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Nominal Income and the Inflation-Growth Divide

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Abstract

This paper deals with aggregate demand fluctuations and their price and output effects. Starting with a nominal income solution, a rule for determining the inflation and output growth effects is presented. Assigning alternative values to the key parameters of the suggested rule generates different closure rules, such as the classical and the Keynesian and their modern counterparts. An application to major industrial country data indicates that the suggested rule is robust. Both inflation and output growth are affected by nominal shocks, but response patterns vary among the countries.

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SUMMARY

This paper is concerned with the macroeconomic issue of how to decompose nominal income into its inflation and output growth components. Several fundamental theories, which are very different and the source of much controversy, have been proposed. Despite the improvement in the power and sophistication of statistical tests, it has not been possible to discriminate conclusively among these theories.

This paper suggests a different, hierarchical, approach for undertaking the decomposition. Starting with the nominal income solution, a rule is proposed for its decomposition into subsidiary inflation and output solutions. It possesses the useful encompassing property of being able to generate the basic rules in the literature by varying the values taken by the few easily estimated parameters.

The suggested approach is applied to major industrial country data. The results obtained are robust and support the underlying causal assignment. They indicate that both prices and output respond to nominal income fluctuations, ruling out extreme Keynesian or classical positions, but also the Phillips curve. The countries sampled exhibited some diversity–with some closer to a Keynesian, more output-oriented, longer-drawn-out dynamic adjustment response–while others were more classical.

I. INTRODUCTION

A fundamental issue in macroeconomics concerns the decomposition of nominal income into its price and output components or, in the usage of this paper, the decomposition of nominal income growth into its inflation and output growth components. Several controversial solutions have been proposed. However, despite the increase in the power and sophistication of statistical test procedures, it is still not possible to discriminate conclusively between these seemingly very different theories.[2]

An approach that could help would be to set up an encompassing rule for undertaking the decomposition, from which the other rules can be derived. This paper presents a candidate for such a rule that involves only a few parameters. It is possible that countries, depending on their economic structures and behavioral patterns, will exhibit different parameter values, suggesting that the same macroeconomic theory need not apply to all. A country could also undergo shifts in parameter values in response to regime changes and other shocks, indicating changes in the underlying explanatory theory. A purpose of this paper is to test for the existence of such phenomena using the suggested rule.

The paper begins in section 2 with a brief account of the major competing macroeconomic theories. Section 3 develops an alternative theory for dividing nominal income. This approach is hierarchical: it involves first obtaining a solution for nominal income and then dividing it in a consistent manner between inflation and output growth components. Section 4 demonstrates the encompassing properties of the proposed rule, and examines some of its econometric properties. An application to the major industrial countries is presented in Section 5.

II. A SELECTIVE REVIEW OF THE LITERATURE

Long ago, Hume remarked on the tendency for both prices and output to respond to monetary expansion. However, it was not until the discovery of the Phillips (1958) curve that an explicit relationship was postulated between inflation and output (unemployment). For many years the dominant analytical view, as expressed by the classical closure rule that underlay the quantity theory of money, was that nominal prices bore the primary impact of demand fluctuations, since output was assumed to be at its potential (full employment) level. The inapplicability of this extreme rule in periods of recession, and certainly during the Great Depression, together with the rise of Keynesian economics, led to an alternative and equally extreme mode of analysis. According to the Keynesian closure rule, demand impacts solely on output, with the nominal price level exogenously determined by factors such as union negotiated wages. For a while, especially in the early 1950's, an uneasy truce prevailed between the two rules: the classical closure rule being invoked in situations of overfull

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[2] Ball and Mankiw (1994) propose relying on personal priors in choosing between competing theories. Lucas (1994) strongly criticizes this approach as being non-scientific, arguing that the choice should be based on empirical analysis.

employment to explain inflation, with the Keynesian one taking over in under-employment situations to account for output fluctuations.[3]

The Phillips curve, which can be interpreted as postulating a positive relationship between inflation and the gap between actual and potential output, appeared initially to reproduce the observed co-movements of nominal price and output increases. However, Friedman (1968) and Phelps (1967) showed that the implication of a long-run, permanent, tradeoff between inflation and output related variables was illusory because it failed to allow for changing inflation expectations. At most it described a short-run tradeoff, whereby an expansionary demand policy would temporarily raise the output growth rate. Over time, as the higher inflation rate came to be expected, the effects of that expansionary policy would wear off and output would then revert to its potential level. This led to a revision of the Phillips curve into an expectations-augmented version that soon became a staple of macroeconomic models.

Lucas and his followers rejected the systematic short-run tradeoff implied by the expectations augmented version of the Phillips curve, on the grounds that if expectations are rational, and markets function properly, correctly anticipated expansionary policies would have no real impact. The observed correlation between inflation and output, in the face of rational expectations, was explained as the result of misperception. Rational transactors mistook price signals because of their variability and modified their output supply behavior, when there should have been a purely nominal price response. Obviously, no systematic, exploitable, relationship could be based on misperceptions. The thrust of Lucas's (1973) criticism is that the Phillips curve imposes a spurious relationship between two variables, one nominal and the other real, and cannot explain how the relationship between the two can change as, for example, when stagflation occurs and the postulated positive relationship between inflation and output is reversed.[4]

Lucas (1973) establishes the effects of aggregate demand fluctuations on inflation and output by taking explicit account of aggregate supply considerations. The aggregate demand side is identified with nominal income, while the supply response is derived from making specific assumptions about the microeconomic behavior of producers. The division of nominal income between price and output components is determined by the interaction of aggregate demand with the supply side, and is influenced by rational expectations and misperceptions.

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[3] See Frisch (1983) for a historical review. Keynes (1940) had argued for this interpretation.

[4] The failure of the Phillips curve to account for the stagflation of the early- to- mid-70s was pronounced by Lucas and Sargent (1979) as fatal for Keynesian theorizing, which had by then fully embraced the Phillips curve.

Lucas's framework allows for the possibility of divergent movements between inflation and output, unlike with the Phillips curve.[5]

It was not long before a counterattack was mounted on Lucas and his followers' revival of classical nominalism by so-called new-Keynesians, who demonstrated that even if the demand fluctuation is fully anticipated misperceptions are not required for output to be affected.[6] Just as with the traditional Keynesian analysis the demonstration relies on non-instantaneous market clearance. However, this time around such consequences are derived more rigorously from micro foundations that can generate frictions when behavior is optimizing, or nearly so, because of institutional or other impediments and externalities. As there are likely to be many different potential sources of frictions and externalities, Keynesian micro foundations lack the uniformity of the friction free new-classical micro foundations. Their approach, therefore, suffers from conveying the impression of being more *ad hoc* than the new classical approach.

The alternative positions summarized above do not exhaust the macroeconomic options.[7] Although there is a lack of consensus regarding the appropriate macroeconomic theory, nonetheless, the Phillips curve remains in widespread use. This is presumably for want of a better alternative, which neither the Lucas model nor the new-Keynesian alternatives appear to have supplied, at any rate in a sufficiently convincing manner. Despite exhaustive empirical tests across different countries, a stable Phillips curve does not appear to have been adequately confirmed, at least to the satisfaction of all. It is not possible to report here on the vast amount of empirical work that has been undertaken in connection with these theories. For the purpose of this paper, two frequent findings of the empirical work on impulse response functions should be noted: a sustained increase in nominal income growth leads to initial increases in both output growth and the inflation rate. However, the surge in the output growth rate will decay and eventually disappear, while the inflation rate will continue rising until it accounts for all of the increase in the nominal income growth rate.

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[5] Subsequently, Lucas (1976) indicated that in his 1973 paper he thought that he was estimating a two-equation model, whereas, in fact, there was only one independent equation, which was being used to estimate the inflation and output terms, respectively. This is because, given nominal income, a solution for the output term automatically implies that for the nominal price level. Paldam and Christensen (1990) claim that a two-equation system can be restored if nominal income is replaced by a behavioral theory. Of the three variables only two can be independent and which two are selected has important implications for causality, which is discussed further in Section 4.

[6] See Blanchard and Fischer (1989) for a review.

[7] See Phelps (1990) for a compendium. One approach that is not discussed further in this paper is the real business cycle theory. Some view this strand, which eschews the existence of cyclical growth variations around a well defined trend, as the logical culmination of the Lucas model, but it has not performed well empirically.

III. DERIVING THE THEORY

On the face of it, the five basic approaches outlined in Section 2 could not look more dissimilar. This section develops a closure rule that will be shown in Section 4 to capture their salient macroeconomic features. A hierarchical procedure is adopted, which begins with a nominal income solution that is then decomposed into its inflation and growth terms. A justification for the hierarchical approach is first provided.

A. Nominal Income as the Starting Point

For illustrative purposes, it is convenient to begin the analysis with the fundamental monetary identity

$$(1) \qquad MV \equiv PT$$

where M is the stock of money, V is the velocity of circulation over a defined period of this money, P is the price level and T represents the volume of transactions over the defined period.

By assuming that velocity is stable, the quantity theory of money can be generated from (1). Three equations are needed for an equilibrium solution. First, a stable demand for money function

$$(2) \qquad M^d = kPQ \equiv kY$$

where k is the inverse of its assumed constant velocity of circulation v, Q is the output that underlies the volume of transactions T, and Y is nominal income.

Second, the money stock M, which is given at a point in time, is assumed to be growing at a constant rate m, using small case letters to denote proportional rates of change.

$$(3) \qquad m^s = m.$$

Third, for monetary flow equilibrium the rate of growth in the demand for money, derived from the logarithmic differentiation of (2) with respect to time, must equal the rate of growth in its supply

$$(4) \qquad m = y.$$

The critical feature to note about (4) is that the solution is for **nominal** income and not for the separate price and output components. As Friedman (1971) pointedly remarked there is a fundamental indeterminacy in basic macroeconomic models, whether monetarist or Keynesian, in that the conditions that suffice for overall model equilibrium do not permit the

separate determination of price and output terms.[8] An additional equation is required—Friedman's famous missing equation.[9]

B. A Theory for Dividing Nominal Income Growth

The nominal income growth rate is identically equal to the sum of the inflation rate and output growth terms[10]

(5) $\qquad y \equiv p + q.$

Re-express the preceding identity as follows

(6) $\qquad y \equiv p - p_{-1} + q - q^* + p_{-1} + q^*.$

Re-arranging,

(7) $\qquad (p - p_{-1}) + (q - q^*) \equiv (y - [p_{-1} + q^*])$

The left hand side (LHS) of equation (7) sums the acceleration in the inflation rate and deviations of the rate of growth from its potential (trend) rate - the cyclical growth rate. This is identically equal to the difference between the rate of growth in nominal income and the potential rate of growth, valued at the preceding period's rate of inflation, on the right hand

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[8]This outcome can be viewed as an implication of aggregation across budget constraints. Aggregating individual budget constraints, involving money balances and income flows on the basis of which demands are formulated, can result in an imbalance between total income flows and planned outlays. The basic macroeconomic equilibrium conditions that Friedman refers to, whether monetarist or Keynesian, provide for the elimination of the imbalance between cash income and planned outlay through an adjustment in nominal income. To decompose this adjustment into its output and nominal price components, the supply side has to be explicitly introduced.

[9] The IMF monetary model that was pioneered by Polak stops at the nominal income solution. Polak's recent stock taking of the Fund monetary model forty years after its initial formulation is of interest. Polak notes "The model stops at the explanation of ΔY and does not continue to an explanation of the real and price components...This may seem surprising...But why was this gap never filled? " (Polak (1997), p8.). He attributes the reason to the fact that while a number of equations can be written down to determine either the rate of inflation or output growth, they lack the empirical validity of the basic monetary and import equations of the Fund model.

[10] To simplify the exposition cross-product terms have been left out, but could be readily added back or, alternatively, the exposition could be undertaken in terms of differences in the logarithms of variables.

side (RHS) of the equation. The latter expression is henceforth referred to as the "excess income gap (EIG)".[11]

A theory for the determination of the inflation acceleration and cyclical growth components of y can now be incorporated into the identity stated in (7). This is done by expressing each component on the LHS as a function of the term on the RHS.

$$(8) \qquad p - p_{-1} = a(y - p_{-1} - q^*).$$

The acceleration in the inflation rate is postulated to equal some stable proportion **a** of the EIG.

Analogously, cyclical output growth equals some fraction **1-a** of any nominal income gap.

$$(9) \qquad q - q^* = (1-a)(y - p_{-1} - q^*)$$

Taking nominal income as the starting point for the decomposition implies that any solutions obtained for the acceleration in inflation and cyclical output growth terms must satisfy an adding up requirement.[12] The precise distribution between the two will depend on the size of the coefficient **a**, which is influenced by the structure and behavioral characteristics of the economy. The stability of this coefficient is tested subsequently.

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[11] The dimensionality adopted for the exposition above, involving the **acceleration** in inflation and the **velocity** of output, facilitates the subsequent econometric work. It is important to note that arguments could have been presented in level terms. Thus interpreting capital letters as representing logarithms of the levels of variables, $Y \equiv P + Q$. Repeat steps (6) and (7) to derive $(P - P_{-1}) + (Q - Q^*) \equiv Y - (P_{-1} + Q^*)$. This identity relates the sum of the inflation rate (first differences in the logarithms of the nominal price levels) and the deviation of the actual level of output from its potential level - the cyclical output gap - to the difference between the levels of nominal income and potential output that is valued at the preceding period's price level. On analogy with the derivation of equation (8), the present inflation version would also be related via the parameter **a** to the EIG, which is expressed now in logarithms of levels instead of growth rates. For the reader who prefers to operate with levels or rates of change rather than acceleration, all the small-cased variables in the equations can be read as being one dimension higher, provided these letters are viewed as denoting the logarithm of levels instead of proportional rates of change.

[12] Adding equations (8) and (9) reconstitutes (7), which on simplifying reduces to (5).

Dynamical properties

The EIG is the difference between nominal income growth and the nominally valued growth in potential supply. The latter can be viewed as an offer curve indicating the income flow needed to induce producers to supply in accordance with their productive potential. The rate of increase in the costs of supply is represented here by the preceding period's rate of inflation (which indicates the current period's rate of increase in input prices). Because of the presence of a lagged term in the EIG, the inflation and output growth equations are dynamical. Hence, every time a disturbance affects these equations, a dynamical sequence is triggered, which comes to a stop only when the current rate of inflation equals the immediately preceding period's rate.

The solutions provided for the acceleration in the inflation rate and the cyclical output growth rate require only information that is already available such as the nominal income growth solution generated by a macroeconomic model or otherwise given, the previous period's rate of inflation, and the potential rate of growth of output. It needs to be emphasized that the solutions are not based on notions of the **real** output gap, or changes in it, that are widely used in the literature.[13] Basing the explanation of inflation on the real output gap would imply knowledge of actual real output. But if nominal income is the starting point, a circularity results as the output solution becomes available only when the inflation solution is obtained. In the hierarchical approach of this paper subsidiary level solutions such as for inflation or output growth can only be based on prior level solutions such as that for nominal income growth. This issue and a test procedure to validate it are examined further in Section 4.

Reverting to the earlier example of a quantity theory of money explanation of nominal income, suppose a policy action of permanently raising the money supply growth rate. Nominal income growth adjusts immediately by the amount of increase in the money growth rate. Given an unchanged potential rate of growth of output, the long-run inflation rate will also rise in step with the higher money supply growth rate. However, if $a < 1$, the inflation rate will not adjust instantaneously to its new, higher, long-run, inertial rate, but only over time via a dynamic adjustment sequence. The path followed is described by equation (8), which is solved each period over the adjustment path. In the short-run, the monetary action accelerates the rate of inflation by a proportion **a** of the EIG. Next period, the rate of acceleration begins to decline as the nominal income gap in equation (8) will have become smaller. This is because the valuation of potential output growth will be higher by the amount that the inflation rate in the preceding period increased, while nominal income continues to grow at its new constant rate. The dynamic sequence will continue until the nominal income gap disappears at which point the rate of inflation will settle at its new constant level. The higher the value of the parameter **a** the quicker the inflation rate adjusts to its new level, and the more limited the effect on growth.

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[13]Thus see the so-called mainstream model presented in Gordon (1985).

With respect to output growth, there will also be a dynamic sequence, except that the convergence is to the given, assumed unchanged, rate of growth of potential output. This is readily seen by noting that if **a** lies in the unit interval, the parameter value (1- **a**) that features in the output growth equation also lies in that interval. The emergence of a positive EIG as a consequence of the assumed monetary shock will raise the actual output growth rate. Over time, as the EIG declines because of the lagged inflation effect noted above, the output growth rate also declines. When the dynamic adjustment is complete, which under the assumptions here follows a linear path dictated by the parameter **a**, output growth will settle at its potential rate, while inflation will reflect the new, higher, money growth rate.[14]

C. A Further Generalization of the Theory

The decomposition of the basic identity stated in (5) was undertaken solely by reference to EIG. Nevertheless, the acceleration in the inflation rate can be influenced by many other factors such as rising unit labor costs, tax increases, movements in various administered prices, and fluctuations in the exchange rate. These effects are felt insofar as their unweighted contribution to the acceleration in the rate of inflation deviates from the general rate of cost increase that is proxied by p_{-1}. With n such factors, each represented by a proportional rate of growth x_i to which the weight β_i is applied to represent their inflationary impact, equation (8) is modified to

$$(10) \qquad p - p_{-1} = \sum_{i=1}^{n} \beta_i(x_i - p_{-1}) + a(y - p_{-1} - q^*)$$

The adding up condition requires that these same factors be subtracted from the solution for the output growth rate, with the result that (9) is transformed into

$$(11) \qquad q - q^* = \sum_{i=1}^{n} \beta_i(x_i - p_{-1}) + (1 - a)(y - p_{-1} - q^*)$$

While demand shocks operating through EIG affect both inflation and growth in the same direction, the other factors impact on these variables in opposite directions. Those factors that increase the inflation rate lower the output growth rate, and conversely. Thus reducing consumption-based taxes that are passed forward, lowering the rate of wage increase or slowing down the rate of depreciation of the exchange rate, all serve to reduce the acceleration in the rate of inflation. At the same time, they will have the effect of raising the rate of growth of output.

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[14] Note, however, that if **a** = 0, a positive EIG will impact entirely on output growth. Under the assumption that the potential output growth rate remains unchanged, the higher output growth rate cannot be sustained. Another mechanism will have to be introduced, for example, a delayed impact on the inflation rate through rising unit labor costs, that would reduce and eventually eliminate the initially positive EIG.

IV.   SOME IMPLICATIONS OF THE THEORY

This section shows how the decomposition rules set out in (8) or (9), or there expanded versions in (10) and (11), can generate basic rules found in the literature. It also examines certain econometric implications before subjecting the theory to test in Section 5.

A. Encompassing Properties

Classical

To show that the general model comprised by equations (8) - (9) is consistent with the classical monetary closure rule, set a = 1. From (9), the actual rate of output growth will equal its potential rate. The inflation rate can then be solved from equation (8) as the difference between nominal income growth and the potential output growth rate.

$$(12) \qquad p = y - q^*.$$

Reverting to the quantity theory of money example, substitute into (12) the solution for y from (4). This shows that the rate of inflation is simply the difference between the rates of growth in the money supply and in output - the classical quantity theory of money result.

$$(13) \qquad p = m - q^*.$$

Keynesian

To reproduce a Keynesian closure rule set a = 0. From equation (8), the acceleration term is no longer responsive to EIG as nominal prices cease to be enodgenous, while equation (9) reduces to

$$(14) \qquad q = y - p_{-1}$$

Since p_{-1} is predetermined, the actual rate of output growth fluctuates with the nominal income growth rate. Such a theory can only be descriptive of the short-run, which is the characteristic scope of this closure rule.

The Phillips curve

The Phillips curve, interpreted in this paper as a positive relationship between inflation and the gap between actual and potential levels, can be readily derived from (8) and (9).[16]

$$(15) \qquad p - p_{-1} = a(y - p_{-1} - q^*)$$

$$(16) \qquad q - q^* = (1 - a)\ (y - p_{-1} - q^*)$$

Solving out the EIG in (16) and substituting the results in (15) yields

$$(17) \qquad p - p_{-1} = \frac{a}{(1-a)}\ (q - q^*)$$

The above is a familiar relationship that is widely employed, but excludes an expectations augmentation term. This can be readily supplied if use is made of the expanded version of equations (10) and (11) in which a wage adjustment term $(w - p_{-1})$ is incorporated, and allowance is made for the influence on wage changes of expected inflation.

$$(15a) \qquad p - p_{-1} = a(y - p_{-1} - q^*) + b(w - p_{-1})$$

$$(16a) \qquad q - q^* = (1 - a)\ (y - p_{-1} - q^*) - b(w - p_{-1})$$

Let the growth in unit labor costs equal the expected rate of inflation, $w = p^e$. Analogous to the derivation of (17), (15a) and (16a), with these assumptions yield

$$(17a) \qquad p - p_{-1} = \frac{a}{(1-a)}\ (q - q^*) + \frac{b}{(1-a)}\ (p^e - p_{-1})$$

Three features should be noted about the Phillips curve. First, the curve suggests a positive trade-off between the inflation and output gap terms. This is valid only if the source of the inflationary shock is on the demand side. A supply related inflationary shock, for example, an increase in energy prices, could cause output to decline and reverse the postulated relationship. There is an issue as to how such additional factors are incorporated in the Phillips curve, in the absence of an underlying theory such as that supplied by equations (10) and (11).

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[16] Once again, the exposition here is in terms of acceleration in inflation and the rate of change in the output gap (or using Okun's law, the rate of change in the unemployment ratio), but the variables can be read alternatively as logarithms of levels, using the trick stated in footnote 11.

Second, the Phillips curve does not convey the underlying dynamics. As portrayed by (17), it suggests the possibility of a permanent trade-off. However, if (8) and (9) constitute the true underlying model, the selection of a point on the curve generated by (17) can only be temporary. As the inflation rate rises, the EIG progressively declines reducing the rate of growth of output. In terms of the experiment conducted in Section 3 of a permanently higher rate of growth of the money supply, a dynamic sequence would be triggered that eventually restores the potential rate of growth, but at a higher rate of inflation. This implies that the Phillips curve derived in (17) would be shifting each period. Consequently, (17) only conveys the potential trade-offs in one time period that are contingent upon the size of the EIG.

Third, and related to the preceding comment, the implication of an automatic adjustment dynamic underlying the Phillips curve does not depend on its augmentation by an expected inflation term, as was argued by Friedman (1968) and Phelps (1967). The latter mode of introducing dynamics, while sufficient, is not necessary to ensure the output converges to its potential level. This can be seen from (17a) on specifying an expectational hypothesis (alternatively, an indexation system) whereby the expected rate of inflation governing wage growth equals the preceding period's inflation rate, $p^e = p_{-1}$. The expected inflation term disappears from (17a), which now reduces to (17).

Lucas's new-classical rule

This theory depends heavily on the assumption of rational expectations, which will need to be explicitly introduced before showing how the proposed rule can be made compatible with this one.

Expectations

Equation (10) combines cost-push elements in the first term and demand and supply elements in the final term. Changes in currently held expectations of future events can exert their influence on behavior through different channels. One channel would be through the nominal income solution that features in EIG. Another, more direct influence, would be for the actual inflation outcome to be equated to its expected level. This process can be represented as

$$(18) \qquad p_t = E_{t-1}(p_t) + \omega_t$$

where ω_t is an error term assumed to be white noise. The time subscript t has been introduced to differentiate between the current period and the preceding period, but is dropped subsequently. The expectation is assumed to be formed on the basis of information that is available in the previous period.

If expectations of next period's inflation rate are formed in accordance with the model of the inflation process set out in (8), the process of taking expectations yields

$$(19) \qquad E_{-1}(p) = E_{-1}(p_{-1}) + a(E_{-1}(y) - E_{-1}(p_{-1} + q^*)) \qquad \text{or,}$$

$$(20) \qquad E_{-1}(p) = p_{-1} + a(y^* - (p_{-1} + q^*))$$

by the rules governing the procedure of taking expectations. Here y* is the expected value of nominal income growth for the current period. Using (18) to substitute for the expected term in (20) shows that actual inflation is determined by the expected nominal income gap and an error term

$$(21) \qquad p - p_{-1} = a(y^* - (p_{-1} + q^*)) + \omega.$$

The error term can encompass several different types of errors. One type on which focus is placed here involves nominal income deviating from its expected value. The EIG will then differ from its expected value.

Split the error term ω into two components, one to reflect all other errors and the other to represent the income error,

$$(22) \qquad \omega = \varphi + a(y - y^*).$$

Using (22) to substitute for ω in (21) and simplifying results in

$$(23) \qquad p - p_{-1} = a(y - (p_{-1} + q^*)) + \varphi. \; [17]$$

The preceding equation reproduces the formal structure of the basic inflation acceleration equation of the hierarchical approach (see (8)). However, it was based on imposing the same coefficient both on the income error term and on the expected EIG. But in Lucas's theory deviations between expected and realized aggregate demand do make a difference to the inflation outcome. This can be reflected in the above formulation by noting that expected nominal income gaps will impact only on the inflation rate - the classical result, while the unexpected error would affect both inflation and output growth. The size of the coefficient **d** in the following equation would depend on factors adduced in Lucas's (1973) misperception model regarding the relative variability of aggregate demand and of relative prices, being closer to unity if the former is the more variable of the two.

$$(24) \qquad p - p_{-1} = a(y^* - (p_{-1} + q^*)) + d(y - y^*) + \varphi$$

where a=1; and $0 \le d \le 1$.

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[17] The actual rate of growth of income replaces its expected value on substitution. While the above operation suffices for the demonstration here, a more complete expectational analysis requires the forward integration of the expectations process.

New-Keynesians

The preceding equation, which demarcates expected from unexpected explanatory variables could, with a change in the restriction on the value of **a**, also apply to the macroeconomic postulates of the new-Keynesians. More generally, **a** can take any value in the interval $0 \leq a \leq 1$, depending on the underlying micro foundations. For example, if the latter were on the lines of the staggered price setting formulations presented in Blanchard and Fischer (1989), the parameter **a** would take a fractional value depending on the term of the price contract and the proportion of transactors renegotiating their contracts at a point in time. Depending on the particular theory, new-Keynesians would argue for greater or less sluggishness in price responsiveness to nominal excess demands.

B. Econometric Issues

To bring out certain key econometric properties of the hierarchical approach, express equations (8) and (9) in stochastic form:

$$(8a) \qquad p - p_{-1} = a(y - p_{-1} - q*) + \varepsilon_t$$

$$(9a) \qquad q - q_{-1} = (1-a)(y - p_{-1} - q*) + v_1$$

with the stochastic variables assumed to be white noise.

The adding up property of the hierarchical approach is reflected in cross-equation restrictions: the coefficients of the EIG term must sum to 1, while the coefficients attached to pairs of all other terms, including the stochastic variables, sum to zero. These restrictions imply a causal structure that starts with the assumed, independently determined, nominal income from which solutions are obtained for the inflation and growth terms. Only one of the latter two can be independent, with the selected dependant variable determined jointly by the solutions for nominal income and the other variable.

An alternative causal structure would be for nominal income to be causally implied by the inflation and output growth terms, with the latter two independently determined. The above cross-equation restrictions would then cease to hold, in particular, the stochastic terms are no longer of equal and opposite signs. A shock to the inflation rate, say, is not then accompanied by an offsetting movement in the growth term, but would be absorbed by nominal income changing.

A test regarding which causal structure applies could be based on estimating both the inflation and growth equations and establishing whether the cross-equation restrictions hold. If the equations are not independent, the cross-equation restrictions should be observed.

The validity of the Phillips curve is affected by which of the two alternative causal structures is operative. From (8a) and (9a), the Phillips curve is derived as

$$(25) \qquad p - p_{-1} = \frac{a}{1 - a}(q - q*) + \varepsilon - \frac{a}{1-a}v.$$

Imposing the cross-equation restriction on the stochastic variables modifies (25) to

$$(26) \qquad p - p_{-1} = \frac{a}{1 - a}(q - q*) - \frac{v}{1 - a}.$$

This operation shows that the stochastic term and the assigned independent variable are not independant. However, if the alternative causal structure is assumed then they would be independant and the relationship could be estimated using standard OLS procedures.

V. AN APPLICATION TO MAJOR INDUSTRIAL COUNTRIES

This section presents some results from applying the hierarchical approach to major industrial countries. Particular emphasis is placed on demonstrating the robustness of the approach and the stability of the estimated parameters. A stringent strategy is adopted for this purpose. For each country the sample of time series observations, obtained from the WEO databank, is divided into two sub-samples: the first, ranging from 1971 to 1983, is used for estimating the parameters of the basic inflation and output growth equations, while the second sub-sample is used to check the *ex post* prediction properties over the period 1983-1995.

A. Estimation

The expanded equations for inflation and output growth set out in (15a) and (16a), respectively, which allow for the effect of unit labor costs in addition to the nominal income gap, were used

$$(27) \qquad dp = c_0 + aed + bdw + \varepsilon$$

$$(28) \qquad dq = c_1 + (1-a)ed - bdw + v$$

Here the definitions used are $dp = p - p_{-1}$ and $dq = q - q*$. The term **ed** denotes the EIG measure derived earlier, while **dw** reflects the influence of excess wage growth and is defined as the growth in unit labor costs, calculated as the productivity corrected growth in the index of manufacturing wage increases, from which the previous period's rate of inflation has been subtracted.

Initial testing of the time series on the price level, the inflation rate, and output levels indicated that they were nonstationary. Overcoming this problem, which could seriously bias the parameter estimates, required further differencing of the time series. This dictated the form of the variables featuring in (27) and (28) and its earlier versions such as (10) and (11). Each of the terms in the above equations were then tested, applying the augmented Dickey-Fuller

tests (ADF), using equations involving lagged terms of the respective dependant variables and a time trend. The tests were conducted for the entire sample period (1971 - 1995). As the sample size is relatively small, thereby reducing the power of the ADF test, the results should be interpreted with caution. Nevertheless, the variables in the above two equations exhibited neither the presence of unit roots nor any deterministic trends. It was therefore decided to proceed with estimation using ordinary least squares (OLS).

Estimates were obtained for each country with respect to the first sub-period and for the period as a whole. These results, which relate to cyclical output growth and acceleration in inflation variables, are presented in the appendix table and charts.[18] As can be noted there the estimated equations generally exhibit a high degree of resolution in terms of the adjusted R-squares. The estimated Durbin-Watson d-statistics, interpreted broadly as a general purpose diagnostic test, fell within acceptable bounds.

Applying the standard diagnostic tests (not reported here) to each of the estimated equations indicated that the model is acceptable. With very few exceptions, there were no signs of serial correlation according to the Breusch and Godfrey Lagrange multiplier test. Nor, using Ramsey's RESET test, were there more than a very few indications of the inadequacy of the linear functional form. The assumption of a normally distributed error term was also not rejected by a CHI-SQUARE test of the residuals for skewness and kurtosis. Furthermore, for virtually all of the cases the estimated equations were not found to exhibit significant heteroscedasticity, as indicated by the Breusch-Pagan test involving the regression of squared residuals on squared fitted values.

Chow's first test was applied to test for the stability of the regression coefficients that were estimated using first period sample data. With the exception of Canada, the parameter estimates were found to be stable. However, even for Canada, application of Chow's second test of the adequacy of predictions revealed, in common with the other sample countries, that the model forecasts well. Results from applying Chow's structural stability test were borne out by the CUSUM test of structural stability.

The charts, each of which distinguishes between an estimation period and a forecast period, provide visual confirmation of the diagnostic test conclusions that the model is robust. The actual inflation and output growth rates are well tracked, and acceptable *ex post* forecasts were obtained. The last is reassuring, given the major shocks that occurred over the sample period.[19] The stability of the estimated parameters suggests that the model is capturing some

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[18] While the constructed variables in deviation form were needed to ensure stationarity, once unbiased, consistent, parameter estimates have been obtained the implied fitted inflation rate and output growth series, or higher dimensioned series, can be readily reconstructed.

[19] It is possible that the fits, while generally very good, could be further improved on taking systematic account of various general shocks such as the oil price shocks in 1974 and in 1979,

basic structural features. A virtue of the model is that it is parsimonious. Relying on only two parameters, the coefficient attaching to the EIG term and another to the excess wage term, a large part of the variation in both inflation and short-run output growth appears to be explained.

Tables 1 and 2 summarize results regarding the responsiveness of the inflation acceleration term and cyclical output growth to the EIG and wage growth factors. It may be noted from the tables that the adding up constraints discussed earlier are essentially observed. The coefficients shown in Table 1, regarding the impact of the EIG on the inflation and output growth rates, respectively, should sum to unity. The results obtained are close to this requirement, although there is a rather puzzling systematic shortfall of a small amount.[20] At the same time, the coefficient values shown in Table 2, governing the impact of the excess wage term on the inflation rate, should be positive, while those with regard to the output growth rate should be negative and of equal size. These expectations are amply confirmed indicating the robustness of the hierarchical causal assignment and equation specifications.[21]

B. Interpretation of Results

The results obtained for the different countries demonstrate that, to varying degrees, both inflation and output growth are affected by nominal income shocks. None of the countries yielded results in conformity with the extreme traditional classical or Keynesian predictions. Furthermore, for all of the countries excess wage growth was a significant influence on both inflation and output growth. This indicates that there is scope for factors affecting costs to disrupt the relationship postulated by the Phillips curve. Recourse to this relationship is thus not supported, which further reinforces the indication of non-support from the causal view set out in Section 4 above. However, additional tests are needed, which are not undertaken here, to establish the applicability of the new-classical and new-Keynesian theories.

The sample of countries can be split into two groups, according to the nature of their response patterns. For four of the countries - USA, Germany, France and the U.K. - the EIG term impacts more on the output growth rate than on the inflation rate. This suggests that for

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[19](...continued)
or individual country specific shocks such as German reunification.

[20] One can speculate on influences that impart a systematic bias to the parameter **a**, one of which could be the way in which potential output is estimated.

[21] The stability of the **a** parameter suggests stable structural dynamics operating via the EIG term. An alternative formulation of the dynamics would be based on a cointegration approach (see Engle and Granger (1987)). However, the lack of any theory-based restrictions such as those implied by (27) and (28) on the short-run dynamics may result in unstable dynamic specifications, with poor forecasting properties.

**Table 1. Major Industrial Countries: Estimated Inflation
and Growth Effects of Nominal Income Gap (1971-95)
(coefficient values)**

	Growth	Inflation	Sum 1/ (cols. 1+2)
USA	0.73	0.22	0.95
Japan	0.17	0.79	0.96
Germany	0.68	0.28	0.96
France	0.64	0.31	0.95
U.K.	0.59	0.35	0.94
Italy	0.40	0.53	0.93
Canada	0.40	0.55	0.95

Source: Appendix table.
Growth = deviation of actual output growth from its potential rate.
Inflation = first difference of the inflation rate.

1/ According to the adding-up constraint these should sum to 1.

these economies there is considerable short-run price sluggishness and that response patterns
are closer to Keynesian predictions. Thus for the United States, nearly three-quarters of any
increase in nominal income involves an output expansion in the same year, with the remaining
one-fourth impacting on the price level. The indication of a small value for the a coefficient
suggests a more drawn out dynamic adjustment process. This is because a small proportion of
the EIG is absorbed by the contemporaneous adjustment in nominal prices so that next
period's EIG declines only by a small amount, and so on.

At the same time it is of interest to note (see Appendix) that for three of the preceding
group of countries - USA, Germany, France - the excess wage term is more significant in its
impact on inflation than is the EIG, bearing out the hypothesis of a more Keynesian type
adjustment process. The last is even more the case for the U.K. for whom the excess wage
term dominates over the EIG both in the inflation and growth equations, although relatively
more so for inflation than on output.

**Table 2. Major Industrial Countries: Estimated Inflation
and Growth Effects of Excess Wage Increases (1971-95)
(Coefficient values)**

	Growth	Inflation	Sum 1/ (cols.1+2)
USA	-0.26	0.27	0.01
Japan	-0.28	0.30	0.02
Germany	-0.20	0.21	0.01
France	-0.24	0.26	0.02
U.K.	-0.47	0.52	0.05
Italy	-0.17	0.19	0.02
Canada	-0.26	0.27	0.01

Source: Appendix table.

1/ According to the adding-up constraint these should sum to zero.

Drawing on Mundell's criterion of comparative efficiency for assigning instruments, these findings suggest that for this group of countries demand management policies that impact on EIG should be assigned to influencing growth, while policies that influence wage behaviour, which could but need not include an incomes policy, should be paired with the inflation target.[22] The implication follows that in the event of an economic slowdown some demand stimulus should be combined with policies that induce a negative growth in unit labor costs. The latter would counteract the adverse effect on inflation of the stimulus to demand. It is possible that the workings of a similar policy assignment helps account for the current period of prolonged but benign growth performance of the USA. However, if additional loops were incorporated in the model, principally between output growth and the decline in the unemployment ratio impacting on wage behaviour, at some stage the excess wage term would turn adverse. Growth would then suffer but it might have to be reduced further to

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[22] See Mundell (1962). The policies mentioned here are those most readily activated in the short-run. However, structural policies that affect potential output and productivity growth will also influence EIG and the wage term.

trigger a dynamic adjustment sequence that would bring inflation down to acceptable levels. In the absence of wage control, the adjustment could be prolonged.

For the second group of countries - Canada, Italy, and especially Japan - the results are reversed. The bulk of the impact of EIG is on inflation rather than on output growth. For Japan estimated **a** is 0.83 indicating that the adjustment dynamics to shocks are very quick, being largely completed in one year. Interestingly, this indication of a more classical response pattern is reflected in the excess wage term being the dominant term in the equation explaining output growth, instead of the inflation rate. These findings suggest that a policy pairing that would promote growth would be to rely on negative cost effects accompanied by some demand stimulus to avoid price deflation, but with primary emphasis on policies that encourage productivity growth. The last is especially important because if the response pattern is heavily classical the growth process would be dominated by the potential output growth rate, with limited cyclical output deviations. While beyond the scope of this paper, it is nonetheless interesting to speculate about the underlying reasons for these different results. Could it be that Japanese producers encounter more market segmentation and view an increase in demand for their product as a signal that capacity must be increased, the financing for which is then obtained by raising prices?

Chart 1. Major Industrial Countries: Tracking and Forecasting Inflation
Acceleration (dp) and Cyclical Output Growth (dq) 1/

(In percent per year)
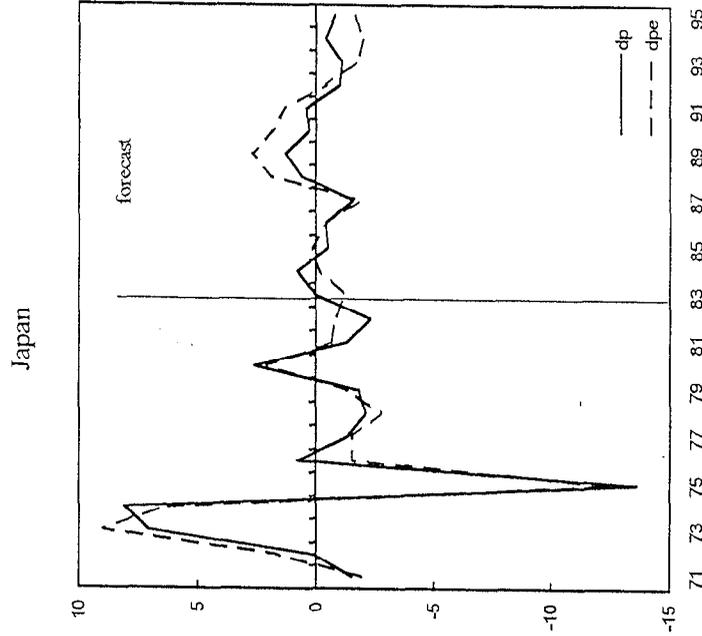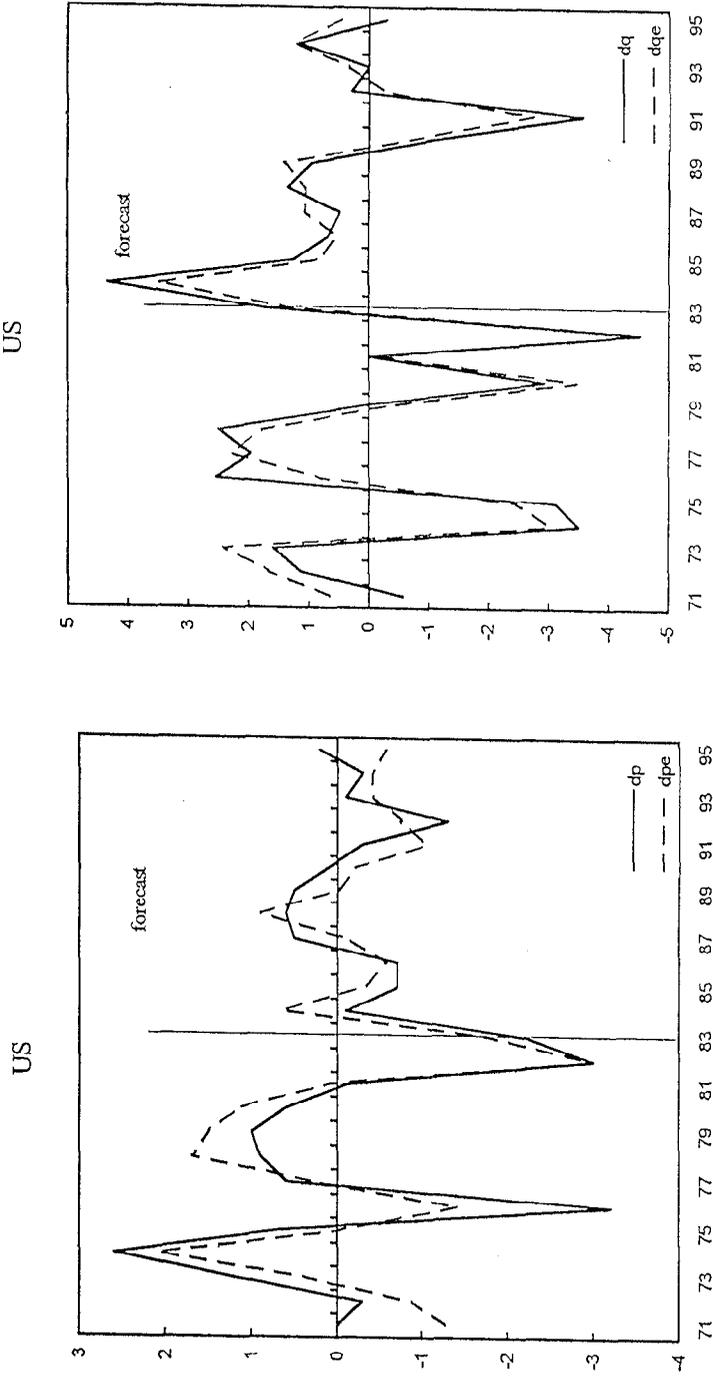
Sources: IMF WEO databank, Appendix table and staff estimates.

1/ dpe = estimated inflation acceleration; dqe = estimated cyclical output growth.

Chart 1a. Major Industrial Countries: Tracking and Forecasting Inflation
Acceleration (dp) and Cyclical Output Growth (dq)
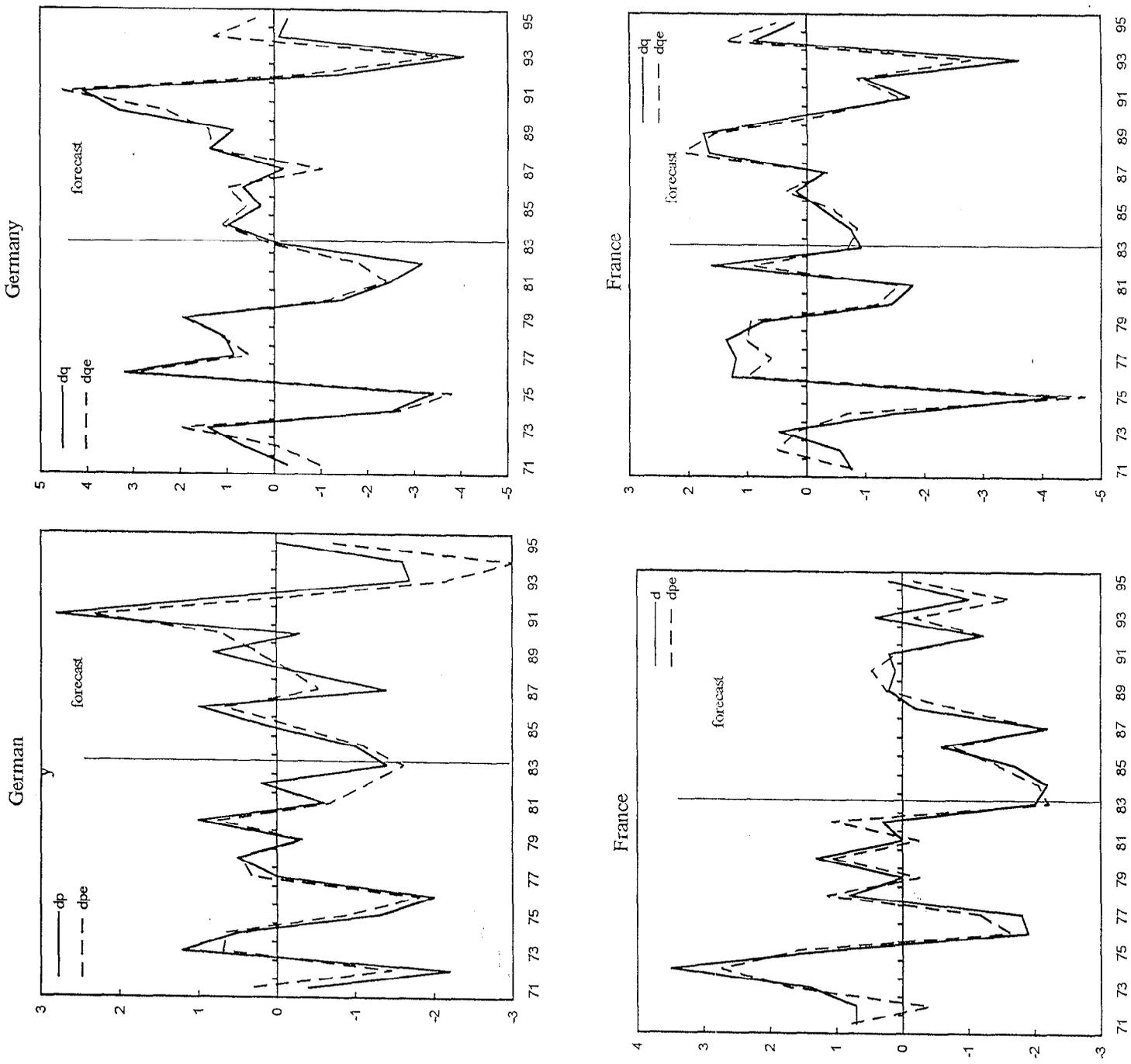
(In percent per year)

Sources: IMF WEO databank, Appendix table and staff estimates.

Chart 1b. Major Industrial Countries: Tracking and Forecasting Inflation
Acceleration (dp) and Cyclical Output Growth (dq)

(In percent per year)

Italy

Italy

U K

UK
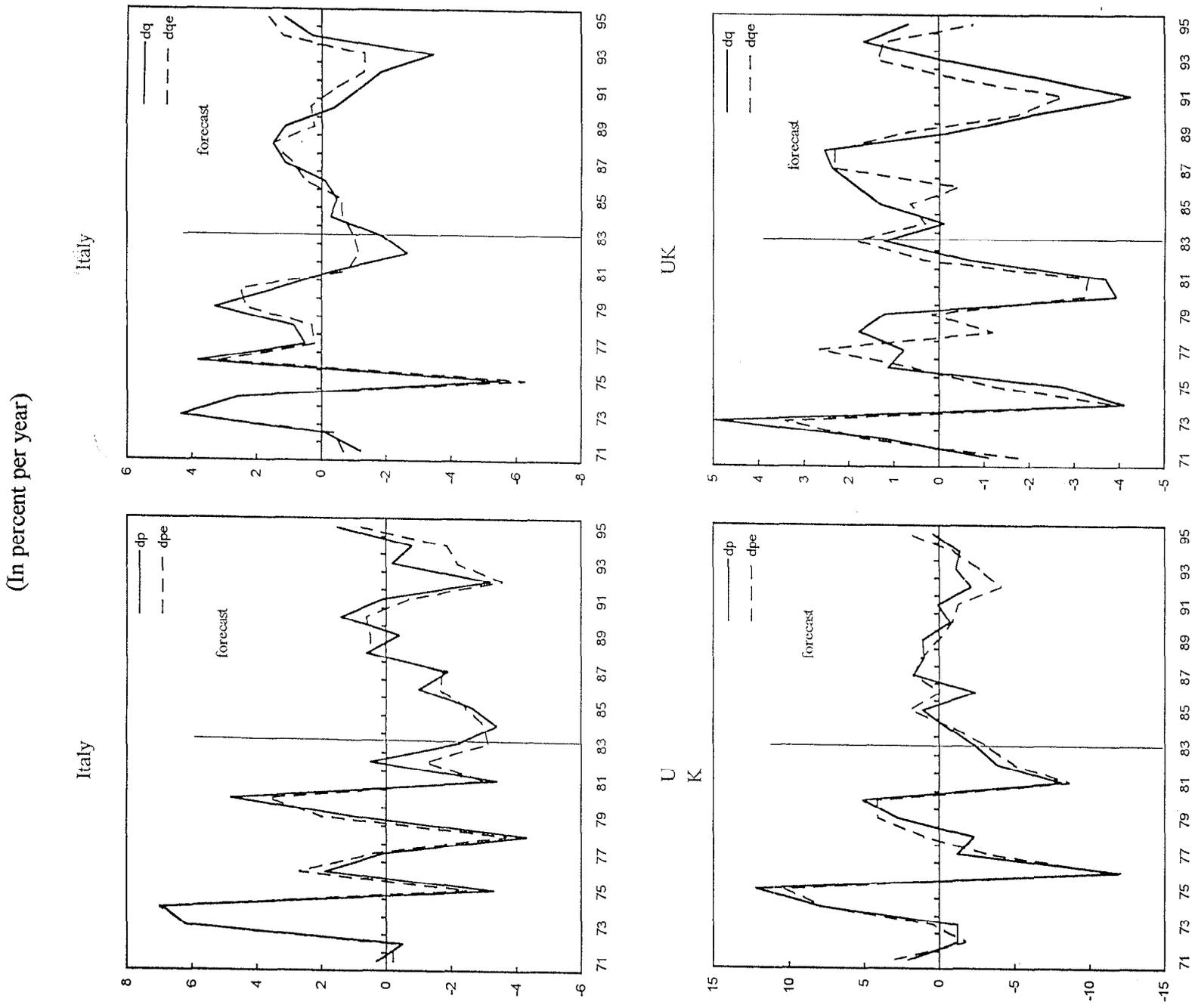
Sources: IMF WEO databank, Appendix table and staff estimates.

Chart 1c. Major Industrial Countries: Tracking and Forecasting Inflation Acceleration (dp) and Cyclical Output Growth (dq)

(In percent per year)

Canada
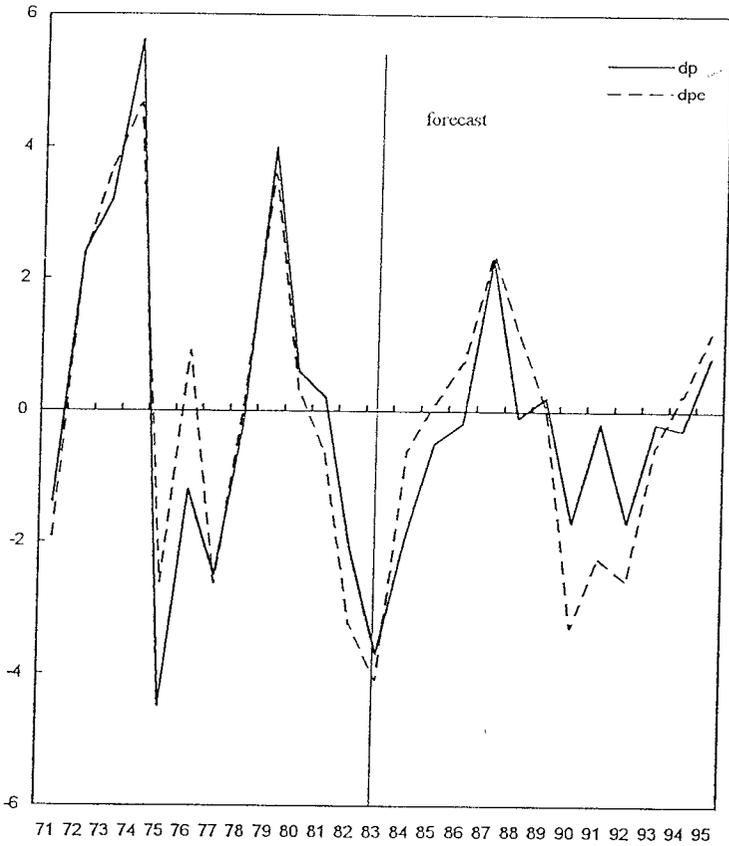
Canada
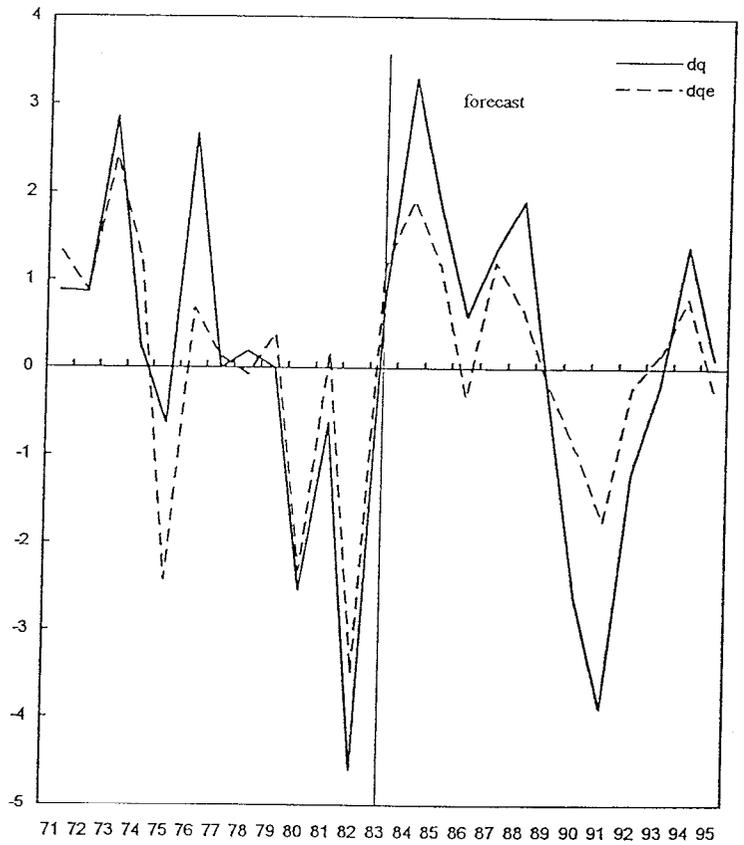
Sources: IMF WEO databank, Appendix table and staff estimates.

VI. Conclusions

The results presented above appear quite favorable to the hierarchical approach to decomposing a nominal income solution into its real and price components. They confirm that traditional choices of closure rules - classical, Keynesian, or Phillips curves - are too limiting. However, further testing is needed to establish the applicability of the new-classical and new-Keynesian approaches.

The closure rule that was proposed allows for nominal prices and real output to respond to nominal shocks. Its application to the G-7 countries shows that both these two variables respond, but to varying degrees. For some countries response patterns tend to be closer to classical predictions, while others exhibit a more output-oriented, Keynesian, pattern. Accordingly, different implications are borne for the kind of policies that would trigger a suitable dynamic adjustment path to a more satisfactory state. An interesting finding is that the underlying dynamic adjustment process appears stable.

Table 3. Major Industrial Countries: Primary Influences on Inflation Acceleration (dp)
and Cyclical Output Growth (dq) in Period I (1971-83)
and for Whole Period (1971-1995)

			ed	dw	$\bar{R}^2$	DW
USA	I	dp	0.26 (2.95)	0.27 (4.90)	0.73	1.62
		dp	0.22 (3.89)	0.27 (6.44)	0.69	1.65
	I	dq	0.69 (8.30)	-0.26 (-4.86)	0.88	1.63
		dq	0.73 (13.15)	-0.26 (-6.29)	0.90	1.64
Japan	I	dp	0.83 (11.03)	0.32 (5.43)	0.92	2.54
		dp	0.79 (13.14)	0.30 (6.47)	0.89	2.13
	I	dq	0.12 (1.83)	-0.29 (-5.50)	0.73	2.53
		dq	0.17 (3.00)	-0.28 (-6.33)	0.68	2.00
Germany	I	dp	0.27 (3.49)	0.25 (5.13)	0.70	1.49
		dp	0.28 (5.08)	0.21 (5.35)	0.68	1.73
	I	dq	0.68 (8.70)	-0.24 (-5.01)	0.92	1.48
		dq	0.68 (12.40)	-0.20 (-5.25)	0.88	1.74
U.K.	I	dp	0.38 (2.86)	0.53 (5.46)	0.93	2.33
		dp	0.35 (3.74)	0.52 (7.23)	0.90	2.02
	I	dq	0.56 (4.74)	-0.47 (-5.57)	0.71	2.41
		dq	0.59 (6.98)	-0.47 (-7.17)	0.70	2.02

Table 3. Major Industrial Countries: Primary Influences on Inflation Acceleration (dp) (concluded)
and Cyclical Output Growth (dq) in Period I (1971-83)
and for Whole Period (1971-1995)

			ed	dw	$\bar{R}^2$	DW
Italy	I	dp	0.54 (12.58)	0.21 (4.29)	0.93	1.67
		dp	0.53 (14.75)	0.19 (5.16)	0.91	1.73
	I	dq	0.38 (10.05)	-0.18 (-4.26)	0.91	1.71
		dq	0.40 (11.95)	-0.17 (-4.93)	0.87	1.71
Canada	I	dp	0.64 (8.58)	0.25 (3.59)	0.87	1.46
		dp	0.55 (9.25)	0.27 (4.77)	0.81	1.54
	I	dq	0.30 (4.24)	-0.24 (-3.59)	0.72	1.47
		dq	0.40 (6.67)	-0.26 (-4.62)	0.74	1.52

Source: WEO data base

dp = first difference in inflation rates.

dq = difference between actual real output growth and potential rate of growth.

ed = nominal income gap.

dw = growth in unit labor costs in manufacturing less preceding period's rate of inflation.

I = period 1971 - 1983.

Note: Constant term estimates were all around zero; items in parentheses are t - ratios.

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