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ON THE LONG RUN PHILLIPS CURVE GENUS

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SUMMARY: This note points out that the long run Phillips curve genus contains upward and downward sloping species as well as the vertical species. Observers have found it difficult to sight the vertical species in certain countries, in certain epochs. This difficulty could well arise from the observers having looked for the wrong species.

The natural rate of unemployment theory invented by Milton Friedman (1968) and Edmund Phelps (1967) is normally taken to imply a genus of long run Phillips curves which are vertical lines corresponding to different natural rates of unemployment, the natural rate of unemployment being determined by "real" factors which are independent, or largely independent, of the rate of inflation. This note points out that this is an incomplete classification of the long run Phillips curve genus because the genus actually contains a more varied set of species, there being upward and downward sloping long run Phillips curves as well as the more commonly identified vertical line. The vertical species is the one which has captured the attention of many policy makers, and it is towards the identification of this species that academic research has been directed. The contention of this paper is that too much attention has been focussed on the vertical species of the long run Phillips curve to the neglect of the possibly more interesting upward and downward sloping species. To paraphrase Burke on the French revolution, too much attention has been paid to the plumage of natural rate theory, and not enough attention paid to the bird itself.

The first post-1945 sightings of the vertical Phillips curve species are reported in Phelps (1967), who spotted U*, and Friedman (1968), who termed U* the natural rate of unemployment. Reports of the downward sloping species came later, in Phelps (1972). The upward sloping species, and the possible existence of a downward sloping species were recorded in Friedman (1977). It is these later sightings which have been neglected.

Section I of this note will discuss the different long run Phillips curve species to be found in Friedman (1977) and sketch some of the implications which the lesser known upward and downward sloping species hold. Since the early 1970s the new classical analytical framework formalised in Robert Lucas (1972) has become the main framework for investigating the properties of economic models containing vertical Phillips curves. Section II will make

a detour to explain how the factors which lead to an upward sloping Phillips curve in Friedman are taken to generate changes in the slope of the short run Phillips curve in the new classical analysis. Section III will discuss the downward sloping species of Phillips curve to be found in Phelps (1972).

I THE FRIEDMAN SPECIES

Friedman (1968) distinguished the long run Phillips curve genus from the short run genus which had been identified by Irving Fisher (1926) and A.W. Phillips (1958) - though see Meghnad Desai (1975) for the argument that the effect and purpose of the Phillips estimation procedure was to estimate a wage change-unemployment locus for some equilibrium in which unemployment was unchanging, i.e. $\dot{U} = 0$. The long run equilibrium rate of unemployment was termed the natural rate by way of analogy to Knut Wicksell's natural rate of interest (Wicksell 1898). This natural rate of unemployment was postulated to depend on "real" factors - "... the structural characteristics of the labour and commodity markets ..." (Friedman 1968, p.8) - and to be independent of monetary factors. The postulated independence of the natural rate from monetary factors implies a set of vertical Phillips curves corresponding to each natural rate of unemployment - see Diagram 1. The adjustment to the vertical Phillips curve, however, is likely to take a long time: "... a full adjustment to the new rate of inflation takes about as long for employment as for interest rates, say, a couple of decades". (Friedman 1968, p.11).

The Positive-Sloped Phillips Curve

The analysis of the adjustment period is taken up in more detail in Friedman's Nobel Prize lecture. The conditions for the vertical long-run Phillips curve to hold are "... that inflation is steady or at least no more variable at a high rate than at a low ... that the inflation is, or can be open, with all prices free to adjust to a higher rate, so that relative

price adjustments are the same with a 20 per cent inflation as with a zero inflation ... (and) that there are no obstacles to indexing of contracts." (Friedman 1977, pp.464-465). Such conditions, however, are not likely to be met unless "... inflation at an average rate of 20 per cent per year were to prevail for many decades ... when a country initially moves to higher rates of inflation, these requirements will be systematically departed from ... and such a transitional period may well extend over decades" (Friedman 1977, p.465).

In an attempt to explain what happens over the "many decades" it takes to adjust to the vertical long-long-run Phillips curve Friedman puts forward a theory of a long-run positively sloped Phillips curve - see Diagram 2. Such a curve traces rates of unemployment consistent with unchanging rates of inflation and so constitutes a locus of natural rates of unemployment and anticipated rates of inflation. Friedman outlines two main sets of reasons for expecting this long-run natural rate curve to be positive in slope. First, the variability of the rate of inflation is postulated to be higher at higher rates of inflation, such higher variability is postulated to make it more difficult to distinguish relative prices from money prices, and this higher level of uncertainty or confusion regarding relative prices is postulated to discourage employment: "... The more volatile the rate of general inflation the harder it becomes to extract the signal about relative prices from the absolute prices ... it seems plausible that the average level of unemployment would be raised by the increased amount of noise in market signals, at least during the period when institutional arrangements are not yet adapted to the new situation" (Friedman 1977, p.467). Second, higher rates of inflation are postulated to stimulate more government interference in the price mechanism in the form of such as wage and price controls, and this is postulated to involve a "... reduction in the capacity of the price system to guide economic activity ... and, very likely, a higher recorded rate of unemployment" (Friedman 1977, pp.467-468).

This theory, if accepted, means that governments can achieve sustained changes in unemployment over the "many decades" to which the long-run positively sloped Phillips curve is relevant. Thus the slogan that "there is no long-run trade-off between inflation and unemployment" relates only to the long-long-run. The slogan relevant to the "many decades" of the long-run is that "higher anticipated inflation leads to higher unemployment". It is this slogan which has been adopted by many governments in the late 1970s and early 1980s to rationalise anti-inflation policies. The argument has been that higher rates of unemployment are necessary in the short-run in order to achieve a lower rate of inflation and a lower long-run rate of unemployment.

A Simple Model

In order to investigate the properties of the long-run Phillips curve postulated by Friedman it might be illuminating to construct a simple model. The following model contains the bare bones of the Friedman argument and nothing more. It is designed to investigate the qualitative properties of Friedman's argument, not as a justifiable representation of the main features of any particular economy.

$$\ddot{P} = \alpha(U^* - U) \qquad \alpha > 0 \qquad (1)$$

$$U^* = U_R + \beta\dot{P} \qquad \beta > 0 \qquad (2)$$

$$U = \bar{U} - \gamma Y \qquad \gamma > 0 \qquad (3)$$

$$\dot{Y} = \dot{M} - \dot{P} \qquad (4)$$

All variables except unemployment are measured in natural logs; a dot indicates a time derivative; P is the general price level; U^* is the natural rate of unemployment, U the actual rate of unemployment; U_R represents the component of the natural rate which is determined by "real" factors, $\bar{U}$ the

component of actual unemployment which is independent of output; Y is real output; and M is the nominal money stock.

Equation (1) captures the central characteristic of natural rate theory that inflation accelerates if the actual is held below the natural rate of unemployment, and decelerates if the actual is above the natural rate. Equation (2) distinguishes two components of the natural rate: the first component represents the "real" factors such as the ratio between unemployment insurance benefits and wages which are conventionally taken to determine the natural rate; the second component represents the positively sloped Phillips curve hypothesis that the natural rate is a positive function of the rate of inflation because of the distortions induced by higher inflation. Equation (3) is the inverted form of a primitive production function. Equation (4) is the equilibrium condition for a money market characterised by a constant velocity of circulation. The economy analysed is taken to be in a stationary state, so necessary conditions for equilibrium are that $\dot{Y} = 0$, $\dot{M} = \dot{P}$ and $U = U^*$.

Differentiating (1), (2) and (3) with respect to time yields

$$\dddot{P} = \alpha(\dot{U}^* - \dot{U}) \qquad (5)$$

$$\dot{U}^* = \beta \ddot{P} \qquad (6)$$

$$\dot{U} = -\gamma \dot{Y} \qquad (7)$$

taking the case where U_R and $\bar{U}$ do not change over time. Substituting (4) into (7) and solving for P yields

$$\dddot{P} - \alpha\beta\ddot{P} + \alpha\gamma\dot{P} = \alpha\gamma\dot{M} \qquad (8)$$

Equation (8) can be analysed as a second-order linear differential equation having a homogeneous form $\dddot{P} + A\ddot{P} + B\dot{P} = 0$ where $A \equiv -\alpha\beta < 0$ and $B \equiv \alpha\gamma > 0$. This equation is clearly unstable. If $(-\alpha\beta)^2 - 4(\alpha\gamma) > 0$ the roots of the equation will be real, and the price level will

diverge from equilibrium in a monotonic fashion if disturbed. If $(-\alpha\beta)^2 - 4(\alpha\gamma) < 0$ the roots of the equation will be complex, and the price level will oscillate around equilibrium in an explosive manner if disturbed. Thus the introduction of the rate of inflation as a determinant of the natural rate of unemployment produces unstable natural rate equilibria. This instability is similar to that arising from the Wicksell process in other models of monetary equilibrium (see Douglas Gale 1982, pp.136-144, for example). An intuitive rationale for this result is that any increase in the rate of inflation will increase the natural rate of unemployment, which will, *mutatis mutandis*, lead to a further increase in the rate of inflation. The irony here is that Friedman, in borrowing Wicksell's natural rate of interest for application to unemployment, has also taken on board the type of instability arising from Wicksell's cumulative process.

This means that any disturbance to the long-long-run equilibrium arising from a change in the anticipated rate of inflation produces the explosive result that the steady rate of inflation will tend to ever-increase or ever-decrease. Thus the long-long-run equilibrium of the vertical Phillips curve is itself a knife-edge. If governments pursue policies to reduce the anticipated rate of inflation, the anticipated rate of inflation and the natural rate of unemployment will tend to fall without limit. If governments pursue policies which increase the anticipated rate of inflation, the anticipated rate of inflation and the natural rate of unemployment will tend to rise without limit. This in turn means that what happens over the "many decades" to which the positively sloped Phillips curve is relevant will ensure that the long-long-run equilibrium of the vertical Phillips curve is never regained if disturbed. In the long-long-run we are all dead, and so is the vertical Phillips curve.

Evidence

Of the two hypotheses invoked by Friedman to yield a positive-sloped long-run Phillips curve, the one concerning the variability of inflation has attracted most empirical investigation. Two sub-hypotheses are involved: that a higher rate of inflation is associated with greater variability in the rate of inflation; and that greater variability in inflation leads to less output and more unemployment. An early study of the relationship between the level and variability of inflation gave support to the Friedman hypothesis (Arthur Okun 1971). Robert Gordon (1971) challenged Okun's findings as far as industrialised countries or countries experiencing only moderate rates of inflation were concerned, arguing that there was virtually no correlation between the level and variability of inflation in such countries once certain special factors, such as changes in agricultural support prices, were taken into account. Dennis Logue and Thomas Willett (1976) produced evidence supporting the Gordon qualification of the increasing variance postulated by Friedman, Richard Parks (1978) and Edward Foster (1978), evidence supporting the original Okun findings.

Given that the Friedman conjecture can be taken to imply increasing variance in the errors associated with estimates of the rate of inflation at higher rates of inflation, models which allow for heteroscedasticity, such as the ARCH (autoregressive conditional heteroscedasticity) model introduced by Robert Engle (1982, 1983), are likely to be more suitable than the standard homoscedastic model. Engle's conclusion, after inspecting data for the U.K. and U.S., is that "... a high rate of inflation does not necessarily imply a high variance of inflation ... in fact, the 1970s provide a clear counterexample" (Engle 1983, p.292). In the U.S. case, for example, "... the salient result is that the variance of inflation in the seventies was only slightly greater than in the sixties and both were

well below the variances in the late forties and early fifties ... although the level of inflation in the seventies was high, it was predictable based on available information and, hence, the variance did not increase". (Engle 1983, p.297). The judgement here is that the weight of evidence does not support Friedman's conjecture for low to moderate rates of inflation, but that the conjecture holds at very high rates of inflation. If this is the case, then Friedman's positively sloped long-run Phillips curve is relevant only to very high rates of inflation.

Evidence supporting the second sub-hypothesis, that more variable rates of inflation are associated with lower output and higher unemployment, can be found in such as Blejer and Leiderman (1980), though this relationship could well arise from the effects of real shocks on price dispersion, rather than from the effects of monetary shocks (see Zvi Hercowitz 1982, for example). Most studies of the relationship between output, unemployment and the variability of inflation have been conducted inside the analytical framework of the new classical macroeconomics, with a more variable rate of inflation leading to a more steeply sloped short-run Phillips curve (see Robert Lucas 1973), rather than to a positively sloped long-run Phillips curve, as in Friedman. These studies will be discussed in the next section of the paper, which deals with Phillips curves in the new classical macroeconomics.

The second main hypothesis invoked by Friedman, that higher rates of inflation stimulate more government interference in the price mechanism, has not to date been the subject of detailed empirical investigation. It is possible to think of cases where governments have introduced wage and price controls, have created obstacles to the indexation of contracts and so on at higher rates of inflation - in the late 1960s in the U.K., for example. It is also possible, however, to cite examples where the opposite has been the case - the U.K. in 1979-80, the U.S. in the early 1980s, for instance.

Perhaps the main issue here is whether governments believe the Friedman theory of inflation - unemployment interaction, in which case they would not be more prone to interfere with the price mechanism at higher rates of inflation, or whether governments believe in theories which have different implications.

The Negative-Sloped Curve

A major difficulty with the positive-sloped long-run Phillips curve theory is that it fails to account for the prolonged higher unemployment which has been associated with measures to reduce the anticipated rate of inflation, as in the 1925 return to gold episode in the U.K., and as in many industrial countries in the early 1980s. Friedman deals with this problem by suggesting that the positive-sloped Phillips curve may be relevant only to periods in which there is an increase in the rate of inflation, a negative-sloped Phillips curve being relevant to the long-run associated with the adjustment to a lower rate of inflation - see Diagram 3. The argument is that "... the adoption in the new monetary framework of a successful policy of low inflation would in its turn require new adjustments, and these might have ... adverse transitional effects on the level of employment. There would appear to be an intermediate-run negatively sloped Phillips curve instead of the positively sloped one I have tried to rationalise" (Friedman 1977, p.468).

The problem with this conjecture is that Friedman does not explain why the factors which work to raise the natural rate of unemployment during periods of rising inflation do not operate symmetrically to reduce the natural rate during periods of falling inflation. We are told only that "... new adjustments ..." would be required. A further point is that if the natural rate rises during the "quinquennia or decades" it takes to adjust to both higher and lower rates of inflation, governments would have to be far-sighted

to opt for any strategy to change the rate of inflation. Friedman has endorsed several strategies involving a reduction in the rate of inflation, whereas the conjunction of a positive-sloped Phillips curve for rising inflation with a negative-sloped Phillips curve for falling inflation suggests that constant inflation rate strategies would be advisable for governments not afflicted by hypermetropia. The negative-sloped long-run Phillips curve, as identified by Phelps, is discussed further in Section III of this paper.

II THE NEW CLASSICAL SPECIES

In the new classical macroeconomics the vertical Phillips curve appears as a relationship that will be established once agents are able to distinguish aggregate from local shocks - usually after a one period lag in acquiring information about aggregate shocks (Lucas 1972). Thus the vertical species of Phillips curve is seen as being relevant to much shorter time periods than in Friedman (though see George Alogoskoufis and Christopher Pissarides 1983 for an appraisal). The main innovation is that the short-run Phillips curve is derived from a framework of optimising behaviour in which agents exploit all advantageous trades, except as far as the acquisition of information regarding current aggregate shocks is concerned. The (short) long-run vertical Phillips curve is seen as the inevitable outcome of trading on markets which clear continuously subject to the information available. The greater variability of inflation at higher rates of inflation is postulated to increase the slope of the short-run Phillips curve, not to lead to a positive-sloped long-run Phillips curve, as in Friedman. Other factors that might lead to non-neutrality in the (short) long-run, such as government interference with the price mechanism, non-indexed government debt

counting as private sector net worth, capital or inventory accumulation responding to the rate of monetary expansion, non-indexed taxes and so on, are taken to be insufficienty important to upset the (short) long-run neutrality proposition (see Steven Sheffrin 1983, for a review). This leaves the new classical approach with the severe problem of explaining the persistence of observed deviations from natural levels of output and employment over the business cycle (see Gordon 1981, for example).

The "new" implications of this approach relate to the short-run Phillips curve. Producers have the problem of working out the extent to which variations in their own price $P(z)$ reflect variations in the general price level P, and how much such variations reflect deviations in their own price from the general price level, z, where $P(z) \equiv P + z$ (this exposition is taken from Lucas 1973). Given that producers know from history the mean and variance of the general price level, $\bar{P}$ and σ^2, and that z is distributed independently of P with a zero mean and variance r^2, the rational expectation for the mean of the general price level given the information $I(z)$ available at time t is

$$E(P_t \mid I(z)_t) = E(P_t \mid P(z)_t, \bar{P}_t)$$
$$= (1-\theta)\, P(z)_t + \theta \bar{P}_t \qquad (9)$$

The supply curve for output in z is

$$y(z)_t \equiv y^*(z)_t + y(z)_{ct} \qquad (10)$$

where y^* is the natural or trend level of output and y_c is the cyclical component, specified as

$$y(z)_{ct} = \gamma \left[P(z)_t - E(P_t \mid I(z)_t) \right] + \lambda\, y(z)_{ct-1} \qquad (11)$$

Aggregating over individual markets yields the familiar Lucas supply curve

$$y_t = y^*_t + \pi\left[P_t - \bar{P}_t\right] + \lambda\left[y_{t-1} - y^*_{t-1}\right] \tag{12}$$

where $\pi = \theta\gamma$ and $\theta = \frac{r^2}{\sigma^2 + r^2}$ (13)

Expression (13) summarises the main novelty in the new classical short-run Phillips curve: the slope of this curve, π , depends on the proportion of the local price variance which is due to the relative price variance rather than to the variance in the general price level. If the variance of the general price level, σ^2, is greater at higher rates of inflation, this means that the slope of the short-run Phillips curve will be steeper at higher rates of inflation - see Diagram 4.

In the original Lucas study the main negative correlation for (π,σ^2) arose when comparing countries with very highly variable inflation rates - Argentina and Paraguay - with Western industrial countries having less variable inflation rates. Inside the Western industrial group of countries there was not a clear negative correlation for (π,σ^2). Richard Froyen and Roger Waud (1980), on extending the data period to the 1970s, found a more clearly discernible negative correlation for (π,σ^2) inside Western industrial countries, though in some countries, especially the U.S. and Belgium, a markedly higher σ^2 in the 1970s compared to the 1960s was accompanied by a higher rather than lower value of π. The evidence thus provides clear support for the conjecture that there is a significant deterioration in the short-run output-inflation trade-off at very high, very variable rates of inflation, but not very clear support for the conjecture that such a deterioration occurs at lower rates of inflation. Although studies suggest that price dispersion does increase with the rate of inflation (see Alex Cukierman and Paul Wachtel 1982, for a review), the conjecture that there is a clear positive correlation between price dispersion and unanticipated money

or the variance of nominal income is not supported by the evidence (see Froyen and Waud 1980 and Hercowitz 1982).

Thus although the new classical approach to the Phillips curve has been fruitful in yielding interesting conjectures as to how the inflation-output (or employment) trade-off is related to price dispersion and aggregate shocks, some of the more important conjectures do not appear to hold empirically. This leaves the door open for other theories, such as the Friedman short, long and long-long-run Phillips curves discussed earlier, and such as the Phelps *hysteresis* theory discussed in the next section.

III THE PHELPS SPECIES

In his seminal paper on the long-run Phillips curve, Phelps was concerned with the implications for inflation and unemployment policy of a fixed natural rate of unemployment, not with the question of whether it is reasonable to expect such a rate of unemployment to be independent of monetary factors (Phelps 1967). The latter question was investigated in his subsequent book on the subject, and here Phelps produces reasons for expecting the natural rate not to be independent of monetary factors (Phelps 1972). In particular Phelps outlines a *hysteresis* theory which implies that the natural rate of unemployment will depend on the time path of actual unemployment experienced during the movement from one steady rate of inflation to another. This theory implies that movements in the natural rate of unemployment will have a negative association with movements in the steady rate of inflation. Thus Phelps has a theory whose implications are at variance with the vertical long-run Phillips curve theory, being more in accord with the non-neutrality results to be found in such as James Tobin (1965), where a higher rate of inflation leads to portfolio substitution

from money to capital, and a higher steady state stock of capital. In the Phelps analysis the movement to a higher rate of inflation generates an increase in the stock of human capital - that is a better-trained, more productive labour force.

Hysteresis Effects

Hysteresis is a term often used in physics to refer to the lagging of magnetic induction behind the magnetising force. Thus there will be a time lag between the force applied to a body being released and the body reverting to its previous shape. The implication for the natural rate of unemployment is that: "... the transition from one equilibrium to the other tends to have long-lingering effects on the labour force, and these effects may be discernible in the equilibrium rate of unemployment for a long time. The natural rate of unemployment at any future date will depend upon the course of history in the interim. Such a property is sometimes called *hysteresis*" (Phelps 1972, p.xxiii).

Phelps outlines two *hysteresis* effects which would lead the natural rate of unemployment to depend on the history of actual unemployment (Phelps 1972, Chs. 3 and 4). The first relates to the way the employment experience of the labour force helps shape the characteristics of the labour force. A higher employment level leads to more people receiving on-the-job training and learning by doing; and habits conducive to employment, such as being able to get to work on time, are instilled in more people. Thus higher unemployment is likely to produce a less-skilled labour force containing more people with habits which are not conducive to work. This effect on the supply side of the labour market will be reinforced by any tendency of employers to see those who have long or frequent spells of unemployment on their *curricula vitae* as being unsuitable for employment. The pattern of

wages and of job vacancies is not likely to adjust overnight to accommodate such changes in the characteristics of the labour force, and so the natural rate of unemployment will rise. The argument here rests on the theory that longer or more frequent spells of unemployment tend to make people less employable rather than allow those unemployed to acquire new skills and habits which are conducive to employment. Various studies tend to support the Phelps hypothesis (see Stephen Nickell 1979 and George Akerlof and Brian Main 1980, for example).

The second hysteresis effect outlined by Phelps relates to the role of labour unions. A rise in employment is postulated to be accompanied by a rise in the number employed in jobs covered by labour unions. This increase in union membership is postulated to reduce the mark-ups that labour unions can achieve over non-union jobs because the higher union employment is bought at the cost of lower union mark-ups. Thus higher employment would reduce any component of the natural rate of unemployment associated with the relative price distortions arising from union mark-ups. The theoretical rationale for this *hysteresis* effect is open to considerable question (see Andrew Oswald 1982), and the empirical evidence does not obviously lend support to this theory (see George Bain and Farouk Elsheikh 1976 and Henry Farber 1978, for example). The case that the effect works in the opposite direction can be made by postulating that lower unemployment means that unions can achieve higher mark-ups because their members are more likely to find employment elsewhere should they lose their present union jobs as a result of any higher mark-up achieved.

Even if the second type of *hysteresis* effect is indeterminate in sign, the evidence relating to the debilitating effects of longer or more frequent spells of unemployment on those concerned suggests that there is likely to be a significant *hysteresis* effect linking the natural rate to the history of actual unemployment on the lines suggested by Phelps (see Pilgrim Trust

1938, and Manpower Services Commission 1982). This *hysteresis* effect implies that the natural rate of unemployment depends on the actual rate of unemployment as well as on the "real" factors such as the ratio of unemployment benefits to wages conventionally invoked to explain the natural rate. People are changed by the experience of unemployment and so is the natural rate.

A Simple Model of Hysteresis Effects

The effects of *hysteresis* on the natural rate of unemployment can be investigated by modifying the model used earlier to analyse the qualitative implications of Friedman's positive-sloped Phillips curve conjecture.

$$\ddot{P} = a(U^* - U) \qquad a > 0 \qquad (14)$$

$$U^* = U_R + b\dot{U} + c\int_{t=o}^{t=45} (U - U_R)\, dt \qquad b, c > 0 \qquad (15)$$

$$U = \bar{U} - dY \qquad d > 0 \qquad (16)$$

$$\dot{Y} = \dot{M} - \dot{P} \qquad (17)$$

The model is the same as that employed in Section I of this note (see equations (1)-(4)), except for equation (15). This equation distinguishes two components of the natural rate of unemployment. The first component, U_R, is determined by the conventional "real" factors, which are here deemed to be independent of the unemployment experience of the labour force. The second component is determined by *hysteresis* factors. The variable $\dot{U}$ captures the hypothesis that rising unemployment will - provided that it is associated with a fall in the rate of outflow from unemployment rather than a rise in the rate of inflow (this has been the recent U.K. experience, see Nickell 1982) - lead to more people experiencing the debilitating effects of long spells of unemployment. The variable $\int_{t=0}^{t=45} (U - U_R)\, dt$ is similar

to that employed in an earlier paper by Hargreaves Heap (1980), and captures the hypothesis that the debilitating effects of long spells of unemployment will be felt if actual unemployment has on average been above U_R, even though actual unemployment might be falling, i.e. $\dot{U} < 0$. Integration over the period t=0 to t=45 reflects the fact that the effects of debilitating long spells of unemployment in the past will decay as the people concerned retire from the labour force.

Differentiating (14), (15) and (16) with respect to time yields

$$\dddot{P} = a(\dot{U}^* - \dot{U}) \tag{18}$$

$$\dot{U}^* = b\ddot{U} + c(U - U_R) + ck \tag{19}$$

$$\dot{U} = -c\dot{Y} \tag{20}$$

taking the case where U_R and $\bar{U}$ do not change over time. Solving for P yields

$$\dddot{P} - abd\ddot{P} + ad\dot{P} - acdP = -abd\ddot{M} + ad\dot{M} - acdM - cU_R + ack \tag{21}$$

This equation is a third-order linear differential equation having an homogeneous form $\dddot{P} + A\ddot{P} + B\dot{P} + CP = 0$. Given that A and C are negative in sign the price level is unstable, and remains unstable if we set either b or c equal to zero. This means that the natural rate of unemployment is also unstable: any shock to the actual rate of unemployment will push the natural rate in the same direction, and the old natural rate equilibrium will not be regained. The intuitive explanation for this result is that shocks to the actual rate of unemployment are accompanied by changes in the number of people who experience the debilitating effects of long spells of unemployment, thus changing the characteristics of the stock of people who constitute the labour force. People cannot be placed in cold storage should they become unemployed for long spells. Rather they experience an actual

an actual or perceived decline in their productivity or capacity to work. Byegones are not byegones.

Implications

The Phelps *hysteresis* augmented version of the natural rate of unemployment is plausible, and has unnatural implications which are interesting. To the extent that the experience of more or longer spells of unemployment changes the people concerned, and in such a way as to reduce their employability, we would expect *hysteresis* effects to shape the natural rate of unemployment along with the other "real" factors conventionally invoked. This means that the actual unemployment experienced while moving from one steady inflation rate to another will change the natural rate of unemployment. Anti-inflation policies, for example, will increase the natural rate of unemployment rather than be accompanied merely by transitory increases in unemployment. Thus there will be a negative association between changes in the steady rate of inflation and changes in the natural rate of unemployment - see Diagram 5. A very long-run vertical Phillips curve may exist but is relevant only to periods in which the steady rate of inflation does not change. Changes in the steady rate of inflation produce irreversible changes in the natural rate of unemployment.

The implication for research is that it is futile to search for vertical long-run Phillips curves over periods in which the steady rate of inflation has changed substantially. Rather, attempts to identify the natural rate of unemployment in such periods should introduce the history of actual unemployment as an explanatory variable. Although the *hysteresis* theory says nothing about the nature of the impulses which shock economic systems, it does give an account of how such shocks are propagated. Major shocks which serve to raise unemployment - such as the 1925 return to gold episode in Britain, the events of 1929-31 in the U.S., the oil price hikes of 1973 and 1979-80 and

the anti-inflation policies pursued by many countries in the early 1980s - will be propagated by *hysteresis* effects and lead to sustained rather than once-off increases in the natural rate of unemployment. Thus the *hysteresis* theory can help to explain why unemployment remained high through the 1920s and 1930s in Britain after the initial shocks at the beginning of each decade, and why a similarly prolonged depression was experienced by the U.S. and many other countries after the shock at the beginning of the 1930s. The prediction for the 1980s is that the higher rates of unemployment associated with anti-inflation policies will leave a legacy of higher natural rates of unemployment through the 1980s.

IV CONCLUSION

The aim of this note has been to bring to attention some of the lesser known members of the long-run Phillips curve genus. The upward and downward sloping species are often ignored, even though observation suggests that the vertical species has a propensity to become extinct over time periods to be measured in quinquennia or decades. The evidence to date suggests that the downward sloping species may be easier to observe in countries with fairly low rates of inflation, and the upward sloping species in countries with very high rates of inflation. The vertical species does not appear to survive well in major recessions or hyperinflations.

DIAGRAM 1: The Vertical Species

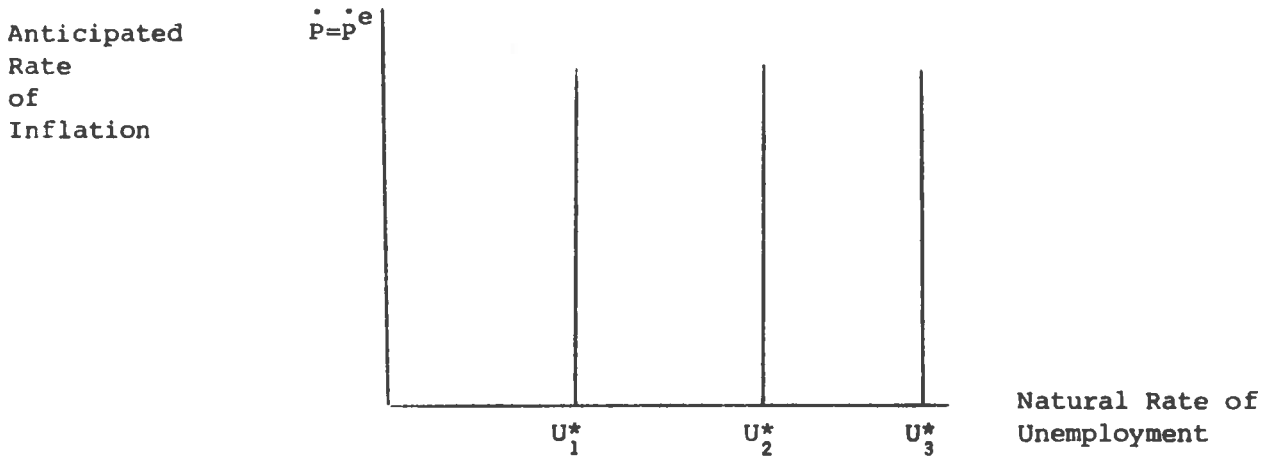


DIAGRAM 2: The Upward Sloping Species : Increasing Inflation

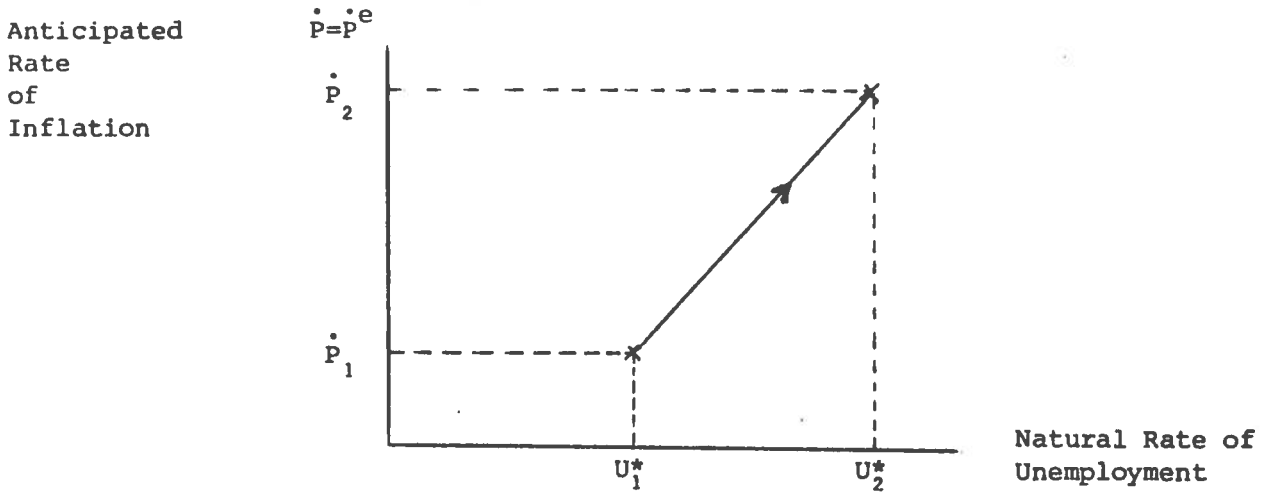


DIAGRAM 3: The Downward-Sloping Species : Falling Inflation

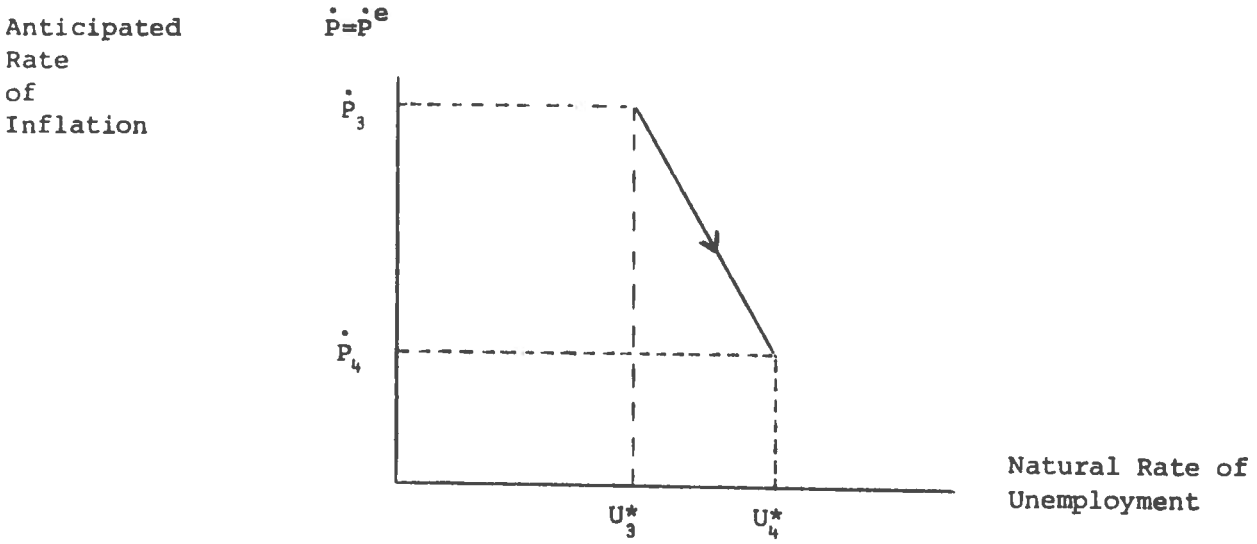


DIAGRAM 4: The New Classical Species

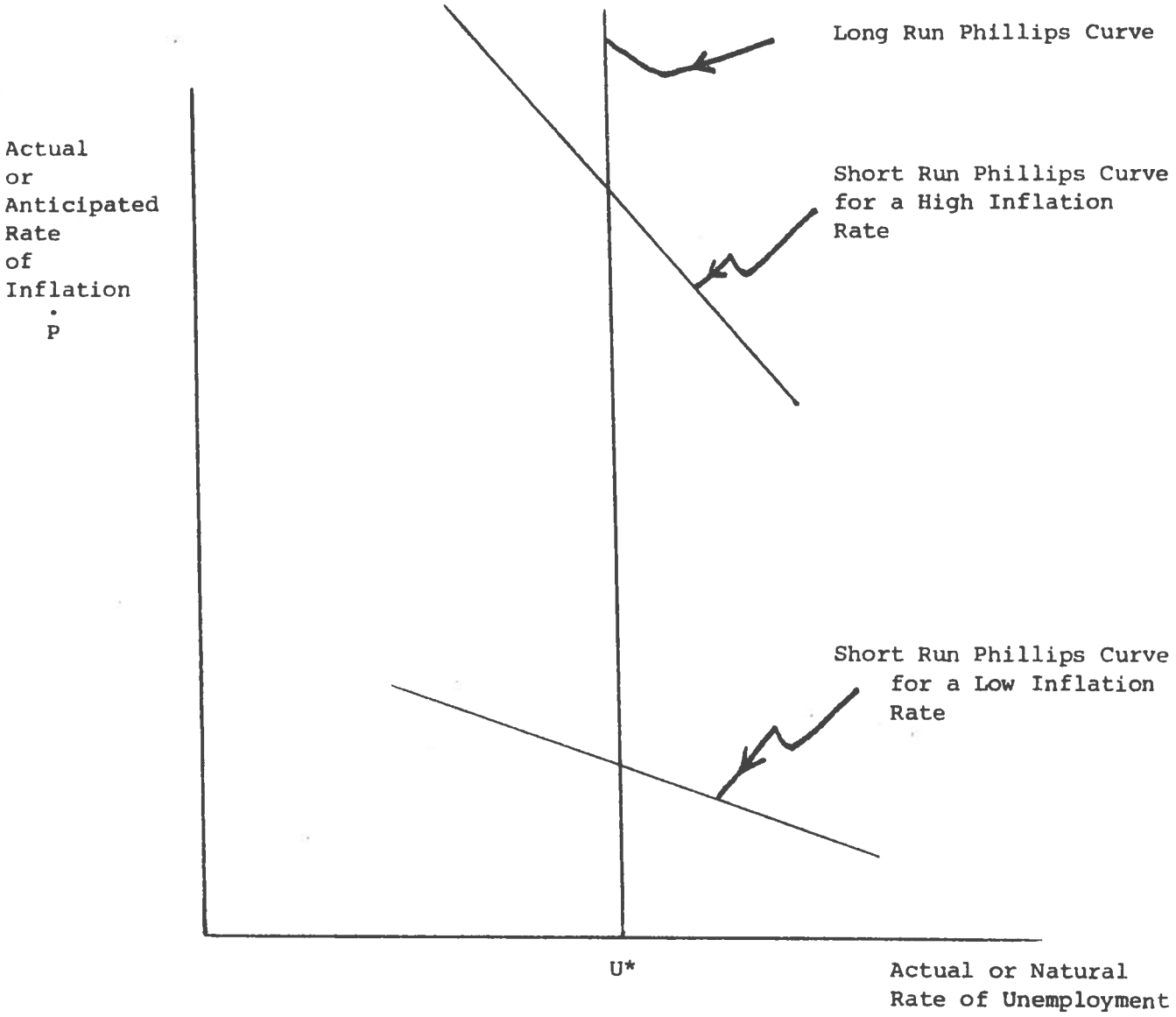
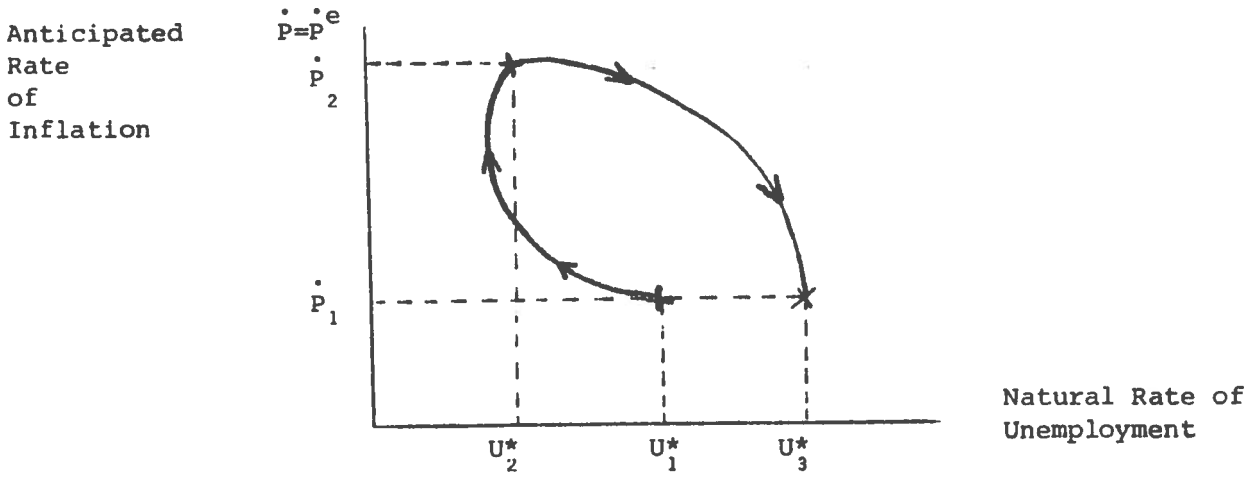


DIAGRAM 5: Hysteresis and the Natural Rate



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