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The Inflation Debate: An Attempt to Clear the Air

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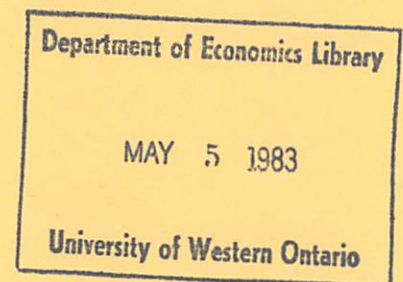
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THE INFLATION DEBATE: AN ATTEMPT TO CLEAR THE AIR

Michael Parkin

This paper contains preliminary findings from research work still in progress and should not be quoted without prior approval of the author.

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THE INFLATION DEBATE: AN ATTEMPT TO CLEAR THE AIR

By

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April, 1983

This paper has benefitted from discussions and exchanges of papers with Richard Lipsey and Pierre Fortin.

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THE INFLATION DEBATE: AN ATTEMPT TO CLEAR THE AIR
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I. INTRODUCTION

The central purpose of this paper is to review the theory of, and empirical evidence on, the inflation process. The practical question of concern is: What can we do to achieve and maintain low inflation with adequate real economic performance?

The originally perceived task was for Richard Lipsey and myself to set out as clearly as we could a research agenda, the successful pursuit and completion of which, would lead to a consensus on the central question of concern--and the related question--Why has Canada's inflation been so stubborn? It quickly became apparent to both of us, however, that we were too far apart in our views on this topic to be able to draw up that agenda. Our disagreements are fundamental and concern (a) whether or not there exists a viable neo-Keynesian explanation for inflation that stands in contrast to what I call a rational explanation, and (b) on what constitutes an explanation for the phenomenon under discussion.

A major purpose of this paper, therefore, is to address these deeper issues. In pursuing my task I am, going to say very little explicitly about Canada and Canadian inflation. We are not, in my view, yet ready for that. Our differences are too deep. Rather, I am going to address the issues in general terms and where I do draw on evidence, I shall pay as much attention to the United States as to Canada for it is American studies that seem to have been the most influential in shaping Lipsey's views on the inflationary process.

This means that, for the most part, I am going to have to ignore the details of the interesting paper that accompanies this and Lipsey's (1983) by Pierre Fortin (1983) and that deals, at greater length than here, with some open economy issues. Important though these issues are, addressing them here would cause too great a diversion from my central purpose.

To ensure that there is a minimum of misunderstanding about Lipsey's neo-Keynesian analysis of inflation, I shall begin (in part I) by stating that theory as presented by Lipsey's declared authority--Otto Eckstein (1981)--and in as uncritical a manner as possible. I shall also report (as far as is possible from Eckstein's own incomplete and ambiguous account of his work) the results of the empirical implementation of the neo-Keynesian theory on the U.S. data. Pierre Fortin's (1983) summary of similar open Canadian work, done primarily at the Bank of Canada, complements my summary of Eckstein.

I shall then (in part II) embark upon a critique of the neo-Keynesian theory of inflation. I shall show that Eckstein's analysis of core inflation, which Lipsey claims to be the definitive statement has two fundamental defects. First, the theory of core inflation is either empty or is a proposition stating that core inflation is identically equal to the expected rate of inflation. If it is the latter it leads to a need for a theory of inflation expectations. I shall show that adaptive expectations will simply not do the job. In its simplest forms it does not fit the facts and in its most general form it is a description and not a theory. Second, the empirical implementation of the core theory of inflation is seriously defective and may, at best, be regarded as a description of the phenomenon to be explained, and, at worst, a smoke screen which renders clear thinking virtually impossible.

I shall then go on (in part III) to describe and discuss the serious and constructive efforts being made by classical and Keynesian scholars alike to find an adequate theory of the inflationary process and (in part IV) the efforts of econometricians to develop ways of identifying, estimating and testing the new generation of rational models. Whether or not these models

will deliver the answers remains to be seen. They are, for the moment, all that we have available and they do look promising.

I now turn to my first task: a presentation of the neo-Keynesian theory of inflation.

II. THE NEO-KEYNESIAN APPROACH

My central purpose in this section is to present as clear a statement as possible of the neo-Keynesian theory of inflation, and of its empirical implementation, as set out by Otto Eckstein in Core Inflation. I do this for two reasons. First, Lipsey states that "with one or two caveats I would be prepared to take Otto Eckstein's 'model' in his book Core Inflation as the neo-Keynesian mainline price equation." (Lipsey, 1983, p. 2, emphasis in original). I take it that this means that the neo-Keynesian theory as stated by Eckstein is not a straw man and is indeed, if not the definitive statement of the theory, one of its definitive statements. Second, I want the Eckstein model and an account of its empirical content to be on the record in a compact and accurate form so that I can develop a critique of it in the next section. Let me begin with the theory.

(i) The Neo-Keynesian Theory

The starting point for the Neo-Keynesian theory presented by Eckstein is to decompose the inflation rate into three components, core (\dot{p}_c), demand (\dot{p}_d), and shock (\dot{p}_s) inflation. That is;

$$\dot{p} = \dot{p}_c + \dot{p}_d + \dot{p}_s \quad (1)$$

"The core rate of inflation...[is]...the rate that would occur on the economy's long-term growth path, provided the path were free of shocks, and the state of demand were neutral in the sense that markets were in long-run

equilibrium. The core rate reflects those price increases made necessary by the increases in the trend costs of the inputs to production." (Eckstein, p. 8). "The demand inflation rate...depend[s]...on utilization rates of resources. ...[B]oth the unemployment rate and the operating rate of physical capital are pertinent, and the effects are non-linear." (Eckstein, p. 9). "The shock inflation rate is, by definition, exogenous to the analysis." (Eckstein p. 9).

Eckstein goes on to elaborate on these three elements of inflation starting with core inflation. In developing the analysis of the core inflation rate Eckstein assumes a Cobb-Douglas production function with Hicks-neutral technical change. This enables him to write the relationship between the core inflation rate and the increases in factor prices as:

$$\dot{p}_c = a_1 \dot{q} + a_2 \dot{w} - h \quad (2)$$

where a_1 is the exponent on capital and a_2 the exponent on labour in the production function, h is the rate of Hicks-neutral technical progress, q is the rate of change of the rental price of capital and w is the rate of change of money wages.

Eckstein proceeds from here to develop propositions about the behaviour of the rate of change of the rental price of capital and money wages. Specifically, he postulates that the rate of change of the rental price of capital depends upon "a composite cost of financial capital variable" (r) and "a composite tax variable on capital and its income" (J_q): Thus,

$$\dot{q} = \alpha(r, J_q) \quad (3)$$

The financial cost variable (r) "is determined by the long-term inflation expectations embodied in nominal interest rates and equity yields" \dot{p}^e , (Eckstein p. 9) so that

$$\dot{q} = \alpha(\dot{p}_q^e, J_q) \quad (4)$$

"Similarly, wages on the equilibrium path are determined by the price expectations underlying wage claims (\dot{p}^e) and possible tax effects J_w " (Eckstein p. 9), i.e.

$$\dot{w} = \beta(\dot{p}_w^e, J_w) \quad (5)$$

"Price expectations are formed on the basis of inflation experience as measured by distributed lags on actual prices and need not be the same for bond buyers as for workers." Eckstein p. 9) i.e.

$$\dot{p}_q^e = \sum_{t=0}^{-\infty} \lambda_t \dot{p}_t \quad (6)$$

$$\dot{p}_w^e = \sum_{t=0}^{-\infty} \mu_t \dot{p}_t \quad (7)$$

Using (6) in (4) and (7) in (5) and substituting the results into (2) gives

$$\dot{p}_c = a_1 \alpha \left(\sum_{t=0}^{-\infty} \lambda_t \dot{p}_t, J_q \right) + a_2 \left(\sum_{t=0}^{-\infty} \mu_t \dot{p}_t, J_w \right) - h \quad (8)$$

Eckstein goes on to observe that "since the actual inflation of a period...is composed of the three components,....[core, demand and shock inflation]...., and the core inflation rate is affected by the actual record of inflation as processed into current expectations, the core inflation rate can be written in terms of previous demand and shock inflation, productivity, and taxes," (Eckstein, p. 9) i.e.

$$\dot{p}_c = \delta \left(\dot{p}_d, p_{d_{t-1}}, \dots, p_s, p_{s_{t-1}}, \dots, h_t, h_{t-1}, \dots, J_{q_t}, J_{q_{t-1}}, \dots, J_{w_t}, J_{w_{t-1}}, \dots \right) \quad (9)$$

This completes the theory of core inflation.

Demand inflation is determined by the utilization rates of labour (u_ℓ) and of capital (u_{cap}) that is

$$\dot{p}_a = \gamma(u_\ell, u_{cap}) \quad \gamma_1, \gamma_2 < 0 \quad (10)$$

Using these determinants of demand inflation to eliminate the history of demand inflation from equation (9) gives the final statement concerning the

determination of core inflation as

$$\dot{p}_{c_t} = f(u_{l_t}, u_{l_{t-1}}, \dots, u_{cap_t}, u_{cap_{t-1}}, \dots, \dot{p}_{s_t}, \dot{p}_{s_{t-1}}, \dots, h_t, h_{t-1}, \dots, J_{q_t}, J_{q_{t-1}}, \dots, J_{w_t}, J_{w_{t-1}}, \dots) \quad (11)$$

By combining equation (11) and (10) together with the current period's shock inflation we obtain a statement about the actual rate of inflation as:

$$\dot{p}_t = f(u_{l_t}, u_{l_{t-1}}, \dots, u_{cap_t}, u_{cap_{t-1}}, \dots, \dot{p}_{s_t}, \dot{p}_{s_{t-1}}, \dots, h_t, h_{t-1}, \dots, J_{q_t}, J_{q_{t-1}}, \dots, J_{w_t}, J_{w_{t-1}}, \dots) + \gamma(u_{l_t}, u_{cap_t}) + \dot{p}_{s_t} \quad (12)$$

Thus, the current period rate of inflation will be equal to the core rate that in turn depends upon the entire history of the utilization rates of labour and capital, of shock inflation, productivity growth, and of capital and labour taxes as well as the current utilization rates of labour and capital and the current inflationary shock.

(ii) Empirical Implementation

Although Eckstein states his theory of core inflation in just two pages, it takes virtually the rest of his book (approximately a further one-hundred pages) to describe the way in which the theory is implemented empirically and the way in which it may then be used to decompose inflationary history (of the United States) into its core, demand, and shock components. The description of the empirical work is not quite complete, though with care, it is possible to piece together the empirical counterparts of most of the

parameters that appear in the theoretical statement of the model. What follows is my best effort to produce a succinct summary of those parameters.

The equations requiring estimation are those listed as (2) through (7), and (10) above. In addition, although shock inflation is exogenous, it is, for empirical purposes, decomposed into five separate shock sources each of which are analyzed as exogenous processes. I shall review each of these equations and propositions in order.

First, consider equation (2). It requires Cobb-Douglas production function exponents together with a productivity growth trend. The production function parameters are taken from average factor shares and are .35 for capital and .65 for labour. I could not find the productivity growth trend assumed but one may presume that it is some long-term average (which possibly declined in the second half of the seventies).

Equation (3), the behaviour of the rental price of capital is derived analytically from a Jorgensen (1963) type analysis and is not, therefore, estimated empirically. In order to make the transition, however, from equation (3) to equation (4) a proposition linking inflationary expectations to the market rate of interest is required. This provides the first estimated empirical relationship in the model. The easiest way to summarize this interest rate equation is in tabular form and Table 1 provides the relevant details. Since that table uses readily interpreted descriptions of the dependent and independent variables there is no need to provide further elaboration of the equation here.

Equation (5), the wage equation, is the second behavioural equation that is estimated by Eckstein and it is summarized in Table 2. Like Table 1, it also is sufficiently detailed in its description of the dependent and independent variables to require no further elaboration.

The inflation expectations equations, (6) and (7), are given by:

$$\dot{p}_{q_t}^e = 0.79\dot{p}_t + 0.21\dot{p}_{q_{t-1}}^e \quad (13)$$

$$\dot{p}_{w_t}^e = 0.86\dot{p}_t + 0.14\dot{p}_{w_{t-1}}^e \quad (14)$$

Additionally, in the interest rate equation, the expected Standard and Poor's (S & P) stock index appears (not specified in the theoretical statement of the model) and it in turn is generated by

$$(S \& P)_t^e = 0.34(S \& P)_t + 0.66(S \& P)_{t-1}^e \quad (15)$$

To estimate equation (10), the demand inflation equation, Eckstein subtracts core inflation from the actual rate of inflation and also subtracts the shocks to inflation (see below). He then regresses the calculated demand inflation on adjusted unemployment and capacity utilization rate variables together with dummy variables for controls as follows:

$$\begin{aligned} \dot{p}_d = & -7.7 + \sum_{i=-7}^{-1} \alpha_i (1/(\text{Unemployment less an adjustment for} \\ & \text{demographic factors})) \\ & + \sum_{i=-7}^{-1} \beta_i (1/(1.1 \text{ less capacity utilization rate} \\ & \text{in manufacturing})) \quad (16) \\ & + 0.2 \quad (\text{Price control dummy} - 0.05 \text{ another price} \\ & \text{control dummy}) \end{aligned}$$

$$\sum \alpha_i = 13.8, \quad \sum \beta_i = 1.1, \quad \bar{R}^2 = 0.91, \quad DW = 0.75$$

The shock rate of inflation, although exogenous, is modelled in a considerable amount of detail. "In order to isolate the components of the shock variable, full...[DRI]...model simulations were run to measure reduced-form impacts on the price level...[of changes in energy prices, food prices, the exchange rate, the social security tax rate, and the minimum wage rate]....The relationships identified through the model runs yield[ed] time series which...[were]...combined with historical values of the exogenous variables to derive the shock effects." (Eckstein, p. 17). The exogenous processes driving these five shock effects are:

$$\begin{aligned} \dot{p}_s \text{ energy} &= a(L) \text{ Percentage change in wholesale price} \\ &\quad \text{index for fuels, etc.} \qquad (17) \\ a(L) &= 0.008 + 0.013L + 0.014L^2 + 0.015L^3 \end{aligned}$$

$$\begin{aligned} \dot{p}_s \text{ food} &= b(L) \text{ Percentage change in wholesale price} \\ &\quad \text{index for farm products} \qquad (18) \\ b(L) &= 0.007 + 0.012L + 0.014L^2 + 0.014L^3 \end{aligned}$$

$$\begin{aligned} \dot{p}_s \text{ exchange rate} &= c(L) \text{ Percentage change in Morgan} \\ &\quad \text{Guaranty Trust trade-weighted} \\ &\quad \text{index of U.S. dollar exchange} \\ &\quad \text{rate} \qquad (19) \\ c(L) &= -.001 - .003L - .005L^2 - .008L^3 \end{aligned}$$

$$\begin{aligned} \dot{p}_s \text{ social security} &= d(L) \text{ Percentage change in Federal} \\ &\quad \text{Social Security Contributions} \qquad (20) \\ d(L) &= 15.4 + 16.8L + 9.5L^2 + 0.9L^3 \end{aligned}$$

$$\begin{aligned} \dot{p}_s \text{ minimum wage} &= e(L) \text{ Percentage change in Federal} \\ &\quad \text{minimum wage} \qquad (21) \\ e(L) &= 0.0004 + 0.001L + 0.002L^2 + 0.003L^3 \end{aligned}$$

The above constitutes an almost complete description of the way in which the neo-Keynesian theory of inflation has been implemented empirically by Eckstein. It is incomplete in that it has not described the way in which taxes are modelled as influencing the rental price of capital and wages, nor has it explained the way in which the model (the DRI model) generates the rates of unemployment and capacity utilization. To embark upon a description of that detail would divert me too far from my present objective.

Using the equations described above (together with the additional inputs just noted) it is possible to calculate a decomposition of actual inflation into its core, demand and shock components. Eckstein does that and provides an extensive commentary upon the decomposition. This historical review is summarized in Table 3.

This completes my factual summary of the neo-Keynesian theory of inflation as developed by Eckstein. I now turn to a critical appraisal of that theory.

III. A CRITIQUE OF THE NEO-KEYNESIAN THEORY

The neo-Keynesian theory of core inflation as presented by Eckstein certainly fits the fact. What exactly is it, however, that fits the facts? That is, what is the theory that fits the facts? Any theory that is to be useful must satisfy at least two requirements. First, its predictions must be the logical consequences of its assumptions and second, the theory must represent an abstraction from the real world which identifies parameters that are stable and provide a stable relationship amongst the variables so that it may be used to generate predictions that are reliable in a wide variety of circumstances. The neo-Keynesian theory of inflation suffers on both these counts. First, I want to investigate its lack of logical coherence.

(i) A Critique of the Core Inflation Theory

It will be most convenient to begin by ignoring taxes. It turns out that the incorporation of taxes makes only a slight difference and gets in the way of a clear-headed presentation of the central relationships involved.

I shall follow Eckstein and assume a Cobb-Douglas production function with Hicks-neutral technical change so that the relationship between the core inflation rate and rate of change of factor prices is given by

$$\dot{p}_c = \alpha \dot{q} + (1 - \alpha) \dot{w} - h \quad (22)$$

The parameter α is the share of capital in GNP and $1 - \alpha$ is the share of labour.

To investigate the way in which the rates of change of factor prices are generated when the conditions for the core rate of inflation are satisfied it is necessary to recall what the core inflation rate is. Eckstein's definition (quoted above) states that "the core rate of inflation...[is] ...the rate that would occur on the economy's long-term growth path, provided the path were free of shocks and the state of demand were neutral in the sense that markets were in long-run equilibrium." (Eckstein p. 8). To calculate the factor price movements that would obtain in such a situation let us begin by considering the rental price of capital. Using the standard definition of that rental price (obtained from the Euler equation) we know that

$$Q = P_Q (R + \delta - \dot{P}_Q / P_Q) \quad (23)$$

Differentiating equation (23) with respect to time it is apparent that

$$\dot{q} = \dot{p}_Q + \dot{r}/r \quad (24)$$

where

$$\dot{q} \equiv \dot{Q}/Q, \dot{p}_Q = \dot{P}_Q/P_Q, r \equiv (R + \delta - \dot{P}_Q/P_Q)$$

Thus, the rate of change of the rental price of capital is equal to the rate of inflation of the price of capital goods plus the proportionate rate of change of the real rate of interest. Notice the contrast between this and Eckstein's equation. He makes the rate of change of the rental price of capital depend upon "the composite cost of financial capital". In long-run equilibrium, when the economy is on its long-term growth path, (the conditions for the core inflation rate) the rate of inflation of capital goods prices (\dot{p}_Q) will be equal to the core rate of inflation plus the Hicks-neutral rate of technical progress. That is,

$$\dot{p}_Q = \dot{p}_c + h \quad (25)$$

Further, the real rate of interest will be constant so that

$$\dot{r}/r = 0 \quad (26)$$

Using these two conditions in equation (24) gives

$$\dot{q} = \dot{p}_c + h \quad (27)$$

The contrast with Eckstein's equation is quite remarkable. Using (27) in (22) (in the definition of core inflation) gives

$$\dot{p}_c = \dot{w} - h \quad (28)$$

Evidently the core inflation rate has nothing whatsoever to do with the rate at which rental prices are changing for those rental price changes are themselves uniquely related to the core inflation rate. We have not, however, finished.

As written in equation (28) it appears as if the core rate of inflation is the rate of growth of unit labor costs. As a matter of definition that is clearly so. It would be wrong, however, to conclude that the core inflation rate is somehow uniquely determined by the rate of growth of unit labour costs. Such a conclusion would be unwarranted for the following reason. We know that in a long-run equilibrium when the economy is on its long-term growth path the share of labour in the national income will be a constant given by the exponent on labour in the Cobb-Douglas production function. That is, $WL = (1-\alpha)PY$. Dividing by L , taking the logarithms of both sides, and differentiating with respect to time and noting that the rate of growth of output per head is equal to the Hicks-neutral rate of technical progress

delivers the proposition that

$$\dot{w} = \dot{p}_c + h \quad (29)$$

Using this in (28) gives the rather obvious but entirely empty proposition that

$$\dot{p}_c = \dot{p}_c \quad (30)$$

The only objection that can be raised to the analysis developed from equation (22) to equation (30) is that it was obvious from the beginning that the exercise is redundant. I sympathize with that view but, in the light of the fact that Eckstein seems to believe that he has discovered a theory of core inflation and that so many neo-Keynesians (not only Lipsey, but also, for example, Alan Blinder (1982) in his review of Eckstein's book), it seemed necessary to be pedantic in spelling out the vacuity of this alleged theory.

An alternative route to that taken above would propose that, in long-run equilibrium, equation (27) should read

$$\dot{q} = \dot{p}^e + h \quad (27')$$

emphasizing the fact that in long-run equilibrium factor prices fully reflect underlying inflation expectations. Further, on this interpretation, equation (29) would read

$$\dot{w} = \dot{p}^e + h \quad (29')$$

I have specified the inflation expectations in equations (27') and (29') to be the same reflecting the idea that in long-run equilibrium, when the economy is on its long-term growth path, (a phrase which I keep repeating to remind the reader that these are Eckstein's declared conditions under which the core inflation concept is relevant) any disparate expectations would give rise to continuing divergences of relative factor prices and, therefore, could not be consistent with the concept of core inflation.

Combining equations (27') and (29') with equation (22) gives

$$\dot{p}^c = \dot{p}^e \quad (30')$$

Thus, on this (more generous) interpretation of the core theory, the core rate of inflation is identical to the expected rate of inflation.

Why does Eckstein not get these results? The answer is that he obscures the relationships between inflation expectations (or the core inflation rate) and the factor price movements that will occur when the conditions defining a core situation are satisfied. His equations (4), (5) and (6) (equations (3), (4) and (5) in the presentation earlier in this paper) are specified with insufficient precision. In relating the rate of change of the rental price of capital to a "composite cost of capital" variable (Eckstein's equation 4, equation (3) above) simply obfuscates the correct relationship. Failing to impose equality of expectations and failing to impose the appropriate relationships between core inflation rates, productivity growth rates and factor price changes on the functions $\alpha(\cdot)$ and $\beta(\cdot)$ fails to take account of restrictions that are implied by Eckstein's own theory. A failure to take account of those restrictions leads to a misleadingly general statement of the determination of core inflation.

Viewed in narrow and precise terms the core rate of inflation is indeterminate. Viewed more generously is a definition of the expected inflation rate. Clearly Eckstein has something like this broader idea in mind for he says "the cost increases...[that underlie the core rate of inflation]...are largely a function of underlying price expectations" (Eckstein p. 8). On this interpretation the core inflation rate and the expected inflation rate are identical and we are no further forward until we have a theory (and I emphasize theory) of inflation expectations.

It may be objected that by ignoring taxes I have lost the essence of Eckstein's theory of core inflation. A moment's reflection will reveal that not to be so. Incorporating taxes into the analysis presented above would leave everything exactly as it is if those taxes were not changing on the steady state growth path. If taxes were changing then the rate of change of taxes would appear in the relevant equations. The levels of taxes would not appear. It is difficult (though not impossible) to imagine taxes changing on an ongoing basis. It does seem, however, much more sensible to treat tax changes as part of shock inflation rather than as part of the core. Nevertheless, to the extent that tax systems are not fully neutral so that taxes do change as a result of ongoing inflation (for example, so-called bracket-creep) ongoing changes in tax rates would become relevant variables in the equations determining the changes in factor prices. They would operate, however, in exactly the same way as productivity growth does. That is, the relationship between core inflation and factor prices would have to be determined in terms of net of tax factor prices.

Further, the relationship between the rate of change of factor prices, the expected rate of inflation, and the rate of change of taxes would also have to be specified to be consistent with the Euler equation and to

incorporate the long run equilibrium changes in net of tax relative factor shares generated by the ongoing steady state changes in tax rates. (It is curious that Eckstein does not incorporate net of tax factor prices in his statement defining the relationship between core inflation and factor price changes but only puts taxes in the equations generating factor price movements themselves.)

Once the above errors are corrected we are left with the bottom line proposition that the core rate of inflation is either indeterminate or is the same thing as the expected rate of inflation.

If the core rate of inflation is interpreted as the expected rate of inflation it is clear that the neo-Keynesian theory becomes nothing other than the traditional expectations-augmented Phillips curve. Core inflation itself is the expected rate of inflation, demand inflation is the short-run Phillips curve and shock inflation is the random disturbance that would normally appear on an expectations augmented Phillips curve. In order to complete that theory a theory of expectations is required and the shocks themselves would have to have a zero mean.

Let me now turn to appraise the way in which Eckstein has estimated the neo-Keynesian model.

(ii) A Critique of the Empirical Implementation of the
Neo-Keynesian Core Theory

If the neo-Keynesian theory of core inflation is empty it follows that no empirical work can be done using that theory. Any empirical work purporting to constitute a testing and an estimation of the parameters implied by that theory must, of necessity, be misconceived. Whatever the model being estimated and tested it is emphatically not the neo-Keynesian model of core inflation.

Reviewing the empirical work reported in the previous section, it appears that the best interpretation that may be placed upon it is that it constitutes a description of the phenomenon to be explained and not an explanation. It describes the time series of the inflation rate in a particular country during a particular historical episode in terms of a set of parameters and relationships that are neither derived from nor consistent with the stated theory of core inflation.

Several detailed aspects of Eckstein's empirical work reinforce this claim. First, the core inflation rate depends on inflation expectations that differ depending on whether the interest rate or rate of wage inflation is being modelled. It is true that the differences in the expectations formation schemes are slight and true that no statistical significance tests attach to those differences (the parameters being reported without standard errors). Nevertheless, different point estimates for the parameters of the expectations generating mechanisms in the two equations are reported as being a feature of the world described. They are not consistent with the theory.

Second, the theory of core inflation implies that both the nominal interest rate equation and the wage inflation equation will be homogeneous of degree one in the core rate of inflation. Such homogeneity is neither imposed nor found, though it is quite likely not significantly rejected.

Third, and quite perplexingly, demand pressure variables appear in the wage equation even though that wage equation is purportedly describing the behaviour of the core rate of inflation of wages.

These details pale into insignificance when a further factor is considered and that concerns the excessive greediness of this particular theory in terms of the degrees of freedom it swallows. On my count I was able to identify (and find the values of) 76 parameters. I was not able to

find the detailed parameters concerning the tax structure that influences the rental rate of capital. Nor was I able to identify and count the parameters used to adjust the unemployment rate for demographic factors. Finally, I was not able to count all the zeros that were imposed as a result of experimentation to find the "best equation". When one recognizes that only slightly more than 100 data points (in quarterly data) are being explained--approximately twenty-six years--it becomes clear that this so-called theory of inflation is nothing other than an alternative way of representing the time series.

If we need 76 (at least) parameters to "explain" (i.e. to "understand") twenty-six years of inflation behaviour for one country, how many parameters should we need to understand the inflation behaviour of all the major countries and over a more lengthy and varied time period? I leave the question in rhetorical form. The question serves to underline the inevitable conclusion that this so-called neo-Keynesian theory of inflation is not a theory at all. It is an obfuscating description. A time-series graph would be more revealing and give greater insight into the inflationary process in the United States (and Canada) in the last twenty-five years than does what can only be described as a garbage heap of computer print-out masquerading as an explanation.

If these considerations are not sufficient there is a further one that must be severely disquieting for anyone seeking to understand the inflation of the 1970s and it concerns the role played by so-called shocks in this analysis. First it is instructive to notice what the shocks are. One of them is the price of oil, another is the price of food. A third one is the behaviour of the exchange rate. In treating these as shocks to the inflation rate we seem to be losing sight of the fundamental problem to be explained. Inflation is, by definition, the percentage rate of change of the price

level. The price level is a weighted average of the money prices of all goods. Some prices rise faster than others and it is the average that we seek to explain. Now it is, of course, a historical fact the average has been increasing at an increasing rate during the decade of the 1970s. To select items from the average whose behaviour has been substantially above the average and to call those items sources of shock and therefore a "source" of inflation is mischievously fallacious. Evidently, if the inflation rate had been declining rather than rising during the 1970s it would be because of the negative shocks being injected from the price of computing equipment and related electronic gadgetry!

The same remarks apply with even greater force to the behaviour of the exchange rate. The foreign exchange rate being the relative price of domestic to rest-of-world money is itself a price. It is true that it is not a price that directly forms part of the weighted average whose behaviour we seek to explain. It almost gets into that average directly however through its effects upon the money prices of internationally traded commodities that appear in the index.

None of this perhaps would matter were it not for the fact that shock inflation has been sizeable and persistently positive during the decade of the 1970s. Inspection of Table 3 shows that, the accumulated shocks through the 1970s amounted to 14.5 percent. Since, on the open admission of the neo-Keynesians, the shocks are exogenous, this amounts to saying that there is no explanation within this theory for the rising inflation of the 1970s.

The overall conclusion that I reach--and that seems to me to be the only conclusion that a disinterested scholar could reach--is that there is no neo-Keynesian theory of inflation. What has been presented as a theory is analytically sterile and empirically empty.

I now want to turn my attention away from the neo-Keynesian void towards the mainstream developments in post-Keynesian macroeconomics and examine how attempts to develop further the notion of individual rationality, especially in the area of expectation formation, is leading to new models of inflation which do stand some chance of helping us to understand that phenomenon.

IV. RATIONAL EXPLANATIONS OF INFLATION

The rational expectations hypothesis introduces into macroeconomics an assumption so radical that it transforms beyond recognition any theory into which it is incorporated. It is a much misunderstood hypothesis and one that is widely resisted. This is surprising for, properly understood, it provides a neat and powerful way of reconciling the flexible price models of the classical tradition and the fixed-price models of the Keynesian tradition. The hypothesis forces us to distinguish sharply between anticipated and unanticipated changes in exogenous variables. In rational expectations models, the economy responds to a fully anticipated shock in a manner that is identical to the predictions of classical theory while it responds to an unanticipated shock in a manner that is qualitatively identical to the predictions of Keynesian theory. Notwithstanding this, the hypothesis remains widely resisted and misunderstood.

The main misunderstandings seem to arise from two confusions: between rational expectations and perfect foresight, and between rational expectations and market clearing. The rational expectations hypothesis implies neither perfect foresight nor market clearing.

The confusion between rational expectations and perfect foresight seems to be related to the notion that to form rational expectations people have to be "smart". In fact it implies no such thing. In its simplest form it is nothing other than an assumption that people are not so stupid as to

knowingly waste information. It visualizes people calculating averages (conditional means) on the basis of all information available to them. Not much information is needed to calculate a mean but of course the less information there is the less confidently will the calculated point estimate be believed. Furthermore, the more frequent and the larger will be the errors typically made.

The confusion between rational expectations and market clearing probably arises from the fact that the first generation of rational expectations models did indeed incorporate the assumption of market clearing (particularly the work of Robert E. Lucas Jr. (1973) and Robert J. Barro (1975)). There has, however, now grown up an impressive body of non-market clearing models that incorporate rational expectations (particularly the work of Edmund Phelps and John Taylor (1977), Stanley Fischer (1977), and John Taylor (1979) an overview of which is presented in Parkin (1982).

Although the idea of rational expectations does not imply that people are smart and only requires them to be able to calculate means, the implementation of the hypothesis in the context of a macroeconomic model can only be achieved by assuming that people in fact know the model that is being analyzed. This is a technical requirement, essential for solving such models and is not a statement about the behaviour of people in the real world. It is recognized that the assumption is an "as if" one. By making this assumption strong restrictions are placed on a model making it more, not less, likely that it will be rejected by the facts. This is regarded by advocates of the rational expectations hypothesis as one of its great strengths for it does not enable loose ad hoc lag structures to be brought to the rescue of a faltering theory.

It is important to emphasize that the assumption that people behave "as if" they know the model being analyzed is in no way inconsistent with the simpler idea that what they in fact do is calculate conditional means. One can imagine that, in calculating rational expectations, people simply calculate the predictions made by an unrestricted reduced form model. If the economist investigating behaviour assumes a model and then postulates the people that inhabit that model form their expectations as the predictions of the model, the economist's reduced form will be a special case of the reduced form used by agents in the actual world. It will be the special case that imposes the overidentifying restrictions on that reduced form implied by the theory.

It is a valid test of the assumed model that its overidentifying restrictions are not rejected by the data. If they are not rejected then the restricted reduced form parameters are not significantly different from those of the unrestricted reduced form. Thus, rational agents forming expectations on the basis of the unrestricted reduced form, will have the same expectations as those generated by the particular (and non-rejected) model employed by the economist.

The economist's predictions might have a tighter distribution on them than those of people who simply calculates means. It is possible, however, to refine the notion of rational expectations and suppose that people do not only calculate means but also higher moments of the frequency distributions of variables of relevance to their behaviour. These considerations, however, take us well beyond the simplest notions of rational expectations that are incorporated in the current generation of macroeconomic models.

The rational expectations hypothesis, as applied to the task of understanding inflation, requires the development of a model of the economy

capable of predicting the rate of inflation. If, as will usually be the case, one of the variables in the structural model is the expected rate of inflation, that expectation must be the prediction of the model concerning inflation. The rational expectations hypothesis, as such, places no restrictions on which particular model one may advance and, as already noted, there has developed two main traditions in this regard, one usually labelled new-classical (market clearing) and the other new Keynesian (non-market clearing). These two models differ in their specification of the supply side of the economy and, in particular, in what they assume about the labour market. I shall first provide an intuitive and general guide to these two approaches and then give an example of each.

(i) Overview of Rational Classical and Keynesian Models

In the new-classical rational model, factors of production are supplied in response to their perceived real price. This perceived real price is the ratio of a known price (in money terms) of the good being traded and the expectation of the general price level. The higher is the perceived relative price of the good being supplied the more of it will be supplied. The hypothesis is usually augmented with an assumption about non-linear adjustment costs that introduce inertia into factor supply decisions. Markets are assumed to clear at all times so that the quantities traded are "on" both the supply and demand curve. The quantity traded is not, however, the amount that would have been traded given full information for the position of the supply (and demand) curve depends on the current state of information.

In the new-Keynesian rational model labour services) are traded on contracts. A contract establishes the money wage rate for a period into the future based on forecasts of what the price level will be at various stages

through the duration of the contract. The quantity of labour traded is determined by the demand side of the market. In the most interesting version of the theory (John Taylor (1979), contracts are negotiated at different dates so that they overlap and, in setting a contract wage at some given date, account is taken of the decisions that have already been embodied into existing contracts. This produces inertia.

Both classes of models employ the same theory of aggregate demand based on the IS-LM set-up. Aggregate demand depends on the price level, the money stock and, in general, fiscal policy and rest-of-world variables.

The solutions to rational expectations models are reduced form equations for output, inflation and other real variables, that have a well defined structure. In particular, real variables depart from their full-information levels in proportion to the deviations of the actual values of the exogenous variables such as the money supply from their currently perceived (new-classical) or previously anticipated (new-Keynesian) values. These variables are sometimes called "surprises". Inflation depends on both the expected money supply and on surprises. Thus, for example, a fully anticipated x percent growth in the money stock would produce an x percent inflation. Over and above this, if the money supply grew by an unexpected amount this would influence the inflation rate in the direction of the surprise.

In terms of points in Phillips curve diagrams the rational expectations hypothesis does not place any restrictions on the possible configurations. If the money supply was expected to grow but actually grew less than was expected the economy would move in a north-easterly direction in Phillips' curve space. If the money supply was expected to grow and actually grew by more than expected the economy would move in a north-westerly direction. If the money supply was expected to fall but actually fell by less than was

expected the economy would move in a south-easterly direction, and finally, if the money supply was expected to fall but did not fall by as much as was expected then the economy would move in a south-westerly direction.

The fact that, under the rational expectations hypothesis, inflation and unemployment can, in principle, move in any direction in Phillips' curve space does not render that hypothesis empty. One is not permitted simply to decide on the extent to which exogenous variables (such as the money stock) changed by expected and unexpected amounts on the basis of directions of movement of inflation and unemployment. Expected and surprise movements in the money supply must themselves be generated from the statistical regularities that describe the money supply process. The same applies to movements in other exogenous variables. The "normal" state of affairs would be one in which variations in the actual values of the exogenous variables displayed larger amplitude than variations in their expected values. This would mean that variations in the actual money supply, for example, would typically be in the same direction as variations in the surprise in the money supply. Such "normal" fluctuations would generate the "normal" shaped Phillips curve. Over and above this, however, there may be unusual jumps in the expectation of monetary growth (or fiscal policy or exports, etc.) which produce movements in the rate of inflation that are independent of the level of unemployment or of real output.

(ii) Two Examples of Rational Models

I shall now present two examples of rational models in the classical and Keynesian traditions and show how they generate rich predictions concerning the behaviour of inflation.¹ In order to emphasize the power of the rational expectations hypothesis and to highlight the importance of the differences in assumptions concerning supply behaviour and market clearing, I

shall employ the same formulation of aggregate demand in both examples. Further, I shall use the simplest theory of aggregate demand--the vertical LM curve, or equivalently horizontal IS curve version. This may be expressed as:

$$y_t = m_t - p_t + v_t \quad (31)$$

where y is real income demanded, m is the money stock, p is the price level and v is the velocity of circulation (all variables being measured in logarithms); t is time. The assumption of a vertical LM curve or, equivalently for present purposes, a horizontal IS curve is incorporated by assuming that the logarithm of the velocity of circulation is a zero mean random variable. (Modifying this assumption would make the analysis more algebra-intensive but would not yield any material insights that are not available in this simple formulation.)

(a) A new-classical example

Let us first examine an example of the new-classical analysis. I shall follow closely that presented by Lucas (1973) but the exposition and derivation of solutions will be somewhat different from those contained in the Lucas paper.

The key objective of the new-classical theory is not to develop an explanation for inflation alone but also an analysis of the business cycle. That is, it seeks to explain the comovements of output and prices. The key idea employed by Lucas in developing such a theory lies in the restriction of the information available to individuals when making their supply decisions. How that idea is implemented is less important than the idea itself. The simplest "story" is that based on an economy that is composed of a series of "islands" each of which is informationally distinct from the rest of the

economy. On each island producers supply the profit maximizing quantity of output based on the price at which they are currently able to sell that output (the price prevailing on the island) and the price which they expect (but do not know) prevails throughout the economy as a whole. In addition, so as to capture inertia in output, it is supposed that current output depends on output in the previous period (reflecting non-linear costs of adjustment in the rate of output). These ideas give rise to the following supply equation on an individual "island".

$$y_t^s(z) = \gamma(p_t(z) - E(p_t | I_t(z))) + \lambda y_{t-1}(z) \quad (32)$$

The variable z denotes the island; the price level on the island is denoted as $p_t(z)$ and the expectation of the economy-wide price level is formed on the basis of information available at time t on island z denoted ($I_t(z)$). This information consists of knowledge on all the variables in the economy up to and including time $t-1$ and also includes one piece of information generated at time t , namely the price prevailing on island z .

Two disturbances hit the island. One is in the aggregate money supply and velocity of circulation. This is common to all islands. The second is a relative disturbance--a disturbance that affects each island in a different way. For precision it is assumed that these island-specific shocks (which will be denoted as z) cause the price level on each island to deviate from the economy average price level in accordance with

$$p_t(z) = p_t + z_t \quad z_t \sim N(0, \tau^2) \quad (33)$$

The shocks (z) are assumed to be normally distributed with an average value of zero and a constant variance τ^2 . Further the relative shocks are assumed to be distributed independently of the aggregate shocks influencing the economy as a whole.

The aggregate economy is the sum of the individual islands so that aggregate output, the average price level and the sum of the relative shocks are:

$$y_t^s = \sum_z y_t^s(z) \quad (34)$$

$$p_t = \sum_z p_t(z) \quad (35)$$

$$\sum_z z_t = 0 \quad (36)$$

The key distinguishing feature of the new-classical model is that markets clear at each point in time so that the actual quantity traded is on both the supply and demand curve. This may be stated as:

$$y_t^d = y_t^s = y_t \quad (37)$$

To complete our description of the economy a statement is needed about how the money supply behaves. I shall for the moment defer a discussion of that and suppose that, no matter how the money supply behaves, it is possible to decompose it, at any given point in time into that part which was

expected on the basis of information available at the previous point in time $[E(m_t | I_{t-1})]$ and a purely random disturbance (ϵ_t). That is,

$$m_t = E(m_t | I_{t-1}) + \epsilon_t \quad (38)$$

The random disturbance to the money supply ϵ_t , is assumed to have a zero mean and the constant variance (σ_ϵ^2). As noted above the monetary shock (ϵ) and the real shock (z) are distributed independently of each other.

The economy has now been described sufficiently completely for it to be possible to work out how the money supply and the random velocity shock affect both prices and output.

To solve for the price level it is convenient to conjecture a solution based on the structure of the model, to use that conjectured solution to calculate the rational expectation of the price level and then, subsequently, to evaluate the parameters in the conjectured solution. It seems reasonable to conjecture a solution for the price level of the form:

$$p_t = \pi_0 + \pi_1(\epsilon_t + v_t) + \pi_2 E(m_t | I_{t-1}) + \pi_3 y_{t-1} \quad (39)$$

The coefficients π_0 , π_1 , π_2 and π_3 are as yet undetermined but will be calculated below.

Evidently each agent on each island wishes to calculate an expectation of the economy average price level based on the information available on each island at time t . That is, each agent will seek to calculate

$$E(p_t | I_t(z)) = \pi_0 + \pi_1 E((\epsilon_t + v_t) | I_t(z)) + \pi_2 E(m_t | I_{t-1}) + \pi_3 y_{t-1} \quad (40)$$

The first, third and fourth terms on the right-hand side of (40) are, of course, known to the agent whereas the second term has to be inferred. It is true that at time $t-1$, and based on all information available up to time $t-1$, the expectation of that second term will be zero. That is not the case, however, once the agent on island z knows the price level prevailing on that island at the current date. To see that notice that if we combine equation (33) with (39) we obtain

$$p_t(z) = \pi_0 + \pi_1(\epsilon_t + v_t) + \pi_2 E(m_t | I_{t-1}) + \pi_3 y_{t-1} + z_t \quad (41)$$

This tells us that the price level that is being observed on island z at time t is equal to the sum of some known components (the first, third and fourth terms on the right-hand side of (41)) and two unknown components (the second and fifth terms). Rearranging equation (41) makes this clearer. Subtracting the known terms on the right-hand side of (41) from the left-hand side gives

$$p_t(z) - \pi_0 - \pi_2 E(m_t | I_{t-1}) - \pi_3 y_{t-1} = \pi_1(\epsilon_t + v_t) + z_t \quad (42)$$

Each agent on island z sees the composite random variable defined by equation (42). The expectation of that random variable at time $t-1$ is zero. At time t however, the variable takes on a particular realization and the task of the agent is to unscramble as best can be done from this noisy information an inference about $\epsilon+v$. A different way of saying all this is that people on island z observe the economy aggregate shock $\epsilon+v$ contaminated by the relative price shock z . They do not know to what extent the observation is being generated by z and to what extent it is being generated by the aggregate shock $\epsilon+v$. They do however, want to form the best inference they can of

$\epsilon+v$ knowing that $\epsilon+v$ (weighted by π_1) plus z is equal to some now known number.

The most natural way to proceed with this inference is to hypothesize that $\epsilon+v$ (the number whose conditional expected value is required) is some fraction of the observed composite shock plus some additional random disturbance. That is, it may be supposed that:

$$\epsilon_t + v_t = (1-\theta)[\pi_1(\epsilon_t + v_t) + z_t] + e_t \quad (43)$$

The fraction $1-\theta$ can be estimated by minimizing the squared expectation of the error e . That is, a least squares estimation of the parameter $1-\theta$ may be formed. That estimation gives

$$1 - \theta = \frac{\pi_1^2 (\sigma_\epsilon^2 + \sigma_v^2)}{\pi_1^2 (\sigma_\epsilon^2 + \sigma_v^2) + \tau^2} \quad (44)$$

Using these calculations it is now possible to eliminate the expectation of the economy average price level from equation (32) to give

$$y_t(z) = \gamma \theta (p_t(z) - \pi_0 - \pi_2 E(m_t | I_{t-1}) - \pi_3 y_{t-1}) + \lambda y_{t-1}(z) \quad (45)$$

Aggregating this over the whole economy gives an aggregate supply relation of

$$y_t = \gamma \theta (p_t - \pi_0 - \pi_2 E(m_t | I_{t-1}) - \pi_3 y_{t-1}) + \lambda y_{t-1} \quad (46)$$

Aggregate demand may be written using the decomposition of the money supply (equation 38) along with equation (31) as

$$y_t = E(m_t | I_{t-1}) + \epsilon_t - p_t + v_t \quad (47)$$

These last two equations now may be solved for output and prices.

First, let us focus on prices. We can make (41) and (47) equal to each other and then solve for the price level as

$$p_t = \frac{1}{1+\gamma\theta} \{ \gamma\theta \pi_0 + \epsilon_t + v_t + (1+\pi_2\gamma\theta) E(m_t | I_{t-1}) + (\gamma\theta \pi_3^{-\lambda}) y_{t-1} \} \quad (48)$$

Inspection of this equation reveals that the price level is determined as a function of some constants, the aggregate random shock $+v$, the expectation of the money stock formed on the basis of information available at $t-1$ and lagged output. Evidently equation (48) and equation (39) (the conjectured solution for the price level) agree with each other in the sense that they each contain the same variables. It is possible by comparing (39) with (48) term by term to determine the values of the previously undetermined coefficients π_0 , π_1 , π_2 and π_3 . Evidently those coefficients are

$$\pi_0 = 0; \pi_1 = \frac{1}{1+\gamma\theta}; \pi_2 = 1; \pi_3 = -\lambda \quad (49)$$

Using these now determined coefficients we may obtain a simpler statement of the solution for the price level and also for real income as

$$p_t = \frac{1}{1+\gamma\theta} (\epsilon_t + v_t) + E(m_t | I_{t-1}) - \lambda y_{t-1} \quad (50)$$

$$y_t = \frac{\gamma\theta}{1+\gamma\theta} (\epsilon_t + v_t) + \lambda y_{t-1} \quad (51)$$

where

$$\theta = \frac{\tau^2}{\pi_1^2(\sigma_\epsilon^2 + \sigma_v^2) + \tau^2} \quad (52)$$

The price level depends upon the expectation of the money supply formed at $t-1$ (with a coefficient of unity). Both the price level and output depend upon the current random shock to the money supply plus the current random shock to velocity ($\epsilon+v$). This aggregate random shock is allocated between prices and output in accordance with the composite parameter $\gamma\theta$. The larger is $\gamma\theta$, the larger is the effect of current random shocks on output and the smaller the effect on prices. The two shocks taken together add up to unity. The magnitude of the parameter θ depends upon the relative magnitudes of the variance of the relative price shocks (τ^2) and the aggregate variance measured by $\pi_1^2(\sigma_\epsilon^2 + \sigma_v^2)$. The larger is the aggregate variance, the smaller is θ and the larger therefore, is π_1 . Put directly in terms of economic entities, the larger is the variance of the aggregate shocks influencing the economy, the more will be the effect of those shocks on the price level and the less will their effect be upon real income. Both the price level and output display inertia arising from the role of lagged output in the aggregate supply process.

It is a central prediction of this model that real income is in no way influenced by the deterministic part of the money supply rule--only the unexpected component of the current money supply (ϵ_t) has an effect on real income. In fact, real income simply follows a first-order stochastic difference equation.

The price level, in contrast, depends both on the current period random

shock to the money supply and on the deterministic part of the money supply rule. This is evident from the fact that the expectation of the money supply (formed on the basis of $t-1$ information) has a one-for-one effect upon the price level.

The prediction of the classical rational model concerning real income (equation (51) above) is complete in the sense that it shows how real income responds to the exogenous shocks to aggregate demand as well as to lagged real income. The solution for the price level shown as equation (50) above is, however, incomplete. It is incomplete because it includes the expected value of the money supply based on information available one period earlier. To obtain a complete solution for the behaviour of the price level (and the inflation rate) it is necessary to be more precise about the process generating the money supply and to solve for the expected future money supply.

In an explicit empirical implementation of this theory it would be necessary to specify the actual stochastic process generating the money stock in the given historical situation. For current purposes, however, it is instructive to explore the implications of three simple but rather different money supply processes.

The first process investigated is one which makes the deviations from a deterministic path for the level of the money supply random. That is

$$m_t = \mu t + \epsilon_t, \quad \epsilon_t \sim N(0, \sigma_\epsilon^2) \quad (53a)$$

What this says is that the money supply fluctuates randomly around a trend level that grows at the rate μ .

The second money supply process considered is one in which the level of the money supply is a random walk or, equivalently the growth rate of the

money supply is a constant disturbed by a random variable. That is

$$m_t = m_{t-1} + \mu + \epsilon_t \quad (53b)$$

This states that the money supply will grow at the constant rate μ and will deviate from that constant growth rate by a random amount. Both of these rules may be thought of as variants of Friedman's (1959) so called k-percent rule. The first one puts randomness on the level of the money supply while the second puts it on the growth rate. Both imply a long-term expected money supply growth rate that is the same but the expected growth rate of the money supply from the current period to the next period will differ between the two cases. The first rule says that any deviation from the level of the money supply will be corrected next period whilst the second rule simply states that bygones are bygones concerning the level of the money supply and only the growth rate will be returned.

A third example will be explored since it is rather different from the other two. This is the case in which the growth rate of the money supply is a random walk. That is

$$\Delta m_t = \Delta m_{t-1} + \epsilon_t \quad (53c)$$

In this case the growth rate of the money supply is not bolted down. It is simply equal to its previous value plus a random disturbance so that the expected growth rate of the money supply through the indefinite future is equal to the most recently known growth rate. Shocks to the growth rate are permanent.

It is possible to calculate the expected money supply from each of these three alternatives and, as a result of so doing, to obtain expressions for the behaviour of the price level, and, more interestingly, of the inflation rate. These are set out as follows for the inflation rate:

$$\Delta p_t = \lambda \Delta p_{t-1} + \frac{1}{1+\gamma\theta} (\Delta m_t + \Delta v_t) - \lambda (\Delta m_{t-1} + \Delta v_{t-1}) + \frac{\gamma\theta}{1+\gamma\theta} \mu \quad (54a)$$

$$\Delta p_t = \lambda \Delta p_t + \frac{1}{1+\gamma\theta} (\Delta m_t + \Delta v_t) - \lambda (\Delta m_{t-1} + \Delta v_{t-1}) + \frac{\gamma\theta}{1+\gamma\theta} \Delta m_{t-1} \quad (54b)$$

$$\Delta p_t = \lambda \Delta p_{t-1} + \frac{1}{1+\gamma\theta} (\Delta m_t + \Delta v_t) - \lambda (\Delta m_{t-1} + \Delta v_{t-1}) + \frac{\gamma\theta}{1+\gamma\theta} (\Delta m_{t-1} + (\Delta m_{t-1} - \Delta m_{t-2})) \quad (54c)$$

Notice that in all cases the inflation rate is an autogressive process reflecting the autogression in aggregate supply as indicated by the parameter λ). In addition, in each case, the inflation rate is influenced by the current growth rate of the money supply and change in velocity and in exactly the same way regardless of the money supply process. Third, and again regardless of the money supply process, the lagged value of the change in the money stock and velocity influence the inflation rate. Here the similarities end. The final term describing the inflation path depends upon the specific money supply rule.

In the case of the first rule it is the long-term trend growth rate of the money supply that has a further effect upon inflation. In the second case it is the lagged value of the growth rate of the money stock and in the third case it is the lagged value of the growth rate of the money stock plus

the lagged value of the change in the growth rate of the money stock. Evidently the inflation rate will be least variable under rule a and most variable under rule c. The behaviour of output, of course, will be the same under all rules.

The foregoing serves to highlight the prediction of the new-classical model concerning the behaviour of output and prices--the comovements that we observe in Phillips curve space. These comovements depend crucially upon the stochastic behaviour of the exogenous variables (in this case the money supply)² generating aggregate demand.

Let us now leave the new-classical world behind and go on to examine the efforts to develop rational models in the Keynesian tradition.

(b) A new-Keynesian example

To highlight the key distinction between the new-Keynesian and new-classical models I shall continue to assume exactly the same behaviour for aggregate demand as in the new-classical case. (This follows the treatment by John Taylor (1979)). Equation (31) above remains the aggregate demand curve for this new-Keynesian model. Output will be determined, however, not at the point at which supply equals demand but by aggregate demand.

It is the supply side of the economy that the new-Keynesian approach models in an innovative way. Prices are presumed to be determined by a mark-up over costs. It will be convenient here to treat that mark-up as zero. Additionally, it will be convenient to suppose that the only costs are labour costs. Thus the key element in the determination of prices is the determination of wages. The latter are determined by a process of negotiations between employers and employees and different groups of workers and firms negotiate at different times and for periods that differ from each

other. A powerful simplification that makes formal analysis easy has been suggested by John Taylor. It is to imagine that the economy consists of two equal sized groups of workers and firms one of which sets its wages in "odd" periods to run for two periods and the other of which sets its wages in "even" periods to run for two periods.

With these assumptions it is evident that the price level at any point in time will simply be a weighted average (the weights being one half) of the wages that were set in the current period and one period earlier. That is

$$p_t = \frac{1}{2} (q_t + q_{t-1}) \quad (55)$$

where q_t represents the wages set in period t .

The hypothesis concerning the determination of wages is one that is analogous to the expectations augmented Phillips curve. The wages of any particular group are assumed to be set to equal the expected average of the other wages prevailing in the economy over the period for which wages are now being set and in addition to respond in part to expectations of any excess demand over the relevant period in question. John Taylor's specific hypothesis (modified slightly for simplicity) is:

$$\begin{aligned} q_t = & \frac{1}{4} E(q_{t+1} | I_t) + \frac{1}{2} E(q_t | I_t) + \frac{1}{4} q_{t-1} \\ & + \frac{\delta^2}{\delta} (E(y_t | I_t) + E(y_{t+1} | I_t)) + \eta_t \end{aligned} \quad (56)$$
$$\eta_t \sim N(0, \sigma_\eta^2), \quad 0 < \delta < 1$$

The first three terms in equation (56) reflect the competitive influence of past, current and expected future wages; the next term reflects the role of excess demand and the final term reflects the role of what may be thought of as cost-push phenomena. It is clear from equation (56) and the assumptions

made about the cost-push term that, in the absence of contemporaneous knowledge of the cost-push element in the wage settlements of other groups, every one will have an expectation of wages being set at time t equal to the actual wages set minus the random cost-push term. That is

$$E(q_t | I_t) = q_t - \eta_t \quad (57)$$

Using this in (56) and simplifying gives

$$q_t = \frac{1}{2} E(q_{t+1} | I_t) + \frac{1}{2} q_{t-1} + \delta^2 (E(y_t | I_t) + E(y_{t+1} | I_t)) + \eta_t \quad (58)$$

This is what John Taylor calls the "reduced form contract equation". It is, in effect the new-Keynesian equivalent of the new-classical theory of aggregate supply. It is, however, a statement about how prices will respond to excess demands and not about how quantities traded will respond to prices relative to their expectations. It is important to note that the wage determining equation has both a forward and backward looking component and, in this treatment, those two components have equal weights.

If equation (58) is combined with equation (55) we have a statement concerning the relationship between the price level and the expected future price level, the past actual price level and expected current and future excess demands. This combined with the statement about aggregate demand (equation (31)) is a complete model and may be solved for the behaviour of output and prices.

To obtain that solution the aggregate demand function (31) is used to

calculate the expected output level at time t and $t+1$ as

$$\left. \begin{aligned} E(y_t | I_t) &= E(m_t | I_t) - \frac{1}{2} (E(q_t | I_t) + q_{t-1}) \\ E(y_{t+1} | I_t) &= E(m_{t+1} | I_t) - \frac{1}{2} (E(q_{t+1} | I_t) + E(q_t | I_t)) \end{aligned} \right\} \quad (59)$$

Using these propositions in equation (58) and calculating the expectations on the basis of current information provides the expression:

$$E(q_t | I_t) = \frac{1}{2} \frac{(1-\delta^2)}{(1+\delta^2)} (E(q_{t+1} | I_t) + q_{t-1}) + \frac{\delta^2}{1+\delta^2} (E(m_t | I_t) + E(m_{t+1} | I_t)) \quad (60)$$

A solution (though as a matter of fact not a unique solution) to equation (60) (a non-homogeneous second order difference equation) will take the form

$$q_t = \phi q_{t-1} + \sum_{i=0}^{\infty} \pi_i E(m_{t+i} | I_t) + \eta_t \quad (61)$$

As in the conjectured solution to the new-classical model, the coefficients ϕ and π_i are undetermined coefficients the values of which now need to be established.

The conjectured solution in (61) is suggested by virtue of the fact that current wages depend upon current expectations of future wages and on past wages. It is this latter consideration that forces us to take account of wages that have already been set at time $t-1$ in the solution of current wages. Since current wages depend on current expectations of future wages and since they in turn depend upon expectations of excess demand which further depend upon expectations of the money supply, these latter variables appear in the conjectured solution. They appear into the indefinite future since current wages depend upon expectations of one period ahead wages which in turn will be set to depend upon expectations of two period ahead wages and

so on ad infinitum. Equation (61) may be used to calculate the expectation of wages being set at the current period as

$$E(q_t | I_t) = \phi q_{t-1} + \sum_{i=0}^{\infty} \pi_i E(m_{t+i} | I_t) \quad (62)$$

and, leading this equation one period but eliminating the expectation of wages at the current period provides a statement about future expectations of wages as

$$E(q_{t+1} | I_t) = \phi^2 q_{t-1} + \phi \sum_{i=0}^{\infty} \pi_i E(m_{t+i} | I_t) + \sum_{i=0}^{\infty} \pi_i E(m_{t+i+1} | I_t) \quad (63)$$

If we substitute these last two propositions into equation (60) we obtain

$$E(q_t | I_t) = \frac{1}{2} \frac{(1-\delta^2)}{(1+\delta^2)} \left\{ \phi^2 q_{t-1} + \phi \sum_{i=0}^{\infty} \pi_i E(m_{t+i} | I_t) + \sum_{i=0}^{\infty} \pi_i E(m_{t+i+1} | I_t) + q_{t-1} \right\} + \frac{\delta^2}{1+\delta^2} (E(m_t | I_t) + E(m_{t+1} | I_t)) \quad (64)$$

Examination of equation (64) shows that the conjectured solution (61) has the correct form. The terms appearing in (64) are similar to those that appear in (61). A term-by-term evaluation of the undetermined coefficients reveals that

$$\phi = \frac{(1-\delta)}{(1+\delta)}; \quad \pi_0 = 2 \left(\frac{\delta}{1+\delta} \right)^2; \quad \pi_1 = 4 \frac{\delta^2}{(1+\delta)^3}; \quad \pi_i = \phi^{i-1} \pi_1 \quad \text{for } i \geq 2 \quad (65)$$

Having determined the wages that are being set at time t those solutions may be used in the price level equation to provide a statement about prices as

$$p_t = \phi p_{t-1} + \frac{1}{2} \sum_{i=0}^{\infty} \pi_i (E(m_{t+i} | I_t) + E(m_{t+i-1} | I_t)) + \frac{1}{2} (\pi_t + \pi_{t-1}) \quad (66)$$

Although this price level solution is not quite complete in the sense that it contains the as yet unresolved future expectations of the money supply it is worth pausing and examining what this result is telling us. First, we learn that the price level will follow an autoregressive path. The coefficient of autoregression depends, according to equation (65), purely upon the slope of the responsiveness of prices to excess demand. The less responsive are wages to excess demand the closer will the price level become to a random walk. This seems to be an intuitively plausible idea for, if wages are not very strongly affected by the currently anticipated level of excess demand any excess demand that is expected will not deflect wages far from the course that they would otherwise have been following. Since, by hypothesis, prices respond in a one-for-one manner to wages it follows that neither will prices be much deflected from their otherwise course.

Second, prices will follow a moving average process reflecting the underlying wage-push shocks that hit the economy. This will be a moving average because of the timing structure of contracts. Third, expectations of future money supplies running through the infinite future will affect the current price level.

To obtain full solutions for the behaviour of the price level, and of the inflation rate, it is necessary to make explicit assumptions about the behaviour of the money stock. As in the case of the new-classical analysis, any empirical work done with this model would require an identification of the actual money supply growth process. Again, as done above, it will be convenient to illustrate the working of this model with the three examples of money supply growth processes introduced as equations (53a), (53b), and (53c) above.

Following money supply growth rule a and utilizing that rule in equation

(66) but expressing the result as an inflation rate gives

$$\Delta p_t = \phi \Delta p_{t-1} + \frac{2\delta}{1+\delta} \mu + \frac{1}{2} (\Delta \eta_t + \Delta \eta_{t-1}) \quad (67)$$

Thus, when the money supply follows a rule based on a target money stock with random deviations about that level the inflation rate is equal to some constant disturbed by a first order autoregression and first order moving average process.

Using the money supply growth rule b (where the growth rate of the money supply is a random variable with a constant mean) the inflation rate becomes

$$\Delta p_t = \phi \Delta p_{t-1} + \frac{2\delta}{1+\delta} \Delta m_{t-1} + \frac{1}{2} (\Delta \eta_t + \Delta \eta_{t-1}) \quad (68)$$

This is very much like (67) except that the inflation rate will now be repeatedly disturbed by the lagged value of the actual growth rate of the money supply.

In the case of the money supply growth rule c in which the growth rate itself is a random walk the price level will respond as follows

$$\Delta p_t = \phi \Delta p_{t-1} + \frac{2\delta}{1+\delta} \Delta m_{t-1} + \Delta m_{t-1} - \Delta m_{t-2} + \frac{1}{2} (\Delta \eta_t + \Delta \eta_{t-1}) \quad (69)$$

The behaviour of the inflation rate in this last case is similar to the second case except that in addition to the lagged growth rate of the money supply influencing the inflation rate the lagged acceleration of the money stock also influences the current inflation rate.

In the new-classical analysis the behaviour of output was independent of the growth rate of the money stock. This is not the case with the

new-Keynesian theory. Output will now depend upon which money supply growth rule is being followed. Specifically, output will respond according to the following three alternative equations:

$$y_t = \phi(y_{t-1} - \epsilon_{t-1} - v_{t-1}) + \epsilon_t + v_t - \frac{1}{2} (\eta_t + \eta_{t-1}) \quad (70a)$$

$$y_t = \phi(y_{t-1} - \epsilon_{t-1} - v_{t-1}) + \epsilon_t + v_t - \frac{1}{2} (\eta_t + \eta_{t-1}) + \phi(\Delta m_{t-1} - \mu) \quad (70b)$$

$$y_t = \phi(y_{t-1} - \epsilon_{t-1} - v_{t-1}) + \epsilon_t + v_t - \frac{1}{2} (\eta_t + \eta_{t-1}) + \phi(\Delta m_{t-1} - \Delta m_{t-2}) \quad (70c)$$

The reason why the money supply growth rule influences output in this case arises very naturally from the fact that wages set in the previous period which in the current period are in effect precommitments cannot respond to reflect new information concerning random disturbances to the money supply. Bygones are bygones and any errors incorporated into past wages must forever remain to influence current real variables. Notice that the three solutions for output are identical in their first three terms. They each reflect the autoregressive element in prices, the current noise in the money supply and velocity and the moving average in wage-push.

The first growth rule is the one that least disturbs output for it has no other terms. In the case of the second money supply growth rule deviations of the lagged money supply growth rate from its average level will affect output and in the case of the third growth rule variations in the acceleration of the money stock (lagged one period) will influence current output. These can be thought of as the effects of surprises about which nothing can be done because of money wage pre-commitments.

It cannot be emphasized too strongly that these are but examples and stem

from the strong and special assumptions made concerning the relative timing of wage adjustments and the particular money supply processes investigated.³ A more general formulation is provided by John Taylor (1980).

Let us pause and reflect on the purpose of the foregoing. I have presented, in a fair amount of detail, two rational models of the behaviour of inflation and output. Those models incorporate rational expectations but each incorporate very different propositions about the behaviour of markets and, in particular, about the behaviour of labour markets. Each, however, generates strong and clear predictions concerning the comovements of inflation and output. The particular models presented are, of course, examples of a broad class of such models. Each (of the examples and of the broader class of models) is capable of being tested (and of being rejected) by the data. This stands in marked contrast to the empirically empty notions of "core" inflation reviewed extensively in parts I and II above. I shall now go on to discuss (in brief terms) some of the econometric implications of the models discussed in this section.

V. TESTING RATIONAL MODELS OF INFLATION

As we have seen, rational expectations models were developed explicitly to track the stylized facts about inflation along with the other business cycle related variables. As a consequence, much of the econometric work with rational models extends to a wider range of issues than those addressed here.

Just as with non-rational models two ways of proceeding with empirical work are on rational models are available. First, the reduced forms of models may be estimated. Second, a structural model may be identified and

estimated and the model tested by testing the validity of the overidentifying restrictions implied by the structure in the reduced form. The second approach is, of course, the most useful one and indeed, ultimately the only appropriate way of testing a theory and discriminating amongst alternative theories. Both approaches have been used in the testing of rational models. In the inflation area, however, work with structures is less common than the alternative of estimating reduced forms.

The rational expectations hypothesis has generated econometric identification and estimation problems that are special to that class of models. A substantial amount of work has, by now, been done addressing those special problems. I shall describe these developments. I shall then go on to describe the applied work (the attempts to estimate models) that has been done.

(i) Implications of Rational Expectations for Identification and Hypothesis Testing

The implications of the rational expectations hypothesis for identification, parameter estimation, and hypothesis testing has been studied extensively over the past decade. It was not until the late 1970s, however, that attention was directed explicitly and in general terms (independently of some particular applied problem) to the issues raised by rational models. In 1980 three papers on this topic appeared almost simultaneously (Lars Hansen and Thomas Sargent (1980), Kenneth Wallis (1980), and Gregory Chow (1980)). Each deals with the problem of identification, estimation and hypothesis testing in the context of a rational expectations model. None of them, however, is entirely general. For present purposes, the most interesting exclusion from the class of models considered in these papers are those that incorporate the signal extraction problem. Such models have the feature that

some of the currently observed endogenous variables condition the expectations of the current values of unobserved endogenous variables and expectations of the future values of endogenous variables. The Lucas classical rational model presented in the preceding section is an example of such a model--though the new-Keynesian model discussed above is not.

Of the three papers, that by Wallis is the most general. He examines, in the context of a general linear model, three cases: One contains only expectations of current variables and has lagged exogenous variables in the structure; another has current and future values of expected variables and no lagged exogenous variables in the structure; a third model has current expectations and lagged exogenous variables. Identification conditions are established and estimation procedures discussed. Models with future expectations give rise to the greatest difficulty and the other two classes of models are relatively straightforward to handle.

The papers by Hansen and Sargent and Chow are similar to each other in the sense that each exploits the deeper structure of an optimization problem that agents are hypothesized to solve. Specifically, agents solve a quadratic stochastic dynamic programming problem that delivers exact linear decision rules. The overidentifying restrictions that the solution to such a problem places upon the time series of the variables whose values are being chosen constitutes the central way in which the model is tested.

Hansen and Sargent develop, more extensively than does Chow, the connection between estimation of rational models and the a priori less demanding multiple time-series analysis. They show that Granger (1969) - causality is a concept that has a natural role to play in the time series implementation of rational models. Several models make strong predictions

concerning the Granger causality--or lack thereof--amongst variables. For example, in the classical rational model discussed above, a clear implication of the theory is that exogenous nominal variables do not Granger cause real variables but do Granger cause nominal variables. A low level test of that theory is thereby immediately available. Hansen and Sargent discuss these matters at length.

More recently, two problems not addressed by the above papers have been tackled. One concerns the implications of signal extraction. In such cases models become non-linear in the parameters of the deeper structure and, typically, do not have unique solutions. The problems to which this gives rise are discussed (albeit negatively) in Pesaran (1981).

Another serious problem for rational models arises from the possibility of speculative bubbles. In the case of models that have forward expectations it is well known that the general class of solutions involves the addition of terms that have no place in the "market fundamentals" but could nevertheless influence behaviour through a kind of "bootstraps" expectations effect. If people believe in a speculative bubble it is possible that one can occur and be entirely rational. Some models based on intemporal optimization rule out such speculative bubbles as violating one of the conditions for optimality. Some models do not, however, permit that let-out. In such cases the possibility of a speculative bubble perhaps has to be allowed for. The most comprehensive general treatment of this class of problems is provided by Kent Wall (1980).

The above sketchy (and incomplete) review of the theoretical literature on the econometrics of rational expectations has provided a quick overview of the highlights in that literature. It cannot, of course, be a substitute for an urgently needed, thorough, and extensive review and evaluation of that literature.

Let me now go on to describe some of the empirical work that has been done with rational models.

(ii) Empirical Applications

Most of the empirical applications of the rational expectations hypothesis have not dealt with the topic of this paper--inflation. Rather, they have dealt with other aspects of macroeconomics in general and the business cycle aspects of macroeconomics in particular. For example, the consumption function has been studied by Sargent (1978), Robert Hall (1978), and Marjorie Flavin (1981); the demand for money function has been studied by Sargent (1977); the term structure of interest rates by Sargent (1979); and the demand for labour by Sargent (1978).

In the area of inflation most of the studies undertaken have estimated reduced form models rather than attempting to identify the underlying structure. Let me first turn to a description of those.

(a) Reduced Form Studies of Inflation

The first rational expectations macroeconomic model seeking to account for, among other things, inflation was that advanced by Robert E. Lucas Jr. (1970) and was more extensively applied in Lucas (1973). Lucas (1973) estimated (for a series of countries) reduced form equations which differ from equations (51) and (54b) above only in that they use nominal income rather than the money supply as the exogenous nominal variable. The ability of these reduced form equations to track the time series was treated as one test of the model.

A more important test, however, is available from the cross section (cross country) implications of the model. The theory of rational expectations with market clearing developed by Lucas and described above implies that the relative responsiveness of prices and output to demand

shocks (the slope of the output-inflation tradeoff) will depend upon the variability of nominal demand. An economy in which nominal demand is highly variable (a larger value of $\pi_1^2(\sigma_\epsilon^2 + \sigma_v^2)$) will be one in which prices are highly responsive and output relatively unresponsive to demand disturbances. In addition, therefore, to testing the model's time series predictions its cross section predictions were also tested. Lucas' results on the time series were not outstanding but those on the cross section were quite remarkable. A subsequent extension of the Lucas analysis by Parkin, Bentley and Fader (1980) which took account of economic openness and changes in exchange rate regimes provided an improvement of the model's time series performance and some further limited confirmation of its cross section predictions though again was not fully satisfactory as an account of the data. Further work on small open economies by Cozier (1983) is, however, apparently having more success.

Another early study of inflation was that by Sargent and Wallis (1973). They focussed on the hyperinflation episodes that Philip Cagan (1956) had studied using the adaptive expectations hypothesis. They retained Cagan's specification but assumed rational rather than adaptive expectations. They showed that a rational expectations model incorporating the Cagan demand for money function was capable of tracking the inter-war hyperinflation experience of the European countries studied by Cagan but only if it was assumed that the money supply was not exogenous but rather was responding to the underlying inflation process. Subsequent work on these episodes using a rational expectations framework and allowing for the rational expectation that a currency reform will occur at some stage to terminate the hyperinflation has been studied by Robert Flood and Peter Garber (1980).

The most extensive reduced form estimations of rational expectations

models are those initiated by Robert Barro in a series of inter-related papers (Barro, 1977, 1978,) and with Mark Rush (1980). In these papers Barro investigated a more general specification of the reduced form implied by rational expectations models than those set out in the preceding section. Furthermore, Barro concentrated on the money supply as the only source of shocks to the economy instead of the broader level of nominal aggregate demand used by Lucas. His strategy was to estimate an equation that adequately characterized the behaviour of the money supply (an empirical version of equation (53) above) and to use that equation to decompose the actual growth rate of the money stock into its anticipated and unanticipated components. He then postulated that real variables (output and unemployment) would depend only on the unanticipated components of money represented by a distributed lag of the residuals from the estimated money growth equation. The behaviour of prices was postulated to depend both on the fully anticipated and unanticipated components of money. Barro implemented these ideas on the annual and (with Rush) quarterly time series for the United States.

The models track the data remarkably accurately. There are, however, some controversies surrounding that work mainly concerning the way in which Barro chose to model the behaviour of the natural rate of unemployment and also one major puzzle that has still not been satisfactorily resolved. The controversy concerning the measurement of the natural rate of unemployment does not appear to be one of major consequence. This view is strongly underlined by the results generated in a recent paper by David Lilien (1982). Lilien has developed a measure of the (varying) natural rate of unemployment which is statistically exogenous with respect to monetary innovations and indeed orthogonal to them. When that variable is used, along

with Barro's monetary innovation variables, a very accurate tracking of the unemployment rate is obtained with this rational expectations equilibrium approach.

The major puzzle surrounding Barro's work, however, has not been resolved. This concerns the differences in the time lags required on monetary innovations to explain unemployment as compared with prices. The theory, as developed by Barro, (and just about any theory that anybody has advanced) implies that the time lags on the monetary innovations will be the same in both the output and the price level equations. (See the examples in the previous section). That prediction is not found in the data. There is a significantly longer time lag on the effects of innovations in money on prices as compared to output.

Barro's approach has been applied to data for Canada by Gillian Wogin (1979) and to data for the United Kingdom by Attfield, Demery and Duck (1981).

A major problem concerning the reduced form approach applied by Barro (and others) concerns the interpretation of the findings and in particular concerns the question as to what structure is capable of generating these observations. Thomas Sargent (1976) has shown that, with data available from only one policy regime, rational and non-rational theories of macroeconomic behaviour may be observationally equivalent. In other words, Sargent shows that it may not be possible to discriminate between rational and non-rational models on the basis only of the observed data for one sample period.

The exercises conducted by Barro (and others) and described above seem to have done precisely what Sargent says is impossible. As a matter of fact, the appearance is incorrect. Barro has not defied Sargent's law of observational equivalence. Rather he has imposed some structural assumptions that do indeed make it possible, maintaining the structural hypotheses

embedded in the analysis, to test the rational model under consideration. (See Parkin, 1981) for a fuller discussion of this matter. The essential trick is to assume that there is at least one variable that determines money growth that does not determine output or prices directly and that can be used to identify the rational expectations model.

Thus, it is not, strictly speaking, possible to use a pure reduced form approach to the estimation of a rational expectations model. Some minimal structural assumptions have to be injected into the reduced forms in order to render the models observationally distinct from some possible non-rational equivalents. Let us then now turn to an examination of structural approaches to rational models.

(b) Structural Approaches

Settling the controversies surrounding the work of Barro and others clearly requires the identification and estimation of a structural model. Reduced forms alone will never answer the questions that are of ultimate concern.

Two studies have attempted to exploit structural restrictions in order to estimate and test rational models: those by Sargent (1976) and Taylor (1979).

Sargent specifies what he calls a "small classical model" of the United States economy. It is classical in the sense that it has an aggregate supply curve of the new-classical variety described above. It is also classical in that it has, in effect, a horizontal IS curve. It has a standard portfolio balance (or LM) schedule.

Although the Sargent model is an explicit structural model it is its reduced forms that are used as the basis for testing the model. They are used, however, in a manner that does utilize the properties of the underlying structure. In particular, Sargent searches for the existence (or lack

thereof) of Granger causality amongst the various exogenous and real and nominal endogenous variables. Sargent does not use the explicit methods suggested in more recent papers (reviewed above) of using the model to generate the rational expectations of the variables appearing in its structure.

Sargent reports that the classical model, although performing surprisingly well, does not provide a convincing account of U.S. macroeconomic history. The main finding that contradicts the classical model is that the money wage rate is exogenous and Granger-causes unemployment. Clearly this is contrary to the predictions of the new-classical approach described above and inconsistent with the more general new-classical setup proposed by Sargent.

The other attempt at specifying a structural model--that by John Taylor--approached the problem from a new-Keynesian perspective. Setting out a new-Keynesian model with a price equation identical to that set out in the previous section of this paper and an aggregate demand function that incorporates the usual variables in an IS-LM reduced form--Taylor showed that the United States quarterly time series between the early 1950s and middle 1970s could be adequately modelled. Having estimated his model Taylor went on to undertake some policy experiments that properly allowed the way in which people form their expectations to respond to the underlying policy rules in place. He showed that, on the basis of the policy invariant parameters identified and estimated, a feedback rule for the money supply could be devised that would dominate a fixed rule (and dominate history) in terms of lowering the variance of both real output and the inflation rate.

It is worth remarking that, according to the new-classical setup, the variance of output is invariant to the deterministic component of the

feedback policy rule. The new-Keynesian setup does not, of course, carry that implication. It is also worth noting, that on Taylor's calculations, the pursuit of a fixed money supply growth rule (k-percent rule) would represent only a slight improvement on the actual historical performance whilst the use of the optimal feedback rule makes it possible virtually to reduce to one half the variance of both output and the inflation rate.

(c) Rational Market Clearing vs. Rational Non-Market Clearing

The empirical work of Sargent and Taylor seems to point in the direction of rejecting the new-classical model and not rejecting the new-Keynesian model. Although the work leans in that direction, we should be careful not to be overly hasty in concluding that the race has been run and the outcome determined. Virtually all the empirical work that has been done with the rational expectations models has been understructured in the sense that it has not directly addressed the question of whether a market clearing (new-classical) or non-market clearing (new-Keynesian) approach is the appropriate one. The work reported above does shed some light on this matter and some other studies that I shall now examine also provide some clues. None of them, however, can be taken as decisive until we have seen some explicit nesting of one hypothesis inside the other or the careful application of non-nested testing to these two alternative cases.

One piece of work that is suggestive in favour of the non-market clearing approach is a recent empirical study by Robert J. Gordon, (1982). In that study, Gordon compares a traditional non-rational model (what he calls the NRH-GAP model for natural-rate hypothesis--Gradual Adjustment of Prices) with a rational expectations model of the market clearing type. He shows that the market clearing model can be rejected whilst the NRH-GAP model cannot.

Additionally, the work of John Boschen and Herschel Grossman, (1982) shows that one of the implications of the market clearing rational approach is inconsistent with data on monetary revisions in the United States. Further, in a recent interesting exercise by Grossman and William Haraf (1983) exploits one of the institutional features of the Japanese economy--bunched wage setting or (shunto)--to test for the importance of the timing of wage changes in the evolution of output and prices. This study suggests rather conclusively that a rational non-market clearing as opposed to market clearing approach is required.

None of these studies have definitively shown the rational expectations approach to be correct. They do, however, point firmly in the direction of a rational but non-market clearing model as being the one that explains the data. The careful extension of such models, however, to deal explicitly with open economies, and with other pieces of contemporaneously available information such as interest rates and the exchange rate, as well as to model foreign and fiscal policy shocks all remain tasks to be undertaken. In the absence of such an extensive set of empirical investigations all that we may conclude in present circumstances is that there does exist a large research program and a promising approach available to us.

If we can agree that this is where we now stand and that the way forward lies in attempts to refine, further develop and test rational models of the non-market clearing as well as market clearing type then we shall be ready to begin the task that Richard Lipsey and I originally wanted to pursue but found ourselves unable to find a basis to embark upon.

Footnotes

¹This sub-section draws on Parkin (1983).

²In a more general model the set of exogenous variables would be extended to include fiscal policy and rest-of-world variables. Also, the inertia in output would be modelled more explicitly by way of an analysis of the (non-linear) costs of adjustment of all factor inputs.

³The remarks in note (2) above apply, of course, with equal force to this model.

Table 1

Interest Rate Equation

Average Yield on New Issues of High Grade Corporate Bonds

Equals:

<u>Coefficient</u>	<u>t-statistic</u>	<u>Independent Variable</u>
-13.3	1.3	Constant
- 5.2	6.0	Real per capita adjusted monetary base
+ 0.15	2.1	A measure (unspecified) of bank liquidity
+ 0.27	1.9	Vietnam War dummy
+ 6.7	13.0	Real per capita GNP (1972 prices)
+ 3.9	1.1	Percentage change in real per capita stock of non-financial corporate bonds
+ 0.43	5.6	Lagged stock of tax exempt bonds (apparently nominal aggregate rather than real per capita)
-17.5	6.3	Percentage change in real per capita stock of life insurance reserves outstanding
+ 0.79	6.6	Expected rate of inflation of PCE deflator
- 0.06	5.3	Product of previous variable and average unemployment rate in preceding year
+ 0.006	3.2	Expectation of Standard and Poor's stock price index
+ a(L)	4.3	Growth rate of real per capita monetary base

$$a(L) = -5.8 - 5.3L - 4.8L^2 - 4.4L^3 - 3.9L^4 - 3.4L^5 - 2.9L^6 - 2.4L^7 - 1.9L^8 - 1.5L^9 - 1.0L^{10} - 0.5L^{11}$$

$$\bar{R}^2 = 0.99 \quad DW = 1.89 \quad T = 1954:1 \text{ to } 1979:3 \quad 103 \text{ observations.}$$

Note: Source, Eckstein (Table 9.4, p. 81).

Table 2

Wage Equation

(Allowing for Structural Changes After 1973)

Percentage Change (At Annual Rate) in Index of Hourly Earnings of
Private Non-Farm Production Workers

Equals:

<u>Coefficient</u>	<u>t-statistic</u>	
1.7	1.2	Constant
+7.0	4.1	1/(Actual unemployment <u>less</u> full employment unemployment rate)
+a(L)	4.5	Percentage change in minimum wage ($a(L) = 0.02 + 0.01L + 0.01L^2 + 0.005L^3$)
+0.3	1.3	Guidepost dummy
+2.6	4.1	Phase I of Nixon controls dummy
-2.9	3.9	Dummy in 1964(1) for "apparent data error"
+0.01	3.7	Percentage change in ratio of after-tax profits to GNP
+0.7	5.3	Actual percent change in PCE deflator over previous year (entered up to 1973 only)
-1.7	1.5	Dummy = 0 up to 1973, = 1 after 1973
+0.4	2.6	Expected rate of inflation of PCE deflator

$\bar{R}^2 = 0.88$ DW = 1.78 T = 1956:1 to 1980:1 97 observations

(OLS)

Expected Rate of Inflation = 0.86 Actual Rate + 0.14 Expected Rate
in previous period.

Note: Source, Eckstein (Table 9.2, p. 78).

Table 3

Historical Review

	\dot{p}	\dot{p}_c	\dot{p}_d	\dot{p}_s
1957	3.4	3.6	-0.6	0.6
8	2.7	3.3	-0.5	0.1
9	0.9	2.6	-1.2	-0.3
1960	1.5	3.1	-1.6	0.1
1	1.1	2.1	-1.1	0.0
2	1.2	1.3	-0.3	0.1
3	1.2	1.1	0.2	-0.1
4	1.3	1.0	0.5	-0.2
5	1.6	0.6	0.7	0.3
6	3.0	0.9	1.4	0.7
7	2.8	1.6	1.2	0.0
8	4.2	1.9	2.1	0.2
9	5.4	3.0	2.0	0.5
1970	5.9	4.1	1.4	0.4
1	4.3	4.3	-0.7	0.7
2	3.3	4.2	-1.7	0.8
3	6.2	4.4	-1.1	2.9
4	11.0	6.0	1.2	3.8
5	9.2	7.9	0.1	1.2
6	5.7	7.7	-2.6	0.6
7	6.5	7.7	-1.9	0.8
8	7.7	7.8	-1.2	1.0
9	11.2	8.2	0.7	2.3

Note: Source, Eckstein (Tables 4.1; 4.2; 4.3; 4.4; 4.5: pp. 25, 27, 29, 31, 33).

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