in K. Brunner and A. Meltzer,
THE PHILLIPS CURVE AND LABOR MARKETS
Amsterdam: North-Holland, 1976.

THE PHILLIPS CURVE AND MACROECONOMIC POLICY

ROBERT E. HALL
Massachusetts Institute of Technology

Introduction

Policy-makers responsible for regulating the aggregate level of economic activity must choose constantly between the alternative levels of unemployment and inflation mapped out by the Phillips curve. The focus of thought on the optimal choice between the alternatives has shifted from consideration of the immediate costs and benefits of unemployment and inflation to considerations of the future implications of today's policy. The main deterrent to economic expansion today, in fact, is not so much fear of the inflation it would cause today but rather fear of the expectations of future inflation that it would bring about.

In this paper I will try to give a rough quantitative appraisal of the importance of future considerations in shaping current optimal policy. I begin with a fairly simple model of the relationship over time among unemployment, inflation, and productivity. I then posit an intertemporal social welfare function of conventional form and discuss the analytical characterization of the optimal policy.[1] The main original contribution of the paper is the calculation of actual optimal policies under alternative assumptions about the parameters of the model and of the social welfare function. The calculations suggest that even when the cost of reduced unemployment today is a permanent increase in future inflation (the accelerationist hypothesis), the optimal policy starts from a fairly low rate of unemployment and rises over a ten-year period to its steady state (the natural rate of unemployment). The key assumptions underlying this conclusion are the following. First, unemployment is a burden on those experiencing it; they do not receive full compensation in the form of better jobs after periods of search for jobs. Second, the economy starts with an expected rate of inflation not too much greater than the rate that is optimal considering only its effect on the price of liquidity. Third, the social welfare function must discount the future relative to the present. Fourth, the expected rate of inflation must lag behind the actual rate, at least briefly at the beginning of inflation. The various experiments reported toward the end of the paper demonstrate these and other conclusions about the properties of the model.

---

[1]Edmund Phelps has covered the same ground much more thoroughly in Part III of his Inflation Policy and Unemployment Theory.

A Simple Model of Inflation and Unemployment

The model presented here attempts to bring together recent theoretical and empirical results on the relations among the unemployment rate, the wage level, and the price level. The following ideas are embodied in the model:

1. Excess demand for labor drives up the wage. There is a functional relationship between excess demand and the unemployment rate, so low unemployment is associated with rapid wage inflation, and *vice versa.*
2. To some extent, the Phillips curve is shifted upward when inflation is expected to be higher.
3. Expectations about inflation are formed on the basis of past experience with price changes.
4. There is no systematic tendency for wage inflation to lead or lag price inflation.
5. There are artificial barriers to upward mobility in the labor market, and a sharp expansionary policy may cause these barriers to break down temporarily.

The first four of these ideas form the basis for a large body of recent empirical research.[2] The following is a simplified model typical of the ones studied in that research:

Phillips curve:

$$(1)\qquad y_t = \phi_1 + \phi_2 \frac{1}{u_t} + \phi_3 x_t.$$

Formation of expectations:

$$(2)\qquad x_t = \lambda y_{t-1} + (1 - \lambda) x_{t-1}.$$

where the variables are defined as follows:

y_t = rate of price inflation;
x_t = expected rate of price inflation;
u_t = unemployment rate.

In the short run, expectations are fixed, and the relation between inflation and unemployment is governed by the term $\phi_2 \frac{1}{u_t}$. If a given rate of inflation is maintained for a sufficiently long period, however, the expected rate will equal that rate (x = y) so the set of alternative inflation-unemployment combinations in the long run is

$$(3)\qquad y = \frac{\phi_1 + \phi_2 \frac{1}{u}}{1 - \phi_3}.$$

The critical parameter ϕ_3 thus governs the relation between the slopes of the instantaneous and long-run Phillips curves. Milton Friedman [2] and others have argued, persuasively in my view, that the Phillips curve is shifted upward by the full amount of anticipated inflation, so $\phi_3 = 1$ and $\phi_1 + \phi_2 \frac{1}{u}$ must equal zero in the long run. This natural rate of unemployment, $u^* = -\frac{\phi_2}{\phi_1}$, is the minimum and the maximum rate sustainable in the long run at a constant rate of inflation, no matter how high or low.

The effects of unemployment apart from its influence on the rate of inflation have received rather less attention, especially in the empirical literature: Edmund Phelps presents a comprehensive review of current thought in this area in chapters 4 and 5 of *Inflation Policy and Unemployment Theory* [11]. In this paper I will concentrate on one general class of possible effects of unemployment, namely its effect on the present and future productivity of the workers who remain employed. I distinguish two categories of effects of current and past unemployment rates on today's productivity. First, the current level of unemployment is related to current productivity, directly through the diminishing marginal product of labor and indirectly through the impact of conditions in the labor market on the decisions of employers and workers. Second, productivity depends on the rate of change of unemployment. Declining unemployment stimulates productivity temporarily through the operation of Okun's Law, and may have more lasting effects as well.

The diminishing marginal product of labor does not seem to bring about an important relation between unemployment and productivity. If the elasticity of output with respect to employment is 0.75, then the elasticity of the average product of labor with respect to employment is -0.25: an increase of 4 per cent in employment decreases productivity by only one per cent, with capital input held constant. In the short run this effect is dominated by the opposing influence of Okun's Law, and in the long run the adjustment of the capital stock presumably eliminated any negative relation between productivity and employment arising from this source. For simplicity, I will assume in what follows that when the

[2] See Gordon ([3], [4], [5]) and the other works he cites.

other variables in the model are held constant, the average product of labor is independent of the level of employment.

Unemployment is not merely the complement of employment, however. It serves as an indicator of a wide variety of conditions in the labor market.[3] When the unemployment rate is low, the market is tight. Employers find it difficult and expensive to recruit new workers and are induced to stabilize their work forces by holding overhead labor. A smaller fraction of employed workers are actually at work when unemployment is low than when it is high, so productivity varies inversely with the unemployment rate. It appears virtually impossible to test this hypothesis in aggregate time series data, again because of the strong opposing influence of Okun's Law in the short run. I have found weak evidence in its favor by studying cross sections of cities at a single point in time, but the magnitude of the effect is very much in doubt.

The cyclical relation between productivity and unemployment summarized by Okun's Law has received a good deal of attention recently.[4] It now appears that Okun's Law is largely a transitory phenomenon – in the long run, the relation between labor input and productivity is not nearly as strong as in the short run.[5] For this reason, the Law does not have an important role in determining the optimal unemployment rate over time. However, the model does consider a related cyclical effect operating through labor mobility.[6] Among the many imperfections of the labor market, an outstanding one is the apparent success of some groups of workers in excluding other workers from good jobs. The result is the crowding of the excluded workers, many of them blacks or women, into low-paying, unproductive jobs. Labor unions are only the most visible institutions of many that exist to restrict the number of holders of good jobs. The hypothesis embodied in the model is that restrictive institutions are vulnerable to unexpected expansions in demand. For example, the monopoly power of a labor union is diluted by the new workers hired during a brisk increase in demand. If the upward mobility of individuals is stimulated by expansion of demand[7], and if some of this mobility is irreversible because it represents the breaking down of artificial barriers, then expansionary policies make a lasting contribution to productivity.

[3] I have written fairly extensively on this subject in "Turnover in the Labor Force," [7] pp. 724-738.

[4] See especially the recent contribution of George Perry [10], William Nordhaus [8], Robert J. Gordon [6] and Arthur Okun [9] in the Brookings Papers.

[5] Nordhaus and Gordon find the effect almost purely transitory, but Okun disputes their view.

[6] Phelps discusses this effect ([11], pp. 75, 76) and mentions an idea of mine.

[7] Research of mine with Richard Kasten on the occupational mobility of young men shows that upward mobility was much more common in the superheated economy of 1968 than in the slacker economy of 1969.

The model contains an equation that determines the distribution of the labor force between good and bad jobs through an asymmetric cyclical effect on upward mobility or slippage from good to bad jobs.

The following equations embody the cyclical relation between unemployment and productivity that I have in mind:

(4) $$w_t = \psi_1 b_1 + \psi_2 (1 - b_t).$$

Here w_t is the average product of labor, b_t is the fraction of the labor force holding good jobs, ψ_1 is the relative wage paid for good jobs and ψ_2 is the relative wage for bad jobs. Mobility between the two kinds of jobs is governed by the following equation:

(5) $$b_t = \beta_1(u_{t-1} - u_{t-2}) + \beta_2 \mid u_{t-1} - u_{t-2} \mid + (1 - \beta_3)b_{t-1} \; .$$

Here β_1 determines the magnitude of the effect of changes in unemployment on b_t (and thus on productivity) for the part of the effect that is symmetrical for positive and negative changes in unemployment. The first term makes productivity vary cyclically in accordance with Okun's Law. The second term introduces an asymmetry in the response of b_t to changes in the unemployment rate – if β_2 is positive, b_t increases more when unemployment decreases than it decreases when unemployment increases by the same amount. If β_1 and β_2 are equal, an increase in unemployment has no effect at all, in which case the improvement brought about by an expansion is irreversible in the short run. Finally, β_3 measures the rate of decline of the fraction of the labor force holding good jobs in the absence of changes in the unemployment rate. The higher β_3 is, the more rapidly are restrictive institutions able to expand their monopoly power.

<u>The Social Welfare Associated with Alternative Paths of Inflation, Unemployment and Productivity</u>

Three variables in the model just described determine the level of well being of the society. These are the unemployment rate, u_t, the rate of inflation, y_t, and the productivity of employed workers, w_t. Since the present is connected to the future through the evolution of the economy as portrayed by the difference equations of the model it is necessary to evaluate the alternative paths of u_t, y_t and w_t through an explicitly intertemporal social welfare function. A function of the following additive form is analytically convenient and not altogether unreasonable:

$$(6) \qquad W = \sum_{t=1}^{T} \left(\frac{1}{1+\delta_1}\right)^t V(u_t, w_t, y_t) .$$

Here δ_1 is the social rate of time preference. I will assume that the unemployment rate is subject to direct control by the governing authorities through the use of monetary and perhaps fiscal policy. The optimal policy makes the marginal contribution of increased or decreased unemployment zero in each period, taking into account both the immediate costs and future benefits of unemployment. Marginal social welfare is:

$$(7) \qquad \frac{\partial W}{\partial u_t} = \left(\frac{1}{1+\delta_1}\right)^t \frac{\partial V}{\partial u_t} + \sum_{\tau=t}^{T} \left(\frac{1}{1+\delta_1}\right)^\tau \left(\frac{\partial V}{\partial w_\tau} \frac{\partial w_\tau}{\partial u_t} + \frac{\partial V}{\partial y_\tau} \frac{\partial y_\tau}{\partial u_t}\right).$$

The first term is the negative of the current marginal benefits of decreased unemployment and the second is the summation of the marginal social benefits of the impact of current unemployment on future productivity and inflation. Evaluation of the second term requires the use of the equations describing the evolution of the economy:

$$(8) \qquad x_\tau = \lambda y_{\tau-1} + (1-\lambda) x_{\tau-1} .$$

$$(9) \qquad b_\tau = -\beta_1 (u_{\tau-1} - q_{\tau-1}) + \beta_2 \mid u_{\tau-1} - q_{\tau-1} \mid + (1-\beta_3) b_{\tau-1} .$$

$$(10) \qquad q_\tau = u_{\tau-1} .$$

Here I have introduced an additional variable, q_t, in order to make the system a first order difference equation. The future effects of changes in u_t can be obtained by differentiating this system with respect to u_t, first for $\tau > t + 1$:

$$(11) \qquad \frac{\partial x_\tau}{\partial u_t} = \lambda \frac{\partial y_{\tau-1}}{\partial u_t} + (1-\lambda) \frac{\partial x_{\tau-1}}{\partial u_t} = (1-\lambda+\lambda\phi_3) \frac{\partial x_{\tau-1}}{\partial u_t} .$$

$$(12) \qquad \frac{\partial b_\tau}{\partial u_t} = \beta_1 \frac{\partial q_{\tau-1}}{\partial u_t} - \beta_2 \,\mathrm{sgn}(u_{\tau-1} - q_{\tau-1}) \frac{\partial q_{\tau-1}}{\partial u_t} + (1-\beta_3) \frac{\partial b_{\tau-1}}{\partial u_t} .$$

$$(13) \qquad \frac{\partial q_\tau}{\partial u_t} = 0.$$

This system can be evaluated recursively, starting at $\tau = t + 1$ with the following initial conditions:

$$(14) \qquad \frac{\partial x_{t+1}}{\partial u_t} = -\frac{\lambda\phi_2}{u_t^2} .$$

$$(15) \qquad \frac{\partial b_{t+1}}{\partial u_t} = -\beta_1 + \beta_2 \,\mathrm{sgn}\,(u_t - u_{t-1}).$$

$$(16) \qquad \frac{\partial q_{t+1}}{\partial u_t} = 1.$$

To evaluate the marginal social cost of unemployment given in (7), the responses of future productivity and inflation to current unemployment $\frac{\partial w_\tau}{\partial u_t}$ and $\frac{\partial y_\tau}{\partial u_t}$ are required. First,

$$(17) \qquad w_\tau = \psi_3 b_\tau + \psi_4 (1-b_\tau) ,$$

so

$$(18) \qquad \frac{\partial w_\tau}{\partial u_t} = (\psi_3 - \psi_4) \frac{\partial b_\tau}{\partial u_t} .$$

Second,

$$(19) \qquad y_\tau = \phi_1 + \phi_2 \frac{1}{u_\tau} + \phi_3 x_\tau ,$$

so

$$(20) \qquad \frac{\partial y_\tau}{\partial u_t} = \phi_3 \frac{\partial x_\tau}{\partial u_t} .$$

Today's unemployment affects future productivity through its impact on the fraction of the labor force holding advantageous jobs, $\frac{\partial b_\tau}{\partial u_t}$. Equations (12) and (13) show that after two periods, $\frac{\partial b_\tau}{\partial u_t}$ declines each period by the fraction β_3

eventually approaching zero. There are no permanent costs or benefits of unemployment operating through productivity.

According to equation (20), today's unemployment affects future inflation solely through its impact on inflationary expectations, $\frac{\partial x_\tau}{\partial u_t}$. Equation (11) shows that the future impact declines by a constant fraction $\lambda(1-\phi_3)$. If the long run Phillips curve is not vertical (that is, if ϕ_3 is less than 1), then the benefits of increased unemployment today in the form of reduced expectations of inflation in the future approach zero for periods far in the future; no permanent benefits result from an increased unemployment rate today. When the long run curve is vertical, however, the flow of benefits is permanent. The importance of the exact value of ϕ_3 depends on the social rate of time preference, δ_1; if the future is discounted heavily, then the permanence of the future benefits matters relatively little. I will illustrate this point shortly.

The evaluation of an unemployment policy, $u_1,\dots,u_T$, proceeds in the following way. First, calculate the paths of the variables x_t and b_t from the difference equations (8), (9) and (10), and from these calculate the paths of productivity, w_t, and inflation y_t. Second, calculate the immediate costs of unemployment along the path, $(\frac{1}{1+\delta_1})^t \frac{\partial V}{\partial u_t}$. Third, calculate the sum of the future benefits of unemployment, $\sum_{\tau=t}^{T} (\frac{1}{1+\delta_1})^\tau [\frac{\partial V}{\partial w_\tau}\frac{\partial w_\tau}{\partial u_t} + \frac{\partial V}{\partial y_\tau}\frac{\partial y_\tau}{\partial u_t}]$, using equations (11) through (16) to evaluate $\frac{\partial x_\tau}{\partial u_t}$, $\frac{\partial b_\tau}{\partial u_t}$, and $\frac{\partial q_\tau}{\partial u_t}$, and equations (18) and (20) to evaluate $\frac{\partial w_\tau}{\partial u_t}$ and $\frac{\partial y_\tau}{\partial u_t}$. At the optimum, the immediate costs equal the sum of the future benefits, and the net social return, $\frac{\partial W}{\partial u_t}$, is zero for all t. The optimum can be found by an iterative process that increases (decreases) unemployment in periods when its net social return is positive (negative). For sufficiently small changes of this kind, the value of the social welfare function increases at each iteration, and the process converges to a local maximum of social welfare.

It remains to specify a form for the one-period indicator of social welfare, $V(u_t, w_t, y_t)$. The function should reflect considerations of distribution as well

as efficiency. For example, a unit of real income lost from unemployment probably should receive more weight than a unit lost from reduced productivity, because unemployment compensation redistributes only a fraction of the income lost from the employed to the unemployed. The function I have used is

$$V(u_t, w_t, y_t) = \delta_2 \log(1-u_t) + \delta_3 \log w_t - \delta_4(y_t - \delta_5)^2. \tag{21}$$

Here δ_2 presumably exceeds δ_3 for the reason mentioned above. The parameter δ_5 is the optimal rate of inflation considering only the social costs and benefits of providing liquidity. Liquidity should be taxed along with everything else, and a convenient way to do this is through inflation. If the optimal tax rate on liquidity is, say, 5 per cent, then δ_5 should be 5 per cent less the real interest rate. An alternative and probably superior arrangement is to permit interest payments on money and then to tax the payments as income. The defect in taxing liquidity through inflation under current institutions is that the proceeds of the tax become the excessive profits of the private banking monopolies.

My choice of a quadratic function to measure the social loss of departures of y_t from δ_5 is an approximation to the area under the demand curve for money between the optimal price, δ_5, and its actual price, y_t. This region is roughly triangular, so its area is approximately proportional to the square of its height.

Parameters of the Benchmark Solution

The model is fully specified by supplying the values of its various parameters and initial values of the variables (u_0, x_0, z_0, b_0 and u_{-1}). I will refer to the following set of values as defining a benchmark solution.

Social Welfare

$$W = \sum_{t=1}^{T} (\frac{1}{1+\delta_1})^t [\delta_2 \log(1-u_t) + \delta_3 \log w_t - \delta_4(y_t - \delta_5)^2] . \tag{22}$$

δ_1 = .05; Social rate of time preference
δ_2 = 1.5; Relative weight of unemployment
δ_3 = 1.0; Relative weight of productivity of employed workers
δ_4 = 5.0; Relative weight of inflation
δ_5 = .05; Optimal rate of inflation considering only the social costs and benefits of liquidity

When $u_t = .045$ and w_t is 1.0, the immediate social marginal rate of substitution between them is:

$$\frac{\frac{\partial V}{\partial u_t}}{\frac{\partial V}{\partial w_t}} = -\frac{\delta_2}{\delta_3}\frac{w_t}{1-u_t} = 1.57 \quad . \tag{23}$$

From the point of view of the effects in year t alone, the society will trade a decrease of, say, .0157 in productivity for a decrease of .01 in the unemployment rate. At a rate of inflation of .05, the social marginal rate of substitution (MRS) between inflation and unemployment,

$$\frac{\frac{\partial V}{\partial y_t}}{\frac{\partial V}{\partial u_t}} = 2\frac{\delta_4}{\delta_2}(y_t - \delta_5)(1-u_t) \tag{24}$$

is zero; the society will not be willing to increase unemployment at all for a decrease in inflation. At a rate of inflation of .10 and an unemployment rate of .045, the MRS is 0.32; society will trade a decrease of .0032 in the unemployment rate for an increase of .01 in the rate of inflation.

Phillips Curve

$$y_t = \phi_1 + \phi_2 \frac{1}{u_t} + \phi_3 x_t \quad . \tag{25}$$

ϕ_1 = -.033; Intercept
ϕ_2 = .0015; Parameter controlling slope
ϕ_3 = 1.0; Shift caused by anticipation of inflation

The natural rate of unemployment,

$-\frac{\phi_1}{\phi_2}$, is .045, which is not inconsistent with recent empirical findings. At u_t = .045, the slope of the curve is

$$\frac{\partial y_t}{\partial u_t} = -\frac{\phi_2}{u_t^2} = -0.74 \quad . \tag{26}$$

An increase of .01 in the unemployment rate decreases the rate of inflation by .0074, again in accord with recent findings. The benchmark solution incorporates Friedman's hypothesis that the Phillips curve shifts upward by the full amount of anticipated inflation. The recent work of Eckstein and Brinner [1] and Gordon [5] seems to support this hypothesis, although earlier empirical studies did not.

Formation of Expectations About Inflation

$$x_t = \lambda y_{t-1} + (1-\lambda)x_{t-1} \quad . \tag{27}$$

λ = 0.4; The fraction of last year's inflation that enters this year's expected inflation rate. The average lag of expectations behind experience is $\frac{1}{\lambda}$ = 2.5 years.

Relations Between Productivity and Conditions in the Labor Market

$$w_t = \psi_1 b_t + \psi_2(1-b_t) \quad . \tag{28}$$

$\psi_1 = \psi_2$ = 1.0; Productivity does not depend on the distribution of the labor force.

In the benchmark solution, productivity is constant; neither Okun's Law nor other influences on productivity are considered.

Distribution of the Labor Force

$$b_t = -\beta_1(u_{t-1} - u_{t-2}) + \beta_2 \mid u_{t-1} - u_{t-2} \mid + (1 - \beta_3)b_{t-1} \quad . \tag{29}$$

β_1 = 1.0; Cyclical effect of unemployment on the distribution.
β_2 = 0.5; Irreversible effect.
β_3 = .02; Rate of slippage of workers from good to bad jobs.

A decrease of unemployment of .01 increases b_t by .015 while an increase of .01 decreases b_t by only .005. This equation is relevant only for certain experiments.

Initial Values of Variables

x_o = .05; Initial expectations of inflation
z_o = .045; Initial moving average of past unemployment
b_o = 0.5; Initial distribution of labor force
$u_o = u_{-1}$ = .045; Initial values of unemployment rate

The economy always starts at the natural unemployment rate, expecting a rate of inflation of five per cent.

The Benchmark Solution

Figure 1 gives the optimal path of unemployment for the economy defined in the previous section, together with the paths of actual and expected inflation it implies. This and subsequent figures show the first twenty-five years of fifty-year solutions. In the benchmark solution, the economy trades a period of about ten years of unemployment below the natural rate for a rate of inflation permanently above the optimum level of five per cent. The trade is favorable because the cost of excess inflation far in the future is heavily discounted. It is the inheritance of a favorable expected rate of inflation at the beginning of the period that makes an extended period of low unemployment possible. Were the expected rate of inflation at its steady-state value of roughly eight per cent, it would not be optimal to push the unemployment rate below the natural rate at the outset. Similarly, if the optimal rate of inflation, δ_5, were lower, then the future cost of the expected inflation generated by decreased unemployment would be higher, and the optimal transitory reduction in unemployment would be less. In the concluding section, I will give a fairly complete list of the assumptions necessary to justify the large and lengthy period of reduced unemployment shown in the benchmark solution.

First Experiment – Non-Vertical Long Run Phillips Curve

The economy of Figure 2 differs from the benchmark economy in only one respect – the parameter ϕ_3 is 0.6 instead of 1.0, so anticipated inflation shifts the Phillips curve upward by only 60 per cent of the amount of the inflation. The slope of the long-run Phillips curve, as defined earlier, is about 1.9 percentage points of inflation per percentage point of unemployment. In spite of this rather adverse long-run payoff to inflation, the optimal path of aggregate policy results in substantially less unemployment and somewhat more inflation than in the benchmark case. In the first year the optimal unemployment rate is a full percentage point lower. The issue of the long-run upward shift of the Phillips curve is an important one in determining immediate policy.

Second Experiment – Lower Social Cost of Inflation

The first experiment increased the payoff to inflation while holding its cost constant. The second does the opposite, by reducing the parameter δ_4 to 2.5 from its value in the benchmark solution of 5.0. The economy of Figure 3 will trade only half as much unemployment for a given reduction of inflation as will the benchmark economy. Consequently, the optimal policy calls for a longer period of low unemployment, starting from an unemployment rate in the first year that is about 0.25 percentage points lower than in the benchmark case. Even

toward the end of the twenty-five year period, the economy is still taking advantage of the opportunity to keep the unemployment rate below the natural rate by accelerating the rate of inflation.

Third Experiment – Higher Optimal Inflation Rate

Doubling the optimal inflation rate, δ_5, (to a value of 0.10) has an even more dramatic effect on the optimal policy. In Figure 4, the economy begins with a rate of inflation that is suboptimal even without considering the tradeoff between inflation and unemployment. For the first six years, unemployment is held below the natural rate not just for its own sake but for its beneficial effect on the rate of inflation as well. The convex shape of the Phillips curve explains the fairly slow movement toward higher inflation – an attempt to accelerate more quickly would result in a lower average reduction in unemployment. Even after twenty-five years, the rate of inflation is still accelerating and the unemployment rate is well below the natural rate.

Fourth Experiment – Shorter Lag in Forming Expectations of Inflation

If the long-run Phillips curve is vertical, the benefits of inflation are really just the benefits of unanticipated inflation. Where expected inflation reacts quickly to actual experience, the unanticipated component of inflation will be small, and the benefits in the form of reduced unemployment will likewise be small. The importance of this consideration is shown in Figure 5, where the parameter, λ, of the expectations equation has been raised to 0.8 from its value of 0.4 in the benchmark solution. The unanticipated component of inflation never exceeds a third of a percentage point. The optimal rate of inflation in the steady-state is a little over six per cent compared to eight per cent in the benchmark. The optimal unemployment rate never drops below four per cent and rises rapidly toward the natural rate of 4.5 per cent.

Fifth Experiment – No Discounting of the Future

In this experiment the social rate of time preference, δ_1, is set to zero from its benchmark value of 0.05. No figure is necessary to illustrate the solution because the economy simply remains in its initial state: unemployment at the natural rate of 0.045 and actual and expected inflation both at the rate of 0.05. Since the costs of raising the expected rate of inflation are permanent while the benefits are transitory, in the absence of discounting, it never pays to push the unemployment rate below the natural rate.

Sixth Experiment – Business Cycle Stimulates Mobility

Figure 6 illustrates the rather dramatic difference in the optimal aggregate policy in an economy where barriers in the labor market can be overcome by a sharp expansion in demand. The optimal policy is a business cycle whose period varies between two and three years. Unemployment varies from over seven per cent in the trough to around three per cent at the peak. Each downward movement of the unemployment rate causes workers to move from bad jobs to good jobs. Some slip back in the next year or two, as governed by equation (29) and the parameter values listed below it, but others remain more or less permanently in good jobs. In the economy of Figure 6 good jobs pay about ten per cent more than bad jobs – the parameter ψ_1 is set at 1.05 and ψ_2 at .95. This rather small differential generates a surprisingly variable optimal unemployment rate. I suspect that this comes in part from the model's neglect of the social costs of fluctuations in demand.

Conclusion

The benchmark solution takes full account of the present benefits and future costs of expansionary policies in an economy with a vertical long-run Phillips curve. Even though the optimal unemployment rate inevitably tends toward the natural rate in the long-run, the economy enjoys a decade of lower unemployment sustained by mildly accelerating inflation. The natural rate is not by itself a good indication of the target of today's best policy.

The experimental variations around the benchmark solution give an indication of the conditions under which this conclusion holds. First, the economy must start with a favorable endowment of expectations about inflation. If the Phillips curve at the outset has been shifted too far upward by past inflation, the period of low unemployment suggested by the benchmark solution is too costly. With a history of extensive inflation, it might even be necessary to have an initial period of high unemployment to shift the Phillips curve downward. I believe, however, that the present American economy is in a situation more like the benchmark case, where inflation is low relative even to the rate that would be optimal considering the costs and benefits of liquidity alone.

Second, today's optimal policy is substantially more expansionary if anticipated inflation does not shift the Phillips curve upward by the full amount of the anticipation. Although the natural rate is absolutely constraining only over the long-run in an economy with a vertical long-run Phillips curve, today's policy is quite sensitive to the slope of the long-run curve.

Third, the conclusions are sensitive to the assumptions about the relative

costs of inflation and unemployment. The benchmark case uses a conservative marginal rate of substitution that favors price stability over reduced unemployment to an extent that would be completely unjustified by the simple views that unemployment is a pure waste of resources and the cost of inflation is the cost of a few extra trips to the bank. The second and third experiments illustrate the optimal policy when the social cost of inflation is lower, while the sixth experiment treats the opposite case of reduced social costs of unemployment.

Fourth, the benefits of inflation derive from the use of expansionary policy to trick economic agents into behaving in socially preferable ways even though their behavior is not in their own interest. In the model, the gap between actual and expected inflation measures the extent of the trickery. The fourth experiment demonstrated that the optimal policy is not nearly as expansionary when expectations adjust rapidly, and most of the effect of an inflationary policy is dissipated in costly anticipated inflation.

Fifth, the conclusions depend on the assumption that the social welfare function discounts the future. If unborn generations count just as much as those alive today, then the optimal policy is quite different, as shown in the fifth experiment. In the absence of discounting, the optimal unemployment rate today is exactly the natural rate.

Finally, the conclusion that the optimal policy is one that converges smoothly to the natural unemployment rate depends on the assumption that change by itself is not beneficial. The sixth experiment showed that fluctuations in demand need only a small payoff to make the optimal policy one of wide swings in demand.

REFERENCES

1. Otto Eckstein and Roger Brinner, The Inflation Process in the United States, Joint Economic Committee, 92 Cong. 2 Sess., 1972.

2. Milton Friedman, "The Role of Monetary Policy," American Economic Review, Vol. 58, pp. 1-17, March 1968.

3. Robert J. Gordon, "The Recent Acceleration of Inflation and Its Lessons for the Future," Brookings Papers on Economic Activity, (1:1970), pp. 8-41.

4. ______________, "Inflation in Recession and Recovery," Brookings Papers on Economic Activity, (1:1971), pp. 105-158.

5. ______________, "Wage-Price Controls and the Shifting Phillips Curve," Brookings Papers on Economic Activity, (2:1972), pp. 385-421.

6. ______________, "The Welfare Cost of Higher Unemployment," Brookings Papers on Economic Activity, (1:1973), pp. 133-195.

7. Robert E. Hall, "Turnover in the Labor Force," Brookings Papers on Economic Activity, (3:1972), pp. 709-756.

8. William Nordhaus, "The Recent Productivity Slowdown," Brookings Papers on Economic Activity, (3:1972), pp. 493-536.

9. Arthur Okun, "Upward Mobility in a High-Pressure Economy," Brookings Papers on Economic Activity, (1:1973), pp. 207-252.

10. George Perry, "Labor Force Structure, Potential Output, and Productivity," Brookings Papers on Economic Activity, (3:1971), pp. 533-565.

11. Edmund S. Phelps, Inflation Policy and Unemployment Theory: The Cost-Benefits Approach to Monetary Planning, Norton, New York, 1972.

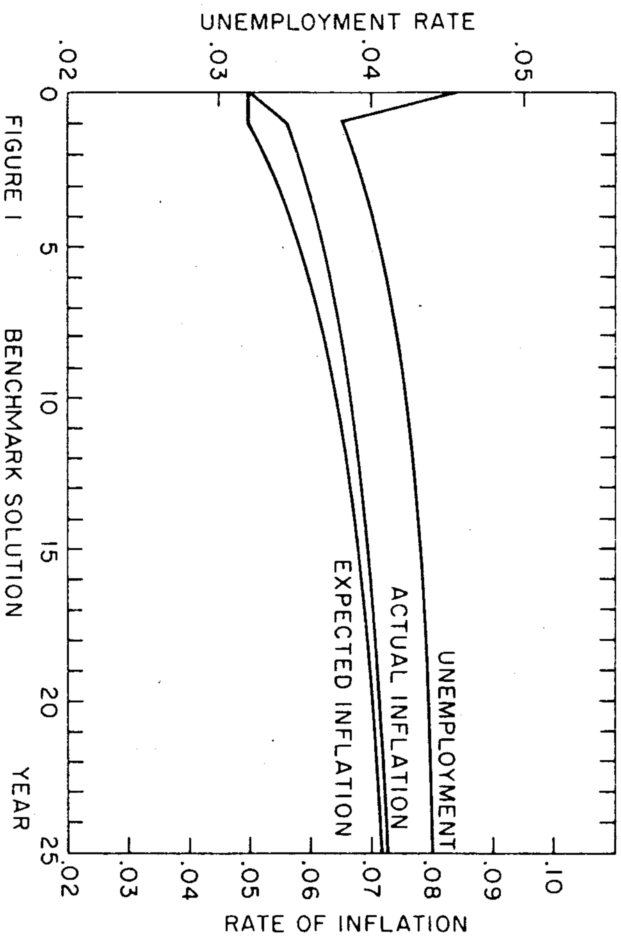


FIGURE I BENCHMARK SOLUTION

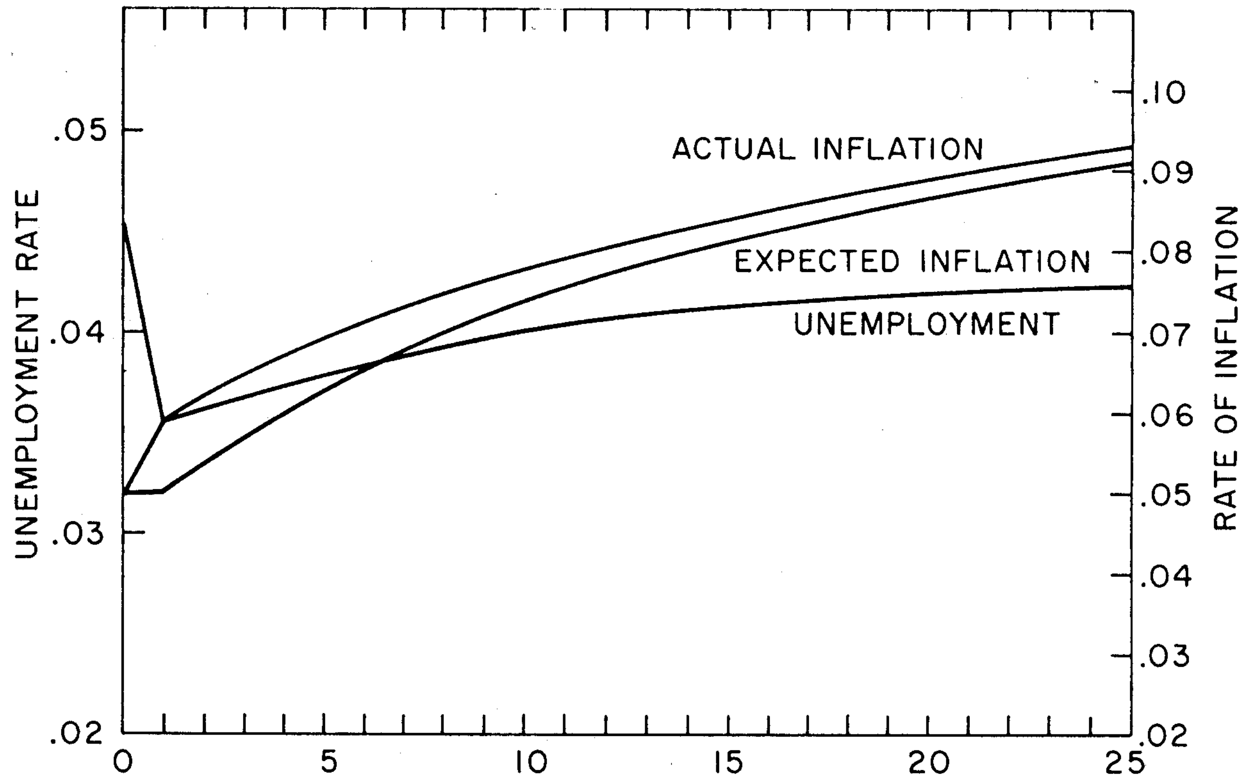
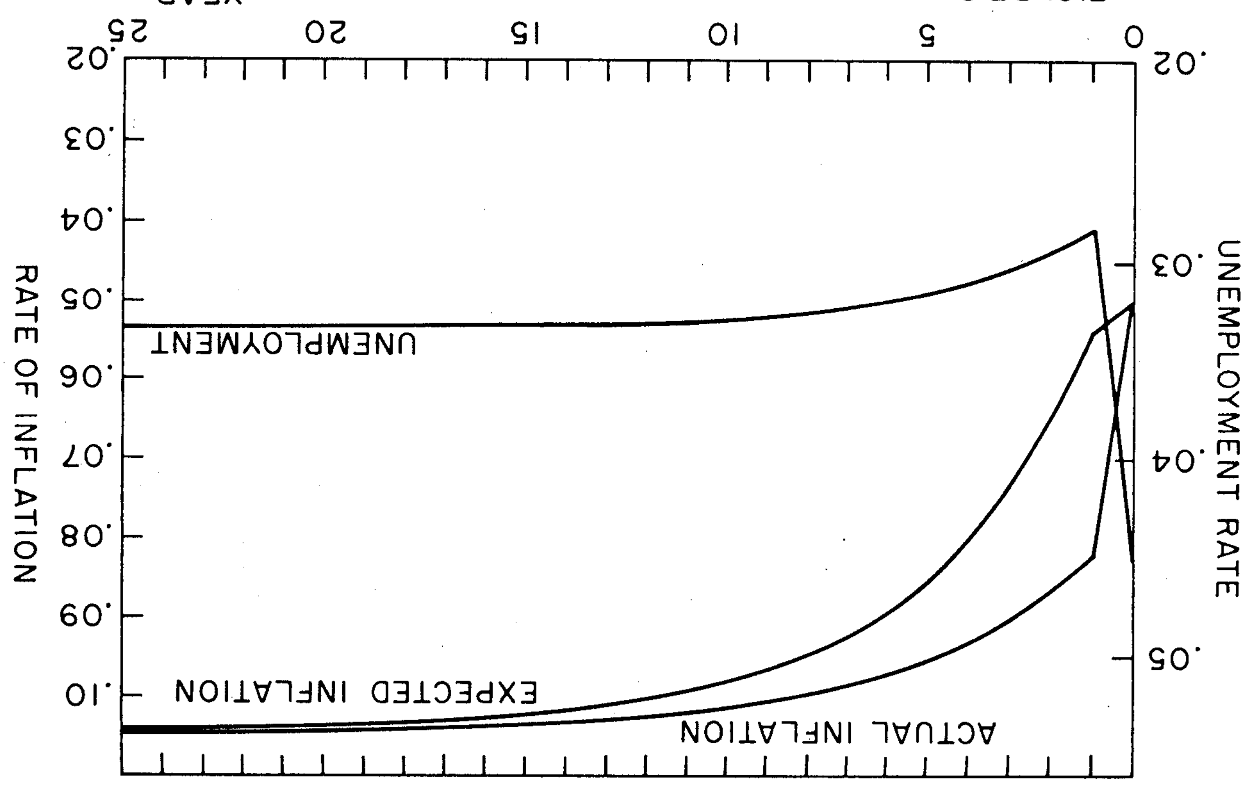


FIGURE 3 LOWER COST OF INFLATION

FIGURE 2 NON-VERTICAL LONG RUN PHILLIPS CURVE



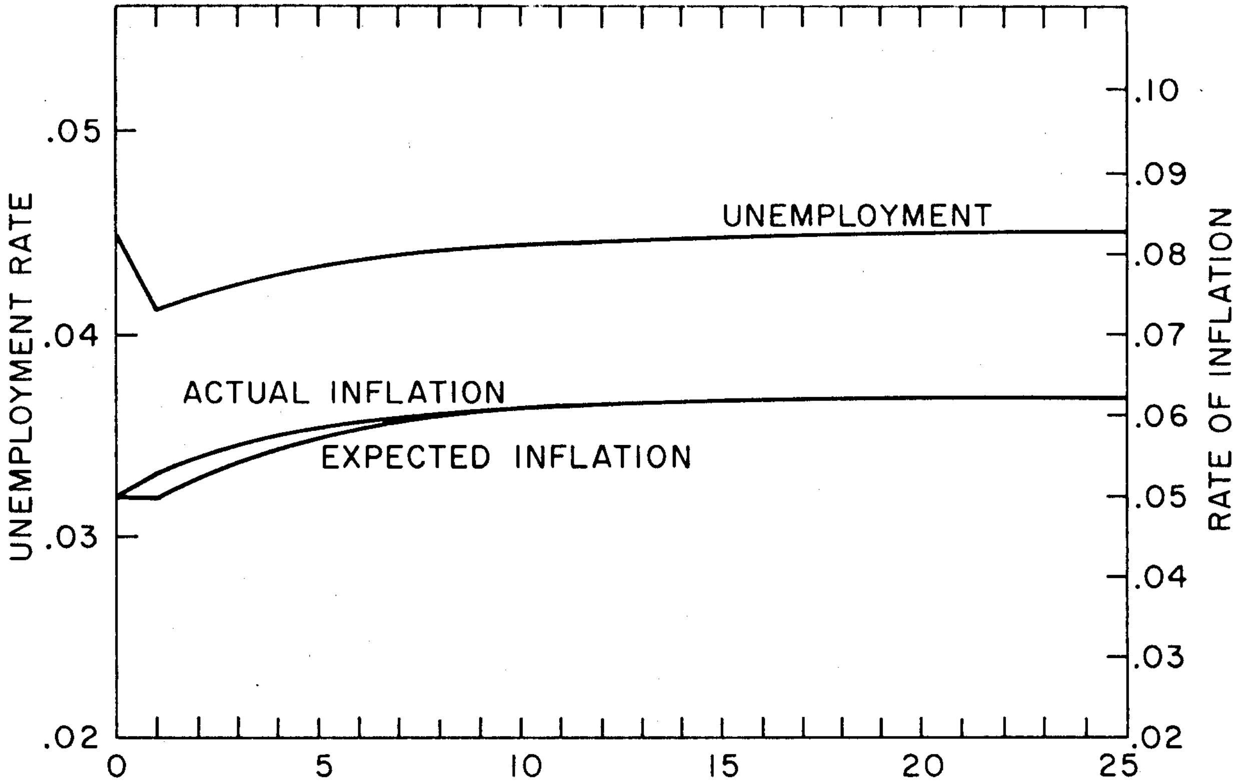


FIGURE 5 SHORTER LAG IN FORMING EXPECTATIONS

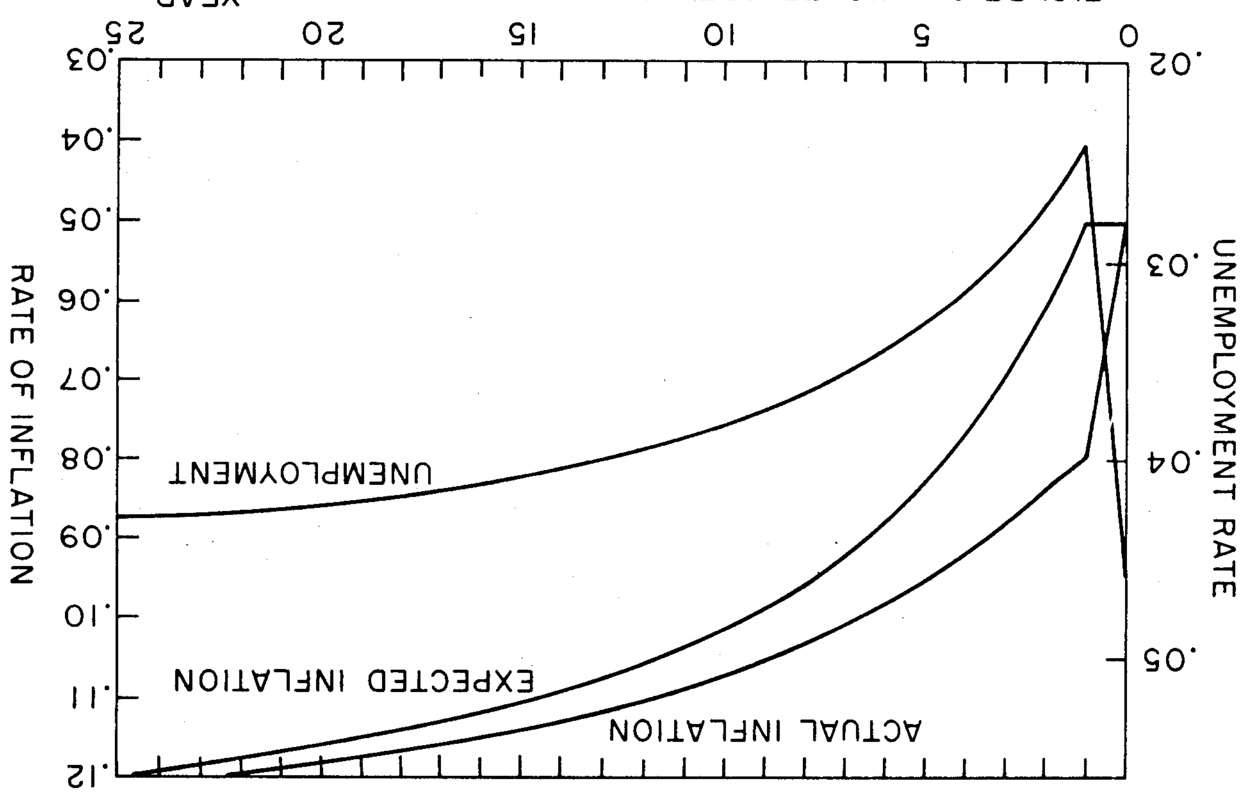


FIGURE 4 HIGHER OPTIMAL INFLATION RATE

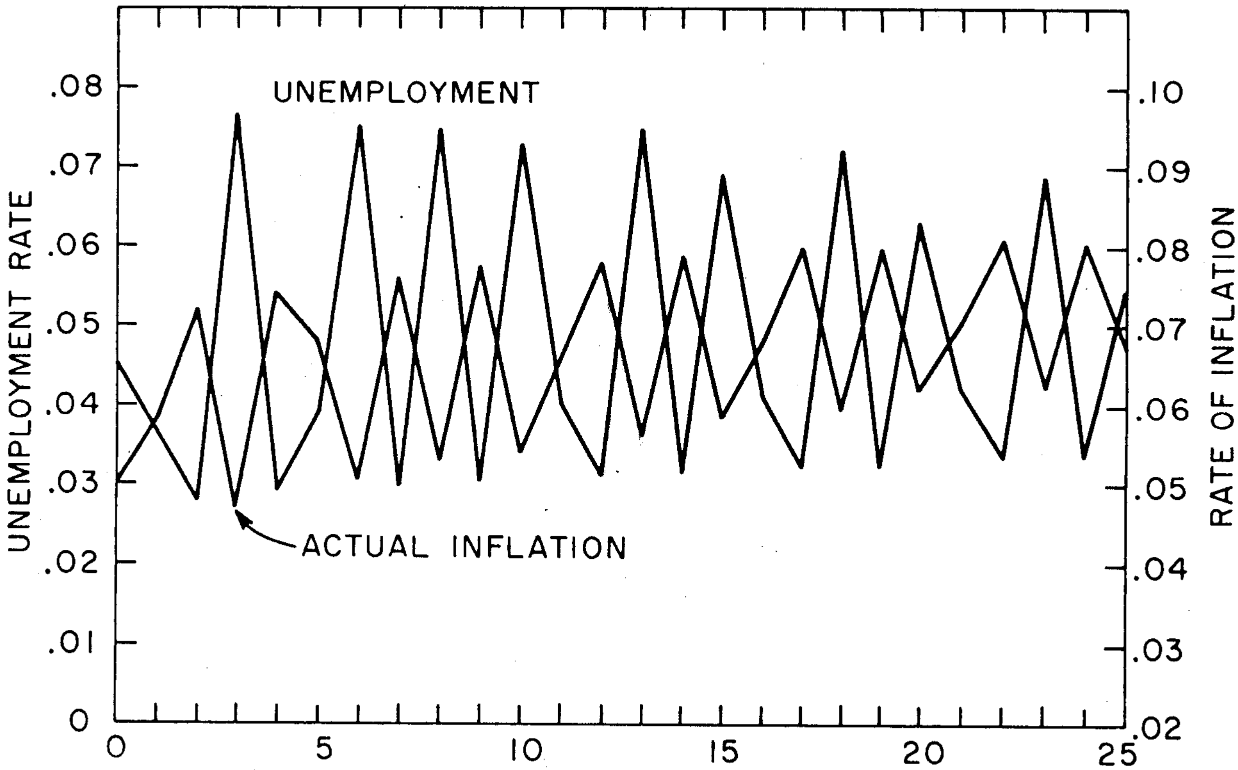


FIGURE 6 BUSINESS CYCLE STIMULATES MOBILITY