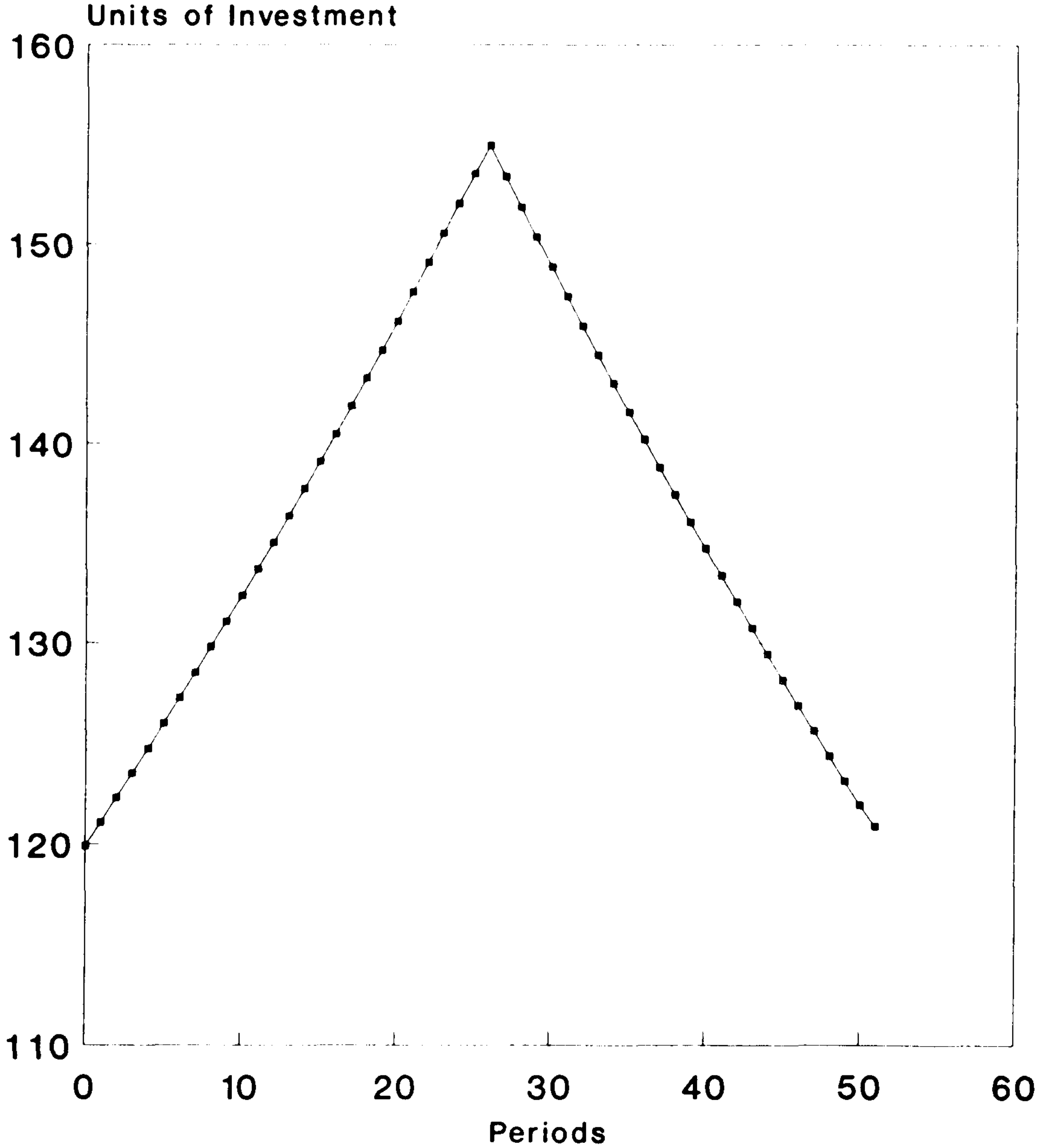
Lg(t) Conditional on
Exogenously Variable Output
Chart 9



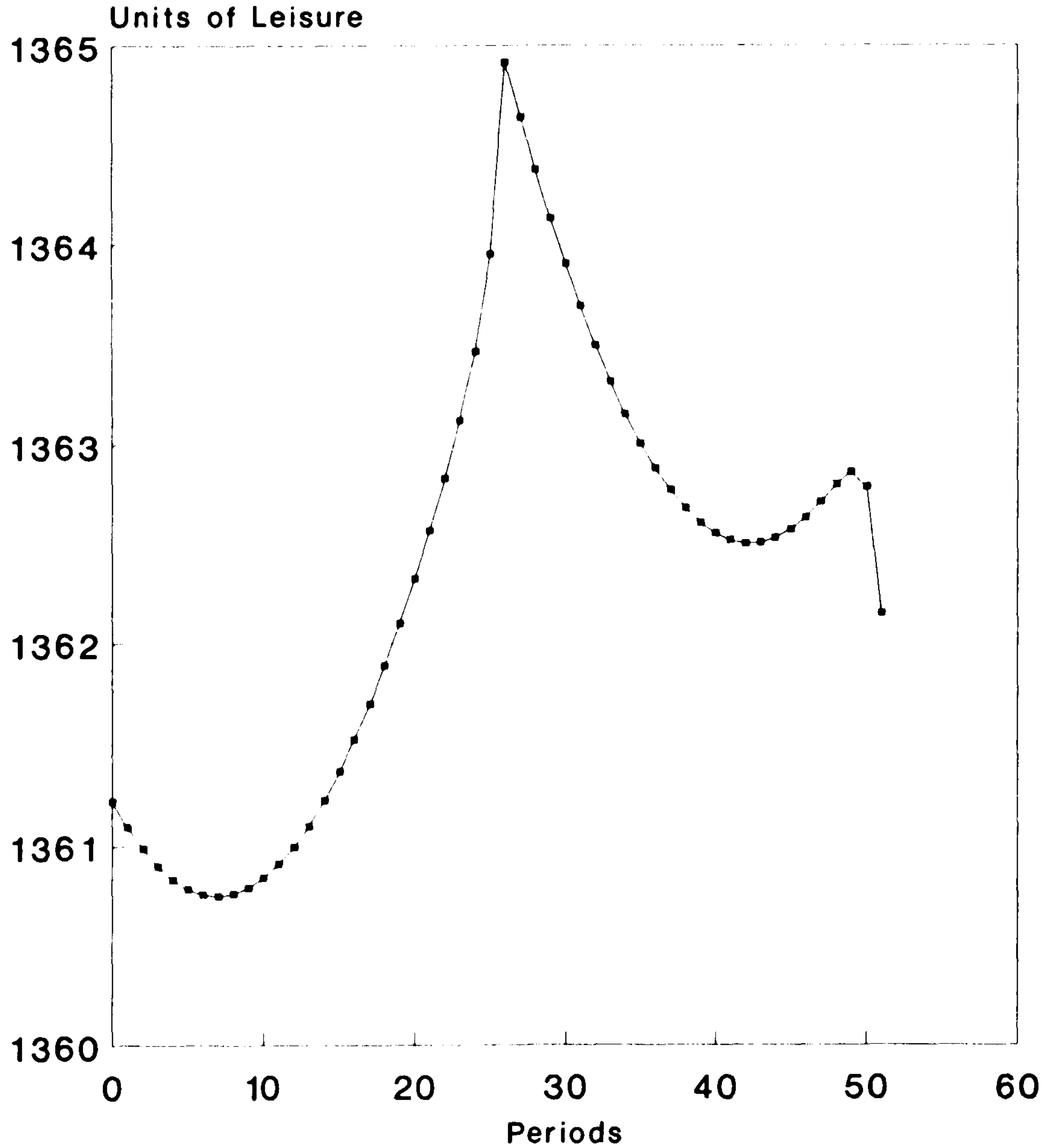
Consumption Conditional on
Exogenously Variable Output
Chart 10



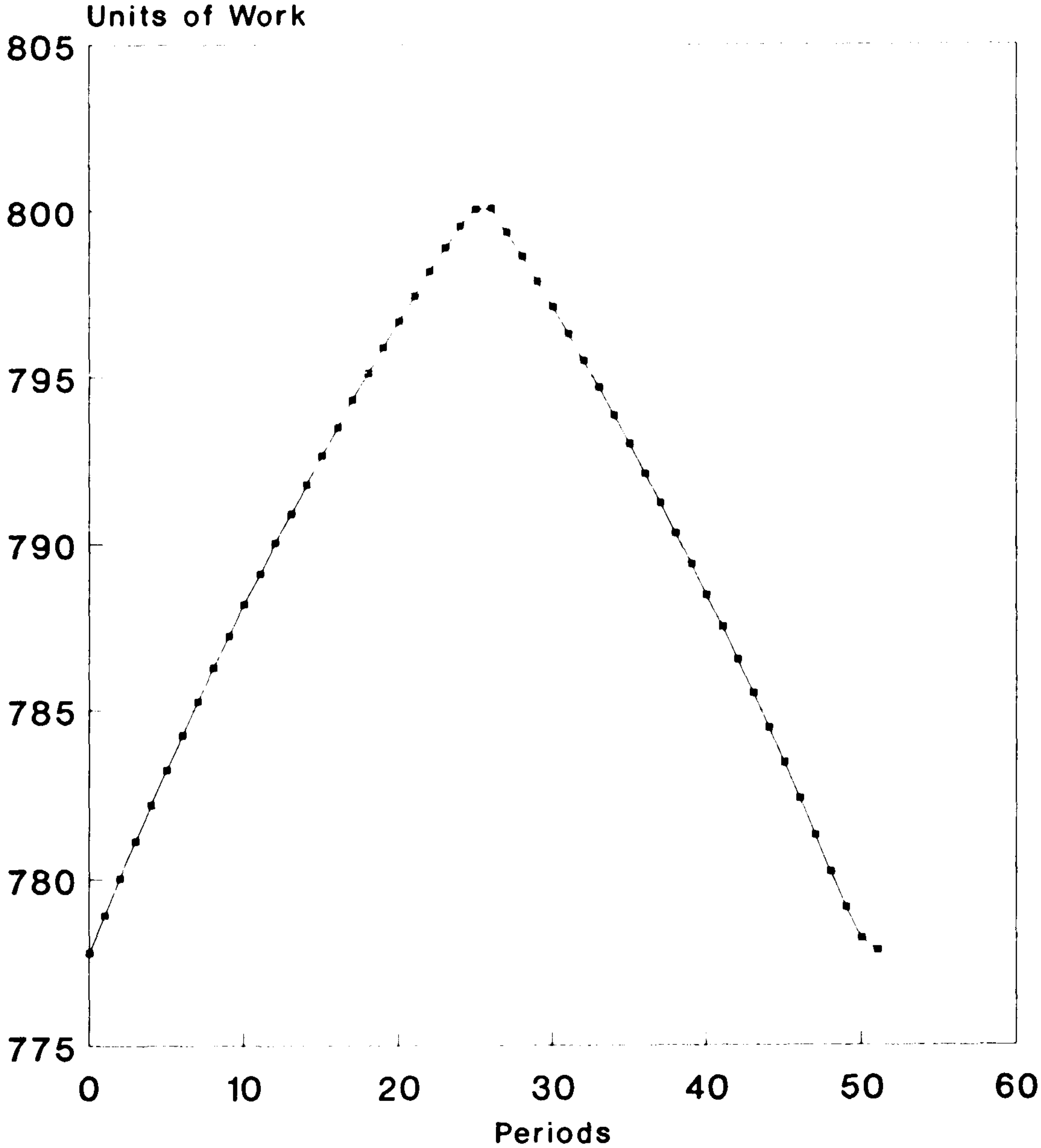
Investment Conditional on Exogenously Variable Output
Chart 11



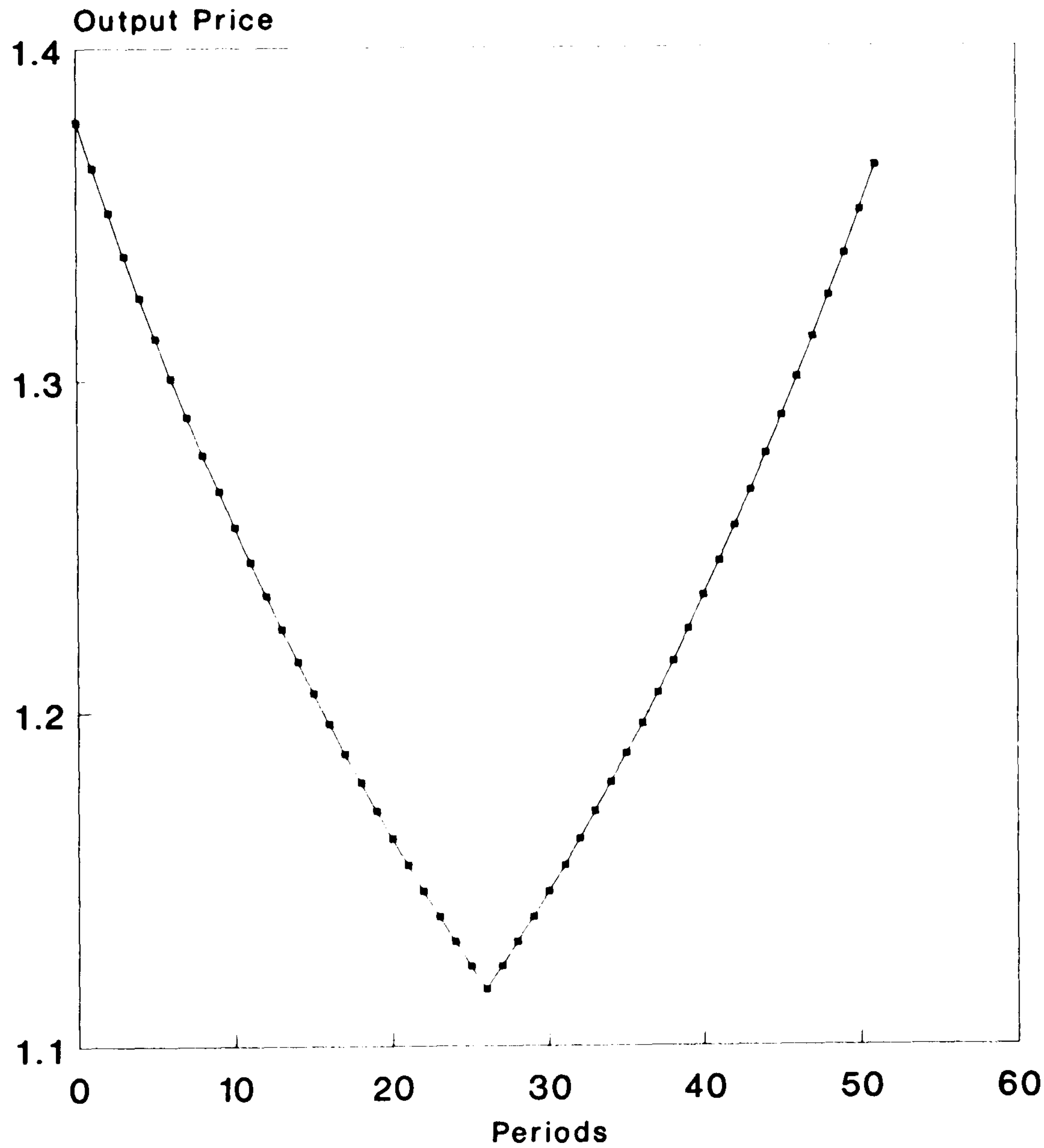
Leisure Conditional on
Exogenously Variable Output
Chart 12



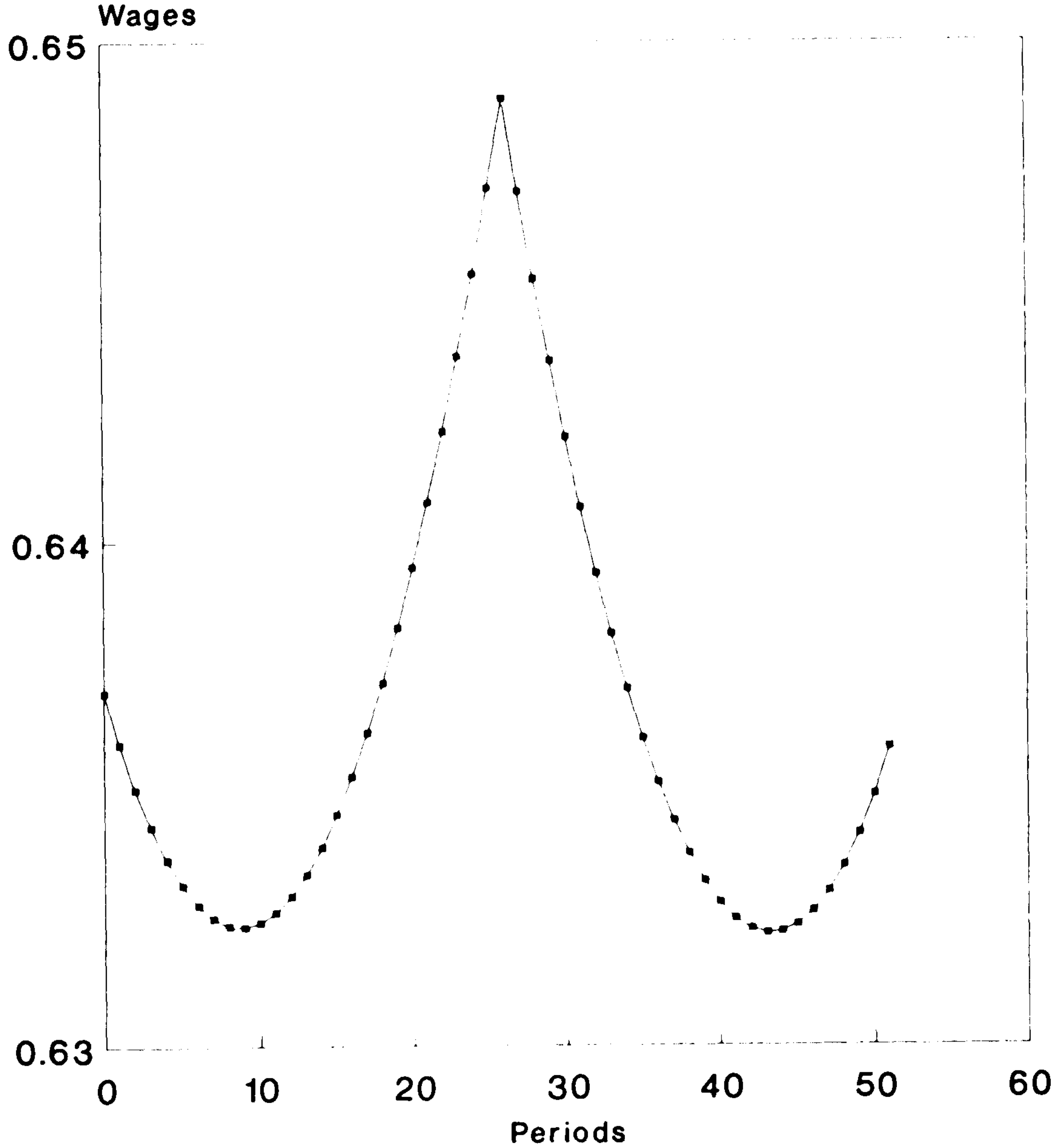
Work Hours Conditional on
Exogenously Variable Output
Chart 13



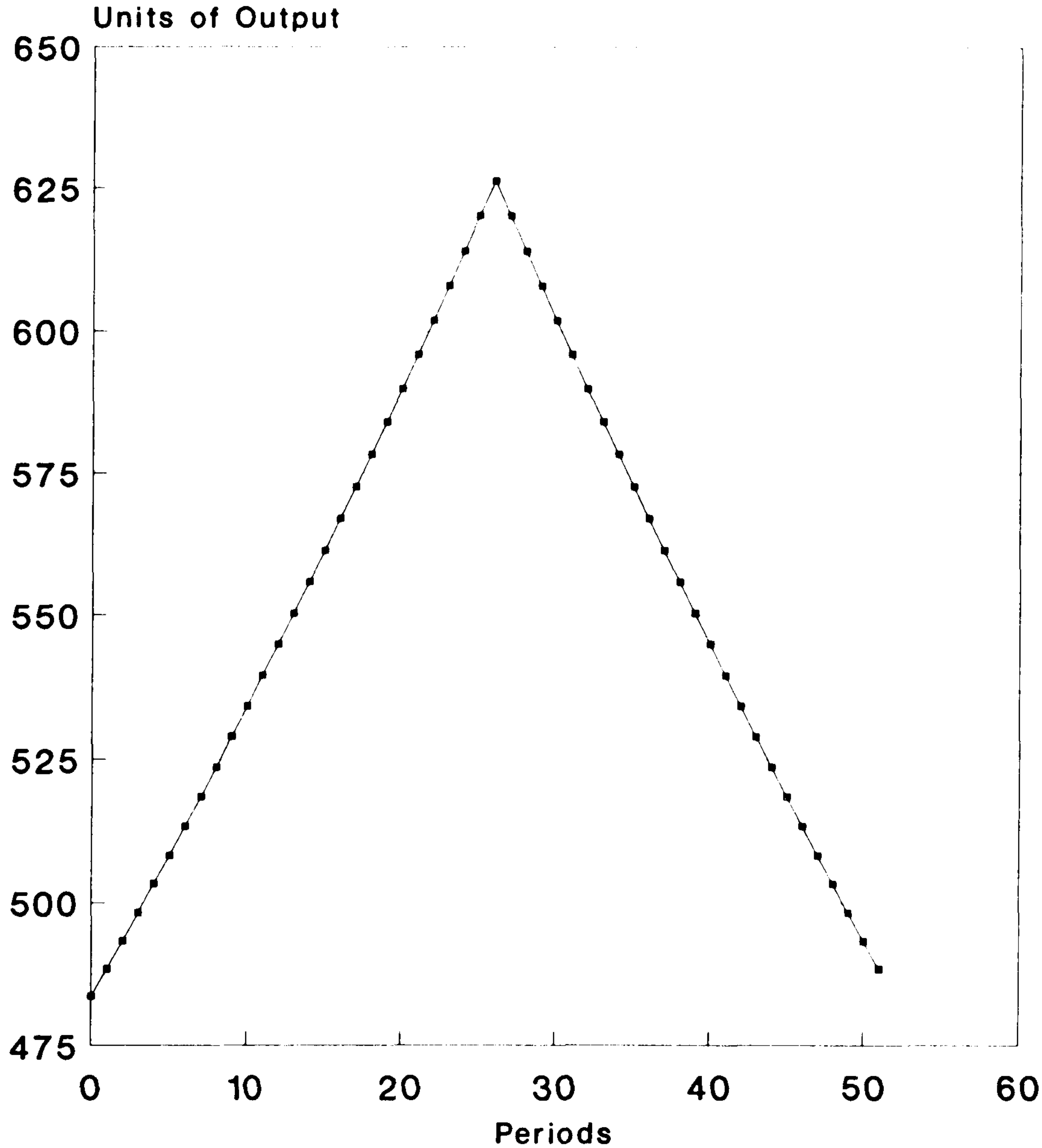
Output Price Conditional on Exogenously Variable Output
Chart 14



Wages Conditional on Exogenously Variable Output
Chart 15



Exogenously Variable Output
Chart 16



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