THE EVOLUTION AND POLICY IMPLICATIONS OF PHILLIPS CURVE ANALYSIS

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At the core of modern macroeconomics is some version or another of the famous Phillips curve relationship between inflation and unemployment. The Phillips curve, both in its original and more recently reformulated expectations-augmented versions, has two main uses. In theoretical models of inflation, it provides the so-called "missing equation" that explains how changes in nominal income divide themselves into price and quantity components. On the policy front, it specifies conditions contributing to the effectiveness (or lack thereof) of expansionary and disinflationary policies. For example, in its expectations-augmented form, it predicts that the power of expansionary measures to stimulate real activity depends critically upon how price anticipations are formed. Similarly, it predicts that disinflationary policy will either work slowly (and painfully) or swiftly (and painlessly) depending upon the speed of adjustment of price expectations. In fact, few macro policy questions are discussed without at least some reference to an analytical framework that might be described in terms of some version of the Phillips curve.

As might be expected from such a widely used tool, Phillips curve analysis has hardly stood still since its beginnings in 1958. Rather it has evolved under the pressure of events and the progress of economic theorizing, incorporating at each stage such new elements as the natural rate hypothesis, the adaptive-expectations mechanism, and most recently, the rational expectations hypothesis. Each new element expanded its explanatory power. Each radically altered its policy implications. As a result, whereas the Phillips curve was once seen as offering a stable enduring trade-off for the policymakers to exploit, it is now widely viewed as offering no trade-off at all. In short, the original Phillips curve notion of the potency of activist fine tuning has given way to the revised Phillips curve notion of policy ineffectiveness. The purpose of this article is to trace the sequence of steps that led to this change. Accordingly, the paragraphs below sketch the evolution of Phillips curve analysis, emphasizing in particular the theoretical innovations incorporated into that analysis at each stage and the policy implications of each innovation.

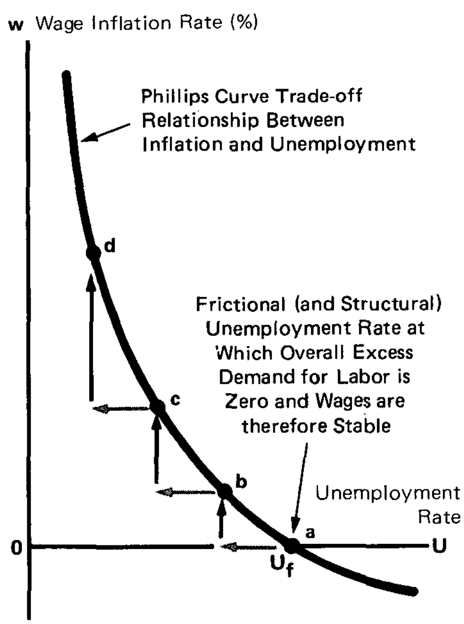
I.

EARLY VERSIONS OF THE PHILLIPS CURVE

The idea of an inflation-unemployment trade-off is hardly new. It was a key component of the monetary doctrines of David Hume (1752) and Henry Thornton (1802). It was identified statistically by Irving Fisher in 1926, although he viewed causation as running from inflation to unemployment rather than vice versa. It was stated in the form of an econometric equation by Jan Tinbergen in 1936 and again by Lawrence Klein and Arthur Goldberger in 1955. Finally, it was graphed on a scatterplot chart by A. J. Brown in 1955 and presented in the form of a diagrammatic curve by Paul Sultan in 1957. Despite these early efforts, however, it was not until 1958 that modern Phillips curve analysis can be said to have begun. That year saw the publication of Professor A. W. Phillips' famous article in which he fitted a statistical equation $w=f(U)$ to annual data on percentage rates of change of money wages (w) and the unemployment rate (U) in the United Kingdom for the period 1861-1913. The result, shown in a chart like Figure 1 with wage inflation measured vertically and unemployment horizontally, was a smooth, downward-sloping convex curve that cut the horizontal axis at a positive level of unemployment.

The curve itself was given a straightforward interpretation: it showed the response of wages to the excess demand for labor as proxied by the inverse of the unemployment rate. Low unemployment spelled high excess demand and thus upward pressure on wages. The greater this excess labor demand the

Figure 1
EARLY PHILLIPS CURVE



At unemployment rate $\mathbf{U_f}$ the labor market is in equilibrium and wages are stable. At lower unemployment rates excess demand exists to bid up wages. At higher unemployment rates excess supply exists to bid down wages. The curve's convex shape shows that increasing excess demand for labor runs into diminishing marginal returns in reducing unemployment. Thus successive uniform decreases in unemployment (horizontal gray arrows) require progressively larger increases in excess demand and hence wage inflation rates (vertical black arrows) as we go from point **a** to **b** to **c** to **d** along the curve.

faster the rise in wages. Similarly, high unemployment spelled negative excess demand (i.e., excess labor supply) that put deflationary pressure on wages. Since the rate of change of wages varied directly with excess demand, which in turn varied inversely with unemployment, wage inflation would rise with decreasing unemployment and fall with increasing unemployment as indicated by the negative slope of the curve. Moreover, owing to unavoidable frictions in the operation of the labor market, it followed that some frictional unemployment would exist even when the market was in equilibrium, that is, when excess labor demand was zero and wages were stable. Accordingly, this frictional unemployment was indicated by the point at which the Phillips curve crosses the horizontal axis. According to Phillips, this is also the point to which the economy returns if the authorities ceased to maintain disequilibrium in the labor market by pegging the excess demand for labor. Finally, since increases in excess demand would likely run into diminishing marginal returns in reducing unemployment, it followed that the curve must be convex—this convexity showing that successive uniform decrements in unemployment would require progressively larger increments in excess demand (and thus wage inflation rates) to achieve them.

Popularity of the Phillips Paradigm

Once equipped with the foregoing theoretical foundations, the Phillips curve gained swift acceptance among economists and policymakers alike. It is important to understand why this was so. At least three factors probably contributed to the attractiveness of the Phillips curve. One was the remarkable temporal stability of the relationship, a stability revealed by Phillips' own finding that the same curve estimated for the pre-World War I period 1861-1913 fitted the United Kingdom data for the post-World War II period 1948-1957 equally well or even better. Such apparent stability in a two-variable relationship over such a long period of time is uncommon in empirical economics and served to excite interest in the curve.

A second factor contributing to the success of the Phillips curve was its ability to accommodate a wide variety of inflation theories. The Phillips curve itself explained inflation as resulting from excess demand that bids up wages and prices. It was entirely neutral, however, about the causes of that phenomenon. Now excess demand can of course be generated either by shifts in demand or shifts in supply regardless of the causes of those shifts. Thus a demand-pull theorist could argue that excess-demand-induced inflation stems from excessively expansionary aggregate demand policies while a cost-push theorist could claim that it emanates from trade-union monopoly power and real shocks operating on labor supply. The Phillips curve could accommodate both views. Economists of rival schools could accept the Phillips curve as offering insights into the nature of the inflationary process even while disagreeing on the causes of and appropriate remedies for inflation.

Finally, the Phillips curve appealed to policymakers because it provided a convincing rationale for their apparent failure to achieve full employment with price stability—twin goals that were thought to be mutually compatible before Phillips' analysis. When criticized for failing to achieve both goals simultaneously, the authorities could point to the Phillips curve as showing that such an outcome was impossible and that the best one could hope for was either arbitrarily low unemployment or price stability but not both. Note also that the curve, by offering a menu of alternative inflation-unemployment combinations from which the authorities could choose, provided a ready-made justification for discretionary intervention and activist fine tuning. Policymakers had but to select the best (or least undesirable) combination on the menu and then use their policy instruments to achieve it. For this reason too the curve must have appealed to some policy authorities, not to mention the economic advisors who supplied the cost-benefit analysis underlying their choices.

From Wage-Change Relation to Price-Change Relation

As noted above, the initial Phillips curve depicted a relation between unemployment and wage inflation. Policymakers, however, usually specify inflation targets in terms of rates of change of prices rather than wages. Accordingly, to make the Phillips curve more useful to policymakers, it was therefore necessary to transform it from a wage-change relationship to a price-change relationship. This transformation was achieved by assuming that prices are set by applying a constant mark-up to unit labor cost and so move in step with wages—or, more precisely, move at a rate equal to the differential between the percentage rates of growth of wages and productivity (the latter assumed zero here).[1] The result of this transformation was the price-change Phillips relation

(1) $p = ax(U)$

where p is the rate of price inflation, x(U) is overall excess demand in labor and hence product markets—this excess demand being an inverse function of the unemployment rate—and a is a price-reaction coefficient expressing the response of inflation to excess demand. From this equation the authorities could determine how much unemployment would be associated with any given target rate of inflation. They could also use it to measure the effect of policies undertaken to obtain a more favorable Phillips curve, i.e., policies aimed at lowering the price-response coefficient and the amount of unemployment associated with any given level of excess demand.

Trade-Offs and Attainable Combinations

The foregoing equation specifies the *position* (or distance from origin) and *slope* of the Phillips curve—two features stressed in policy discussions of the early 1960s. As seen by the policymakers of that era, the curve's position fixes the inner boundary, or frontier, of feasible (attainable) combinations of inflation and unemployment rates (see Figure 2). Determined by the structure of labor and product markets, the position of the curve defines the set of all coordinates of inflation and unemployment rates the authorities could achieve via implementation of monetary and fiscal policies. Using these macroeconomic demand-management policies the authorities could put the economy anywhere on the curve. They could not, however, operate to the left of it. The Phillips curve was viewed as a constraint preventing them from achieving still lower levels of both inflation and unemployment. Given the structure of labor and product markets, it would be impossible for monetary and fiscal policy alone to reach inflation-unemployment combinations in the region to the left of the curve.

The *slope* of the curve was interpreted as showing the relevant policy trade-offs (rates of exchange between policy goals) available to the authorities. As explained in early Phillips curve analysis, these trade-offs arise because of the existence of irreconcilable conflicts among policy objectives. When the goals of full employment and price stability are not simultaneously achievable, then attempts to move the economy closer to one will necessarily move it further away from the other. The rate at which one objective must be given up to obtain a little bit more of the other is measured by the slope of the Phillips curve. For example, when the Phillips curve is steeply sloped, it means that a small reduction in unemploy-

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[1] Let prices P be the product of a fixed markup K (including normal profit margin and provision for depreciation) applied to unit labor costs C,

(1) $P = KC$.

Unit labor costs by definition are the ratio of hourly wages W to labor productivity or output per labor hour Q,

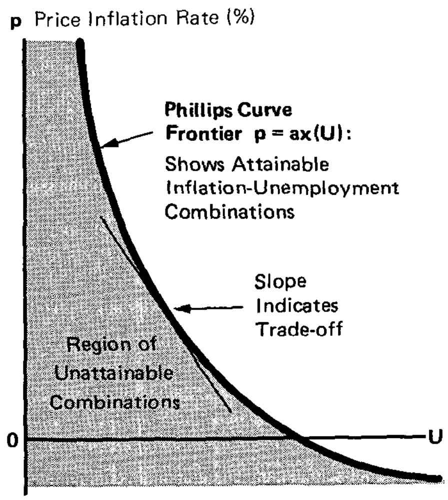
(2) $C = W/Q$.

Substituting (2) into (1), taking logarithms of both sides of the resulting expression, and then differentiating with respect to time yields

(3) $p = w - q$

where the lower case letters denote the percentage rates of change of the price, wage, and productivity variables. Assuming productivity growth q is zero and the rate of wage change w is an inverse function of the unemployment rate yields equation (1) of the text.

Figure 2
TRADE-OFFS AND ATTAINABLE COMBINATIONS



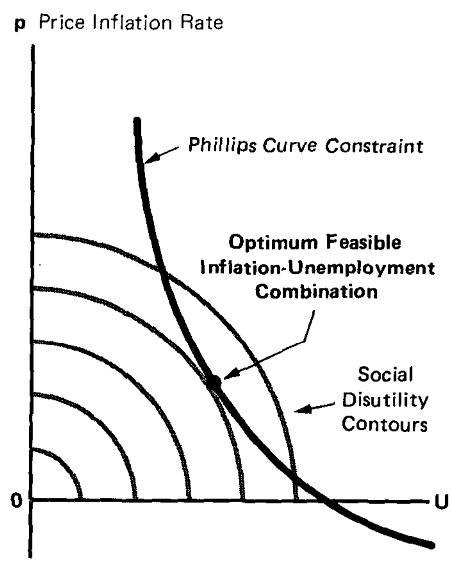
The *position* or *location* of the Phillips curve defines the frontier or set of attainable inflation-unemployment combinations. Using monetary and fiscal policies, the authorities can attain all combinations lying upon the frontier itself but none in the shaded region below it. In this way the curve acts as a constraint on demand-management policy choices. The *slope* of the curve shows the trade-offs or rates of exchange between the two evils of inflation and unemployment.

ment would be purchased at the cost of a large increase in the rate of inflation. Conversely, in relatively flat portions of the curve, considerably lower unemployment could be obtained fairly cheaply, that is at the cost of only slight increases in inflation. Knowledge of these trade-offs would enable the authorities to determine the price-stability sacrifice necessary to buy any given reduction in the unemployment rate.

The Best Selection on the Phillips Frontier

The preceding has described the early view of the Phillips curve as a stable, enduring trade-off permitting the authorities to obtain permanently lower rates of unemployment in exchange for permanently higher rates of inflation or vice versa. Put differently, the curve was interpreted as offering a menu of alternative inflation-unemployment combinations from which the authorities could choose. Given the menu, the authorities' task was to select the particular inflation-unemployment mix resulting in the smallest social cost (see Figure 3). To do this, they would have to assign relative weights to the twin evils of

Figure 3
THE BEST SELECTION ON THE MENU OF CHOICES



The bowed-out curves are social disutility contours. Each contour shows all the combinations of inflation and unemployment *resulting in a given level of social cost or* harm. The closer to the origin, the lower the social cost. The slopes of these contours reflect the relative weights that society (or the policy authority) assigns to the evils of inflation and unemployment. The best combination of inflation and unemployment that the policymakers can reach, given the Phillips curve constraint, is the mix appearing on the lowest attainable social disutility contour. Here the additional social benefit from a unit reduction in unemployment will just be worth the extra inflation cost of doing so.

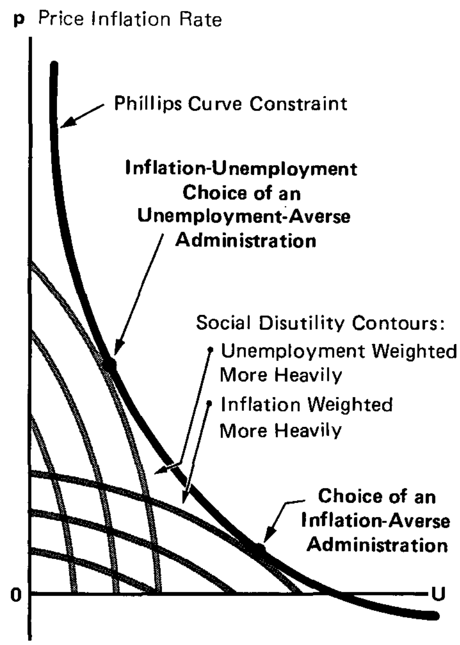
inflation and unemployment in accordance with their views of the comparative harm caused by each. Then, using monetary and fiscal policy, they would move along the Phillips curve, trading off unemployment for inflation (or vice versa) until they reached the point at which the additional benefit from a further reduction in unemployment was just worth the extra inflation cost of doing so. Here would be the optimum, or least undesirable, mix of inflation and unemployment. At this point the economy would be on its lowest attainable social disutility contour (the bowed-out curves radiating outward from the origin of Figure 3) allowed by the Phillips curve constraint. Here the unemployment-inflation combination chosen would be the one that minimized social harm. It was of course understood that if this outcome involved a positive rate of inflation, continuous excess money growth would be required to maintain it. For without such monetary stimulus, excess demand would disappear and the economy would return to the point at which the Phillips curve crosses the horizontal axis.

Different Preferences, Different Outcomes

It was also recognized that policymakers might differ in their assessment of the comparative social cost of inflation vs. unemployment and thus assign different policy weights to each. Policymakers who believed that unemployment was more undesirable than rising prices would assign a much higher relative weight to the former than would policymakers who judged inflation to be the worse evil. Hence, those with a marked aversion to unemployment would prefer a point higher up on the Phillips curve than would those more anxious to avoid inflation, as shown in Figure 4. Whereas one political administration might opt for a high pressure economy on the grounds that the social benefits of low unemployment exceeded the harm done by the inflation necessary to achieve it, another administration might deliberately aim for a low pressure economy because it believed that some economic slack was a relatively painless means of eradicating harmful inflation. Both groups would of course prefer combinations to the southwest of the Phillips constraint, down closer to the figure's origin (the ideal point of zero inflation and zero unemployment). As pointed out before, however, this would be impossible given the structure of the economy, which determines the position or location of the Phillips frontier. In short, the policymakers would be constrained to combinations lying on this boundary, unless they were prepared to alter the economy's structure.

Figure 4

DIFFERENT PREFERENCES, DIFFERENT POLICY CHOICES



Different political administrations may differ in their evaluations of the social harmfulness of inflation relative to that of unemployment. Thus in their policy deliberations they will attach different relative weights to the two evils of inflation and unemployment. These weights will be reflected in the slopes of the social disutility contours (as those contours are interpreted by the policymakers). The relatively flat contours reflect the views of those attaching higher relative weight to the evils of inflation; the steep contours to those assigning higher weight to unemployment. An unemployment-averse administration will choose a point on the Phillips curve involving more inflation and less unemployment than the combination selected by an inflation-averse administration.

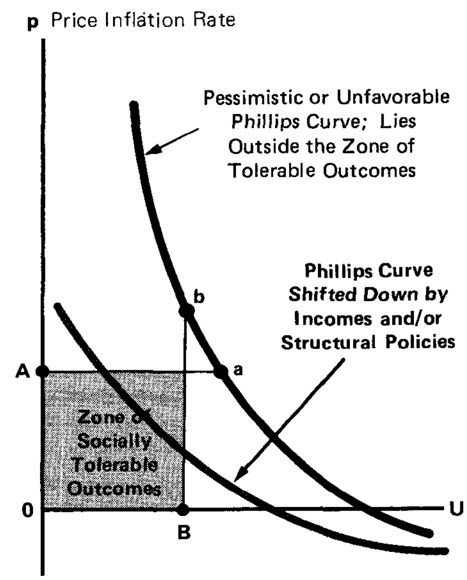
Pessimistic Phillips Curve and the "Cruel Dilemma"

In the early 1960s, there was much discussion of the so-called "cruel-dilemma" problem imposed by an unfavorable Phillips curve. The cruel dilemma refers to certain pessimistic situations where *none* of the available combinations on the menu of policy choices is acceptable to the majority of a country's voters (see Figure 5). For example, suppose there is some maximum rate of inflation, A, that voters are just willing to tolerate without removing the party in power. Likewise, suppose there is some maximum tolerable rate of unemployment, B. As shown in Figure 5, these limits define the zone of acceptable or politically feasible combinations of inflation and unemployment. A Phillips curve that occupies a position anywhere within this zone will satisfy society's demands for reasonable price stability and high employment. But if both limits are exceeded and the curve lies outside the region of satisfactory outcomes, the system's performance will fall short of what was expected of it, and the resulting discontent may severely aggravate political and social tensions.

If, as some analysts alleged, the Phillips curve tended to be located so far to the right in the chart that no portion of it fell within the zone of acceptable combinations, then the policymakers would indeed be confronted with a painful dilemma. At best they could hold only one of the variables, inflation or unemployment, down to acceptable levels. But they could not hold both simultaneously within the limits of toleration. Faced with such a pessimistic Phillips curve, policymakers armed only with traditional demand-management policies would find it impossible to achieve combinations of inflation and unemployment acceptable to society.

Figure 5

PESSIMISTIC PHILLIPS CURVE AND THE "CRUEL DILEMMA"



A = Maximum Tolerable Rate of Inflation
B = Maximum Tolerable Rate of Unemployment

Given the unfavorable Phillips curve, policymakers are confronted with a cruel choice. They can achieve acceptable rates of inflation (point a) or unemployment (point b) but not both. The rationale for *incomes* (wage-price) and *structural* (labor market) policies was to shift the Phillips curve down into the zone of tolerable outcomes.

Policies to Shift the Phillips Curve

It was this concern and frustration over the seeming inability of monetary and fiscal policy to resolve the unemployment-inflation dilemma that induced some economists in the early 1960s to urge the adoption of incomes (wage-price) and structural (labor-market) policies. Monetary and fiscal policies alone were thought to be insufficient to resolve the cruel dilemma since the most these policies could do was to enable the economy to occupy alternative positions on the pessimistic Phillips curve. That is, monetary and fiscal policies could move the economy *along* the given curve, but they could not move the curve itself into the zone of tolerable outcomes. What was needed, it was argued, were new policies that would twist or shift the Phillips frontier toward the origin of the diagram.

Of these measures, incomes policies would be directed at the price-response coefficient linking inflation to excess demand. Either by decreeing this coefficient to be zero (as with wage-price freezes), or by replacing it with an officially mandated rate of price increase, or simply by persuading sellers to moderate their wage and price demands, such policies would lower the rate of inflation associated with any given level of unemployment and thus twist down the Phillips curve. The idea was that wage-price controls would hold inflation down while excess demand was being used to boost employment.

Should incomes policies prove unworkable or prohibitively expensive in terms of their resource-misallocation and restriction-of-freedom costs, then the authorities could rely solely on microeconomic structural policies to improve the trade-off. By enhancing the efficiency and performance of labor and product markets, these latter policies could lower the Phillips curve by reducing the amount of unemployment associated with any given level of excess demand. Thus the rationale for such measures as job-training and retraining programs, job-information and job-counseling services, relocation subsidies, anti-discrimination laws and the like was to shift the Phillips frontier down so that the economy could obtain better inflation-unemployment combinations.

II.

INTRODUCTION OF SHIFT VARIABLES

Up until the mid-1960s the Phillips curve received widespread and largely uncritical acceptance. Few questioned the usefulness, let alone the existence, of this construct. In policy discussions as well as economic textbooks, the Phillips curve was treated as a stable, enduring relationship or menu of policy choices. Being stable (and barring the application of incomes and structural policies), the menu never changed.

Empirical studies of the 1900-1958 U. S. data soon revealed, however, that the menu for this country was hardly as stable as its original British counterpart and that the Phillips curve had a tendency to shift over time. Accordingly, the trade-off equation was augmented with additional variables to account for such movements. The inclusion of these shift variables marked the second stage of Phillips curve analysis and meant that the trade-off equation could be written as

$$(2) \quad p = ax(U) + z$$

where z is a vector of variables—productivity, profits, trade union effects, unemployment dispersion and the like—thought capable of shifting the inflation-unemployment trade-off.

In retrospect, this vector or list was deficient both for what it included and what it left out. Excluded at this stage were variables representing inflation expectations—later shown to be a chief cause of the shifting short-run Phillips curve. Of the variables included, subsequent analysis would reveal that at least three—productivity, profits, and measures of union monopoly power—were redundant because they constituted underlying determinants of the demand for and supply of labor and as such were already captured by the excess demand variable, U. This criticism, however, did not apply to the unemployment dispersion variable, changes in which were independent of excess demand and were indeed capable of causing shifts in the aggregate Phillips curve.

To explain how the dispersion of unemployment across separate micro labor markets could affect the aggregate trade-off, analysts in the early 1960s used diagrams similar to Figure 6. That figure depicts a representative micromarket Phillips curve, the exact replica of which is presumed to exist in each local labor market and aggregation over which yields the macro Phillips curve. According to the figure, if a given national unemployment rate U* were equally distributed across local labor markets such that the same rate prevailed in each, then wages everywhere would inflate at the single rate indicated by the point w* on the curve. But if the same aggregate unemployment were unequally distributed across local markets, then wages in the different markets would inflate at different rates. Because of the curve's convexity (which renders wage inflation more responsive to leftward than to rightward deviations from average unemployment along the curve) the average of these wage inflation rates would exceed the rate of the no-dispersion case. In short, the diagram suggested that, for any given aggregate unemployment rate, the rate of aggregate wage inflation varies directly with the dispersion of unemployment across micromarkets, thus displacing the macro Phillips curve to the right.

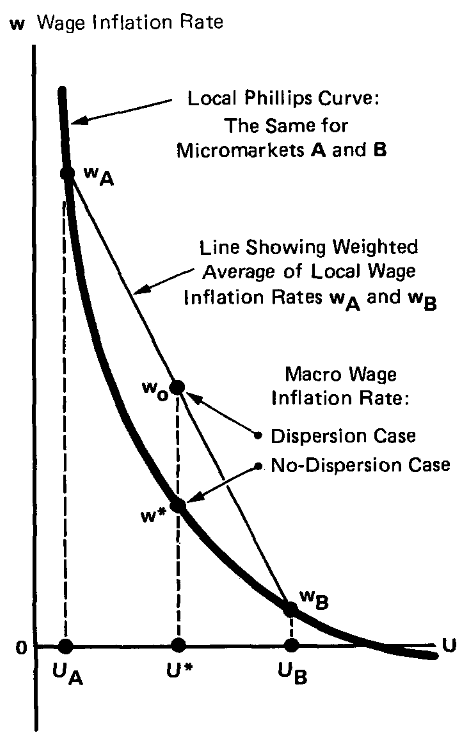
From this analysis, economists in the early 1960s concluded that the greater the dispersion, the greater the outward shift of the aggregate Phillips curve. To prevent such shifts, the authorities were advised to apply structural policies to minimize the dispersion of unemployment across industries, regions, and occupations. Also, they were advised to minimize unemployment's dispersion over time since, with a convex Phillips curve, the average inflation rate would be higher the more unemployment is allowed to fluctuate around its average (mean) rate.

A Serious Misspecification

The preceding has shown how shift variables were first incorporated into the Phillips curve in the early- to mid-1960s. Notably absent at this stage were variables representing price expectations. To be sure, the past rate of price change was sometimes used as a shift variable to represent catch-up or cost-of-living adjustment factors in wage and price demands. Rarely, however, was it interpreted as a proxy for anticipated inflation. Not until the late 1960s were expectational variables fully incorporated into Phillips curve equations. By then, of course,

Figure 6

EFFECTS OF UNEMPLOYMENT DISPERSION



If aggregate unemployment at rate **U*** were evenly distributed across individual labor markets such that the same rate prevailed everywhere, then wages would inflate at the rate **w*** both locally and nationally. But if aggregate unemployment **U*** is unequally distributed such that rate U_A exists in market **A** and U_B in market **B**, then wages will inflate at rate w_A in the former market and w_B in the latter. The average of these local inflation rates at aggregate unemployment rate **U*** is w_o which is higher than inflation rate **w*** of the no-dispersion case.

Conclusion: The greater the dispersion of unemployment, the higher the aggregate inflation rate associated with any given level of aggregate unemployment. Unemployment dispersion shifts the aggregate Phillips curve rightward.

inflationary expectations had become too prominent to ignore and many analysts were perceiving them as the dominant cause of observed shifts in the Phillips curve.

Coinciding with this perception was the belated recognition that the original Phillips curve involved a misspecification that could only be corrected by the incorporation of a price expectations variable in the trade-off. The original Phillips curve was expressed in terms of *nominal* wage changes, $w=f(U)$. Since neoclassical economic theory teaches that *real* rather than nominal wages adjust to clear labor markets, however, it follows that the Phillips curve should have been stated in terms of real wage changes. Better still (since wage bargains are made with an eye to the future), it should have been stated in terms of *expected* real wage changes, i.e., the differential between the rates of change of nominal wages and expected future prices, $w-p^e=f(U)$. In short, the original Phillips curve required a price expectations term to render it correct. Recognition of this fact led to the development of the expectations-augmented Phillips curve described below.

III.

THE EXPECTATIONS-AUGMENTED PHILLIPS CURVE AND THE ADAPTIVE-EXPECTATIONS MECHANISM

The original Phillips curve equation gave way to the expectations-augmented version in the early 1970s. Three innovations ushered in this change. The first was the respecification of the excess demand variable. Originally defined as an inverse function of the unemployment rate, $x(U)$, excess demand was redefined as the discrepancy or gap between the natural and actual rates of unemployment, U_N-U. The natural (or full employment) rate of unemployment itself was defined as the rate that prevails in steady-state equilibrium when expectations are fully realized and incorporated into all wages and prices and inflation is neither accelerating nor decelerating. It is natural in the sense (1) that it represents normal full-employment equilibrium in the labor and hence commodity markets, (2) that it is independent of the steady-state inflation rate, and (3) that it is determined by real structural forces (market frictions and imperfections, job information and labor mobility costs, tax laws, unemployment subsidies, and the like) and as such is not susceptible to manipulation by aggregate demand policies.

The second innovation was the introduction of price anticipations into Phillips curve analysis resulting in the expectations-augmented equation

$$(3) \quad p = a(U_N - U) + p^e$$

where excess demand is now written as the gap between the natural and actual unemployment rates and p^e is the price expectations variable representing the anticipated rate of inflation. This expectations variable entered the equation with a coefficient of unity, reflecting the assumption that price expectations are completely incorporated in actual price changes. The unit expectations coefficient implies the absence of money illusion, i.e., it implies that people are concerned with the expected real purchasing power of the prices they pay and receive (or, alternatively, that they wish to maintain their prices relative to the prices they expect others to be charging) and so take anticipated inflation into account. As will be shown later, the unit expectations coefficient also implies the complete absence of a trade-off between inflation and unemployment in long-run equilibrium when expectations are fully realized. Note also that the expectations variable is the sole shift variable in the equation. All other shift variables have been omitted, reflecting the view, prevalent in the early 1970s, that changing price expectations were the predominant cause of observed shifts in the Phillips curve.

Expectations-Generating Mechanism

The third innovation was the incorporation of an expectations-generating mechanism into Phillips curve analysis to explain how the price expectations variable itself was determined. Generally a simple *adaptive-expectations* or *error-learning mechanism* was used. According to this mechanism, expectations are adjusted (adapted) by some fraction of the forecast error that occurs when inflation turns out to be different than expected. In symbols,

$$(4) \quad \dot{p}^e = b(p - p^e)$$

where the dot over the price expectations variable indicates the rate of change (time derivative) of that variable, $p - p^e$ is the expectations or forecast error (i.e., the difference between actual and expected price inflation), and b is the adjustment fraction. Assuming, for example, an adjustment fraction of ½, equation 4 says that if the actual and expected rates of inflation are 10 percent and 4 percent, respectively—i.e., the expectational error is 6 percent—then the expected rate of inflation will be revised upward by an amount equal to half the error, or 3 percentage points. Such revision will continue until the expectational error is eliminated.

Analysts also demonstrated that equation 4 is equivalent to the proposition that expected inflation is a geometrically declining weighted average of all past rates of inflation with the weights summing to one. This unit sum of weights ensures that any constant rate of inflation eventually will be fully anticipated, as can be seen by writing the error-learning mechanism as

$$(5) \quad p^e = \Sigma v_i p_{-i}$$

where Σ indicates the operation of summing the past rates of inflation, the subscript i denotes past time periods, and v_i denotes the weights attached to past rates of inflation. With a stable inflation rate p unchanging over time and a unit sum of weights, the equation's right-hand side becomes simply p, indicating that when expectations are formulated adaptively via the error-learning scheme, any constant rate of inflation will indeed eventually be fully anticipated. Both versions of the adaptive-expectations mechanism (i.e., equations 4 and 5) were combined with the expectations-augmented Phillips equation to explain the mutual interaction of actual inflation, expected inflation, and excess demand.

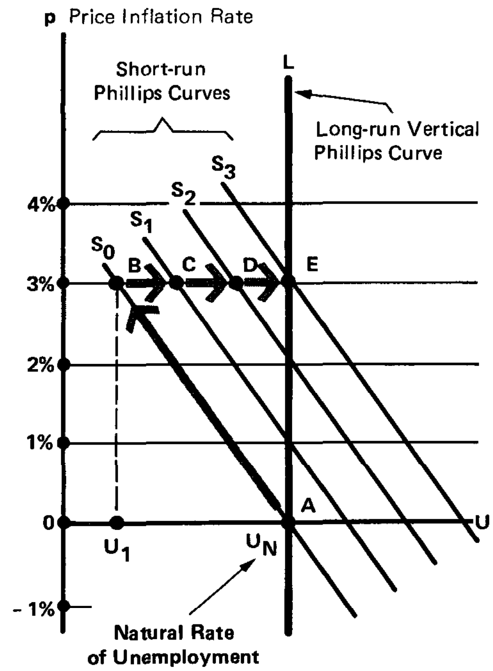
The Natural Rate Hypothesis

These three innovations—the redefined excess demand variable, the expectations-augmented Phillips curve, and the error-learning mechanism—formed the basis of the celebrated *natural rate* and *accelerationist* hypotheses that radically altered economists' and policymakers' views of the Phillips curve in the late 1960s and early 1970s. According to the natural rate hypothesis, there exists no permanent trade-off between unemployment and inflation since real economic variables tend to be independent of nominal ones in steady-state equilibrium. To be sure, trade-offs may exist in the short run. For example, surprise inflation, if unperceived by wage earners, may, by raising product prices relative to nominal wages and thus lowering real wages, stimulate employment temporarily. But such trade-offs are inherently transitory phenomena that stem from *unexpected* inflation and that vanish once expectations (and the wages and prices embodying them) fully adjust to inflationary experience. In the long run, when inflationary surprises disappear and expectations are realized such that wages reestablish their preexisting levels relative to product prices, unemployment returns to its natural (equilibrium) rate. This rate is compatible with all fully anticipated steady-state rates of inflation, implying that the long-run Phillips curve is a vertical line at the natural rate of unemployment.

Equation 3 embodies these conclusions. That equation, when rearranged to read $p - p^e = a(U_N - U)$, states that the trade-off is between *unexpected* inflation (the difference between actual and expected inflation, $p - p^e$) and unemployment. That is, only *surprise* price increases could induce deviations of unemployment from its natural rate. The equation also says that the trade-off disappears when inflation is fully anticipated (i.e., when $p - p^e$ equals zero), a result guaranteed for any steady rate of inflation by the error-learning mechanism's unit sum of weights. Moreover, according to the equation, the right-hand side must also be zero at this point, which implies that unemployment is at its natural rate. The natural rate of unemployment is therefore compatible with any constant rate of inflation provided it is fully anticipated (which it eventually must be by virtue of the error-learning weights adding to one). In short, equation 3 asserts that inflation-unemployment trade-offs cannot exist when inflation is fully anticipated. And equation 5 ensures that this latter condition must obtain for all steady inflation rates such that the long-run Phillips curve is a vertical line at the natural rate of unemployment.[2]

The message of the natural rate hypothesis was clear. A higher stable rate of inflation could not buy a permanent drop in joblessness. Movements to the left along a short-run Phillips curve only provoke expectational wage/price adjustments that shift the curve to the right and restore unemployment to its natural rate (see Figure 7). In sum, Phillips curve trade-offs are inherently transitory phenomena. Attempts to exploit them will only succeed in raising the permanent rate of inflation without accomplishing a lasting reduction in the unemployment rate.

Figure 7
THE NATURAL RATE HYPOTHESIS AND ADJUSTMENT TO STEADY-STATE EQUILIBRIUM

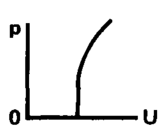


The vertical line **L** through the natural rate of unemployment $\mathbf{U_N}$ is the long-run steady state Phillips curve along which all rates of inflation are fully anticipated. The downward-sloping lines are short-run Phillips curves each corresponding to a different given expected rate of inflation. Attempts to lower unemployment from the natural rate $\mathbf{U_N}$ to $\mathbf{U_1}$ by raising inflation to 3 percent along the short-run trade-off curve $\mathbf{S_0}$ will only induce shifts in the short-run curve to $\mathbf{S_1}$, $\mathbf{S_2}$, $\mathbf{S_3}$ as expectations adjust to the higher rate of inflation. The economy travels the path **ABCDE** to the new steady state equilibrium, point **E**, where unemployment is at its preexisting natural rate but inflation is higher than it was originally.

The Accelerationist Hypothesis

The expectations-augmented Phillips curve, when combined with the error-learning process, also yielded the celebrated *accelerationist* hypothesis that

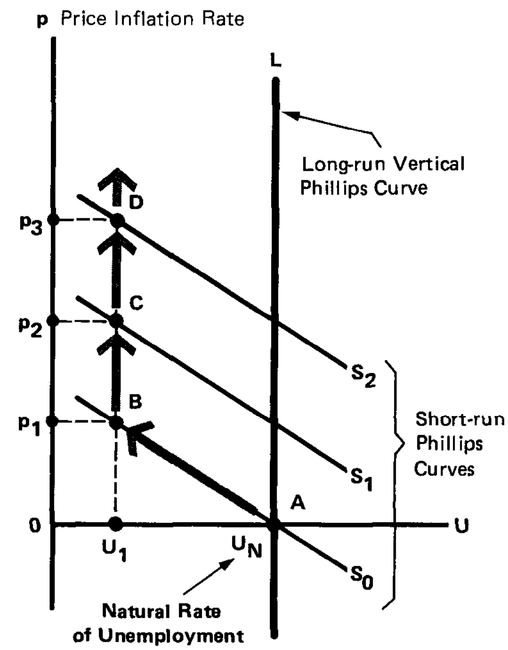
[2] Actually, the long-run Phillips curve may become positively sloped in its upper ranges as higher inflation leads to greater inflation variability (volatility, unpredictability) that raises the natural rate of unemployment. Higher and hence more variable and erratic inflation can raise the equilibrium level of unemployment by generating increased uncertainty that inhibits business activity and by introducing noise into market price signals, thus reducing the efficiency of the price system as a coordinating and allocating mechanism.



dominated many policy discussions in the inflationary 1970s. This hypothesis, a corollary of the natural rate concept, states that since there exists no long-run trade-off between unemployment and inflation, attempts to peg the former variable below its natural (equilibrium) level must produce ever-increasing inflation. Fueled by progressively faster monetary expansion, such price acceleration would keep actual inflation always running ahead of expected inflation, thereby perpetuating the inflationary surprises that prevent unemployment from returning to its equilibrium level (see Figure 8).

Accelerationists reached these conclusions via the following route. They noted that equation 3 posits that unemployment can differ from its natural level only so long as actual inflation deviates from expected inflation. But that same equation together with equation 4 implies that, by the very nature of the error-learning mechanism, such deviations cannot persist unless inflation is continually accelerated so that it always stays ahead of expected inflation.[3] If inflation is not accelerated, but instead stays constant, then the gap between actual and expected inflation will eventually be closed. Therefore acceleration is required to keep the gap open if unemployment is to be maintained below its natural equilibrium level. In other words, the long-run trade-off implied by the accelerationist hypothesis is between unemployment and the *rate of acceleration* of the inflation rate, in contrast to the conventional trade-off between unemployment and the inflation rate itself as implied by the original Phillips curve.[4]

Figure 8
THE ACCELERATIONIST HYPOTHESIS



Since the adjustment of expected to actual inflation works to restore unemployment to its natural equilibrium level U_N at any steady rate of inflation, the authorities must continually raise (accelerate) the inflation rate if they wish to peg unemployment at some arbitrarily low level such as U_1. Such acceleration, by generating a continuous succession of inflation surprises, perpetually frustrates the full adjustment of expectations that would return unemployment to its natural rate. Thus attempts to peg unemployment at U_1 will provoke explosive, ever-accelerating inflation. The economy will travel the path **ABCD** with the rate of inflation rising from zero to p_1 to p_2 to p_3 etc.

Policy Implications of the Natural Rate and Accelerationist Hypotheses

At least two policy implications stemmed from the natural rate and accelerationist propositions. First, the authorities could either peg unemployment or stabilize the rate of inflation but not both. If they pegged unemployment, they would lose control of the rate of inflation because the latter accelerates when unemployment is held below its natural level. Alternatively, if they stabilized the inflation rate,

[3] Taking the time derivative of equation 3, then assuming that the deviation of U from U_N is pegged at a constant level by the authorities such that its rate of change is zero, and then substituting equation 4 into the resulting expression yields

$$\dot{p} = b(p - p^e)$$

which says that the inflation rate must accelerate to stay ahead of expected inflation.

[4] The proof is simple. Merely substitute equation 3 into the expression presented in the preceding footnote to obtain

$$\dot{p} = ba(U_N - U)$$

which says that the trade-off is between the rate of acceleration of inflation $\dot{p}$ and unemployment U relative to its natural rate.

they would lose control of unemployment since the latter returns to its natural level at any steady rate of inflation. Thus, contrary to the original Phillips hypothesis, they could not peg unemployment at a given constant rate of inflation. They could, however, choose the steady-state inflation rate at which unemployment returns to its natural level.

A second policy implication stemming from the natural rate hypothesis was that the authorities could choose from among alternative transitional adjustment paths to the desired steady-state rate of inflation. Suppose the authorities wished to move from a high inherited inflation rate to a zero or other low target inflation rate. To do so, they must lower inflationary expectations, a major determinant of the inflation rate. But equations 3 and 4 state that the only way to lower expectations is to create slack capacity or excess supply in the economy. Such slack raises unemployment above its natural level and thereby causes the actual rate of inflation to fall below the expected rate so as to induce a downward revision of the latter.[5] The equations also indicate that how fast inflation comes down depends on the amount of slack created.[6] Much slack means fast adjustment and a relatively rapid attainment of the inflation target. Conversely, little slack means sluggish adjustment and a relatively slow attainment of the inflation target. Thus the policy choice is between adjustment paths offering high excess unemployment for a short time or lower excess unemployment for a long time (see Figure 9).[7]

IV.

STATISTICAL TESTS OF THE NATURAL RATE HYPOTHESIS

The preceding has examined the third stage of Phillips curve analysis in which the natural rate hypothesis was formed. The fourth stage involved statistical testing of that hypothesis. These tests, conducted in the early- to mid-1970s, led to criticisms of the adaptive-expectations or error-learning model of inflationary expectations and thus helped prepare the way for the introduction of the alternative rational expectations idea into Phillips curve analysis.

The tests themselves were mainly concerned with estimating the numerical value of the coefficient on the price-expectations variable in the expectations-augmented Phillips curve equation. If the coefficient is one, as in equation 3, then the natural rate hypothesis is valid and no long-run inflation-unemployment trade-off exists for the policymakers to exploit. But if the coefficient is less than one, the natural rate hypothesis is refuted and a long-run trade-off exists. Analysts emphasized this fact by writing the expectations-augmented equation as

$$(6)\quad p = a(U_N - U) + \phi p^e$$

where ϕ is the coefficient (with a value of between zero and one) attached to the price expectations variable. In long-run equilibrium, of course, expected inflation equals actual inflation, i.e., $p^e = p$. Setting expected inflation equal to actual inflation as required for long-run equilibrium and solving for the actual rate of inflation yields

$$(7)\quad p = \frac{a}{1-\phi}(U_N - U).$$

Besides showing that the long-run Phillips curve is steeper than its short-run counterpart (since the slope parameter of the former, $a/(1-\phi)$, exceeds that of the latter, a), equation 7 shows that a long-run trade-off exists only if the expectations coefficient ϕ is less than one. If the coefficient is one, however, the slope term is infinite, which means that there is no relation between inflation and unemployment so that the trade-off vanishes (see Figure 10).

Many of the empirical tests estimated the coefficient to be less than unity and concluded that the natural rate hypothesis was invalid. But this conclusion was sharply challenged by economists who contended that the tests contained statistical bias that

[5] The proof is straightforward. Simply substitute equation 3 into equation 4 to obtain

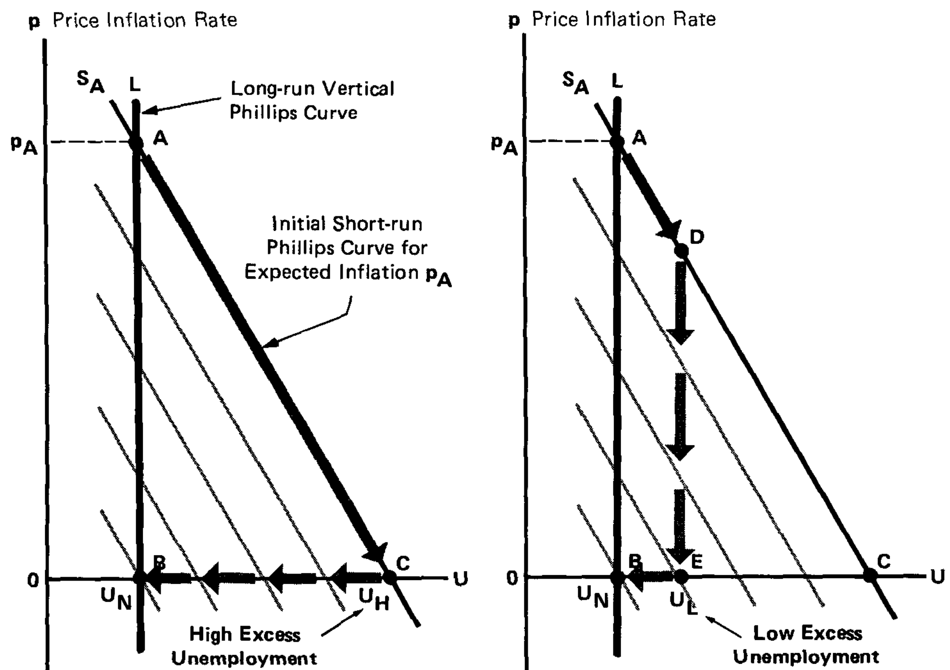
$$\dot{p}^e = ba(U_N - U).$$

This expression says that expectations will be adjusted downward ($\dot{p}^e$ will be negative) only if unemployment exceeds its natural rate.

[6] Note that the equation developed in footnote 4 states that disinflation will occur at a faster pace the larger the unemployment gap.

[7] Controls advocates proposed a third policy choice: use wage-price controls to hold actual below expected inflation so as to force a swift reduction of the latter. Overlooked was the fact that controls would have little impact on expectations unless the public was convinced that the trend of prices when controls were in force was a reliable indicator of the future price trend after controls were lifted. Convincing the public would be difficult if controls had failed to stop inflation in the past. Aside from this, it is hard to see why controls should have a stronger impact on expectations than a preannounced, demonstrated policy of disinflationary money growth.

Figure 9
ALTERNATIVE DISINFLATION PATHS



ACB = Fast disinflation path involving high excess unemployment for a short time.

ADEB = Gradualist disinflation path involving low excess unemployment for a long time.

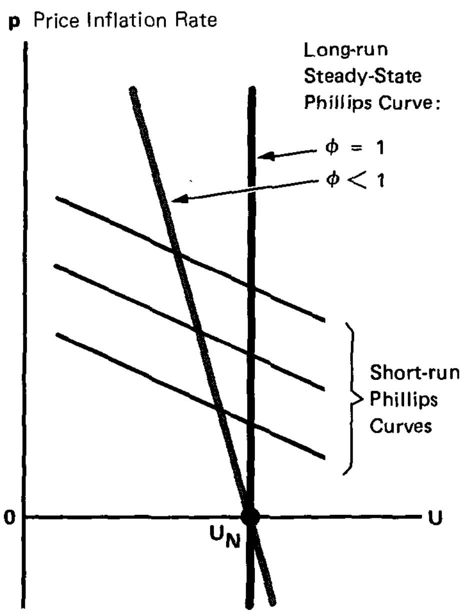
To move from high-inflation point **A** to zero-inflation point **B** the authorities must first travel along short-run Phillips curve S_A, lowering actual relative to expected inflation and thereby inducing the downward revision of expectations that shifts the short-run curve leftward until point **B** is reached. Since the speed of adjustment of expectations depends upon the size of the unemployment gap, it follows that point **B** will be reached faster via the high excess unemployment path **ACB** than via the low excess unemployment path **ADEB**. The choice is between high excess unemployment for a short time or low excess unemployment for a long time.

tended to work against the natural rate hypothesis. These critics pointed out that the tests typically used adaptive-expectations schemes as empirical proxies for the unobservable price expectations variable. They further showed that if these proxies were inappropriate measures of inflationary expectations then estimates of the expectations coefficient could well be biased downward. If so, then estimated coefficients of less than one constituted no disproof of the natural rate hypothesis. Rather they constituted evidence of inadequate measures of expectations.

Shortcomings of the Adaptive-Expectations Assumption

In connection with the foregoing, the critics argued that the adaptive-expectations scheme is a grossly inaccurate representation of how people formulate price expectations. They pointed out that it postulates naive expectational behavior, holding as it does that people form anticipations solely from a weighted average of past price experience with weights that are fixed and independent of economic conditions and

Figure 10
THE EXPECTATIONS COEFFICIENT AND THE LONG-RUN STEADY-STATE PHILLIPS CURVE



Statistical tests of the natural rate hypothesis sought to determine the magnitude of the expectations coefficient ϕ in the long-run steady-state Phillips curve equation

$$p = \frac{a}{1-\phi}(U_N - U).$$

A coefficient of one means that no permanent trade-off exists and the steady-state Phillips curve is a vertical line through the natural rate of unemployment. Conversely, a coefficient of less than one signifies the existence of a long-run Phillips curve trade-off with negative slope for the policymakers to exploit. Note that the long-run curves are steeper than the short-run ones, indicating that permanent trade-offs are less favorable than temporary ones.

policy actions. It implies that people look only at past price changes and ignore all other pertinent information—e.g., money growth rate changes, exchange rate movements, announced policy intentions and the like—that could be used to reduce expectational errors. That people would fail to exploit information that would improve expectational accuracy seems implausible, however. In short, the critics contended that adaptive expectations are not wholly rational if other information besides past price changes can improve inflation predictions.

Many economists have since pointed out that it is hard to accept the notion that individuals would continually form price anticipations from *any* scheme that is inconsistent with the way inflation is actually generated in the economy. Being different from the true inflation-generating mechanism, such schemes will produce expectations that are systematically wrong. If so, rational forecasters will cease to use them. For example, suppose inflation were actually accelerating or decelerating. According to equation 5, the adaptive-expectations model would systematically underestimate the inflation rate in the former case and overestimate it in the latter. Using a unit weighted average of past inflation rates to forecast a steadily rising or falling rate would yield a succession of one-way errors. The discrepancy between actual and expected inflation would persist in a perfectly predictable way such that forecasters would be provided free the information needed to correct their mistakes. Perceiving these persistent expectational mistakes, rational individuals would quickly abandon the error-learning model for more accurate expectations-generating schemes. Once again, the adaptive-expectations mechanism is implausible because of its incompatibility with rational behavior.

V.

FROM ADAPTIVE EXPECTATIONS TO RATIONAL EXPECTATIONS

The shortcomings of the adaptive-expectations approach to the modeling of expectations led to the incorporation of the alternative rational expectations approach into Phillips curve analysis. According to the rational expectations hypothesis, individuals will tend to exploit *all* available pertinent information about the inflationary process when making their price forecasts. If true, this means that forecasting errors ultimately could arise only from random (unforeseen) shocks occurring to the economy. At first, of course, price forecasting errors might also arise because individuals initially possess limited or incomplete information about, say, an unprecedented new policy regime, economic structure, or inflation-generating mechanism. But it is unlikely that this condition would persist. For if the public were truly rational, it would quickly learn from these inflationary surprises or prediction errors (data on which it acquires costlessly as a side condition of buying goods) and incorporate the free new information into its forecasting procedures, i.e., the source of forecasting mistakes would be swiftly perceived and systematically eradicated. As knowledge of policy and the inflationary process improved, forecasting models would be continually revised to produce more accurate predictions. Soon all systematic (predictable) elements influencing the rate of inflation would become known and fully understood, and individuals' price expectations would constitute the most accurate (unbiased) forecast consistent with that knowledge.[8] When this happened the economy would converge to its rational expectations equilibrium and people's price expectations would be the same as those implied by the actual inflation-generating mechanism. As incorporated in natural rate Phillips curve models, the rational expectations hypothesis implies that thereafter, except for unavoidable surprises due to purely random shocks, price expectations would always be correct and the economy would always be at its long-run steady-state equilibrium.

Policy Implications of Rational Expectations

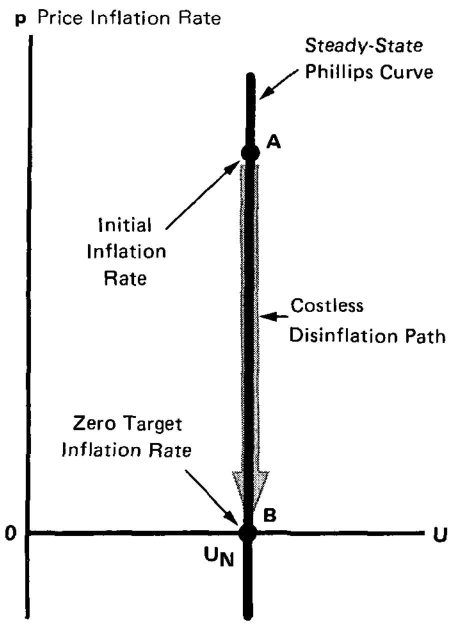
The strict (flexible price, instantaneous market clearing) rational expectations approach has radical policy implications. When incorporated into natural rate Phillips curve equations, it implies that systematic policies—i.e., those based on feedback control rules defining the authorities' response to changes in the economy—cannot influence real variables such as output and unemployment even in the short run, since people would have already anticipated what the policies are going to be and acted upon those anticipations. To have an impact on output and employment, the authorities must be able to create a divergence between actual and expected inflation. This follows from the proposition that inflation influences real variables only when it is unanticipated. To lower unemployment in the Phillips curve equation $p-p^e=a(U_N-U)$, the authorities must be able to alter the actual rate of inflation without simultaneously causing an identical change in the expected future rate. This may be impossible if the public can predict policy actions.

Policy actions, to the extent they are systematic, are predictable. Systematic policies are simply feedback rules or response functions relating policy variables to past values of other economic variables. These policy response functions can be estimated and incorporated into forecasters' price predictions. In other words, rational individuals can use past observations on the behavior of the authorities to discover the policy rule. Once they know the rule, they can use current observations on the variables to which the policymakers respond to predict future policy moves. Then, on the basis of these predictions, they can correct for the effect of anticipated policies beforehand by making appropriate adjustments to nominal wages and prices. Consequently, when stabilization actions do occur, they will have no impact on real variables like unemployment since they will have been discounted and neutralized in advance. In short, rules-based policies, being in the information set used by rational forecasters, will be perfectly anticipated and for that reason will have no impact on unemployment. The only conceivable way that policy can have even a short-run influence on real variables is for it to be unexpected, i.e., the policymakers must either act in an unpredictable random fashion or secretly change the policy rule. Apart from such tactics, which are incompatible with most notions of the proper conduct of public policy, there is no way the authorities can influence real variables, i.e., cause them to deviate from their natural equilibrium levels. The authorities can, however, influence a nominal variable, namely the inflation rate, and should concentrate their efforts on doing so if some particular rate (e.g., zero) is desired.

As for disinflation strategy, the rational expectations approach generally calls for a preannounced sharp swift reduction in money growth—provided of course that the government's commitment to ending inflation is sufficiently credible to be believed. Having chosen a zero target rate of inflation and having convinced the public of their determination to achieve it, the policy authorities should be able to do so without creating a costly transitional rise in unemployment. For, given that rational expectations adjust infinitely faster than adaptive expectations to a credible preannounced disinflationary policy (and also that wages and prices adjust to clear markets continuously) the transition to price stability should be relatively quick and painless (see Figure 11).

[8] Put differently, rationality implies that current expectational errors are uncorrelated with past errors and with all other known information, such correlations already having been perceived and exploited in the process of improving price forecasts.

Figure 11
COSTLESS DISINFLATION UNDER RATIONAL EXPECTATIONS AND POLICY CREDIBILITY



Assuming expectational rationality, wage/price flexibility, and full policy credibility, a preannounced permanent reduction in money growth to a level consistent with stable prices theoretically lowers expected and thus actual inflation to zero with no accompanying transitory rise in unemployment. The economy moves immediately from point **A** to point **B** on the vertical steady-state Phillips curve. Here is the basic prediction of the rational expectations—natural rate model: that fully anticipated policy changes (including credible preannounced ones) affect only inflation but not output and employment.

No Exploitable Trade-Offs

To summarize, the rationality hypothesis, in conjunction with the natural rate hypothesis, denies the existence of exploitable Phillips curve trade-offs in the short run as well as the long. In so doing, it differs from the adaptive-expectations version of natural rate Phillips curve models. Under adaptive-expectations, short-run trade-offs exist because such expectations, being backward looking and slow to respond, do not adjust instantaneously to eliminate forecast errors arising from policy-engineered changes in the inflation rate. With expectations adapting to actual inflation with a lag, monetary policy can generate unexpected inflation and consequently influence real variables in the short run. This cannot happen under rational expectations where both actual and expected inflation adjust identically and instantaneously to anticipated policy changes. In short, under rational expectations, systematic policy cannot induce the expectational errors that generate short-run Phillips curves.[9] Phillips curves may exist, to be sure. But they are purely adventitious phenomena that are entirely the result of unpredictable random shocks and cannot be exploited by policies based upon rules.

In sum, no role remains for systematic countercyclical stabilization policy in Phillips curve models embodying rational expectations and the natural rate hypothesis. The only thing such policy can influence in these models is the rate of inflation which adjusts immediately to expected changes in money growth. Since the models teach that the full effect of rules-based policies is on the inflation rate, it follows that the authorities—provided they believe that the models are at all an accurate representation of the way the world works—should concentrate their efforts on controlling that nominal inflation variable since they cannot systematically influence real variables. These propositions are demonstrated with the aid of the expository model presented in the Appendix on page 21.

VI.

EVALUATION OF RATIONAL EXPECTATIONS

The preceding has shown how the rational expectations assumption combines with the natural rate hypothesis to yield the policy-ineffectiveness conclusion that no Phillips curves exist for policy to exploit

[9] Note that the rational expectations hypothesis also rules out the accelerationist notion of a stable trade-off between unemployment and the rate of acceleration of the inflation rate. If expectations are formed consistently with the way inflation is actually generated, the authorities will not be able to fool people by accelerating inflation or by accelerating the rate of acceleration, etc. Indeed, no systematic policy will work if expectations are formed consistently with the way inflation is actually generated in the economy.

even in the short run. Given the importance of the rational expectations component in modern Phillips curve analysis, an evaluation of that component is now in order.

One advantage of the rational expectations hypothesis is that it treats expectations formation as a part of optimizing behavior. By so doing, it brings the theory of price anticipations into accord with the rest of economic analysis. The latter assumes that people behave as rational optimizers in the production and purchase of goods, in the choice of jobs, and in the making of investment decisions. For consistency, it should assume the same regarding expectational behavior.

In this sense, the rational expectations theory is superior to rival explanations, all of which imply that expectations may be consistently wrong. It is the only theory that denies that people make systematic expectation errors. Note that it does not claim that people possess perfect foresight or that their expectations are always accurate. What it does claim is that they perceive and eliminate *regularities* in their forecasting mistakes. In this way they discover the actual inflation generating process and use it in forming price expectations. And with the public's rational expectations of inflation being the same as the mean value of the inflation generating process, those expectations cannot be wrong on *average*. Any errors will be random, not systematic. The same cannot be said for other expectations schemes, however. Not being identical to the expected value of the true inflation generating process, those schemes will produce biased expectations that are systematically wrong.

Biased expectations schemes are difficult to justify theoretically. Systematic mistakes are harder to explain than is rational behavior. True, nobody really knows how expectations are actually formed. But a theory that says that forecasters do not continually make the same mistakes seems intuitively more plausible than theories that imply the opposite. Considering the profits to be made from improved forecasts, it seems inconceivable that systematic expectational errors would persist. Somebody would surely notice the errors, correct them, and profit by the corrections. Together, the profit motive and competition would reduce forecasting errors to randomness.

Criticisms of the Rational Expectations Approach

Despite its logic, the rational expectations hypothesis still has many critics. Some still maintain that expectations are basically nonrational, i.e., that most people are too naive or uninformed to formulate unbiased price expectations. Overlooked is the counterargument that relatively uninformed people often delegate the responsibility for formulating rational forecasts to informed specialists and that professional forecasters, either through their ability to sell superior forecasts or to act in behalf of those without same, will ensure that the economy will behave as if all people were rational. One can also note that the rational expectations hypothesis is merely an implication of the uncontroversial assumption of profit (and utility) maximization and that, in any case, economic analysis can hardly proceed without the rationality assumption. Other critics insist, however, that expectational rationality cannot hold during the transition to new policy regimes or other structural changes in the economy since it requires a long time to understand such changes and learn to adjust to them. Against this is the counterargument that such changes and their effects are often foreseeable from the economic and political events that precede them and that people can quickly learn to predict regime changes just as they learn to predict the workings of a given regime. This is especially so when regime changes have occurred in the past. Having experienced such changes, forecasters will be sensitive to their likely future occurrence.

Most of the criticism, however, is directed not at the rationality assumption per se but rather at another key assumption underlying its policy-ineffectiveness result, namely the assumption of no policymaker information or maneuverability advantage over the private sector. This assumption states that private forecasters possess exactly the same information and the ability to act upon it as do the authorities. Critics hold that this assumption is implausible and that if it is violated then the policy ineffectiveness result ceases to hold. In this case, an exploitable short-run Phillips curve reemerges, allowing some limited scope for systematic monetary policies to reduce unemployment.

For example, suppose the authorities possess more and better information than the public. Having this information advantage, they can predict and hence respond to events seen as purely random by the public. These policy responses will, since they are unforeseen by the public, affect actual but not expected inflation and thereby change unemployment relative to its natural rate in the (inverted) Phillips curve equation $U_N - U = (1/a)(p - p^e)$.

Alternatively, suppose that both the authorities and the public possess identical information but that the latter group is constrained by long-term contractual obligations from exploiting that information. For example, suppose workers and employers make labor contracts that fix nominal wages for a longer period of time than the authorities require to change the money stock. With nominal wages fixed and prices responding to money, the authorities are in a position to lower real wages and thereby stimulate employment with an inflationary monetary policy.

In these ways, contractual and informational constraints are alleged to create output- and employment-stimulating opportunities for systematic stabilization policies. Indeed, critics have tried to demonstrate as much by incorporating such constraints into rational expectations Phillips curve models similar to the one outlined in the Appendix of this article.

Proponents of the rational expectations approach, however, doubt that such constraints can restore the potency of activist policies and generate exploitable Phillips curves. They contend that policymaker information advantages cannot long exist when government statistics are published immediately upon collection, when people have wide access to data through the news media and private data services, and when even secret policy changes can be predicted from preceding observable (and obvious) economic and political pressures. Likewise, they note that fixed contracts permit monetary policy to have real effects only if those effects are so inconsequential as to provide no incentive to renegotiate existing contracts or to change the optimal type of contract that is negotiated. And even then, they note, such monetary changes become ineffective when the contracts expire. More precisely, they question the whole idea of fixed contracts that underlies the sticky wage case for policy activism. They point out that contract duration is not invariant to the type of policy being pursued but rather varies with it and thus provides a weak basis for activist fine-tuning.

Finally, they insist that such policies, even if effective, are inappropriate. In their view, the proper role for policy is not to exploit informational and contractual constraints to systematically influence real activity but rather to neutralize the constraints or to minimize the costs of adhering to them. Thus if people form biased price forecasts, then the policymakers should publish unbiased forecasts. And if the policy authorities have informational advantages over private individuals, they should make that information public rather than attempting to exploit the advantage. That is, if information is costly to collect and process, then the central authority should gather it and make it freely available. Finally, if contractual wages and prices are sticky and costly to adjust, then the authorities should minimize these price adjustment costs by following policies that stabilize the general price level.

In short, advocates of the rational expectations approach argue that feasibility alone constitutes insufficient justification for activist policies. Policies should also be socially *beneficial.* Activist policies hardly satisfy this latter criterion since their effectiveness is based on deceiving people into making expectational errors. The proper role for policy is not to influence real activity via deception but rather to reduce information deficiencies, to eliminate erratic variations of the variables under the policymakers' control, and perhaps also to minimize the costs of adjusting prices.

VII.

CONCLUDING COMMENTS

The preceding paragraphs have traced the evolution of Phillips curve analysis. The chief conclusions can be stated succinctly. The Phillips curve concept has changed radically over the past 25 years as the notion of a stable enduring trade-off has given way to the policy-ineffectiveness view that no such trade-off exists for the policymakers to exploit. Instrumental to this change were the natural rate and rational expectations hypotheses, respectively. The former says that trade-offs arise solely from expectational errors while the latter holds that systematic macroeconomic stabilization policies, by virtue of their very predictability, cannot possibly generate such errors. Taken together, the two hypotheses imply that systematic demand management policies are incapable of influencing real activity, contrary to the predictions of the original Phillips curve analysis.

On the positive side, the two hypotheses do imply that the government can contribute to economic stability by following policies to minimize the expectational errors that cause output and employment to deviate from their normal full-capacity levels. For example, the authorities could stabilize the price level so as to eliminate the surprise inflation that generates confusion between absolute and relative prices and that leads to perception errors. Similarly, they could direct their efforts at minimizing random and erratic variations in the monetary variables under their control. In so doing, not only would they lessen the number of forecasting mistakes that induce deviations from output's natural rate, they would reduce policy uncertainty as well.

Besides the above, the natural rate-rational expectations school also notes that microeconomic structural policies can be used to achieve what macro demand policies cannot, namely a permanent reduction in the unemployment rate. For, by improving the efficiency and performance of labor and product markets, such micro policies can lower the natural rate of unemployment and shift the vertical Phillips curve to the left. A similar argument was advanced in the early 1960s by those who advocated structural policies to shift the Phillips curve. It is on this point, therefore, that one should look for agreement between those who still affirm and those who deny the existence of exploitable inflation-unemployment trade-offs.

APPENDIX

A SIMPLE ILLUSTRATIVE MODEL

The policy ineffectiveness proposition discussed in Section V of the text can be clarified with the aid of a simple illustrative model. The model consists of four components, namely an (inverted) expectations-augmented Phillips curve

(1) $U_N - U = (1/a)(p - p^e)$,

a monetarist inflation-generating mechanism

(2) $p = m + \epsilon$,

a policy reaction function or feedback control rule

(3) $m = c(U_{-1} - U_T) - d(p_{-1} - p_T) + \mu$,

and a definition of rational inflation expectations

(4) $p^e = E[p|I]$.

Here U and U_N are the actual and natural rates of unemployment, p and p^e the actual and expected rates of inflation, m the rate of nominal monetary growth per unit of real money demand (the latter assumed to be a fixed constant except for transitory disturbances), ϵ and μ are random error terms with mean values of zero, E is the expectations operator, I denotes all information available when expectations are formed, and the subscripts T and —1 denote target and previous period values of the attached variables.

Of these four equations, the first expresses a trade-off between unemployment (relative to its natural level) and surprise (unexpected) inflation.[1] Equation 2 expresses the rate of inflation p as the sum of the growth rate of (demand adjusted) money m and a random shock variable ϵ having a mean (expected) value of zero. In essence, this equation says that inflation is generated by excess money growth and transitory disturbances unrelated to money growth. Equation 3 says that the policy authorities set the current rate of monetary growth in an effort to correct last period's deviations of the unemployment and inflation rates from their predetermined target levels, U_T and p_T. Also, since money growth cannot be controlled perfectly by the feedback rule, the slippage is denoted by the random variable μ with a mean of zero that causes money growth to deviate unpredictably from the path intended by the authorities. Note that the disturbance term μ can also represent deliberate monetary surprises engineered by the policy authorities. Finally, the last equation defines anticipated inflation p^e as the mathematical expectation of the actual inflation rate conditional on all information available when the expectation is formed. Included in the set of available information are the inflation-generating mechanism, the policy reaction function, and the values of all past and predetermined variables in the model.

To derive the policy ineffectiveness result, first calculate mathematical expectations of equations 2 and 3. Remembering that the expected values of the random terms in those equations are zero, this step yields the expressions

[1] There exists a current dispute over the proper interpretation of the Phillips curve equation 1. The rational expectations literature interprets it as an aggregate supply function stating that firms produce the normal capacity level of output when actual and expected inflation are equal but produce in excess of that level (thus pushing U below U_N) when fooled by unexpected inflation. This view holds that firms mistake unanticipated general price increases for rises in the particular (relative) prices of their own products. Surprised by inflation, they treat the price increase as special to themselves and so expand output. An alternative interpretation views the equation as a price-setting relation according to which businessmen, desiring to maintain their constant-market-share relative prices, raise their prices at the rate at which they expect other businessmen to be raising theirs and then adjust that rate upward if demand pressure appears. Either interpretation yields the same result: expectational errors cause output and unemployment to deviate from their natural levels. The deviations disappear when the errors vanish.

(5) $p^e = m^e$ and

(6) $m^e = c(U_{-1} - U_T) - d(p_{-1} - p_T)$

which state that, under rational expectations and systematic feedback policy rules, the anticipated future rate of inflation equals the expected rate of monetary growth which in turn is given by the deterministic (known) component of the monetary policy rule. The last step is to substitute equations 2, 3, 5, and 6 into equation 1 to obtain the reduced form expression

(7) $U_N - U = (1/a)(\epsilon + \mu)$

which states that deviations of unemployment from its natural rate result solely from inflation surprises caused by random shocks.

To see the policy ineffectiveness result, note that only the unsystematic or unexpected random component of monetary policy, $m - m^e = \mu$, enters the the reduced form equation.[2] The systematic component is absent. This means that systematic (rules-based) monetary policies cannot affect the unemployment rate. Only unexpected money growth matters. No Phillips curve trade-offs exist for systematic policy to exploit.[3]

To summarize, the strict (flexible price, continuous market clearing) rational expectations-natural rate model depicted here implies that expectational errors are the only source of departure from steady-state equilibrium, that such errors are random, short-lived, and immune to systematic policy manipulation, and therefore that rules-based policies can have no impact on real variables like unemployment since those policies will be fully foreseen and allowed for in wage/price adjustments. Thus, except for unpredictable random shocks, steady-state equilibrium prevails and systematic monetary changes produce no surprises, no disappointed expectations, no transitory impacts on real economic variables. In short, Phillips curves are totally adventitious phenomena generated by unforeseeable random shocks and as such cannot be exploited by systematic policy even in the short run.

[2] Note that both the monetary-surprise equation $m - m^e = \mu$ and the price-surprise equation $p - p^e = \epsilon$ embody the famous **orthogonality** property according to which forecast errors $m - m^e$ and $p - p^e$ are independent of (orthogonal to) all information available when the forecast is made. In particular, the forecast errors are independent of the past and predetermined values of all variables and of the systematic components of the policy rule and inflation-generating mechanism. This is as it should be. For if the errors were not independent of the foregoing variables, then information is not being fully exploited and expectations are not rational.

[3] Of course **random** policy could affect output. That is, the authorities could influence real activity by manipulating the disturbance term μ in the policy reaction function in a haphazard unpredictable way. Randomness, however, is not a proper basis for public policy.

INFLATIONARY EXPECTATIONS, MONEY GROWTH, AND THE VANISHING LIQUIDITY EFFECT OF MONEY ON INTEREST: A FURTHER INVESTIGATION

*Yash Mehra**

I.
INTRODUCTION

An important issue in discussion of the transmission mechanism of monetary policy is the response pattern of nominal interest rates to changes in the growth rate of money. The traditional analysis of the effects of changes in money growth on nominal interest rates runs in terms of liquidity, income, and expectations effects.[1] Consider an increase in the growth rate of money. Initially, there is an excess supply of money at the existing income, interest rate, and the price level. If the price level and real income adjust slowly, then the nominal interest rate must decline in order to equate money demand and money supply. This initial fall in the nominal and real[2] interest rates is known as the liquidity effect. Over time, nominal income will rise following the increased growth rate of money and this rise in nominal income will increase money demand which in turn leads to higher interest rates. This is the income effect of money on the nominal interest rate. Finally, there is a Fisher or expectations effect as nominal interest rates increase due to a rise in inflationary expectations induced by the higher money growth rate.[3]

The important assumption underlying this description of the time pattern of the effects of higher money growth on interest rates is that income and expectations effects of a current acceleration in money growth occur with a lag as the income and the price level are slow to adjust. If this assumption is not valid, for example, if the expectations effect of higher money growth occurs rapidly or if there is a reduction in the lag in the effect of money on income, the liquidity effect will not be observable.

The early empirical work which examined the time pattern of the effects of higher money growth on interest rates seemed to confirm the previously described stylized pattern. In particular, this work showed the presence of a statistically significant liquidity effect.[4] However, the results of more recent empirical work on this issue have been mixed.[5] Mishkin (1981, 1982) recently suggested that the liquidity effect of money on interest did not exist, and Melvin's (1983) work implies that the liquidity effect existed in the '50s and the '60s but vanished in the '70s. Makin (1983), on the other hand, reports evidence consistent with the presence of a statistically significant but quantitatively weak liquidity effect.[6]

This paper has two objectives. The first objective is to investigate further the existence of the liquidity effect using an improved estimation methodology.

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[1] Friedman (1968, 1969), Cagan (1972), Cagan and Gandolfi (1969, Gibson (1970), Darby (1975), Carlson (1979), and Melvin (1983).

[2] If the price level and inflationary expectations adjust slowly, a reduction in the nominal interest rate implies reduction in the real rate.

[3] If the higher level of inflationary expectations has no effect upon the steady state value of the real rate, then, the nominal interest rate will rise by the full amount of the rise in inflationary expectations. An avenue through which higher money growth can affect the real rate is discussed in Mundell (1963).

[4] Gibson (1970), Cagan and Gandolfi (1969), and Cagan (1972). For a recent confirmation, see Melvin (1983).

[5] Mishkin (1981, 1982), Melvin (1983), and Makin (1983).

[6] In Makin's framework, only unanticipated increases in money growth can depress nominal and real interest rates. Anticipated increases in money growth are not at all associated with declines in interest rates. Moreover, the magnitude of the reduction in interest rates associated with a given positive money surprise is very small. A positive money surprise over a quarter at a 1 percent annual rate depresses the short-term interest rate by 2 to 3 basis points. This implies that if the Fed wants to depress short-term interest rates by 100 basis points in a given quarter, then positive money surprises over a quarter at a 33 percent to 50 percent annual rate are needed.

The existing empirical work employs the questionable assumption that the money growth variable is strictly an exogenous regressor.[7] This is a questionable assumption in view of the way that monetary policy has been conducted. Policy has been aimed at fostering the attainment of macroeconomic objectives such as sustained economic growth, full employment, and low inflation. But in seeking to achieve these objectives, the Federal Reserve has used as guides such financial variables as the monetary aggregates and money market interest rates. Over much of the last three decades, considerable weight has been given to money market conditions and to dampening swings in interest rates. Furthermore, in more recent periods when greater weight has been placed on the monetary aggregates, financial innovations and deregulation of the financial markets occasionally have combined to make money demand a less useful guide to monetary policy, thus forcing the Federal Reserve to place added emphasis on interest rates at the expense of the monetary aggregates. In view of the above considerations, the money growth variable is likely to be correlated with the disturbance term in the usual nominal interest rate regressions. The use of ordinary least squares to estimate the time pattern of the effects of higher money growth on interest rates, therefore, may provide inconsistent estimates of the existence of the liquidity effect. This paper uses a consistent estimation procedure to investigate the existence of the liquidity effect.

The second objective of this paper is to provide some empirical evidence on Milton Friedman's view (1968) that the presence of the liquidity effect of higher money growth depends upon the nature of the response of expected inflation to higher money growth. Friedman (1968) has argued that in a high inflationary environment, inflationary expectations become so responsive to money growth that the expectations effect may be strong enough and prompt enough to overpower the short-run liquidity effect. Since the United States experienced rising inflation in the late '60s and the '70s, Friedman's argument would imply a reduction in the magnitude of the liquidity effect during that time period. This implication will be tested in this paper.

The rest of the paper is organized as follows. Section II presents a simple model of interest rate determination and defines the liquidity effect in the context of this model. It discusses the relevance of the nature of the monetary policy regime in getting consistent estimates of the parameter measuring the existence of the liquidity effect. It also reviews the argument made by Friedman (1968), noted above. Section III reports the empirical results, and Section IV contains the main conclusions and some policy implications.

II.

EXPLANATION OF METHODOLOGY

A Model of Interest Rate Determination, the Liquidity Effect, and the Behavior of the Federal Reserve

Economists have long been interested in investigating the time pattern of the effects of money growth on nominal and real interest rates. The analytical framework that underlies the empirical investigation differs widely among these economists. However, in each case, inferences about the existence of the liquidity effect are based upon a nominal interest rate regression in which money growth appears either as the sole regressor or as one of the right-hand side regressors.[8] A common assumption made in this

[7] In a regression equation, a right-hand side explanatory variable is not exogenous if it is contemporaneously correlated with the disturbance term. In that case, the use of ordinary least squares to estimate the regression parameters will produce estimates which have some undesirable properties. In particular, the estimates will be inconsistent meaning they do not converge to the true values of the parameters as the sample size becomes very large. Therefore, the ordinary least squares estimation procedure is an inconsistent estimation procedure in the presence of an endogenous regressor in the regression equation. However, there exists alternative estimation procedures which can produce consistent estimates of the parameters. Such estimation procedures are sometimes referred to as consistent estimation procedures.

[8] Basically, three approaches have been used to study this issue. One of these is to estimate distributed lag regressions of nominal interest rates on money growth by ordinary least squares and to infer the existence and strength of the liquidity effect from examining the sign and size of the coefficients on the first few lags of the money growth variable; here money growth is the only right-hand side explanatory variable (Melvin (1983)). The second approach employed is to specify explicitly an IS-LM-Aggregate Supply model of the economy and estimate by ordinary least squares the associated reduced form for the nominal interest rate. In this framework, money growth is only one of the right-hand side regressors, which also include a proxy for expected inflation. The presence of the liquidity effect is inferred by examining the sign and size of the coefficient on the money growth variable (Makin (1983), Peek and Wilcox (1984)). The third approach uses the efficient markets-rational expectations theory. If bond markets are assumed to be efficient, then nominal yields will deviate from their equilibrium values only when new information appears on the market. In this framework, changes in nominal yields are regressed upon surprise (i.e., actual minus anticipated) changes in information variables like money growth, inflation, real income, and the presence of the liquidity effect is inferred by examining the sign and size of the coefficient on the surprise money growth variable (Mishkin (1981, 1982)). Here money growth again is one of the right-hand side regressors.

empirical work, that money growth is an exogenously determined variable, allows one to use ordinary least squares to estimate the parameters of the nominal interest rate regressions. As noted above, this assumption is questionable in view of the way the Federal Reserve has conducted its monetary policy.[9]

In order to explain the issues involved as well as motivate the empirical work reported here, this paper investigates the existence of the liquidity effect using the most widely employed (Fisher equation) approach to interest rate determination.[10] This approach amounts to estimating the standard Fisher equation in which the determinants of the real rate are explicitly specified by means of an IS-LM model augmented by some sort of Aggregate Supply or Phillips curve relation. The sign and size of the estimated coefficient appearing on the money growth variable in the associated Fisher equation is then used to infer the existence and magnitude of the liquidity effect. Consider the following simple IS-LM-Aggregate Supply model:[11]

$$\text{IS: } i(1-T) - \pi = \alpha_0 + \alpha_1 (X-Y^n) - \alpha_2 (Y-Y^n) - \alpha_3 SS + \alpha_4 Z_t + U_{1t}, \quad \alpha_1, \alpha_2, \alpha_3, \alpha_4 > 0, \tag{1}$$

$$\text{LM: } i(1-T) = \frac{b_0}{b_2} + \frac{b_0}{b_2}(Y-Y^n) + \frac{1}{b_1}(P-M+Y^n) + U_{2t},^{12} \quad b_1, b_2 > 0, \tag{2}$$

$$\text{AS: } P = c_0 + P^e + c_1 (Y-Y^n) + c_2 SS + U_{3t}, \; c_1, c_2 > 0, \tag{3}$$

where all the variables except i and Z are in natural logs and where Y is actual real output, Y^n is the natural real output, X is the exogenous component of aggregate real demand, M is the nominal money stock, P is the price level, P^e is the expected price level, i is the nominal interest rate, SS is the supply shock variable measuring the relative price of energy, Z is the percentage change in real output lagged one period, T is the average marginal tax rate on interest income, and Us, s=1,2,3, are stochastic error terms.[13]

Figure 1 presents graphs of the IS, LM, and aggregate supply (AS) equations. Equation (1) is the equation of the IS curve showing an inverse relationship between the after-tax nominal rate i(1—T) and real output $(Y-Y^n)$; its position depends upon the exogenous component of the real demand X, the expected inflation rate π, the lagged growth in real income Z, and the supply shock variable SS. Equation (2) is the equation of the LM curve showing a positive relationship between the after-tax nominal rate i(1—T) and real output $(Y-Y^n)$; its position depends upon the price level P and the nominal money stock M. Equation (3) is the equation of the aggregate supply curve implying a positive relationship between the price level and real output; its position depends upon the expected price level P^e and the supply shock variable SS. U_1, U_2, and U_3,

[9] There is another set of very recent papers which looks at the responses of asset prices (or nominal asset yields) to the weekly money stock announcements (Urich (1982, 1984), Grossman (1981), Cornell (1982, 1983a, 1983b), and Gavin and Karamouzis (1984)). In these studies, changes in asset prices are generally regressed upon surprise changes in the weekly money stock numbers. There are two important assumptions underlying this work. The first is that the weekly money stock numbers have a predictive content for the future money stock. The second is that the asset markets are efficient and that the asset prices will respond to any new information contained in these money stock announcements. It is then argued that the predictive content of money stock announcements and the response of asset prices to new information in the announcements vary with changes in the way the Federal Reserve formulates and implements the monetary policy. The implication is that changes in the response of asset prices to money stock announcements can enable us to infer the public's perception of the policy making.

Since the money announcement studies focus on explaining changes in asset prices in the very short run—the period immediately following the announcement—and since information about other potentially related factors is not included in these regressions, one could not necessarily infer the existence of the liquidity effect from examining the sign of the estimated regression coefficient on the money announcement variable in a given asset price regression.

[10] Sargent (1972), Levi and Makin (1978), Peek (1982), Wilcox (1983), Makin (1983), and Peek and Wilcox (1984).

[11] This macromodel is in essence similar to the ones given in Peek (1982), and Wilcox (1983). For a detailed description, see Mehra (1984).

[12] The demand equation for real money balances underlying the LM curve is assumed to be $(M-P-Y^n)^d = b_0 + b_1 (Y-Y^n) - b_2 i(1-T)$. Assuming that the money supply equals money demand, we can solve the equilibrium expression for the after-tax nominal interest rate to get equation (2) of the text.

[13] X captures the effects of changes in the autonomous components of aggregate real demand such as real exports and real government expenditures. Z proxies for the effect of income induced investment expenditures, the so-called investment accelerator effect. SS captures the effect of changes in the relative price of energy. The model is short run in nature and focuses on the cyclical behavior of the economy. Therefore, actual real output is measured relative to its natural level, and some other variables are similarly normalized. For example, X is normalized dividing it by the natural real output. In this context, p^e is to be viewed as the expectation held at time t—1 of the price level at time t. Actual real output will deviate from its natural level whenever the actual price level (P) differs from its anticipated level (P^e) (see equation (3) in the text).

respectively, are the stochastic error terms appearing in the IS, LM, and AS relationships.

In order to derive the Fisher equation associated with this macromodel, we can combine equations (1) through (3) to get the following:

$$i_t = (1/(1-T))\ [A_0 + A_1 X_t + A_2 SS_t + A_3 DM_t + A_4 Z_t + A_5 \pi_t] + V_t, \qquad (4)$$

where DM_t is $(M-P^e-Y^n)$, and where A_1, A_2, A_3, A_4, and A_5 are the parameters in the nominal interest rate equation.[14] The stochastic term V_t in (4) is the reduced form disturbance term and is related to the stochastic terms appearing in the IS, LM, and AS relationships in the following way:

$$V_t = ((c_1 + b_1)\ U_{1t} + \alpha_2 U_{2t} + \alpha_3 U_{3t})/(d), \qquad (5)$$

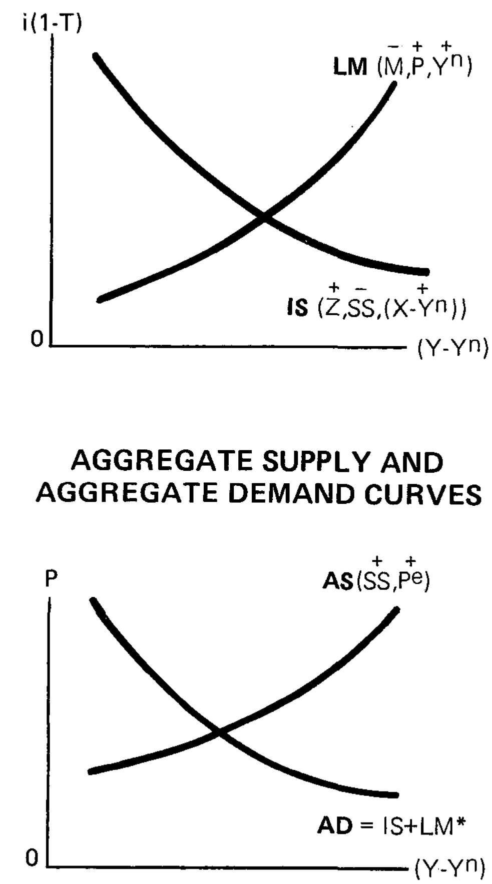
where $d \equiv (b_1 + c_1 + b_2 \alpha_2)$. It can be easily shown[15] that in the nominal interest rate equation (4), the nominal interest rate responds positively to increases in expected inflation ($A_5 > 0$), the exogenous component of real demand ($A_1 > 0$), and real income ($A_4 > 0$). The supply stock variable has an uncertain effect upon the nominal interest rate ($A_2 \gtreqless 0$). The coefficient in front of the money stock variable is negative ($A_3 < 0$), implying that higher money stock depresses the nominal interest rate. Equation (5) is important for the later discussion as it shows that the stochastic shifts occurring in the IS, LM, and AS relationships can cause stochastic shifts in the nominal interest rate equation (4) and thus cause the actual nominal interest rate to deviate *in the short run from the value implied by* the behavior of expected inflation, autonomous real demand, relative price of energy, and money stock. In this framework, the existence of the liquidity effect is investigated by examining the statistical significance of the parameter A_3, which is usually estimated with ordinary least squares.

The main question is whether it is appropriate to estimate the nominal interest rate equation (4) by the ordinary least squares estimation procedure. If any one of the right-hand side explanatory variables appearing in (4) is correlated with the error term V_t, then the ordinary least squares estimates of the parameters are inconsistent and this may yield an incorrect inference about the existence of the liquidity effect. Of interest here is the possibility that the error term V_t may be correlated with the money growth variable due to the way the Federal Reserve implements its monetary policy.

Consider the case in which the Federal Reserve conducts monetary policy by focusing solely on the monetary aggregates. In this case, any random rise in the nominal interest rate ($V_t > 0$) as a result of a

Figure 1

IS AND LM CURVES



*Aggregate demand curve (**AD**) is derived by combining the **IS** and **LM** curves.

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[14] *Equation (4) is the standard Fisher equation adjusted* to allow for the presence of taxes. To see this, rewrite (4) as

(a) $i_t = r_t^e + (1/(1-T))\ A_5 \pi_t + V_t,$

where r_t^e is the after-tax expected real rate assumed to be approximated by the following relationship

(b) $r_t^e = (1/(1-T))\ [A_0 + A_1 X_t + A_2 SS + A_3 DM_t + A_4 Z_t].$

Equation (a) is the standard Fisher equation as one can view r_t^e as the expected real rate component of the nominal interest rate.

[15] For details, see Mehra (1984).

random shift occurring in the IS, the LM, or the AS relationship is not offset by the Federal Reserve letting money growth (M) deviate from its targeted value. Here, the money growth variable is likely to be predetermined and not correlated with the error term V_t.

However, if the Federal Reserve, though still focusing on the monetary aggregates, does partially smooth interest rates, then a positive correlation between DM_t and V_t may exist. Consider, for example, a stronger than expected increase in the exogenous component of real demand causing an upward random shift in the IS relation ($U_{1t} > 0$). It is clear from equation (5) that a positive shock in the IS relation will cause a positive shock ($V_t > 0$) in the nominal interest rate equation (4). This will cause the nominal interest rate to rise. If the Federal Reserve decides to prevent or reduce the extent of this rise, it would let the money stock (M) rise and thereby create a positive covariance between DM_t and V_t.[16] In this case, it can be easily shown that the ordinary least squares estimation procedure will generate an inconsistent estimate of the liquidity effect parameter A_3.[17]

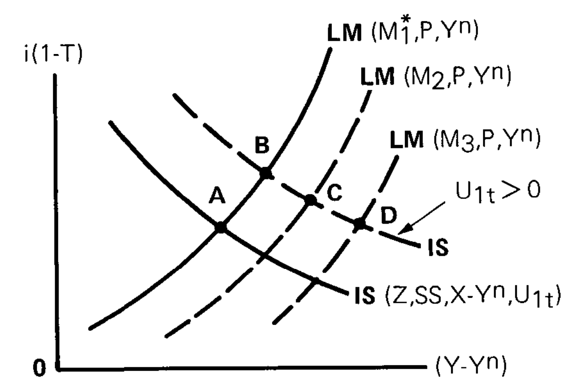
The extent of the least squares bias in the estimate of the liquidity effect parameter in equation (4) becomes more severe if the Federal Reserve conducts monetary policy focusing on interest rates. In the limiting case in which the Federal Reserve fixes a nominal rate and stands ready to maintain it, a regression equation like (4) is not relevant. This is so because the nominal rate is predetermined in this case, and the nominal money stock simply responds to any discrepancy between the actual and the targeted value of the nominal interest rate. In fact, if the Federal Reserve is successful in this interest rate pegging policy, the regression of the nominal rate on the right-hand side explanatory variables as in (4) should yield a coefficient on the money growth variable which is not statistically different from zero.[18]

The basic point is further illustrated in Figure 2 which shows an initial equilibrium point A in the IS-LM diagram. Consider a positive stochastic shock to the IS relationship, arising, say, from a stronger than anticipated increase in the aggregate demand. This shock causes the IS curve to shift upward, moving the (partial) equilibrium point from A to B

[18] In this case, the nominal interest rate regression like (4) is likely to be viewed as representing possibly the reaction function of the Federal Reserve. Therefore, the response of the nominal interest rate to variables other than money growth will depend upon the time period for which the interest rate is pegged and the considerations which cause the Federal Reserve to change the rate it pegs.

Figure 2

IS AND LM CURVES



All variables are as defined in the text. U_{1t} is the stochastic error term in the **IS** relationship, and M_1^* is the targeted level of the money stock. M_2 and M_3 are actual levels of the money stock, $M_3 > M_2 > M_1^*$.

[16] It should be kept in mind that the correlation between DM_t and V_t is mainly due to correlation between M_t and V_t.

[17] The nature of the bias in the estimated parameter is likely to be positive. This point can be easily demonstrated. Consider the following simple version of the interest rate equation

$$i_t = a + b\,M_t + c\,P_t + V_t,$$

where i is the nominal interest rate, M is the money growth variable, P stands for other variables appearing in the equation, and V is the disturbance term. The parameter b is hypothesized to be negative, and it measures the liquidity effect. If this equation is estimated by ordinary least squares, it can be shown that the probability limit (plt) of the least squares estimate of b can be expressed as:

$$\text{plt}(b) = [b + (\text{COV}(M,V)\ \text{COV}(P,P) - \text{COV}(P,V)\ \text{COV}(M,P))/(D)],$$

where D is [COV(M,M) COV(P,P) − COV(M,P)²] COV (M,V) is the covariance between M and V, and COV(P,P) is the variance of P. Other terms can be interpreted in a similar fashion. If the explanatory variables are contemporaneously uncorrelated with the error term V (COV (M,V) = COV (P,V) = 0), it is clear that plt (b) equals b, and the above regression provides a consistent estimate of the liquidity effect. But suppose that M and V are positively correlated, then it is clear that plt (b) equals [b + (COV (M,V) COV(P,P))/(D)]. Since both D and COV(P,P) are positive, the presence of the positive covariance between M and V causes a bias in the estimate of the liquidity effect parameter.

and resulting in upward pressure on the after-tax nominal interest rate. If the Federal Reserve does not smooth interest rates, the actual money stock stays at M_1^*, the targeted level. But if the Federal Reserve does smooth interest rates, it may let the actual money stock rise to M_2, resulting in a new equilibrium at point C in Figure 2. At this point, we have a higher money stock and a higher level of the after-tax nominal interest rate (compare A and C in Figure 2). On the other hand, if the Federal Reserve decides to eliminate completely the rise in the nominal interest rate, it may cause the money stock to rise enough to yield the equilibrium point D shown in Figure 2. Here, we have higher money stock ($M_3 > M_1^*$) accompanied by no important change in the nominal interest rate. Thus, a positive stochastic shock to the IS relationship combined with a partial smoothing of interest rates creates a positive correlation between money and the error term in the nominal interest rate regression.

Inflationary Expectations and Money Growth: Is the Liquidity Effect Temporally Stable?

An important assumption underlying the existence of the liquidity effect is that the price level and real income do not adjust fully as the money supply changes. In the context of the present model higher money growth is associated with a reduction in the nominal interest rate ($A_3 < 0$ in equation (4)) provided the expected inflation rate variable π_t is not immediately affected by the current acceleration in money growth. If the expectations effect of higher money growth occurs rapidly, then higher money growth may not depress the nominal interest rate, even in the short run.

As noted before, Friedman (1968) has argued that the liquidity effect of higher money growth will not be found in countries which have long experienced high inflation. His point is that in a high inflationary environment, inflationary expectations will become more responsive to money growth and the expectations effect of higher money growth will therefore occur rapidly.

In order to investigate the empirical validity of Friedman's argument, this paper examines the temporal stability of the liquidity effect. The average U. S. inflation rate observed in the late '60s and the '70s was certainly higher than that observed in the '50s and the early '60s. Moreover, there has also occurred an increased awareness of the role of money growth in causing inflation. In view of these considerations, one may expect to find a) an increase in the responsiveness of inflationary expectations to higher money growth, and b) a decrease in the magnitude of the liquidity effect over time. Empirical evidence on these issues is provided by examining the temporal stability of the liquidity effect parameter A_3 in the nominal interest rate equation (4). Since the empirical work in this paper uses the Livingston survey measure of expected inflation as a proxy for inflationary expectations, the Livingston measure's sensitivity to higher money growth over time can also be examined.

III.

EMPIRICAL RESULTS

This section reports the empirical results concerning the existence, magnitude, and temporal stability of the liquidity effect. In order to examine the sensitivity of inflationary expectations to higher money growth, equations explaining the formation of inflationary expectations are reported and their stability over time is investigated.

In an attempt to capture empirically the liquidity effect of money on interest rates, the monetary variable is measured in growth form and is represented by the current growth rate of the nominal money stock relative to its most recent trend growth rate. It is these accelerations or decelerations in nominal money growth relative to normal that are likely to affect the real interest rate and generate the liquidity effect. Changes in the nominal money stock induced by a constant trend growth rate of money are likely to be reflected in prices and hence are likely to leave unchanged the real rate.[19]

As stated before, the short-term U. S. monetary policy stance has been constrained by, among other things, the Federal Reserve's concern to promote a stable environment in the financial markets.[20] This

[19] Cagan and Gandlofi (1969), Gibson (1970), and Melvin (1983). See also Carlson (1979) and Wilcox (1983) who employ this measure of money growth. It should be noted that the money stock variable is not divided by the expected price level and the natural real output.

[20] For a description of how the Federal Reserve's ongoing desire to avoid disorderly conditions in financial markets shaped monetary policy in the '50s, the '60s, and the early '70s, see Lombra and Torto (1975). For some empirical evidence on the same issue, see De Rosa and Stern (1977), Feige and McGee (1979), and the references cited in them. For a more recent review of U. S. monetary policy, see Poole (1982) and Axilrod (1985). The paper by Axilrod (1985) provides a good discussion of several other exogenous forces that might have led the Federal Reserve to deemphasize the monetary aggregate (M1) in the short-run formulation of monetary policy.

concern has led the Federal Reserve at various times to dampen fluctuations in interest rates. Hence the money growth variable in the nominal interest rate regression (4) is likely to be correlated with the error term. The interest rate regressions reported in this paper are therefore estimated employing an instrumental variable estimation procedure.[21]

Table I reports estimates of the nominal interest rate equation (4) for two sample periods 1952-1979 and 1952-1983. These estimates, which are obtained using the instrumental variable estimation procedure with a first-order serial correlation correction, imply that most of the explanatory variables have the expected influence on the behavior of the nominal interest rate. That is, rises in expected inflation (PE12), exogenous components of aggregate demand (X), and lagged real income growth (Z) raise interest rates while positive supply shocks (SS) lower them. (See coefficients on these variables in Table I).[22] However, the coefficient measuring the effect of accelerations in money growth on the nominal interest rate (coefficient on LIQ in Table I) is negative but statistically insignificant at the conventional significance level. The estimates based on the full sample periods therefore do not support the presence of a statistically significant liquidity effect.

Table II reports estimates of the nominal interest rate equation over various subperiods. In order to separate the earlier, low-inflation period from the high-inflation period which starts in the mid-'60s, the full sample period is split at the end of 1965 and the estimates of the interest rate equation so obtained are presented in rows 1, 3, and 4. Melvin (1983)

[21] The basic idea behind the instrumental variable estimation procedure is to seek out the variables—called instruments—which are correlated with the endogenous variable in question but not correlated with the error term in the regression equation. The instruments are then used to generate estimates of the regression parameters, which are generally consistent.

[22] The data used are semiannual observations corresponding to the Livingston survey data collected each June and December. Monthly averages of 1-year Treasury bill yield during June and December are used for the nominal interest rate. Second- and fourth-quarter observations are used for the variables measuring the exogenous component of aggregate demand (X), supply shocks (SS), and real income growth (Z). X is the logarithm of the sum of real exports and real government expenditure on goods and services divided by the level of natural real output. The Rasche-Tatom series on the potential GNP constructed at the Federal Reserve Bank of St. Louis is used as a proxy for the natural real output. SS is constructed by taking the ratio of the deflator for imports to the GNP deflator and multiplying this ratio by the nominal effective dollar exchange rate index constructed by the Morgan Guaranty Trust. The latter step eliminates the effect of exchange rate changes on the import deflator. Z is the percentage change in the real GNP lagged one quarter. The data on the LIQ variable were generated using June and December observations on M1 according to the following relationship:

$$LIQ = ((M_t/M_{t-1})^2-1)-((M_{t-1}/M_{t-7})^{1/3}-1).$$

Table I

ESTIMATES OF THE INTEREST RATE EQUATION, SEMIANNUAL DATA, INSTRUMENTAL VARIABLE PROCEDURE WITH A CORRECTION FOR SERIAL CORRELATION

	Coefficients On							
Sample Period	PE12	LIQ	SS	X	Z	$\bar{R}^2$	SER	DW/ρ
1952.06-1979.12	.56 (15.7)	−8.8 (1.4)	−2.4 (−3.9)	6.2 (2.7)	8.9 (2.1)	.97	.676	2.0/.29
1952.06-1983.12	.54 (17.2)	−9.2 (−1.1)	−2.6 (−4.2)	5.8 (2.6)	6.1 (1.4)	.98	.765	2.0/.12

Notes: The nominal interest rate equation estimated and reported above is from the text (equation (4)) and can be expressed, using proxy variables as

$$i = (1/(1-T))[A_0 + A_1 X + A_2 SS + A_3 LIQ + A_4 Z + A_5 PE12],$$

where i is the average market yield on a one-year Treasury bill, X is the normalized value of real exports and real government expenditure, SS is the ratio of the deflator for imports and deflator for GNP adjusted for changes in the exchange rate, PE12 is the Livingston survey forecast of inflation over the 14-month horizon, LIQ is the annualized growth rate of the nominal money stock over the last six months minus its annualized growth rate over the last three years (Carlson 1979, Wilcox 1983), T is the series on the average marginal tax rate prepared by Joe Peek (1982), and Z is the lagged value of the rate of growth of the real GNP. The interest rate equation is estimated employing the instrumental variable procedure, and the data used are semiannual observations corresponding to the Livingston survey data collected each June and December. The instruments used are the current and lagged values of PE12, SS, X, and Z and lagged values of LIQ and i. The estimation corrects for the presence of the first-order serial correlation. The interest rate equation for the period 1952.06-1983.12 includes a dummy which takes value one in 1981.06-1983.12 and zero otherwise; it also includes a credit control dummy. $\bar{R}^2$ is R^2 adjusted for degrees of freedom, SER is the standard error of the regression, DW is the Durbin-Watson statistic, and ρ is the serial correlation coefficient. The parentheses contain t values.

See footnote 22 for further details on the data.

Table II

ESTIMATES OF THE INTEREST RATE EQUATION OVER VARIOUS SUBPERIODS, SEMIANNUAL DATA, INSTRUMENTAL VARIABLE PROCEDURE WITH A CORRECTION FOR SERIAL CORRELATION

	Coefficients On							
Sample Period	PE12	LIQ	SS	X	Z	$\bar{R}^2$	SER	DW/ρ
1. 1952.06-1965.12	.85 (3.0)	−17.4 (−2.3)	−1.9 (−1.3)	4.3 (1.3)	11.2 (2.0)	.95	.644	2.1/.08
2. 1952.06-1970.06	.75 (5.7)	−15.1 (−2.9)	−2.0 (−1.6)	2.7 (1.4)	11.0 (2.3)	.97	.611	2.1/.08
3. 1966.06-1979.06	.78 (6.3)	−4.5 (.6)	−4.3 (−3.9)	11.9 (3.8)	9.1 (1.3)	.99	.684	1.9/.09
4. 1966.06-1983.12	.73 (6.7)	−1.6 (−.2)	−4.0 (−3.6)	10.0 (3.6)	1.4 (.2)	.99	.844	2.0/0.0
5. 1970.12-1979.06	.91 (6.9)	6.1 (.5)	−4.5 (−4.0)	13.5 (1.5)	10.3 (1.5)	.99	.622	1.97/−.2
6. 1970.12-1983.12	.85 (6.9)	−.9 (−.1)	−4.1 (−3.9)	4.4 (.6)	2.9 (.4)	.99	.817	2.1/−.3

Note: See Table I notes.

has argued that a significant change in the response of nominal interest rates to higher money growth occurred in the early '70s, not in the mid-'60s. Rows 2, 5, and 6 present estimates obtained by splitting the sample in 1970.[23]

The estimates obtained for the coefficient associated with accelerations in money growth in the nominal interest rate equation in the low-inflation period clearly imply the existence of a strong and statistically significant liquidity effect (see the coefficient on LIQ presented in rows 1 and 2 in Table II). These estimates imply that one percent positive deviation in the money growth from its most recent trend growth rate reduces the nominal interest rate by 15 to 17 basis points. However, the estimates obtained for the high-inflation period imply the complete disappearance of this liquidity effect (see the coefficient on LIQ presented in rows 3, 4, 5, and 6 in Table II). There is a drastic reduction in the size of the liquidity effect parameter, and it is never statistically significant. These results together then imply that the liquidity effect is not temporally stable; there does not appear to exist a significant liquidity effect over the high inflation period comprising the mid-'60s and the '70s.[24]

In a high-inflation period, inflationary expectations may adjust rapidly and become more sensitive to higher money growth. Therefore, the money growth variable, when introduced as an additional regressor in a nominal interest rate regression that already contains the variables capturing the expectational (and perhaps real income) effects associated with higher money growth, may not add to the explanatory power of the equation, i.e., there may not be the liquidity effect associated with higher money growth. Since inflationary expectations here are proxied by the Livingston survey measure of the expected inflation rate,[25] one may explain the change in the response of the nominal interest rate to higher money

[23] It is not the intent of this paper to search for the exact date where there was a significant change in the structure. However, these two ways of splitting the full periods may broadly be viewed as an attempt to separate the low-inflation period from the high-inflation period.

[24] It might be pointed out that this result about the temporal instability of the liquidity effect is not due to the use of the instrumental variable estimation procedure. The ordinary least squares estimation of these interest rate equations yields a similar inference about the vanishing of the liquidity effect over the high-inflation period. However, the two estimation procedures yield rather different estimates of the magnitude of the liquidity effect over the low-inflation period. The instrumental variable estimation procedure yields estimates of the liquidity effect which are stronger than those produced by the ordinary least squares procedure.

[25] This practice is widespread; see Levi and Makin (1978), Carlson (1979), Peek (1982), Makin (1983), and Peek and Wilcox (1984).

growth in terms of the change that may have occurred in the formation of this survey measure of the expected inflation rate. Is there any evidence to support the view that inflationary expectations as measured by this survey measure are sensitive to money growth and that this sensitivity may have increased over time?

Tables III and IV report some estimates of the equations explaining the formation of inflation expectations by the Livingston survey participants.[26] In an attempt to identify the important variables economic agents look at in forming expectations of inflation, Table III presents several regression equation estimates obtained when the survey measure of expected inflation is regressed on a vector of variables plausibly related to inflation,—namely (1) current and past values of the actual inflation rate, (2) current and past rates of growth of the money supply, (3) budget deficits, (4) the cyclical state of the economy, and (5) supply shocks.[27] The finding that some or all of these variables are significant in these regressions implies that they are used in the formation of survey participants' expectations of inflation. The regression equations presented in Table III imply that the most important variables that the survey participants consider in forming expectations of inflation are the current and past values of the actual inflation rate and the current value of the money growth rate. The contribution made by money growth in explaining the formation of inflationary expectations is very impressive; both the $\bar{R}^2$ statistic and the standard error of the equation improve dramatically when money growth is introduced as an additional regressor in an equation containing only the past history of actual inflation (see equations 1 and 2 in Table III). Other variables including budget deficits (measured here by high employment government deficits), the gap between actual and potential GNP, and supply shocks do not help explain

[26] Several other economists have also examined the Livingston survey measure in an attempt to determine how expectations are formed. See Gordon (1979), Mullineaux (1980), Jacobs and Jones (1980), and Gramlich (1983). However, these authors have examined only the short-term forecasts of inflation (six-month). The focus of the present paper is on the twelve-month forecasts of inflation by the survey participants.

[27] See Gramlich (1983) for an explicit derivation of this equation.

Table III

EQUATIONS EXPLAINING EXPECTATIONS OF INFLATION OF THE LIVINGSTON SURVEY PARTICIPANTS, SEMIANNUAL DATA 1956.06-1983.12

Independent Variables	Dependent Variable: PE12 (1)	(2)	(3)	(4)
Constant		−.71 (−2.8)	−.60 (−1.9)	−.64 (−1.9)
$\dot{P}_t$	.27 (3.8)	.51 (10.9)	.46 (8.1)	.48 (7.4)
$\dot{P}_{t-1}$	−.02 (.3)	.01 (.2)	.04 (.7)	.02 (.4)
$\dot{P}_{t-2}$	−.03 (−.5)	.10 (2.2)	.09 (1.9)	.09 (1.8)
$\dot{M}_t$		.30 (7.0)	.31 (6.8)	.31 (6.6)
HD_t				−3.2 (−.4)
GAP_t				−.02 (−.4)
SS_t			1.4 (1.2)	1.4 (1.1)
$\bar{R}^2$	.34	.91	.87	.86
SER	.546	.445	.444	.451
DW	1.92	1.7	1.9	1.9
ρ	1.0	.5	.6	.6

Note: The general equation explaining the formation of expectations of inflation by the Livingston survey participants is of the form given below:

$$PE12_t = f(A(L)\dot{P}_t, B(L)\dot{M}_t, \dot{f}_t, CS_t, \dot{SS}_t)$$

where PE12 is the Livingston survey forecast made at time t of the annualized inflation rate over the 14-month horizon (t+14), $A(L)\dot{P}_t$ is the distributed lag on the past inflation rates known as of time t, $B(L)\dot{M}_t$ is the distributed lag on the past money growth rates, $\dot{f}$ is the change in the fiscal policy variable approximated here by the change in the high-employment government deficit scaled by nominal GNP (HD_t), $\dot{SS}$ is the change in the supply shock variable, and CS_t is a variable measuring the cyclical state of the economy —*approximated here by the averaged GAP measure* $((Y_t - Y^n)/(Y^n))$. Dummies for the wage-price and credit control periods were also added; they were generally insignificant. This equation and its various versions (equations (1) through (4)) are estimated with a first-order serial correlation correction procedure. The starting year for these regressions is 1956 because the data on the high-employment deficit is only available beginning that year. See footnote 29 for further details on the data. See also notes in Table IV.

this survey measure of expected inflation (see equations (3) and (4) in Table III).[28, 29]

If economic agents do consider money growth in forming expectations of inflation, is this relation stable between low-inflation and high-inflation periods? Table IV presents estimates of the expectation formation equation (equation 2 from Table III) for various subperiods obtained as a result of splitting as before the full sample periods. Rows 1 and 2 present estimates obtained for the low-inflation period and rows 3, 4, 5, and 6 present estimates obtained for the high-inflation period. For each subperiod, the coefficient on the money growth variable is positive and statistically significant. However, the point estimates of this coefficient obtained for the high-inflation period are substantially higher than those obtained for the low-inflation period (compare the coefficient on M_t in rows 1 through 6 in Table IV). This result could be interpreted to imply that the survey participants, in forming their expectations of inflation, give more weight to money growth when the average inflation rate is high. Furthermore, the size of the

28 Several other measures, including the high employment government expenditure and the unemployment rate, were also tried. However, none of these variables entered significantly. In studies of the short-term inflation forecasts, Mullineaux (1980) and Gramlich (1983) also found that fiscal policy-related measures and the measures capturing the cyclical state of the economy (such as the unemployment rate, the GAP measure) did not help explain the formation of inflationary expectations.

29 The data used in these regressions are again semiannual observations corresponding to the Livingston survey data collected each June and December. The data on the (known) past values of actual inflation and money growth are generated using the monthly data on the consumer price index and M1. In constructing these actual inflation and money growth rates, it is assumed that the Livingston survey participants knew the April values for the CPI and M1 at the time of June survey and the October values at the time of December survey. The annualized growth rates were constructed by using the following formulas: the June growth rate = ((April Value in the Current Year/the February value in the previous year)$^{12/14}$—1); the December growth rate = ((the October value in the current year/the August value in the past year)$^{12/14}$—1). The quarterly data are used to construct the annual growth rates for variables measuring changes in the fiscal policy and supply shocks, and the first- and second-quarter observations are used in the regessions reported in Table III. The gap measure uses quarterly data on the real GNP and the natural real output; the latter are averaged over the preceding four quarters.

Table IV

ESTIMATES OF THE EFFECT OF MONEY GROWTH ON INFLATIONARY EXPECTATIONS OVER VARIOUS SAMPLE PERIODS, SEMIANNUAL DATA, THE LIVINGSTON SURVEY MEASURE PE12

	Coefficients On							
Sample Period	Constant	$\dot{P}_t$	$\dot{P}_{t-1}$	$\dot{P}_{t-2}$	$\dot{M}_t$	$\bar{R}^2$	SER	DW/ρ
1. 1952.06-1965.12	.91	.06	−.12	−.17	.17	.46	.285	1.7/.8
		(.7)	(−1.8)	(−4.5)	(2.6)			
2. 1952.06-1970.06		.07	−.08	−.14	.09	.29	.322	1.6/1.0
		(.9)	(−1.4)	(−3.6)	(1.99)			
3. 1966.06-1979.06	−.69	.53	.01	.16	.24	.79	.522	1.8/.4
	(−.9)	(7.4)	(.1)	(2.1)	(2.7)			
4. 1966.06-1983.12	−.81	.52	.04	.07	.32	.82	.506	1.9/.5
	(−1.3)	(8.0)	(.5)	(1.2)	(4.9)			
5. 1970.12-1979.06	−2.5	.61	.00	.17	.44	.96	.390	2.3/−.3
	(−3.9)	(11.7)	(.05)	(3.4)	(6.1)			
6. 1970.12-1983.12	−1.7	.59	−.00	.07	.44	.93	.435	1.8/.2
	(−2.4)	(10.4)	(−.00)	(1.3)	(6.4)			

Notes: The estimates for various subperiods reported here are of the regression equation (2) from Table III. This regression explains the formation of inflationary expectations mainly by current and past actual inflation and money growth rates. $\dot{P}_t$ is the actual yearly inflation rate known as of time t (June or December) the survey is made, $\dot{P}_{t-1}$, the lagged yearly inflation rate measured as of time t in the previous year, $\dot{P}_{t-2}$, the lagged yearly inflation rate measured again as of time t two years ago, and $\dot{M}_t$, the actual yearly money growth measured as of time t.

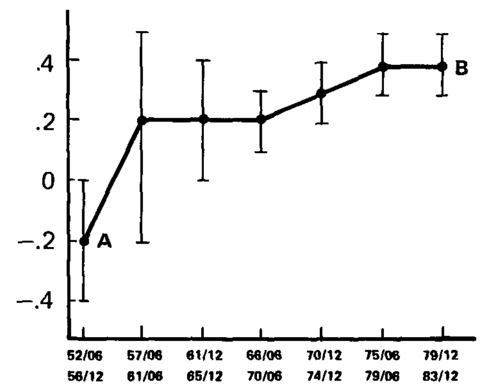
See footnote 29 for details on the way the growth rates are computed.

estimated coefficient on the first known value of the inflation rate in the equation also rises dramatically as one moves from the low-inflation period regressions to the high-inflation period regressions (compare the coefficient on P_t in rows 1 through 6 in Table IV). This probably suggests a relatively fast adjustment of inflationary expectations to current realized rates of inflation.[30]

Another way to examine the sensitivity of inflationary expectations to money growth is to estimate the time path of the coefficient on the money growth variable in the expectations formation equation. One simple way to do so is to estimate and plot the stabilogram for this coefficient. The stabilogram for any coefficient in a regression equation is simply a plot of the estimated coefficients and confidence intervals for various subperiods in a given sample. By choosing sufficiently short intervals and estimating the stabilogram, one can detect any change in the time path of the relevant coefficient by examining the time path of the stabilogram.[31] Figure 3 presents this stabilogram for the coefficient on the money growth variable in the expectation formation equation (2) from Table III. This plot clearly suggests that inflationary expectations proxied by the Livingston survey measure have become more sensitive to money growth over time.

Figure 3

STABILOGRAM ON THE MONEY GROWTH COEFFICIENT IN THE EXPECTATION FORMATION EQUATION 2, TABLE III SEMIANNUAL DATA: 1952/06–1983/12



The stabilogram on the money growth coefficient in the expectation formulation equation is constructed from the following equation.

$$PE12 = f\,(\text{constant}, \dot{P}_t, \dot{P}_{t-1}, \dot{P}_{t-2}, D1\dot{M}, D2\dot{M}, D3\dot{M}, D4\dot{M}, D5\dot{M}, D6\dot{M}, D7\dot{M})$$

where $D1\dot{M}$ is D1 times the money growth variable $\dot{M}_t$, $D2\dot{M}$ is D2 times the money growth variable $\dot{M}_t$, and so on. D1 through D7 are the dummy variables defined below:

D1 is one in 1952/06-1956/12 and zero otherwise,
D2 is one in 1957/06-1961/06 and zero otherwise,
D3 is one in 1961/12-1965/12 and zero otherwise,
D4 is one in 1966/06-1970/06 and zero otherwise,
D5 is one in 1970/12-1974/12 and zero otherwise,
D6 is one in 1975/06-1979/06 and zero otherwise,
D7 is one in 1979/12-1983/12 and zero otherwise.

The coefficients appearing on these dummy variables can be taken as the point estimates of the coefficient on the money growth variable for various subperiods; **AB** is simply formed by connecting these point estimates. The standard errors of the estimated coefficients on these dummies are then used to construct the confidence intervals indicated as vertical lines. The upper and lower limits of this confidence band are from the following relation: [Estimated Coefficient ± (2.0) (Estimated Standard Error of the Coefficient)].

IV.

A SUMMARY, MAIN CONCLUSIONS, AND SOME POLICY IMPLICATIONS

This paper has investigated the issue of whether a significant liquidity effect of money on interest rate exists. The recent empirical evidence on this issue has been mixed. One main problem with the current empirical work on this issue is the use of an inappropriate estimation procedure. The current empirical work usually investigates the existence of the liquidity effect by using OLS to estimate nominal interest rate regressions in which money growth appears as a right-hand side regressor. This procedure implicitly assumes that changes in money growth are exogenously determined and, in particular, are not contemporaneously correlated with the

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[30] Mullineaux (1980) reports similar evidence for the short-term inflationary expectations. Using the varying parameter estimation technique, Mullineaux estimates the time path of the coefficients on the first known values of past inflation rate and money growth. He finds that there is a steady rise in the size of these coefficients over time (see Figure 1, p. 155).

[31] See Ashley (1984) for further details.

error term in these regressions. This is a questionable assumption to make in view of the way the Federal Reserve has conducted its monetary policy over the period 1952-1983. In particular, the shorter term monetary policy stance has been constrained by the Federal Reserve's concern to promote a stable financial environment and has had to be adapted to a variety of exogenous shocks. As a result, money growth is likely to be correlated with the error term in nominal interest rate regressions. The potential presence of this nonzero correlation implies that the ordinary least squares estimates of the parameter on the money growth variable are biased. Such statistical bias could generate an incorrect inference about the existence and the magnitude of the liquidity effect.

The approach taken in this paper is to specify a simple IS-LM-Aggregate Supply model of the economy and to estimate, using the instrumental variable estimation procedure, the implied nominal interest rate equation in which money growth is treated as an endogenously determined variable. The empirical results reported here imply the following conclusions.

First, there did exist a statistically significant liquidity effect in the '50s and the early '60s when the average inflation rate was very low. This liquidity effect, however, has now almost vanished. The coefficient on the money growth variable in the nominal interest rate regression is negative, large, and statistically significant when this equation is estimated over the subperiod beginning in the '50s and ending in the mid-'60s or the early '70s, but it is not significant when the same equation is estimated over the subperiod beginning in the mid-'60s or the '70s but ending in 1979 or 1983.

The second conclusion is that if the behavior of the Livingston survey participants is considered as representative of the behavior of other economic agents in the economy, this vanishing of the liquidity effect in the '70s is probably the result of increased responsiveness of inflationary expectations to higher money growth. An empirical analysis of the factors determining the Livingston survey inflation measure implies that these economic agents have over time paid more attention to money growth in forming their expectations of long-term inflation. This factor tends to reduce directly the magnitude of the liquidity effect associated with a given acceleration in money growth.

The results presented here have important implications for monetary theory and policy. An important issue in discussion of the transmission mechanism of monetary policy is the time pattern of the effects of higher money growth on nominal interest rates. The Keynesian view is that one would initially observe lower nominal and real interest rates following an acceleration in the money growth rate. The policy implication of this view is that the Federal Reserve could bring down interest rates and hold them there in the short run (at least for six to nine months) by accelerating the money growth rate. The results here, however, imply that the Keynesian view may now have to be modified. While nominal interest rates may still decline immediately following an acceleration in the money growth rate, this lowering of interest rates is shorter lived and less exploitable for policy purposes. In the '50s and the '60s, the Federal Reserve could induce falling nominal and real interest rates at least for six months by increasing the growth rate of the money supply. It now appears that its ability to do so has declined, mainly due to the increased responsiveness of inflationary expectations to higher money growth.

Finally, it should be pointed out that the public's perception of the way the Federal Reserve formulates and executes its monetary policy has considerable influence on the responsiveness of inflationary expectations to higher money growth. The upward drift in the growth rate of money which occurred in the '70s probably contributed to the higher inflation rate observed during that period. More recently, however, the United States has had considerable success in curbing inflation, and public confidence in monetary policy as a means of controlling inflationary expectations may have risen as a result. If so, we may observe yet another change in the response of inflationary expectations and nominal interest rates to higher money growth. To the extent such a change is already under way, the empirical results for the sample period ending in the year 1983 must be viewed with caution.

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