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1. Introduction

The 1980s and 1990s promise to be a difficult period for stabilization and growth policy. One of the lessons of the 1970s--that our economies are vulnerable to oil import price risk--must be put to use. The question is how.

In trying to answer that question, we proceed by constructing several highly simplified abstract models. Each model aims at capturing some essential feature (or features) of the problems of macropolicy in the new, supply-troubled international environment of the 1980s. Policy instruments are identified and rules for deriving optimal policies are stated.

This paper has been written with macromodeling for Swedish macroeconomic policy very much in mind, but the author is relatively ignorant of Swedish conditions. Where there are suggestions for experiments with realistic macro models, the models in question are existing models of the Swedish economy. While it would be nice to have a new class of models built from the start with the new environment in mind, many crucial choices must be made long before a new model generation can emerge.

1.1 The Two (or Three) Energy Problems

There is a tendency to talk about "the" energy problem, but we all know better. At least two energy-related problems are worth distinguishing.

There is one looming reality: uncertain energy supplies and prices in the world markets of the 1980s and the 1990s. In a way, this is nothing new: import commodity price instabilities are familiar to every trading country. But oil is not just another commodity. It is the premier commodity traded internationally, and has few short-term substitutes. Because oil prices have since 1973 been set by OPEC, "forecasts" of future world-market oil prices rest in part on forecasts of the stability of the OPEC coalition, and thus upon the relative power of OPEC member states and world demand for OPEC oil.

Forecasting an oil price future is thus akin to forecasting, to the penny, what a compulsive gambler will be worth after a month in the casino of Monte Carlo. The oil-importing countries face an energy price lottery over that period, and what should be "forecast" is the lottery: the spread of future energy prices which must be taken seriously. Identification of the large and noninsurable price risks of oil import dependence as "the" energy problem is our point of departure.

To go further, we need ways of connecting that oil price lottery, and our devices for dealing with the problem, with our objectives. In jargon, we need models tying together the lottery on oil prices, our policy instruments, and our policy objectives. Since the policy instruments at our disposal changes with the time horizon over which they can be deployed, we distinguish two kinds of energy planning periods: a short or middle term of about 2 to 5 years, and a longer term of about 10 to 20 years.

1.2. Energy Policy in the Short-Term

The 1970s have been, and the 1980s and 1990s promise to be, periods in which stabilization policy is destabilized. Prescriptions and decision rules accumulated during the steady expansions of the 1950s and 1960s will be challenged. The oil-import price-risk problem will command careful examination.

What went wrong with conventional stabilization policy in the 1970s? There will never be a decisive answer; we are still far from agreement about the causes of the worldwide depression of the 1930s. The macroeconomic disappointments of the 1970s have forced macroeconomics to a regroup in two camps. In the first camp there is insistence that years and perhaps decades will pass before we have a "good" macroeconomics. Meanwhile, current-generation macroeconomics is judged adequate to the task of explaining what went wrong--and what might have been done. The second camp, after a long hard look at the "foundations" of current generation macroeconomics, despairs of building anything on them, and seeks to rebuild those foundations anew.

I am too unprincipled to choose between these camps; both have something to offer. Begin with the first approach, and in particular with Alan Blinder's recent book.[1] In Blinder's view "what went wrong" in the 1970s is quite simple: the American economy was repeatedly shocked from the supply side--by food and energy price increases and by the devaluation of the dollar. But both policy-makers and some economists clung to the belief that all macroeconomic disturbances are aggregate demand disturbances, and demand restraint the appropriate response. The result at the time was the recession of 1974-75, the worst American recession since the depression of the 1930s. One legacy is enduring controversy about over what current-generation macroeconomics can contribute to macroeconomic policy.

If we accept this view, then we can continue to use the currently-available tools of macroeconomic analysis--either large macroeconomic models or small "summary" versions of those models consisting of equations defining the relationships among wages, prices and unemployment. True, several novel macropolicy instruments must be added to the traditional demand-side instruments. Whereas fiscal and monetary policies once were sufficient for dealing with demand-side disturbances, we now need a roster of complementary supply-side instruments, including one-shot cost-reducing policies like tax reductions. Optimal policy mixes of demand and supply-side instruments can be devised: though the tradeoffs between inflation and unemployment are less appealing than they were for traditional demand-management policy in a slack economy, those tradeoffs are no less real for being less attractive. They can be explored either by large-scale macrosimulation or by systems of wage-price equations. Either method can be used to design optimal policy responses to supply-shocks and disturbances.

This program is appealing: it is after all both practical and labor saving. But it would be a mistake to dismiss attempts to go beyond it. For there is a real, and possibly a serious, problem inherent in the program. The high inflation rates of the 1970s have disrupted the relationships upon which estimates of the structural coefficients of the parameters of a full macroeconomic model, and of all the coefficients of a much smaller wage-price equation system, rest. Because the program suggests that we base the design of optimal policies against stagflation on those estimates, the derived policies may be quite wrong given the new values of the structural coefficients. But our knowledge of those new values is severely limited by the limited number of observations available on the new structure.

There is a way to avoid this difficulty: the relevant structural coefficients can be endogenized, so that we know (for example) how they shift in a period of rapid inflation. That in turn will require both a rethinking of macroeconomics and new kinds of macromodels. We are well into that period of rethinking[2], and some of th early-generation models are up and running. Using those models to design optimal macropolicies against stagflation is prema ure, but the stakes are so high that not using them may be much more costly.

Rather than choose between the two macroeconomic camps, I have instead temporized. I sketch two general analytical methods for designing optimal stabilization policies against oil-price shocks in particular, and against supply-shock induced stagflation more generally. The first method builds on conventional wage-price equations, and is relatively routine, but may give misleading results. The second method builds upon some of the newer work in macroeconomics and macromodeling. It is relatively incomplete and tentative, but promising. In both cases, the objective is the same: to design optimal macroeconomic policies against supply-shock stagflation.

1.3 Energy Policy in the Long Term

Over the long term of 10 to 20 years, the economies of the developed countries must undergo substantial structural change and adjustment to a the new international economic environment. Uncertain oil import prices are only one feature of that new international environment, but they are arguably the least predictable, and least controllable, feature.

OPEC may be able to set the price of energy in the world market over the next twenty years. Individual firms and enterprises cannot be expected to insure themselves against oil-import price risk efficiently. Left to themselves, firms will bear that collective risk individually, by diversifying over activities varying in energy intensity--and therefore in vulnerability to energy prices increases. While rational for each individual firm, individual firm decisions, taken together, will be inefficient. Too much insurance against the collective oil-import price risk will be purchased.

There is an alternative to the market-determined allocation of energy price-related risk: a deliberate policy aimed at encouraging "flexibility" in structural adaption. Though formalization and precision seem disproportionately difficult, the commonsense notion of flexibility is simple enough. Consider the example of a firm planning to invest in capacity with which to meet demand for output over a ten-year planning horizon. Say that the firm is a large multi-product firm with significant market power in several product markets, that demand for the firm's products may fluctuate over the ten-year planning horizon, and that the firm must choose between two kinds of new plant. The first plant type permits a large cost reduction per unit of composite output for the (current-period) output mix; the second permits a smaller cost reduction per unit (composite) output for the current output mix, but also permits cost reductions for other output mixes that may be better matched to future demand conditions. Under these assumptions, the best choice for the firm may be the second kind of plant; that choice gives the firm more "flexibility" in facing uncertain future output demand.

This story is easily recast as a parable for an oil import-dependent economy facing uncertain oil import prices. The uncertainty is on the input, not the demand side, but the idea is the same. Different kinds of domestic capital equipment are characterized by differential factor-input intensities: inputs are disaggregated at least far enough to distinguish capital goods of various energy intensities, labor, and energy. If oil imports are important, and oil import prices uncertain, policies pushing firms (and hence the country) toward investment in less energy-intensive capital equipment may make sense. Such policies increase the "flexibility" of the economy in adapting to an international energy market in which supplies and prices are uncertain.

To make this general idea more precise we need a model. The vintage capital models of growth,[3] developed during the debates of the 1950s over the role of technical change in economic growth, are in fact exactly what we need. In those models capital equipment is tagged by the date at which it is purchased.

Past investments can no longer be changed in response to changing input prices, but current-period investments can be chosen with current-period and expected future period prices in mind.

Section 3 below specifies and explores a vintage capital model of an economy facing uncertain future prices. A definition of the "right amount" of flexibility is proposed, and rules for "buying" that amount of flexibility with a tax on imported oil are derived.

2. Short-term Energy Problems

Here, as elsewhere in this paper, the source of all energy problems is taken to be the uncertain price of imported oil. The focus in this section is on what macropolicy can do after the economy has been shocked by a sudden oil price increase. Thus, we regard short-term energy problems as simply one species of the genus of problems posed for traditional stabilization policy by supply-side shocks to the economy.

Supply-side shocks were a distinguishing feature of the macroeconomic history of the American economy in the 1970s. In the wake of that decade, the impression that macroeconomic theory could not explain what had happened gained currency. The notion that macropolicy "failed" because macrotheory was, and is still, inadequate seemed too obviously true to be questioned seriously.

But the truth is somewhat more complicated. "Current" macroeconomic theory can easily "explain" stagflationary episodes such as those of the 1970s.[4] That it was not used to do so at the time is unfortunate but understandable. And that it can do so after the fact does not prove that current theory is "valid". Still, seeing how far current theory can go towards an explanation is instructive. It is quite easy to see that supply-side shocks can cause stagflationary episodes. The analysis is about as trivial as such things can be. Shift aggregate supply upwards against unchanging aggregate demand: the result, for at least some portion of the (real) time period of adjustment, is simultaneous inflation and contraction of real economic activity--the definition of stagflation.

Whether this genre of macroeconomic analysis, and policies derived from such analyses, are adequate is another question, one which will be open for some time. For the purposes of section 2.1 we assume that the answer to this question is yes. In section 2.2 we throw caution and current macroeconomic theory to the winds. The results are some guidelines for exploring the limitations of current macroeconomic analysis in dealing with supply side shocks--and some sobering insights into the difficulties inherent in that exploration.

2.1. Standard Macroeconomic and Supply-shock Policy Design

Consider first the case in which the government sets macropolicy instruments to insure that real economic activity does not fall in the wake of a supply-side shock. In the jargon that has grown up around this issue, we say that the government "fully accomodates" the shock. Under that full-accomodation assumption, what will be the impact of the shock on the rate of inflation?[5] If we can answer this question, we will be able to design one particular anti-shock policy--a one-time reduction in some cost-increasing tax or program.

Under the assumption that the government fully accomodates the shock by fiscal and monetary policy, the usual price-wage equation systems simplify considerably, since all nonprice and nonwage influences can be isolated in the constant terms of these equations. In a general formulation in which the rate of price change (respectively nominal wage change) depends only upon lagged values of the rate of wage changes (respectively the rate of price changes), two equations describe[6] the evolution of both price and wage inflation:

$$\dot{P}_t = a + \sum_{j=0}^{n} b_j \dot{w}_{t-j} \tag{2.1}$$

$$\dot{w}_t = \alpha + \sum_{i=0}^{m} \beta_i \dot{p}_{t-i} \tag{2.2}$$

These equations can easily be reduced to a single equation describing the evolution of price inflation alone:

$$\dot{P} = A + \sum_{k=1}^{n+m} \gamma_k \dot{p}_{t-k} \tag{2.3}$$

In terms of the constants of the original system, the constants appearing in the single price inflation equation are given by:

$$A = \frac{a + \alpha\Sigma b}{1-b_0\beta_0} \tag{2.4}$$

$$\gamma_k = \frac{\sum\limits_{i+j=k} b_j\beta_i}{1-b_0\beta_0} \tag{2.5}$$

Estimation of this system on United States data gives results that are virtually "accelerationist": the sum of the coefficients in the pure price-level equation is slightly less than one. Thus an initial shock to the price level builds, over many periods, into a substantial increase in the price level.

Even this restrictive framework can help us in the design of policies for dealing with an exogenous shock to the price-level. Remember that this formulation is restrictive precisely because conventional macropolicy settings--fiscal and monetary policies--are assumed accomodationist: the level of real economic activity is held constant. Now consider the choice of one additional policy instrument--a one-time reduction in costs. Because price increases are cost-sensitive, that reduction translates rapidly into a reduction in the rate of price inflation. Devices for carrying out such a reduction are available in many countries: taxes on capital income, or payroll taxes, or both, can be reduced.

Assuming that the tax system was optimal prior to the shock, a one-time cost reduction imposes a social loss. We are willing to incur that loss because there is a benefit associated with reductions in the rate of inflation. Remember what the principal component of that benefit is: inflation causes a "crawl away from money", and a reduction in the efficiency of the transactions mechanism. Though the "transaction function" is conceptually and empirically elusive and the source of much disagreement, any macroeconomic policy choice implicitly rests upon some transactions function. For present purposes, simply assume that the loss from distorting the tax system by the cost reduction, and the transactions benefit of reduced inflation, can be summarized in a loss function[7] $L(c,p)$. Now we have come far enough to promulgate rule S1.

<u>Rule S1</u>: To estimate the optimal cost-reducing post supply-shock policy to be superimposed on accomodation, proceed as follows. Estimate, or guess at, a loss function expressing the tradeoff between the impact of the cost-reducing policy and the in-

flation that policy is intended to slow. Then estimate the above price-wage system, and use it, together with the loss function, to derive the optimal cost-reducing policy.

Some technical comments are inevitable here: they can easily be verified by the reader. The single equation 2.3 describes the evolution of the price level under an accomodationist policy, and translates a reduction in the current-period price level into a reduction in the rate of inflation in every period thereafter. Technically, we should define the loss function L over the rate of inflation in the period in which the cost-reducing policv is implemented and in all successive periods. But in practice something much less ambitious should do: for example, a separable quadratic loss function defined on the cost-reducing policy and on the rate of inflation in a few future periods might be chosen. With a positive definite quadratic form chosen for L, it is easy to show that the optimal cost-reducing policy is always well-defined (by loss minimization) and it has sensible properties. In particular, it is always positive, and vanishes in the limit in which zero social cost is assigned to the rate of inflation.

Rule S1 has the virtue of simplicity. It also has one glaring defect: the presumption that post supply-shock government policies are policies of strict accomodation, with the level of real economic activity maintained in the wake of the shock. That is a very special constraint on the kinds of policy responses to exogenous price shocks that can be considered.

It would be helpful to have a similar framework capable of broader interpretation. One particular extension is straightforward: write down an expanded system of wage and price equations in which measures of real economic activity affecting wage and price inflation appear explicitly. Then construct a loss function over both supply-shock response policies and those measures of real activity. Finally, compute optimal policies by minimizing the loss over the feasible combinations implied by the expanded wage-price system.

Here, in the context of a particular system of expanded wage-price equations, is the proposal. Begin from the following standard equations:

$$\dot{w}_t = A + \sum_{j=0}^{n} B_t \dot{\rho}_{t-j} + \sum_{j=0}^{m} C_j \log U_{t-j} \qquad (2.6)$$

$$\dot{\rho}_t = D + \sum_{j=0}^{\ell} E_j \dot{w}_{t-j} \qquad (2.7)$$

Assume that policy can control the unemployment rate--for example, that fiscal and monetary policy are set to maintain that rate at some constant level. Assume further that some cost-reducing policy is available: that by choosing an instrument c, we can achieve a one-time slowing of the rate of increase of the price level. Then with a loss function[8] $L(U,p,c)$, we can use the above system of equations to choose an optimal c, an optimal constant level of unemployment U, and an optimal rate of inflation p. In particular, we have Rule S2:

Rule S2: To estimate the optimal combination of cost-reducing and conventional (fiscal and monetary) stabilization policy instruments following a supply shock, proceed as follows. Estimate, or guess at, a loss function expressing the tradeoffs between the impact of the cost-reducing policy, the inflation rate, and the constant rate of unemployment. Then estimate the "full" wage-price system. Use it, together with the loss function, to derive the optimal fiscal, monetary and cost-reducing policy settings.

Note that in this case, both aggregate demand management and cost-reducing policies are simultaneously optimized.

Rules like S1 and S2 are about all we can expect from "conventional" macroeconomic formulations that fall short of simulations with full macroeconomic models. The cost and difficulty of such simulations suggest exploiting whatever information is embodied in simple wage price equation systems like (2.6) and (2.7).

But there is a price to be paid for that simplicity. The structural coefficients in wage-price systems may shift rapidly during a period in which many important economic relationships are being redefined or renegotiated. Because the 1970s clearly were such a period, we must be cautious both using rules S1 and S2 as guides to policy in similar periods in the future.

But what are the alternatives? One is clear enough: try to endogenize the structural coefficients.

2.2 Alte native approaches to supply-shock policy design

2.2.1 Motivation

The previous section stated rules for constructing supply-shock optimal policies from the estimated coefficients of wage-price equations. Those derived policies will be open to question if the estimated coefficients are changed by the shock to which we are responding.

But significant shocks to the economy may change the behavioral relationships these coefficients summarize, and hence the coefficients themselves. Faced with this situation, we can do either of two things. We can try to reestimate wage and price equations from post-shock data, or we can try to endogenize the changes in those coefficients. Reestimation will be most difficult when we need it most. For in the months immediately following a shock, when compensatory policies can be most effective, there will be relatively little data from which to estimate the new structure from.

In principle there is an alternative: "endogenize" the structural coefficients appearing in the wage-price equations. For if we know how those coefficients are changed by the shock, we can simply apply rules like Rules S1 and S2 to wage-price equations with the new structural coefficients.

Endogenizing the changes in the coefficients is an ambitious program,[9] related in spirit to the effort to provide a microeconomic foundation for macroeconomics. It will be years before the returns from that effort are in; in the interim, about all we can do is examine the properties of simple models with endogenized structural coefficients. We hope to obtain a specific constructive procedure for the structural coefficients of wage-price equations--in our simplified construct and, by extension, in the full MOSES model[10] of the Swedish economy developed at the Industrial Institute for Economic and Social Research (IUI). The reader is forewarned that much of what follows in this section is speculative and incomplete, and that at least some of what follows is undoubtably wrong.

2.2.2 A model with endogenous structure

Simulations analogous to those suggested at the end of this section may ultimately be run with the MOSES model of the Swedish economy. But MOSES is too complicated for the purposes of this section: the complexity of a large macroeconomic model quickly exhausts the intuition. For that reason we begin with a "reconstruction" of a minimal, and somewhat more tractable, model. The model described here shares certain features with MOSES, but the two should not be confused. It is entirely possible that the two models behave very differently in some important respects.

We want to preserve and mimic those features that distinguish MOSES from the more conventional macroeconomic models: we want firm behavior to be guided by a kind of satisficing planning process, and not by "profit maximization".[11] We want the allocation of labor to firms to be the outcome of a process of search by firms over a segmented labor market. And we want demand in product markets to be Keynesian effective demand, not Walrasian demand.[12]

We begin by constructing a simple version of the MOSES simulation model of the Swedish economy. First, introduce notation as follows. There is a finite number of firms f=1,....,/F/ indexed by the set F. There is a single consumption and capital good: once embodied as capital, it cannot be consumed and does not depreciate. The commodity variables appearing in the model are

Q(t/f)	Firm f output (per year) in year t
Q(t)	Aggregate output
L(t/f)	Firm f labor input
L(t)	Total labor input
K(t/f)	Capital input to firm f
K(t)	Total capital input
E(t/f)	Energy input to firm f
E(t)	Total energy input.

The corresponding price, profit, and rate of return variables are

P(t)	Price of consumption/capital good
$P_E(t)$	Price of energy imports
W(t/f)	Firm f wage
$\pi(t/f)$	Firm f profit
m(t/f)	Firm f target rate of return
$\hat{P}(t/f)$	Expected output price
$\hat{P}_E(t/f)$	Expected energy input price
$\hat{W}(t/f)$	Expected wage
$\hat{\pi}(t/f)$	Expected profit
$\hat{m}(t/f)$	Expected rate of return on capital

Actual and expected variables are distinguished by a carat (or "hat"). Aggregate and firm-level variables are related by the identities

$$L(t) = \sum_{f} L(t/f)$$

$$Q(t) = \sum_{f} Q(t/f)$$

$$Q(t/f) = F^{f}(K(t/f), L(t/f), E(t/f))$$

$$P(t)Q(t/j) = \sum_{f \in F} W(t/f)L(t/f) + P_E(t) \sum_{f \in F} E(t/f) + \sum_{f \in F} \pi(t/f)$$

The ex post identity linking firm f costs, revenues and realized profit is:

$$P(t)Q(t/f) = W(t/f)L(t/f) + P_E(t)E(t/f) + \pi(t/f) \quad (2.8)$$

The heart of the model is firm behavior: firms are the active agents in the labor markets. Each firm f in each period t plans for the next period t+1 in the following way. Beginning from the current-period realized rate of return m(t/f), firm f constructs its next (t+1) period planned capital, labor and energy input vector. Given expected next-period prices, the firm constructs a rate-of-return-feasible region X(t+1) defined by the requirement the expected rate of return will exceed the next-period target rate of return. That requirement is:

$$\frac{\hat{P}(t+1/f)\hat{Q}(t+1/f)-\hat{W}(t+1/f)L(t+1/f)-\hat{P}_E(t+1/f)E(t+1/f)}{\hat{P}(t/f)K(t/f)} \geq \hat{m}(t+1/f) \quad (2.9)$$

where

$$\hat{Q}(t+1/f) = F^{(f)}\left(\hat{K}(t+1/f), \hat{L}(t+1/f), \hat{E}(t+1/f)\right) \quad (2.10)$$

Thus feasibility is guaranteed. The condition (2.9) defines a set of rate-of-return feasible vectors of expected inputs

$$\{\hat{K}(t+1/f),\ \hat{L}(t+1/f),\ \hat{E}(t+1/f)\} \qquad (2.11)$$

Assume now that the firm chooses a vector at random from that domain. That assumption mimics[13] the "satisficing" behavior of firms in the full MOSES model, since each firm employs a rough satisficing criterion, rather than global optimization. The input vector chosen is of course a planned input vector. Plans may not be realized: to go further we must specify a relationship between planned and realized quantities. Assume that planned energy requirements are always realized, so that

$$E(t+1/f) = \hat{E}(t+1/f) \qquad (2.12)$$

This is plausible because planned energy requirements are made firm by committed future purchases of oil imports. Assume next that planned investment is realized if consistent with realized profit; that, if realized profit is positive but insufficient to allow realization of planned investment, realized investment equals realized profits; and that, if realized profit is negative, then realized investment is zero. Summarizing these assumptions, we have:

$$K(t+1/f) = \hat{K}(t+1/f) \text{ if } \pi(t+1/f) \geq \hat{K}(t+1/f) - K(t/f)$$
$$K(t+1/f) = \pi K(t+1/f) \text{ if } \hat{K}(t+1/f) - K(t/f) \geq \pi(t+1/f) \geq 0$$

$$K(t+1/f) = K(t/f) \text{ otherwise.} \qquad (2.13)$$

The really novel market determination in the full MOSES model is the labor market determination of wages and labor allocation. In MOSES, firms enter the labor markets--actually interfirm raiding markets--armed with their planned labor input requirements (L(t+1/f)). Taken together with those plans, the MOSES labor-market search equilibrium concept chosen determines a realized labor input, and therefore determines the next-period production of individual firms. Typically the firm chooses a labor-market search concept s from a set S of feasible search concepts S at the market level. Some specifications of s will be decomposable to the firm level, so that s becomes an /F/-tuple of firm search concepts $(s_1, s_2, \ldots, s_{/F/})$. Later we will add this complication: for the time being suppose that s is specified at the market level. That specification leads to a relatively simple MOSES-type equilibrium concept.

We will need some definition like the following one: a MOSES1 equilibrium is a 3/F/+1 tuple

$$(s; g; (K(\cdot/f), L(\cdot/f), E(\cdot/f)); P_E(t)), \qquad (2.14)$$

where we introduce (or reintroduce) the following notation:

s	Labor-market search algorithm ($s \in S$)
g	Trend growth rate (determined exogenously, e.g. by population growth rate)
$\hat{P}_E(t)$	Energy input price vector.
$K(\cdot/f)$, $L(\cdot/f)$, $E(\cdot/f)$, . . .	Stationary stochastic processes (determined by model).

Why is this MOSES1 equilibrium concept a sensible one? Remember that firm (satisficing) behavior is modelled as firm selection of a planned input vector from a (rate-of-return constraint) feasible set of planned input vectors. The random element in that selection makes the model inherently stochastic. Since the simplest stochastic process is a stationary stochastic process, the most natural outcome--and the simplest equilibrium concept to manipulate--is one in which the output processes generated by the model are also stationary stochastic.[14]

Suppose therefore that we can prove (and not merely assert) that K,L, and E are stationary stochastic processes. Then there will be a relatively simple way in which to think about the way the model describes the economic impact of an abrupt change in the price of imported oil (an "oil price shock"). Before the shock, the economy will be described by one stationary stochastic process; after the shock, it will settle down into another. The effect of the shock can be summarized by listing the parameters of those pre and post-shock stochastic processes.

In the MOSES1 equilibrium concept, the labor market search algorithm is specified for the market as a whole: s was given from the set S of possible labor market search. A more ambitious MOSES equilibrium concept,[15] which we call MOSES2, would allow firms independent choice of their own labor-market search algorithms, with each firm f choosing an s_f from S_f. The point of this extension is to define an equilibrium concept in which all firms are doing "about the right amount" of searching. Each firm's chosen search concept s_f should in some sense be the "best" one for that firm, given the search concepts chosen by all other firms.

What can "best" mean here, since we have abandoned profit maximization as a rule for the determination of firm behavior? Since the searching is going on in the labor market, "best" might mean: the search concept that keeps firm f realized labor closer to firm f planned labor requirement than any other search concept available to firm f--given the search behavior of all other firms.

To close these simplified MOSES-like models we need two things: a demand side describing the product market, and an expectation-formation model describing how target rates of return and expected prices and wages are developed from their current-period analogs. For the demand side, take:

$$\left.\begin{aligned}
C(t/1) &= cY_{DISP}(t) \\
Y_{DISP}(t) &= \sum_{f \in F} W(t/f)L(t/f) + \sum_{f \in F} d(t/f) \\
d(t/f) &= \pi(t/f) - K(t/f) + K(t-1/f) \\
I(t) &= \sum_{f \in F} (\hat{K}(t/f) - K(t-1/f)) \\
M(t) &= P_E(t) \sum_{f} E(t/f) = P_E(t)E(t)
\end{aligned}\right\} \quad (2.15)$$

Then equality of demand and supply reads:

$$C(t) + \hat{I}(t) + M(t) = P(t)Q(t) = \sum_{f} W(t/f)L(t/f) + P_E(t) \sum_{f \in F} E(t/f) + \sum_{f \in F} d(t/f). \quad (2.16)$$

Finally, target rates of return m(t/f) are revised proportionately to the discrepancy between realized and expected profits

$$\hat{m}(t+1/f) = \hat{m}(t/f) + \gamma_m \frac{\Pi(t/f) - \hat{\Pi}(t/f)}{P(t)K(t/f)} \quad (2.17)$$

Similarly, expected (output) prices and expected wages are revised based upon changes in prices and wages over the last two periods

$$\left.\begin{aligned}\hat{P}(t+1) &= P(t) + \gamma_m (P(t) - P(t-1)) \\ \hat{W}(t+1/f) &= W(t/f) + \gamma_w(W(t/f) - W(t-1/f)).\end{aligned}\right\} \quad (2.18)$$

Note that "the" labor market is not in "equilibrium": wages in any given period can differ between firms. With these equations we have completed the description of our simplified MOSES model. We summarize this section in Rule S4, a rule for designing optimal policies for shocks in MOSES-type models.

Rule S3: to design optimal policies for supply shocks in MOSES-type models, proceed as follows. Begin with a loss function describing the trade-offs between inflation, unemployment and the particular policy to be deployed against the shock. Construct the feasibility frontier from the underlying MOSES-type model by simulation: that frontier tells us how a shock of a specified type and given size shifts the parameters of the stochastic processes defined by the model. Pick an optimal policv by constraining the loss function with this frontier and the given shock, and then minimizing loss. The frontier can be constructed in either MOSES1 or MOSES2 equilibrium concept variants. Optimal policies can be constructed in either variant; and in MOSES2 the structural coefficients can actually be endogenized, since firms will alter their labor market search procedure in response to the oil price shock.

Let us close this section with some reflections on the MOSES1 and MOSES2 equilibrium concepts. There are two kinds of issues here: the general issue of which kinds of equilibrium concepts should be taken seriously, and the related issue of the corresponding notions of stability.

Equilibria like MOSES1 and MOSES2 may not exist, or their existence may be hard to prove: this is because the driving process, the selection of a random feasible input vector from a set of feasible vectors, may not have any nice properties of stationarity. Typically, only stationary input processes give rise to stationary output processes, and then only under highly restrictive conditions. But we would argue that the general notion of this kind of "equilibrium", rather than the existence of a special kind of equilibrium with particularly simple properties like stationarity, may be the important thing. Remember what we mean when we talk about "stabilizing" the economy, or about the successes and/or failures of stabilization policy. One picture, often shown to illustrate the success of postwar Keynesian "stabilization" policies, shows that quarterly percentage fluctuations in gross domestic product have been noticeably smaller in the post-war years. Pretend that such a picture really tells us something about the behavior of a dynamical system we both understand and can, to some extent, control. What are we saying about that dynamical system when we claim that postwar stabilization policies have been effective? Possibly that we have been able to steer the system to a (balanced growth) equilibrium. But another , and perhaps a more plausible interpretation, is that we have been able to "bound the orbit" of the dynamical system within a small neighborhood of some balanced growth path. If there are such system orbits which do not coincide with balanced growth paths--either indefinitely or over some time interval--refusing to look at anything but balanced growth paths may be unduly restrictive. We may be throwing away the most interesting system trajectories--and the system trajectories with some descriptive realism.[16]

In going beyond the simplest equilibrium concepts we do of course give up something important: the possibility of a simply-described, or simply-parameterized, equilibria. Thus a balanced-growth equilibrium is completely described by a few parameters: that is why (economic)growth theory has emphasized balanced growth paths. And a stationary stochastic process can also be characterized by a "relatively small" number of parameters. Simple descriptions of equilibria permit simple characterization of the results of a change in exogenous parameters: comparative statics, comparative balanced growth, and the analogs for stationary stochastic equilibria all build on this truism.

Now let us turn to the second kind of issue--stability. Whatever the equilibrium concept, only stable equilibria are of any real interest or importance. Remember the reasons: real-world systems will spend little (real) time in, or in the neighborhood of, unstable equilibria. How, then, should we define stability for the stochastic equilibrium concept introduced in our simplified MOSES model? Remember how stability notions are defined in standard general equilibrium theory. First we impose the Walrasian tatonnement model of price adjustment. Then an equilibrium is called stable if there is a unit-price-simplex neighborhood of the equilibrium price point from any point of which the Walrasian tatonnement moves us toward the equilibrium point. Within this open neighborhood, small price displacements away from equilibrium result in return to equilibrium. Remember, however, that the initial equilibrium depends parametrically upon both the initial endowments of the individual agents and upon their preferences. Thus even in the deterministic pure exchange economy, a second kind of stability is of interest: stability with respect to the parameters of the model endowments and preferences. Again, an isolated equilibrium point is stable in this second sense if small changes in the parameters produce only small changes in the position of the equilibrium in the unit price simplex. In the jargon increasingly fashionable in economic theory, equilibria passing the first test are called "stable", and equilibria passing the second test are called "generic".

We have distinguished between these two notions because we want to examine their natural analogs, for stochastic equilibria, as candidate stability concepts for our simplified MOSES model. It is neither necessary nor desirable to choose between them. Each generalizes to the stochastic case, and each provides a concept useful in examining the stochastic equilibria of our heuristic model.

First consider stability against local price displacement. In a stochastic equilibrium model the initial conditions generally determine stochastic processes-distributions of endogenous variables in future periods. If for small changes in initial conditions the determined distributions converge, for times far enough in the future, to the same distribution, then we say that the equilibrium from which we started is "stochastically stable". Formalization requires some notion of when two probability distributions are "close".

Now turn to the second stability concept, the one we have called genericity of the equilibrium with respect to the model parameters. In our case, the most interesting model parameters are the parameters of the stochastic input processes that drive our model; the parameters of the stochastic firm planning process are examples. Then genericity means that a shock leads to only small ch nges in the input and output stochastic process. To put some teeth into this heuristic definition of stochastic stability, we need a notion of closeness for stochastic processes. Remember that a stochastic process is a sequence of random variables, and that two such sequences are close when the joint distributions of the random variables are close. For the simple case--a serially uncorrelated process, with single-period distributions being generated by a finite parameter distribution--a natural definition of the distance between two stochastic processes is the Euclidean distance between the parameters of the two processes.

The general idea goes through for more complicated processes. Suppose, for example, that the processes are covariance-stationary: covariances depend only on lag length. Then those stochastic processes are completely determined by a vector with either a finite number, or a countable infinity, of components. Given weak conditions on the rate at which serial correlation vanishes with lag length, those vectors will be square-summable and thus lie in the space l^2. Since l^2 is a normed space, the l^2 norm defines a distance between any two stochastic processes.

Thus we have defined concepts of stochastic stability and stochastic genericity for our simplified MOSES model; that simple model embodies many of the difficulties involved in defining such concepts in the full MOSES model. How might one do experiments with our simplified model and, by implication, how should one do experiments with the full MOSES model? We are interested in the response of the model to oil import price shocks, which enter the calculations of th model's economic agents through the oil-price expectation function. In each case we are trying to determine two things. We want to know whether the system returns to the pre-shock long-term growth path or settles into some new long-term growth path. And we want some idea of how long it will be before the oscillations about that new path fall within some predetermined fraction of the initial displacement from the long-term growth path. That some long-term growth path some time will emerge is dictated by use of trended-growth exogenous variable used in MOSES model runs.

Very generally, stability and rapid convergence are assured by capital flexibility and by price expectations which do not depend "too much" on the current price system. Thus, we want to "estimate", by simulation, two kinds of magnitudes. For a given oil price shock, we want to estimate the amplitude and duration of the resulting disturbance as functions of the capital flexibility and price-expectation function parameters. And we want to "estimate", by simulation, the largest oil price shock for which convergence, within some prespec fied time interval, is to the original growth path.

3. Energy Problems in the Long Term

3.1 The Optimal Vintage Capital Structure: A Simple Model[17]

Here we want an answer to a simple question. Suppose that the government has in its possession excellent information on oil-import price risk, and has at its disposal one policy instrument--a tax on imported oil. How should the government set that instrument so as to push the private sector to a level of energy intensity that is optimal given the import price risk? We begin by setting down a formal model. Introduce the following variables and notation:

S	States of nature; $s \in \mathbf{S}$
V	Capital vintages; $v \in V$
$P_F(s)$	Firm (or private-sector) probabilities of future oil prices
$P_G(s)$	Government probabilities of future oil prices
r(v)	Capital rentals
e(s)	Energy prices in state s
C(O)	Initial caital-goods endowment
C(1), C(2, s)	Consumption program
K(v)	Total second-period vintage v capital
E(v, s)	Energy inputs complementary to K(v, s)
W(C)	Social welfare functional on consumption programs
Π	Firm (or private-sector) profit
$f^{(v)}(K(v), E(v, s)$	Vintage v production function.

The states of nature index future oil-import prices: knowledge of the state of nature amounts to knowledge of the future oil import price. There are two periods, and firms can invest in any of several vintages of capital goods. Capital goods of vintage v bear capital market rentals r(v). Output runs in terms of a single good, with output from each capital vintage being produced with complementary energy (oil) inputs E(v, s). There are two time periods, and an initial endowment C(0) of the single consumption good must be allocated between current consumption and investment in the various vintages of capital goods. Firms and the government differ in their views of the likelihood of future oil price increases. Under the special assumption that the government has full confidence in its view of oil import price risk, what should be done?

Uncertainty is the heart of the matter, but let us first get the notation right in the "certainty case", where things are simpler.[18] Assume that the government has some well-specified objective called social welfare, and write it as

$$W(C) = U_1(C(1)) + U_2(C(2)) \qquad (3.1)$$

The government's problem is to max (W(C)) subject to resources (or initial endowments) and technical constraints.

$$C(0) = C(1) + \sum_{v \in V} (K(v)) \qquad (3.2)$$

$$C(2) = \sum_{v \in V} f^{(v)}(K(v), E(v)) - e \sum_{v \in V} E(v) \qquad (3.3)$$

$$\left.\begin{aligned} C(1), C(2) &\geq 0 \\ E(v) &\geq 0 \\ K(v) &\geq 0 \end{aligned}\right\} \qquad (3.4)$$

But the private sector tries to maximize profit, not social welfare. Profit Π is given by

$$\Pi(K(v), E(v)) = \sum_{v \in V} f^{(v)}(K(v), E(v)) - e \sum_{v \in V} E(v) - \sum_{v \in V} r(v)K(v) \qquad (3.5)$$

In the certainty case, there is only one (present and future) energy price, e. Profit is written as three sums for easier comparison with the uncertainty case below. The firm's problem is to max ($\Pi(K(v),E(v))$ by choosing second-period capital and energy inputs.

Now let us turn to the more interesting and realistic uncertainty case. The government tries to maximize expected social welfare,

$$E(W(C)) = U_1(C(1)) + \sum_{s \in S} P_G(s)U_2(C(2, s)) \qquad (3.6)$$

Note that it is the government's subjective probability $P_G(s)$ for future oil prices that enters here. The problem is to max (E(W(C)) subject to resource (or endowment) and technical constraints:

$$C(0) = C(1) + \sum_{v \in V} K(v) \qquad (3.7)$$

$$C(2, s) = \sum_{v \in V} f^{(v)}(K(v), E(v, s)) - e(s) \sum_{v \in V} E(v, s) \qquad (3.8)$$

$$\left.\begin{aligned} C(1), C(2, s) &\gtrsim 0 \\ E(v, s) &\gtrsim 0 \\ K(v) &\gtrsim 0 \end{aligned}\right\} \qquad (3.9)$$

Firm (or private sector) behavior is again given by profit maximization. But now profit $\Pi(K(v), E(v, .))$ is given by:

$$\max_{K(v)} \sum_{s \in S} p_F(s) \left(\max_{E(v,s)} \left(\sum_{v \in V} f^{(v)}(K(v), E(v, s)) - e(s) \sum_{v \in V} E(v, s) - \sum_{v \in V} r(v)K(v) \right)\right) \quad (3.10)$$

Note that two maximizations are required to construct the firm's production plan. In the first (inner bracketed) maximization, the energy inputs E(v, s) to be used with each vintage v of capital are computed, for each state of nature s and for any given capital stock K(v), $v \in V$. In the second (outer bracketed) maximization, the optimal capital stock is computed. The relevant (probalistic) future oil price assessment is $p_F(s)$, the firm's. Once chosen, capital stock is fixed over both periods, but complementary energy inputs E(v, s) can be chosen after the state of nature s is revealed.

Now let us see how we can use this appartus to compute the "best" level of one familiar policy recommendation, a tax on second-period imported oil. Social welfare is again given by (3.6). Again, the problem is to max (E(W(C)) subject to resource and endowment constraints. The intervention in question is a single, second-period tax on oil imports, with the per-barrel tax q independent of second-period prices. Assume that the tax schedule is announced before period one begins, and assume that all tax revenues are distributed as second-period consumption. Then the relevant constraints are:

$$C(0) = C(1) + \sum_{v \in V} K(v) \tag{3.11}$$

$$C(2, s) = \sum_{v \in V} f(v)\Big(K(v), E(v, s)\Big) - e(s) \sum_{v \in V} E(v, s) + q \sum_{v \in V} E(v, s) \tag{3.12}$$

$$\begin{aligned} C(1), C(2, s) &\geq 0 \\ E(v, s) &\geq 0 \\ K(v) &\geq 0 \end{aligned} \tag{3.13}$$

Extension to the case of an oil-import tax dependent on import price is immediate: simply replace e(s) by (e(s) + q(s)). The latter expression is the (state of nature s) price, to domestic producers, of a barrel of oil.

3.2. Optimality: Some Remarks

For the case set out above, conventional restrictions on social welfare and production functions will guarantee the existence and uniqueness of an optimum consumption plan. In the certainty case, this is (C*(1), C*(2)), and in the uncertainty cases (C*(1), (C*(2, s), s $\in$ S)). Moreover, the certainty case can be "decentralized" in the following sense. There are prices (E(v) r(v); v $\in$ V) for which private sector decisions, described in (3.5), guide the economy to the social optimum, defined by the problem (3.1). Note that a discount rate for future consumption can be introduced by introducing a coefficient $p_C(2)$ of the production function term in (3.5).

But for the uncertainty cases, there is an obstacle to "decentralization" of this kind. Because oil-import price risks are noninsurable, we have assumed that there are no contingent (on future oil prices) future consumption-goods markets. Thus in (3.10), which describes firm behavior, there are no coefficients $p_C(2, s)$ of the production function terms (though we might introduce a state-independent coefficient $p_C(2)$). Because there are "too few" prices, in general there will be no hope of using our tax instruments q(s) to guide the private sector to a social welfare-maximizing set of choices.

But we can still pose the following question. If we insist that government interventions operate through a tax instrument q, how well can we do with that tax instrument? To find the answer, proceed as follows. From equations (3.6), (3.8)-(3.9), we find the global optimum. From (3.10), with e(s) replaced by (e(s) + q), find the tax instrument q which gives us the "closest" private sector optimum. In other words: (3.10), with e(s) replaced by (e(s) + q), becomes another constraint. Social welfare is maximized subject to this constraint, and then the q(s) giving the best constrained social welfare optimum is determined.

We summarize the results and conclusions of this section in the following rule:

Rule L: To compute an optimal oil import tax proceed as follows. Choose a probability distribution on future oil prices, a discount rate for future consumption, and crude technological estimates of the energy-intensity of the various capital vintages. Then compute the optimal oil import tax as indicated in equations (3.6) through (3.10).

4. Summary of Rules

We summarize the paper by bringing together, in one place, the rules and recommendations put forward in the text. The reader must return to the text for exposition and qualification.

Rule S1: For a rough estimate of the optimal cost-reducing supply-shock policy to be superimposed on accomodation, proceed as follows. Estimate, or guess at, a loss function expressing the tradeoff between the impact of the cost-reducing policy c and the inflation that policy is intended to slow. Then estimate the above price-wage system, and use it, together with the loss function, to derive the optimal cost-reducing policy.

Rule S2: For rough estimates of the optimal combination of cost-reducing and conventional (fiscal and monetary) stabilization policy instruments following a supply shock, proceed as follows. Estimate, or guess at, a loss function expressing the tradeoffs between the impact of the cost-reducing policy, the inflation rate, and the constant rate of unemployment. Then estimate the "full" wage-price system. Use it, together with the loss function, to derive the optimal fiscal, monetary and cost-reducing policy settings.

Rule S3: To design optimal policies for supply shocks in MOSES-type models, proceed as follows. Begin with the loss function describing the tradeoffs between inflation, unemployment and the particular policy to be deployed against the shock. Construct the feasibility frontier from the underlying MOSES-type model by simulation: that frontier tells us how a shock of a specified type and given size shifts the parameters of the stochastic processes defined by the model. Pick an optimal policy by constraining the loss function with this frontier and the given shock, and then minimize the loss. The frontier can be constructed in either MOSES1 or MOSES2 equilibrium concept variants. Optimal policies can be constructed in either variant; and in MOSES2 the structural coefficients can actually be endogenized, since firms will alter their labor market search procedure in response to the oil price shock.

Rule L: To compute an optimal oil import tax proceed as follows. Choose a probability distribution on future oil prices, a discount rate for future consumption, and crude technological estimates of the energy intensity of the various capital vintages. Then compute the optimal oil import tax as indicated in equations (3.6) through (3.10).

Footnotes

1. See Blinder (1981). Somewhat similar in spirit are Blinder (1980), Fried and Schultze (1975), Gramlich (1979), Modigliani and Papademos (1978), and Pierce and Enzler (1974).

2. Among the major efforts at a reconstruction of macroeconomic theory are Malinvaud (1977), Hicks (1979) and Tobin (1980). About the "new classical macroeconomics" I have nothing to say: Tobin's argument and final judgement--that the world represented therein is intellectually intriguing but not the world we happen to live in--seem persuasive. See also Akerlof (1979).

3. See, for example, the fundamental theoretical papers of Arrow and Kurz (1970) and Calvo (1976). For a textbook exposition see Wan (1971).

4. For a notably clear example of such an exposition see Chapter 2 of Blinder (1981).

5. Here is a selective listing of the published literature in this vein: Ando and Palash (1976), Gramlich (1979), Meltzer and Brunner (1981), Modigliani and Steindal (1977), Modigliani and Papademos (1978), Pierce and Enzler (1974), and Wallich and Weintraub (1971).

6. Here we follow the setup used, for other purposes, in Blinder (1981); see pp. 80-82.

7. For an extended, but obviously incomplete discussion of the notion of a loss function for stabilization policy, see Okun (1981). Though the supporting discussion is scattered through the text, pp. 297-99, summarize Okun's principal arguments.

8. Again, see Okun (1981). Note that, in principle, the loss function cited here is simply a more general variant of the loss function cited in note 7 above. Why, then, do we bother with the more restrictive case at all? There is a reason; the reader will have to judge how compelling it is. If one looks carefully at the loss function concept used, for example, in Okun (1981), it is evident that a consensus version of the loss function--one acceptable to the major macroeconomic policy makers and actors--will be difficult to attain: Implicit in the loss function is the relative social cost of unemployment and inflation, a matter on which there is serious disagreement. Thus the real usefulness of the loss function notion may be as a guide to what the tradeoffs are within some domain of policy choice demarcating the extent of consensus between macroeconomic policy actors and decision makers.

9. It is probably misleading to talk of a "program", since much of what is being done in modern disequilibrium theory is in principle relevant to the objective of endogenizing the structural coefficients of a wage-price equation system.

10. For MOdel of the Swedish Economic System. For documentation on the model, see for instance El asson (1978, 1980).

11. This is not the place to discuss the issue of "satisficing versus maximizing". But since we do use the notion of equilibrium, it may be worth saying that equilibria can of course be defined even when agents are "satisficing". Those equilibria may be more complex than the unique equilibria derived from optimization, but that is another issue. Econ-

omists who study actual firms have long recognized the impossibility of "profit maximizing" behavior by managers. And practical macroeconomists have come to recognize the significance of simple internal summary signals-like rates of return--in internal information transmission. The characteristic lag relationships between wages, prices and costs are unintelligible in the absence of such devices. See Eliasson (1978, pp 56-63 and pp 142 ff), and Okun (1981).

12. In any macroeconomics that is descriptive of actual macroeconomies, demand is of course "effective demand". That the effective demand concept "alone" has significant implications for economic dynamics has recently been shown by several authors, notably Varian (1975) and Eckalbar (1980). For an excellent survey, see Drazen (1980). Very roughly, in this line of work all agents are optimizing, but two changes in the usual Walrasian assumptions are made: demand is effective and not Walrasian demand, and the market tatonnement is on both quantities and prices. The novel result is the possibility of stable non-Walrasian equilibria.

The effort to find out how much we can explain about involuntary unemployment from such simple assumptions is intriguing. But the exclusion from such models of features of real macroeconomics that almost must matter in price and quantity determination leaves one to wonder about descriptive relevance. In particular, the non-Walrasian equilibria in those models are based upon assumptions of "two auctioneers"--one in quantities and one in prices--and full optimization by individual agents.

13. See Eliasson (1978, pp 73-75.) We say "mimics" to emphasize that this mechanism is not identical with the mechanism MOSES-model firms use to make their satisficing decisions. It is however useful for what we want to do here: to define a MOSES-like equilibrium concept. We repeat our caution that the "reduced" model described in this subsection is not identical with the full MOSES model.

14. This kind of "equilibrium in stochastic processes" is the hallmark of the so-called "new classical macroeconomics". See, for example, the equilibrium concepts defined in Lucas and Prescott (1974) and Prescott and Townsend (1980). Though introduced into economics by the proponents of one very particular kind of macroeconomics, this equilibrium concept should be a fruitful one in any rigorous macroeconomics.

15. The notion described here in words is similar to the Nash equilibrium concept of game theory. It is not necessarily identical with the Nash concept, since the noncooperative game is defined only in the labor market. The desirability of some Nash-like concept as a basis for a more plausible equilibrium concept in economics generally, and as a basis for a better macroeconomics, is discussed in Hahn (1977, 1978). A start towards understanding the dynamics such systems can generate is provided in Smale (1980).

16. For an introduction to modern stability theory, and to some of these possibilities, see Hirsch and Smale (1974).

17. This is a stylized version of the IUI dynamic sector model. See Ysander-Jansson-Nordström (1981).

18. The reader familiar with growth theory will quickly note that we are using a two-period model, and may reflect that an infinite-horizon model is more appropriate here. True; but we suspect that there is little to be gained from the added complexity of the general, infinite-horizon case. As a practical matter, political consensus on the weighting of consumption this decade versus consumption next decade will be hard enough to reach. To even talk of a consensus on the weighting of consumption into the indefinite future is, to say the least, optimistic.

References

Akerlof, G. 1979. "The Case Against Conservative Macroeconomics: An Inaugural Lecture", Economica, 46, 219-37.

Ando, Albert and Carl Palash, 1976. "Some Stabilization Problems of 1971-75, with an Application of Optimal Control Algorithms", in M. Intrilligator (ed).

Arrow, Kenneth J. and Mordechai Kurz, 1970. "Optimal Growth with Irreversible Investment in a Ramsey Model", Econometrica, Vol. 38, No. 2.

Azariadis, C., 1975. "Implicit Contracts and Unemployment Equilibrium", J. Polit. Econ., Dec. 1975, 83, 1183-202.

Baily, M. N., 1974. "Wages and Unemployment under Uncertain Demand", Rev. Econ. Stud., 41, 37-50.

Blinder, Alan S., 1980. "Supply Shock Inflation: Money, Expectations, and Accomodation", in J. Flanders and A. Razin (eds).

Blinder, Alan S, 1981. Economic Policy and the Great Stagflation (Academic Press, New York).

Brock, William A. and Leonard Mirman, 1972. "Optimal Economic Growth and Uncertainty: the Discounted Case", JET 4, 479-513.

Calvo, Guillermo, 1976. "Optimal Growth in a Putty-Clay Model", Econometrica, Vol. 44, No. 5.

Drazen, Allan, 1980. "Recent Developments in Macroeconomic Disequilibrium Theory", Econometrica, Vol. 48, No. 2.

Ecklabar, John C., 1980. "The Stability of Non-Walrasian Processes: Two Examples", Econometrica, Vol. 48, No. 2.

Eckstein, Otto, 1978. "The Great Recession". (North-Holland, Amsterdam).

Eliasson, G., 1978. "A Micro-to-Macro Model of the Swedish Economy", IUI Conference Reports 1978:1, Stockholm.

Eliasson, G., 1980. "Experiments with Fiscal Policy Parameters on a Micro-to-Macro Model of the Swedish Economy" in Haveman-Hollenbeck, Microeconomic Simulation Models for Public Policy Analysis, (Academic Press, New York), Volume 2.

Fischer, F. M., 1978. "Quantity Constraints, Spillovers, and the Hahn Process", Review of Economic Studies 45, 19-31.

Fischer, Franklin M., 1981. "Stability, Disequilibrium Awareness, and the Perception of New Opportunities", Econometrica, Vol. 49, No. 2.

Flanders, J. and A. Razin (eds), 1980. "Development in an Inflationary World". (Academic Press, New York).

Fried, E. R. and C. L. Schultze (eds), 1975. Higher Oil Prices and the World Economy (Brookings Institution, Washington, D.C.).

Gordon, Robert Aaron and Lawrence L. Klein (eds), 1965. Readings in Business Cycles (Richard D. Irwin, Inc., Homewood, Illinois).

Gramlich, Edward M., 1979. "Macro Policy Responses to Price Shocks", Brookings Papers on Economic Activity, No. 1, 125-66.

Grandmont, Jean-Michel and Guy Laroque, 1976. "On Temporary Keynesian Equilibria", Review of Economic Studies 43, 53-67.

Grandmont, Jean-Michel et al, 1978. "Equilibrium with Quantity Rationing and Recontracting", Journal of Economic Theory 19, 84-102.

Grossman, Sanford J., 1980. "Rational Expectations and the Econometric Modeling of Markets Subject to Uncertainty: A Bayesian Approach", In Zellner (ed).

Hahn, F. H., 1977. "Exercises in Conjectural Equilibria", Scandinavian Journal of Economics 79, 210-226.

Hahn, F. H., 1978. "On Non-Walrasian Equilibria", Review of Economic Studies 45, 1-17.

Hicks, John, 1979. The Crisis in Keynesian Economics (Basic Books, Inc., New York).

Hildenbrand, K. and W. Hildenbrand, 1978. "On Keynesian Equilibria with Unemployment and Quantity Rationing", Journal of Economic Theory 18, 255-277.

Hirsch, Morris W. and Stephen Smale, 1974. Differential Equations, Dynamical Systems and Linear Algebra (Academic Press, New York).

Intrilligator, M. (ed), 1976. Frontiers of Quantitative Economics, Vol. III (North-Holland, Amsterdam).

Jordan, J. S., 1980. "On the Predictability of Economic Events", Vo. 48, No. 4.

Lindbeck, Assar (ed), 1979. Inflation and Unemployment in Open Economies (North-Holland, Amsterdam).

Lucas, Robert E., Jr. and E. Prescott, 1974. "Equilibrium Search and Unemployment", Journal of Economic Theory 7, 188-209.

Malinvaud, Edmond, 1953. "Capital Accumulation and Efficient Allocation of Resources", Econometrica 21, 233-68.

Malinvaud, Edmond, 1977. The Theory of Unemployment Reconsidered (Joh Wiley and Sons, New York).

Meltzer, Allan H. and Karl Brunner, 1981. Supply Shocks, Incentives, and National Wealth (North-Holland, Amsterdam).

Modigliani, Franco and Charles Steindel, 1977. "Is a Tax Debate an Effective Tool for Stabilization Policy?", Prookings Papers on Economic Activity 1, 175-203.

Modigliani, Franco and Lucas Papademos, 1978. "Optimal Demand Policies Against Stagflation", Weltwirtschaftliches Archiv, Vol. 114, No. 4, pp. 736-82.

Negishi, T., 1960-61. "Monopolistic Competition and General Equilibrium", Review of Economic Studies 28, 196-201.

Okun, Arthur M., 1981. Prices and Quantities: a Macroeconomic Analysis (Brookings Institution, Washington, D.C.).

Perry, George, 1975. "The United States", in E. R. Fried and C. L. Schultze (eds) (1975).

Pierce, James L. and Jared J. Enzler, 1974. "The Effects of External Inflationary Shocks", Brookings Papers on Economic Activity 1, 13-54.

Prescott, Edward C. and Robert M. Townsend, 1980. "Equilibrium and Uncertainty: Multiagent Statistical Decision Theory", in Arnold Zellner (ed).

Radner, R., 1979. "Rational Expectations Equilibrium: Generic Existence and the Information Revealed by Prices", Econometrica, Vol. 47, No. 3.

Sanderson, Allen R. (ed), 1981. DRI Readings in Macroeconomics (McGraw-Hill Book Company, New York).

Samle, Steve, 1980. "The Prisoner's Dilemma and Dynamical Systems Associated to Non-Cooperative Games", Econometrica, Vol. 48, No. 7.

Solow, Robert M. and Joseph E. Stiglitz, 1968. "Output, Employment and Wages in the Short Run", QJE, Vol. LXXXII, No. 4.

Solow, Robert M., 1979. "Alternative Approaches to Macroeconomic Theory: A Partial View", Canadian Journal of Economics, 12, 339-54.

Solow, Robert M., 1980. "On Theories of Unemployment", American Economic Review, Vol. 70, No. 1, pp. 1-11.

Tobin, James, 1980. Asset Accumulation and Economic Activity: Reflections on Contemporary Macroeconomics (University of Chicago Press, Chicago).

Varian, Hal R., 1975. "On Persistent Disequilibrium", Journal of Economic Theory 10, 218-228.

Varian, Hal R., 1977. "Non-Walrasian Equilibria", Econometrica, Vol. 45, No. 3.

Wallich, Hencry C. and Sidney Weintraub, 1971. "A Tax-Based Incomes Policy", Journal of Economic Issues, Vol. 5, pp. 1-19.

Wan, Henry Y., 1971. Economic Growth (Harcourt Brace Jovanovich, Inc., New York).

Wilson, Robert, 1988. "Information, Efficiency, and the Core of an Economy", Econometrica, Vol. 46, No. 4.

Ysander, B.-C., Jansson, L., Nordström, T. "The Structure of the ISAC Model", IUI Working Paper No. 42, 1981.

Zellner, Arnold (ed), 1980. Bayesian Analysis in Econometrics and Statistics (North-Holland, Amsterdam).