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# THE PRICE-WAGE SPIRAL

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*Summary*

The paper opens the neoclassical growth model to unemployment
and inflation and solves for steady-state equilibrium rates
of growth and interest. A price equation is derived from
profit maximization and includes the wage expectations of the
entrepreneurs. A wage equation is based on the Phillips
function and includes the price expectations of labor. A
price-wage equilibrium is defined as self-fulfilling expect-
ations. The existence and the properties of such an equili-
brium are examined. Policy conclusions are drawn. Finally
the paper determines the extent to which Wicksellian, Keynes-
ian, and monetarist ideas may coexist in neoclassical growth.

(Tentative draft of a chapter in a forthcoming book. Feedback requested.)

# THE PRICE-WAGE SPIRAL:

# COULD WICKSELL, KEYNES, AND MONETARISTS COEXIST IN NEOCLASSICAL GROWTH?

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## Zusammenfassung

Der Vortrag fügt die Inflation und die Arbeitslosigkeit in das neoklassische Wachstumsmodell hinein und bestimmt die Zinshöhe und die Wachstumsraten der Produktion, der Preise, der Geldmenge, des Kapitalvorrats und des Nominal- und Reallohns. Eine Preisgleichung wird mit einer Lohngleichung konfrontiert. Die Preisgleichung ist eine Wiederspiegelung der Gewinnmaximierung und enthält die Lohnerwartungen der Unternehmer. Die Lohngleichung ist eine Wiederspiegelung der Phillipskurve und enthält die Preiserwartungen der Arbeiter. Preissteigerungen und Nominallohnsteigerungen sind mit einander in Gleichgewicht, wenn alle Erwartungen in Erfüllung gehen. Die Existenz und die Eigenschaften eines solchen Gleichgewichts werden untersucht und die Konsequenzen für die Geldpolitik gezogen. Zum Schluss bestimmt der Vortrag den Umfang in dem wicksellianisches, keynesianisches und monetaristisches Gedankengut in einem solchen Modell koexistieren kann.

The purpose of the present paper is to open the neoclassical growth model to unemployment and inflation and see to what extent Wicksellian, Keynesian, monetarist, and neoclassical ideas could coexist in it. In two respects we shall modify the standard Solow (1956) neoclassical growth model.

First, our labor market will not be assumed to clear. But let there be a price equation derived from profit maximization and including the wage expectations of the entrepreneurs. Let there be a wage equation representing a Phillips function and including the price expectations of labor. Let a price-wage equilibrium be defined as

self-fulfilling expectations.  We shall examine the existence and the properties of such an equilibrium.

Second, we shall need a bare minimum of monetary arrangements:  Let there be a money market in which firms may borrow by selling interest-bearing claims upon themselves.  Such claims are bought by savers and monetary authorities alike.  The monetary authorities may expand their stock of claims, and with it the money supply, more or less rapidly.  The pace at which they expand it will affect the yield of the claims.  Let the nominal rate of interest be defined as that yield.

## I.  NOTATION

*Variables*

$C$  $\equiv$ physical consumption

$D$  $\equiv$ demand for money

$g_v$ $\equiv$ proportionate rate of growth of variable $v \equiv C, D, I, K, L, M, P, r, \rho, S, w, X,$ and $Y$

I $\equiv$ physical investment

k $\equiv$ present gross worth of another physical unit of capital stock

$\kappa$ $\equiv$ physical marginal productivity of capital stock

L $\equiv$ labor employed

$\lambda$ $\equiv$ proportion employed of available labor force

M $\equiv$ supply of money

N $\equiv$ present net worth of entire physical capital stock

n $\equiv$ present net worth of another physical unit of capital stock

P $\equiv$ price of goods

p $\equiv$ one coefficient of Phillips function representing inflation-
ary potential

r $\equiv$ nominal rate of interest

$\rho$ $\equiv$ real rate of interest

S $\equiv$ physical capital stock

w $\equiv$ money wage rate

X $\equiv$ physical output

Y $\equiv$ money income


*Parameters*


a $\equiv$ multiplicative factor of production function

$\alpha, \beta \equiv$ exponents of production function

$c \equiv$ propensity to consume

$F \equiv$ available labor force

$g_v \equiv$ proportionate rate of growth of parameter $v \equiv a$ and $F$

$m \equiv$ multiplicative factor of demand for money function

$\mu \equiv$ exponent of demand for money function

$\pi \equiv$ exponent of Phillips function

$\phi \equiv$ another coefficient of Phillips function


All parameters are stationary except $a$ and $F$ whose growth rates are stationary. Let us now specify our modified neoclassical growth model.


## II. A MODIFIED NEOCLASSICAL GROWTH MODEL


### 1. *Definitions*


Define the proportionate rate of growth

(1)
$$g_v \equiv \frac{dv}{dt} \frac{1}{v}$$

Define investment as the derivative of capital stock with respect to time:

(2)
$$I \equiv \frac{dS}{dt}$$

## 2. Production and the Price Equation

Let entrepreneurs apply a Cobb-Douglas production function

(3)
$$X = aL^{\alpha}S^{\beta}$$

where $0 < \alpha < 1$; $0 < \beta < 1$; $\alpha + \beta = 1$; and $a > 0$. Let profit maximization under pure competition equalize real wage rate and

physical marginal productivity of labor:

$$(4) \qquad \frac{w}{P} = \frac{\partial X}{\partial L} = \alpha \frac{X}{L}$$

Write (4) as

$$P = \frac{w}{\alpha} \frac{L}{X}$$

used in Chapter 5 to demonstrate that the neoclassical model has mark-up pricing, too: Neoclassical price P exceeds per-unit labor cost wL/X in the proportion $1/\alpha$. Differentiate this form of (4) with respect to time and find

$$(5) \qquad g_P = g_w + g_L - g_X$$

telling us that, given their expectations of the rates of growth of the money wage rate $g_w$ and of per-unit labor input $g_L - g_X$, ent-

preneurs will change the price (5). Our price equation has em-
pirical support: In their price equation Eckstein and Girola
(1978) found no room for demand represented by, say, the rate
of unemployment; "actual prices stay near equilibrium and
trace out the cost curves," 323.

Physical marginal productivity of capital stock is

$$(6) \qquad \kappa \equiv \frac{\partial X}{\partial S} = \beta \frac{X}{S}$$

## 3. *Investment Demand*

Let N be the present net worth of new capital stock S installed
by an entrepreneur. Let his desired capital stock be the size
of stock maximizing present net worth. A first-order condition
for a maximum is

$$(7) \qquad n \equiv \frac{\partial N}{\partial S} = 0$$

To find desired capital stock, proceed as follows. Let entrepreneurs be purely competitive ones, hence price of output P is beyond their control. At time t, therefore, value marginal productivity of another physical unit of capital stock is $\kappa(t)P(t)$. As seen from the present time $\tau$, value marginal productivity at time t is $\kappa(t)P(t)e^{-r(t-\tau)}$, where r is the stationary nominal rate of interest used as a discount rate. Define present gross worth of another physical unit of capital stock as the present worth of all its future value marginal productivities over its entire useful life:

$$(8) \qquad k(\tau) \equiv \int_{\tau}^{\infty} \kappa(t)P(t)e^{-r(t-\tau)}dt$$

Let entrepreneurs expect physical marginal productivity of capital stock to be growing at the stationary rate $g_{\kappa}$:

$$(9) \qquad \kappa(t) = \kappa(\tau)e^{g_{\kappa}(t-\tau)}$$

and price of output to be growing at the stationary rate $g_p$:

(10) $$P(t) = P(\tau)e^{g_p(t - \tau)}$$

Insert (9) and (10) into (8), define

(11) $$\rho \equiv r - (g_K + g_p)$$

and write the integral (8) as

$$k(\tau) = \int_{\tau}^{\infty} \kappa(\tau)P(\tau)e^{-\rho(t - \tau)}dt$$

Neither $\kappa(\tau)$ nor $P(\tau)$ are functions of $t$, hence may be taken outside of the integral sign. Our $g_K$, $g_p$, and $r$ were all said to be stationary, hence the coefficient $\rho$ of $t$ is stationary, too. Assume $\rho > 0$. As a result, find the integral to be

(12) $$k = \kappa P/\rho$$

Find present net worth of another physical unit of capital stock as its gross worth _minus_ its price: .

(13) $$n \equiv k - P = (\kappa/\rho - 1)P$$

Applying our first-order condition (7) to our result (13) find equilibrium physical marginal productivity of capital stock

(14) $$\kappa = \rho$$

Finally take (6) and (14) together and find desired capital stock

(15) $$S = \beta X/\rho$$

Apply the definitions (1) and (2) to (15) and find desired investment as the derivative of desired capital stock with respect to time:

(16) $$I \equiv \frac{dS}{dt} = \beta g_X X/\rho$$

(15) and (16) are capital stock and investment desired by
an individual entrepreneur.  Except X everything on the right-hand
sides of (15) and (16) is common to all entrepreneurs.  Factor
out all common factors, sum over all entrepreneurs, then X becomes
national output, and (15) and (16) become national desired capital
stock and investment.  So desired investment is in direct proport-
ion to the elasticity $\beta$ of output with respect to capital stock,
the rate of growth $g_X$ of output, and output X itself.  Desired
investment is in inverse proportion to $\rho$.  As we shall see in
Sec. III, 2, $\rho$ is the real rate of interest.  Our investment
function (16) neatly encompasses Wicksellian, Keynesian, mone-
tarist, and post-Keynesian ideas.

4.  *Wicksellian, Keynesian, Monetarist, and Post-Keynesian In-
    vestment*

Wicksell (1935), 193, defined a rate of interest which would
equal "the expected yield on the newly created capital" and
called it a "natural" rate.  Keynes (1936), 135, defined the
same thing but called it "the marginal efficiency of capital".

Wicksell and Keynes would have agreed with our Eq. (14) that
"new investment will be pushed to the point at which the mar-
ginal efficiency of capital becomes equal to the rate of in-
terest," Keynes (1936), 184.  But as we saw in Chapters 1 and
2, neither Wicksell nor Keynes distinguished between a nominal
and a real rate of interest.

Monetarists like Turgot (1898), 49, Fisher (1896), 8-9,
and Mundell (1971) did distinguish:  Investment would not be
lower just because the nominal rate of interest were higher;
only "an increase in the real interest rate lowers investment,"
Mundell (1971), 16.

Given an incremental capital coefficient b, post-Keynesians
like Harrod (1948) determine desired investment as $I = bdX/dt$
$\equiv bg_X X$.  As in (16) investment is in direct proportion to the
rate of growth of output and to output itself.

5.  *Consumption Demand*

Let consumption be a fixed proportion c of output:

(17)                                C = cX

where 0 < c < 1.


6.  *Goods-Market Equilibrium*

Goods-market equilibrium requires the supply of goods to equal the demand for them:

(18)                                X = C + I


7.  *Employment, the Phillips Function, and the Wage Equation*

Let labor employed be the proportion $\lambda$ of available labor force:

(19)                                L = $\lambda$F

where 0 < $\lambda$ < 1, and $\lambda$ is so far not a function of time.

Within their province let labor unions seek a relative and temporary gain by raising the money wage rate. Knowing that the gain will be temporary will not keep them from seeking it; on the contrary, in anticipating inflation they are compelled to contribute to it. The original Phillips (1958) curve had no room for labor's inflationary expectations, but Eckstein and Girola (1978), 325-327, found unemployment and current inflation to be "the bulk of the explanation". We write a modern Phillips function by subtracting employment (19) from available labor force F, finding the unemployment fraction to be $1 - \lambda$, and incorporating labor's inflationary expectations $g_p$:

$$(20) \qquad g_w = p(1 - \lambda)^\pi + \phi g_p$$

where $\phi \geq 0$, $\pi < 0$, and p is so far not a function of time. Our wage equation (20) tells us that, given its expectations of the rate of growth of price $g_p$, labor will insist on the rate of growth of the money wage rate (20).


## 8. *National Money Income*


With immortal capital stock, the entire value of national out-

put represents value added, i. e., national money income

(21) $\qquad Y \equiv PX$

## 9. *Money*

Let the demand for money be a function of national money income and the nominal rate of interest:

(22) $\qquad D = mYr^{\mu}$

where $\mu < 0$ and $m > 0$.

## 10. *Money-Market Equilibrium*

Money-market equilibrium requires the supply of money to equal the demand for it:

(23) $\qquad M = D$

Let us now solve our model for its steady-state equilibrium rates of growth and interest.

### III. STEADY-STATE EQUILIBRIUM GROWTH -RATE AND INTEREST-RATE SOLUTIONS

#### 1. *Steady-State Growth*

By taking derivatives with respect to time of all equations involving the thirteen variables C, D, I, $\kappa$, L, M, P, r, $\rho$, S, w, X, and Y the reader may convince himself that the system (1) through (23) is satisfied by the following growth-rate solutions:

$$(24) \quad g_C = g_X \qquad\qquad (27) \quad g_\kappa = g_X - g_S$$

$$(25) \quad g_D = g_M \qquad\qquad (28) \quad g_L = g_P$$

$$(26) \quad g_I = g_X \qquad\qquad (29) \quad g_M = g_Y$$

$$(30) \quad g_p = \frac{p(1 - \lambda)^\pi - g_a/\alpha}{1 - \phi}$$

$$(34) \quad g_w = \frac{p(1 - \lambda)^\pi - \phi g_a/\alpha}{1 - \phi}$$

$$(31) \quad g_r = 0$$

$$(35) \quad g_\chi = g_a/\alpha + g_F$$

$$(32) \quad g_\rho = 0$$

$$(36) \quad g_Y = g_F + g_w$$

$$(33) \quad g_S = g_\chi$$

Our growth was steady-state growth, for no right-hand side of our solutions (24) through (36) was a function of time————the employment fraction $\lambda$ and the coefficient p were assumed not to be.

## 2. Rates of Interest

Wicksell (1935), 193, 201, defined a rate of interest which would equilibrate saving with investment and called it a "normal" rate. Keynes (1930) defined the same rate but called it a "natural" one. Our own system meets that condition: Insert (17) into (18) and

find

(37)                    $(1 - c)X = I$

Keynes (1936), 167, defined a rate of interest which would equilibrate the available quantity of cash with the desire to hold it.  Our Eq. (23) shows that our own system meets that condition, too.  But unlike the Wicksellian and Keynesian systems, our system has two interest rates.  Its real rate of interest is found by inserting solutions (27) and (33) into our definition (11):

(38)                    $\rho = r - g_P$

To solve for $\rho$ insert (16) into (37), assume nonzero physical output X, divide X away, and find

(39)                    $\rho = \beta g_X / (1 - c)$

where $g_X$ stands for our solution (35).  The properties of (39)

are quite Fisherian.   In a thrifty economy a low propensity to
consume c will make the real rate of interest $\rho$ low:   "Where,
as in Scotland, there are educational tendencies which instill
the habit of thrift from childhood, the rate of interest tends
to be low," Fisher (1930), 478.   In a rapidly growing economy
a high $g_X$ will make the real rate of interest $\rho$ high:   "...the
constant stream of new inventions, by making the available
income streams rich in the future, at the sacrifice of immediate
income, tends to make the rate of interest high," Fisher (1930),
481.

Insert (39) into (38) and find the nominal rate of inter-
est

$$(40) \qquad r = \beta g_X / (1 - c) + g_p$$

where $g_p$ and $g_X$ stand for solutions (30) and (35), respectively.

Insert (36) into (29) and find the rate of growth of the
money supply which would uphold (39) and (40):

$$(41) \qquad g_M = g_F + g_W$$

where $g_W$ stands for the solution (34).

## 3. *Self-Fulfilling Expectations*

Our equilibrium growth implies self-fulfilling expectations.
We used the same symbol for the expected and realized values
of any variable, implying the equality between the two.  Is
such equality always possible?  Yes if the system has a set of
solutions.  No if the system has no such set.  Our system did
have the set of solutions (24) through (41).

Specifically, then, our price-wage equilibrium solutions
imply two things.  First, that if entrepreneurs expect labor
to adopt the solution value (34) of the rate of growth of the
money wage rate then the entrepreneurs will adopt the solution
value (30) of the rate of growth of price.  Second, that if
labor expects entrepreneurs to adopt the solution value (30)
of the rate of growth of price then labor will adopt the solu-
tion value (34) of the rate of growth of the money wage rate.

## 4. *Infinitely Many Solutions*

Our system has infinitely many solutions, i. e., for a given

employment fraction $\lambda$ one for each value of the coefficient p,
and for each value of the coefficient p one for each employment
fraction $\lambda$. The reason for such openness is easily seen. Nowhere
did we assume the labor market to clear———$\lambda$ to equal one. No-
where did we think of the coefficient p as an equilibrating vari-
able in such a labor-market clearance. So far, we are begging
the question of how $\lambda$ and p are determined. Are they determined
by public policy? Will they be what the monetary authorities
allow them to be? In Sec. V we shall see.


5. *Some Solutions Are Not Depending on $\lambda$ and p*


We find $g_p$ and $g_w$, and with them $\lambda$ and p, to be absent from the
growth-rate solutions for the eight variables C, I, $\kappa$, L, r, $\rho$,
S, and X and from our solution for the real rate of interest $\rho$.

Subtract (30) from (34) and find the rate of growth of the
real wage rate

(42)
$$g_{w/p} = g_w - g_p = g_a/\alpha \quad .$$

from which $\lambda$ and p have disappeared. Their disappearance has
an important consequence now to be spelled out.


## 6. *Friedman's "Natural" Rate of Unemployment*


Friedman (1968), 8, defined a "natural" rate of unemployment as
one at which "real wage rates are tending on the average to rise
at a 'normal' secular rate, i. e., at a rate that can be indefin-
itely maintained so long as capital formation, technological im-
provements, etc., remain on their long-run trends"[1]. But our real
wage rate was growing like that for any value of the employment
fraction $\lambda$. Any value of the unemployment fraction $1 - \lambda$ was a
Friedmanian "natural" rate! Friedman's "natural" rate was not
unique.


## 7. *Other Solutions Are Depending on $\lambda$ and p*


We find $g_p$ and $g_w$, and with them $\lambda$ and p, to be present in the
growth-rate solutions for the remaining five variables D, M, P,
w, and Y and in our solution for the nominal rate of interest r.
That brings us to the price-wage spiral.

## IV.   THE PRICE-WAGE SPIRAL

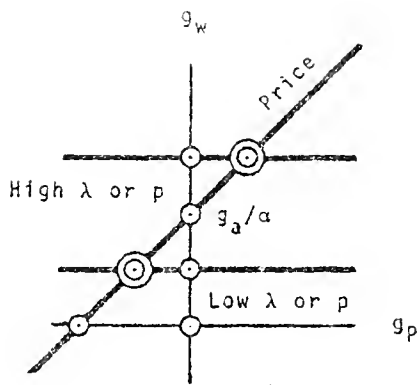### 1.   *Algebraic Solutions (30) and (34) Seen Graphically*

Insert (29) and (35) into our price equation (5).  Write the
price and wage equations with $g_W$ on the left-hand side:

(42) $$g_W = g_a/\alpha + g_P$$
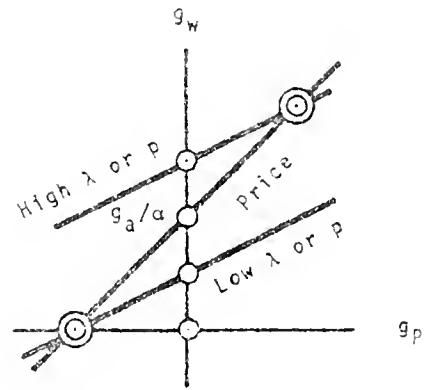
(20) $$g_W = p(1 - \lambda)^{\pi} + \phi g_P$$

and plot them in Figure 1 having $g_W$ on the vertical axis and
$g_P$ on the horizontal axis.  The price equation (42) will then
appear as a single straight line with the intercept $g_a/\alpha$ and
the slope one.  The wage equation (20) will appear as a family
of straight lines with the intercepts $p(1 - \lambda)^{\pi}$ and the slope $\phi$.
Our price-wage equilibrium (30) and (34) is represented graph-
ically by the intersection between the price-equation line and
a wage-equation line.  Intersection points are marked by double
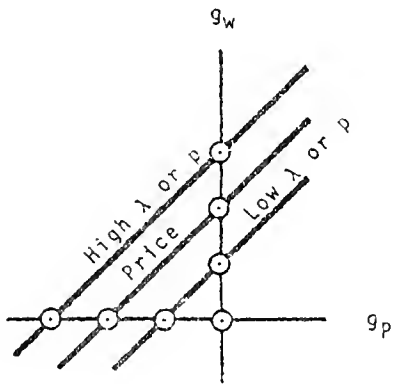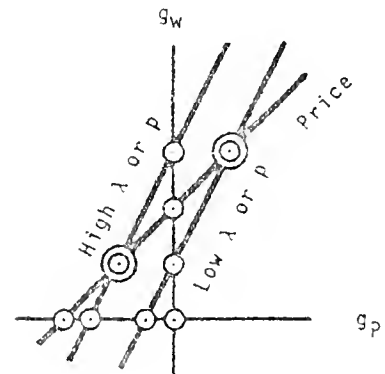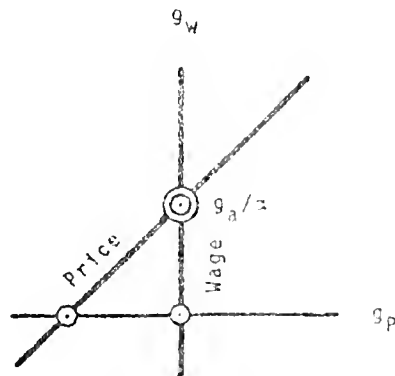
Figure 1.  The Price-Wage Equilibrium:  Five Possibilities

circles in Figure 1.

2. *Sensitivity of the Price-Wage Equilibrium to $p$ and $p(1 - \lambda)^{\pi}$*

Let $\phi$ rise from zero to infinity and distinguish the five cases shown in Figure 1.

First, let $\phi = 0$. Failing to include labor's inflationary expectations, this is the case of the original Phillips curve. The wage equation appears as a family of horizontal lines drawn in the distance $p(1 - \lambda)^{\pi}$ from the horizontal axis. If $p(1 - \lambda)^{\pi}$ is less than, equal to, or greater than $g_a/\alpha$ then the rate of inflation $g_p$ will be negative, zero, or positive, respectively. In other words, the rate of inflation is the higher the higher the employment fraction $\lambda$ and the coefficient $p$.

Second, let $0 < \phi < 1$. Now the wage equation appears as a family of positively sloped lines with the intercepts $p(1 - \lambda)^{\pi}$. Their slope $\phi$ is less than one, hence they intersect the price -equation line from above, and the equilibria are stable. If, say, labor overshoots because it expects a $g_p$ higher than the equilibrium value (30), entrepreneurs will respond along their price -equation line and raise price less than labor expected. Labor

will go from there and respond along its wage-equation line and overshoot less. And so it goes. The parties are moving back towards the equilibrium point. Again if $p(1 - \lambda)^\pi$ is less than, equal to, or greater than $g_a/\alpha$ then the rate of inflation $g_p$ will be negative, zero, or positive, respectively. Again the rate of inflation is the higher the higher the employment fraction $\lambda$ and the coefficient p.

Third, let $\phi \to 1$. Now the wage equation appears as a family of lines with unitary slope and the intercepts $p(1 - \lambda)^\pi$. All have the same slope as the price-equation line and one of them may coincide with the latter. If it does there are infinitely many solutions, otherwise there is no finite solution: The limits of (30) and (34) are

$$\lim_{\phi \to 1} g_p = \lim_{\phi \to 1} g_w = \pm \infty$$

Fourth, let $1 < \phi < \infty$. Now the wage equation appears as a family of positively sloped lines with the intercepts $p(1 - \lambda)^\pi$. Their slope $\phi$ is greater than one, hence they intersect the price-equation line from below, and the equilibria are unstable. If,

say, labor overshoots because it expects a $g_p$ higher than the
equilibrium value (30), entrepreneurs will respond along their
price-equation line and raise price more than labor expected.
Labor will go from there and respond along its wage-equation line
and overshoot even more. And so it goes. The parties are now
veering farther and farther away from the equilibrium point.
Again the rate of inflation will depend on the employment frac-
tion $\lambda$ and the coefficient p but in an upside-down way: Now if
$p(1 - \lambda)^{\pi}$ is less than, equal to, or greater than $g_a/\alpha$ then the
rate of inflation $g_p$ will be positive, zero, or negative, re-
spectively. In other words, the rate of inflation is the _lower_
the higher the employment fraction $\lambda$ and the coefficient p!

Fifth, let $\phi \to \infty$. Now the wage equation appears as a family
of lines all of which are merging into the vertical axis. Divide
the numerator and denominator of (34) by $\phi$ and see that the
limits of (30) and (34) are

$$\lim_{\phi \to \infty} g_p = 0$$

$$\lim_{\phi \to \infty} g_w = g_a/\alpha$$

$$g_p = \frac{p(1 - \lambda)^{\pi} - g_a/\alpha}{1 - \phi}$$
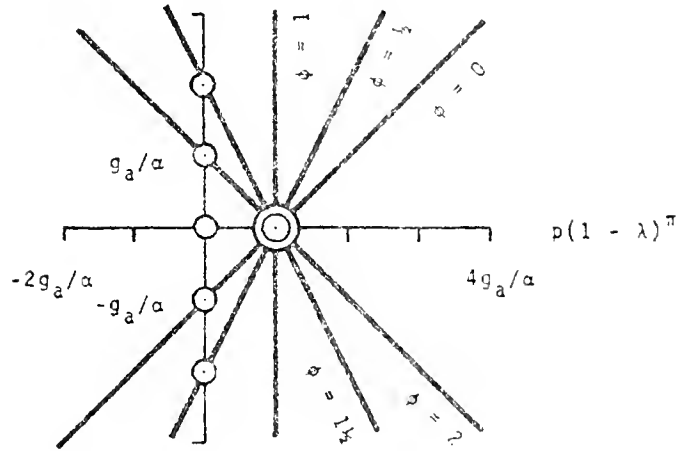


$$g_p = \frac{p(1 - \lambda)^{\pi} - g_a/\alpha}{1 - \phi}$$
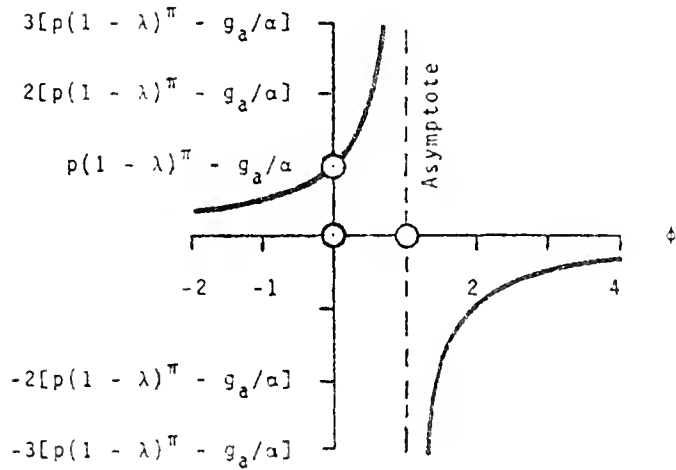


Figure 2.   Mapping the Function (30).

Here an explosive situation might seem to have been defused into the harmless one of no inflation. But the equilibrium is still unstable.

A direct mapping of the function (30) would also have demonstrated the sensitivity of our price-wage equilibrium to $t$ and $p(1 - \lambda)^{\pi}$. Such mapping is shown in Figure 2.

### 3. Conclusion: Inflation Is an Empty Ritual

Subtracting (30) from (34), our Sec. III, 5 above found (42) according to which the rate of growth of the real wage rate was $g_a/\alpha$. The employment fraction $\lambda$ and the coefficient p had disappeared from (42), and Figure 1 agrees: All our double-circled price-wage equilibria are located on the single price-equation line (42). With or without inflation labor can have a real wage rate growing at the rate $g_a/\alpha$, no more, no less. In that sense inflation is an empty ritual. Why bother to go through with it? Could monetary policy gently persuade the parties not to bother? If so, what exactly should monetary policy be doing?

## 4. *The Coefficient p as a Measure of the Inflationary Potential and a Target for Monetary Policy*

As long as $\phi < 1$, our equilibrium solution (30) as well as Figure 1 suggest that a lower rate of inflation $g_p$ would require a depressed $p(1 - \lambda)^\pi$. That, in turn, would require either a depressed employment fraction $\lambda$ or a depressed coefficient p. The monetary authorities, no doubt, would much prefer the latter to the former: A given reduction of inflation should be accomplished by reducing the employment fraction $\lambda$ as little as possible. The coefficient p is the weight with which unemployment $1 - \lambda$ makes itself felt in the Phillips function. If the monetary authorities could reduce that weight they wouldn't have to depress $\lambda$ itself.

In order to eliminate inflation, how far would p have to be pressed? The numerator of our equilibrium solution (30), and with it the rate of inflation $g_p$, could become zero in one and only one way, i. e., if $p(1 - \lambda)^\pi = g_a/\alpha$ or

(43) $$p = g_a/[\alpha(1 - \lambda)^\pi]$$

shown as the double-circled point on the horizontal axis of Figure

2.  In the sense that inflation could be depressed to zero by de-
pressing p to (43) the coefficient p may be called a measure of
the inflationary potential of the economy———and may serve as a
target for monetary policy.

It follows from (43) that the value to which p would have to
be depressed to eliminate inflation is the higher the higher the
technological progress $g_a$ and the lower the employment fraction $\lambda$.
In other words, high technological progress makes inflation fight-
ing easier, but a high employment fraction makes it more difficult.


V.   MONETARY POLICY


Our solutions (24) through (41) defined infinitely many steady
-state equilibrium growth tracks.  Once settled on any one of
them, the economy will tend to stay on it:  On such a track,
whatever its employment fraction $\lambda$ is and whatever its inflation-
ary potential p is, expectations will be self-fulfilling, and
self-fulfilling expectations are not abandoned easily.  They

will be abandoned only after new experience has proved them
nonself-fulfilling.

Could such new experience be generated by monetary policy
trying to switch the economy from one steady-state equilibrium
growth track to another deemed more desirable?  Let us allow
the employment fraction $\lambda$ and the inflationary potential p
to vary with time.  Let us consider anti-inflation policy
and employment policy separately.

## 1.   Anti-Inflation Policy

As long as $\phi < 1$ a price-wage equilibrium exists and is stable.
Let the monetary authorities try to switch the economy from a
high-p steady-state equilibrium growth track to a low-p one.
In their effort to depress p let them force the money supply
to be growing at a rate lower than its steady-state equilibrium
value ($\mu 1$).  At so far unchanged expectations $g_p$, the nominal
and real rates of interest will now rise above their equilibri-
um levels (40) and (39), respectively.  In (18) desired invest-
ment was in inverse proportion to the real rate of interest,

whereas in (17) desired consumption was invariant with it. Raising the real rate of interest, then, will lower the right -hand side of the equilibrium condition (18): There will be negative excess demand.

The immediate effect is inventory accumulation, and inventory accumulation may release two responses, a price response and a quantity response. The hope underlying anti-inflation policy is that the price response will dominate, i. e., that inventory accumulation will be read as a signal to decelerate price.

Decelerating price would directly reduce the second term of the Phillips function (20) by reducing $g_p$, but in itself such a direct effect would accomplish nothing. It would reduce $g_p$ below its equilibrium value (30), creating a nonself-fulfilling expectation. But as long as neither $\lambda$ nor $p$ have been affected, the stable price-wage equilibrium would try to restore itself. The hope underlying anti-inflation policy must be that there will be an additional, indirect, effect. Labor is experiencing receding inflation at a real wage rate growing as always at the rate $g_a/\alpha$. The hope is that such soothing experience might depress the first term of the Phillips function by depressing the
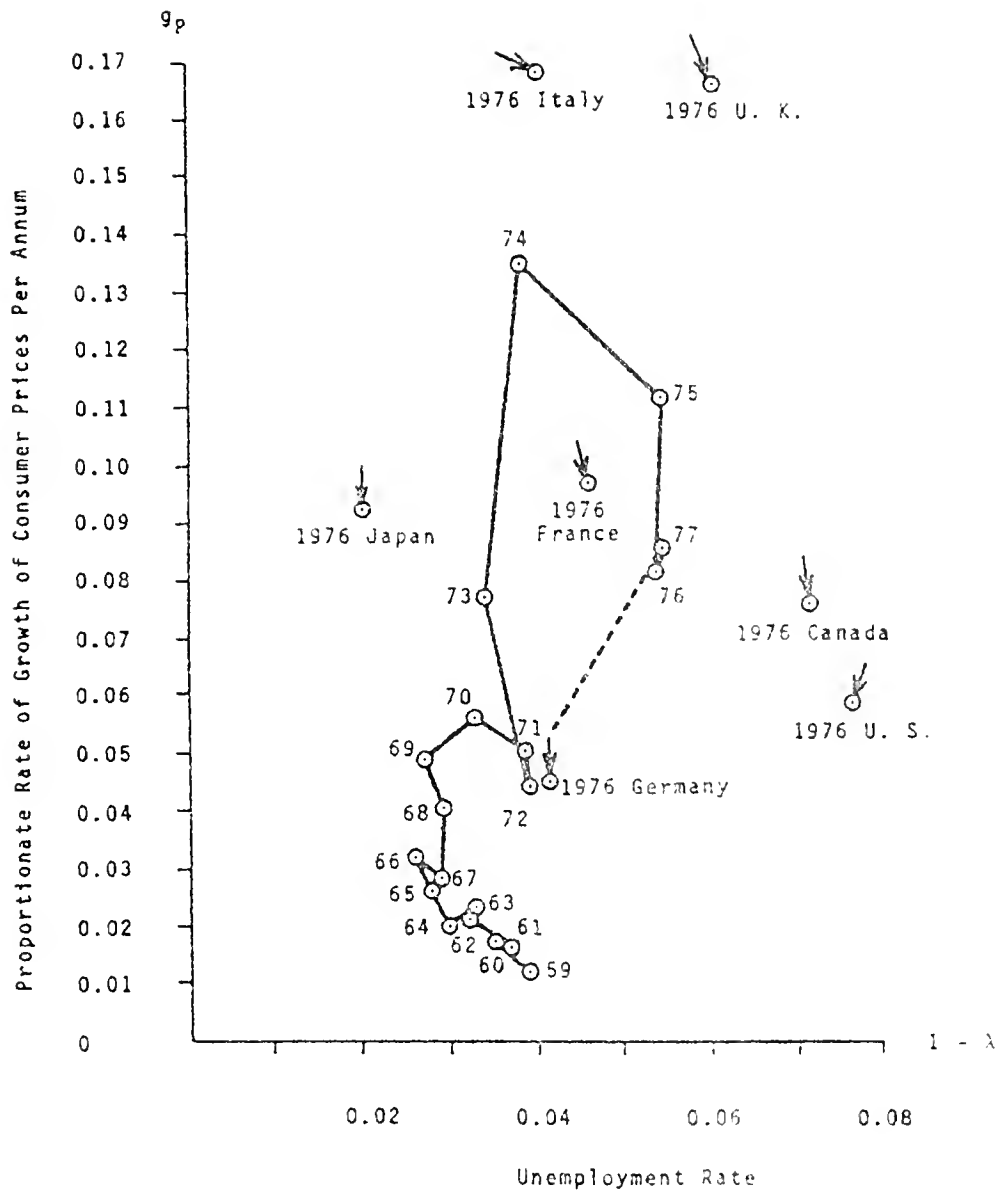
Figure 3. Inflation and unemployment, seven OECD countries 1959-1976.

P. McCracken, G. Carli, H. Giersch, A. Karaosmanoglu, R. Komiya, A. Lindbeck, R. Marjolin, and R. Matthews, *Towards Full Employment and Price Stability, A Report to the OECD by a Group of Independent Experts*, OECD 1977, 314.

inflationary potential p.

However this may be, decelerating price will not eliminate negative excess demand. According to (16) and (17) neither desired investment nor consumption will be stimulated, for P appears nowhere in (16) and (17). Unable to eliminate negative excess demand, the falling inflationary potential p should keep falling. When it has fallen far enough to satisfy the policy maker, the latter may restore the real rate of interest to its equilibrium level (39).

What if $\phi \geq 1$? Here there is either an unstable price-wage equilibrium or no equilibrium at all. The price-wage spiral may be accelerating in a northeasterly direction————something like Figure 3 recording seven OECD countries 1968-1977. Here the monetary authorities must attend to first things first. The wild northeasterly flight must be stopped, and the authorities do have a veto. They may refuse to meet the accelerating transaction demand for money. The effects of a refusal are much like those described for the case $\phi < 1$. But the doses of monetary restraint might have to be heavier and to be applied incessantly if monetary restraint were to be a substitute for the stability of equilibrium.

Is $\phi \geq 1$ likely to happen? Surveying 1968-1977 inflation

theory Frisch (1977) reports that most empirical work has found
$\phi < 1$, that Gordon (1976) was unable to reject the hypothesis that
$\phi = 1$ after 1971, and that $\phi$ may vary procyclically. The latter
possibility fits the events recorded in Figure 3.

## 2. Employment Policy

Suppose it is not considered enough to reduce inflation without
reducing the employment fraction $\lambda$. The latter should be raised!
Let the monetary authorities try to switch the economy from a
low-$\lambda$ steady-state equilibrium growth track to a high-$\lambda$ one.
In their effort to raise $\lambda$ let them allow the money supply
to be growing at a rate higher than its steady-state equilibrium
value (41). At so far unchanged expectations $g_p$, the nominal
and real rates of interest will now fall below their equilibri-
um levels (40) and (39), respectively. In (16) desired invest-
ment was in inverse proportion to the real rate of interest,
whereas in (17) desired consumption was invariant with it.
Lowering the real rate of interest, then, will raise the right
-hand side of the equilibrium condition (18): There will be

positive excess demand.

The immediate effect is inventory depletion, and inventory depletion may release two responses, a price response and a quantity response. The hope underlying employment policy is that the quantity response will dominate. I. e., that inventory depletion will be read as a signal to accelerate physical output. Can entrepreneurs heed the signal? Write (4) as $L = xPX/w$. So accelerating physical output X would accelerate employment L and raise the employment fraction $\lambda$————always feasible under unemployment.

Accelerating physical output will not eliminate positive excess demand. According to (16) and (17) both desired investment and consumption are in direct proportion to physical output X. Consequently the difference $C + I - X$, positive excess demand, is also in direct proportion to physical output X. Unable to eliminate positive excess demand, the expanding employment fraction $\lambda$ should keep expanding. When it has expanded far enough to satisfy the policy maker, the latter may restore the real rate of interest to its equilibrium level (33).

3. *Comparison*

The dilemma of monetary policy is neatly illustrated by the
fact that anti-inflation policy and employment policy are
based on mutually exclusive hopes.  The former hopes for
a price response, the latter for a quantity response.  The
actions taken by the monetary authorities under the two po-
licies are mutually exclusive:  One policy is the other in
reverse.

## VI.  HOW FAR DID OUR SYNTHESIS GO?

We opened the neoclassical growth model to unemployment and
inflation and solved for its steady-state equilibrium rates
of growth and interest.  To what extent could Wicksellian,
Keynesian, monetarist, and neoclassical ideas coexist in it?

## 1.  *Wicksell*

Was our model Wicksellian?  Yes, but only in the sense that it deter-
mined a rate of interest at which saving equals investment.  That
equality guaranteed neither full employment nor absence of in-
flation:  Our infinitely many solutions, one for each value of
the employment fraction $\lambda$ and one for each value of the infla-
tionary potential p, all had the same real rate of interest.

## 2.  *Keynes*

To J. B. Say output was bounded by supply.  Demand was no
problem:  Supply would generate its own demand.  To J. M. Keynes
output was bounded by demand.  Supply was no problem:  Demand
would generate its own supply.  Output would be controllable
to the extent demand was.  Was our model Keynesian?  Yes in
the sense that output was bounded by demand and touched no
supply bound:  $0 < \lambda < 1$.  Was demand controllable?  Certain-
ly.  The monetary authorities could expand their stock of claims,
and with it the money supply, more or less rapidly.  The pace
which they would expand it would affect the yield of the claim.

and might generate positive or negative excess demand, respect-
ively. The response to such excess demand was not controllable.
Whether the response would be a price response or a quantity
response was beyond the control of the monetary authorities.

## 3. Monetarists

Was our model monetarist? Yes, but only in the sense that it
might generate inflation and that it distinguished between a
nominal and a real rate of interest. In its infinitely many
solutions, one for each value of the employment fraction $\lambda$,
the real wage rate was found to be growing at the same rate,
and in that sense any value of the unemployment fraction $1 - \lambda$
was a Friedmanian "natural" rate of unemployment. Friedman's
"natural" rate of unemployment was not unique.

## 4. Neoclassicals

Was our model neoclassical? Yes, but only in the sense that
it simulated labor-capital substitution in a steady-state
equilibrium growth setting: According to our solutions (26),

(33), and (35) capital intensity S/L was growing steadily at the rate $g_{S/L} = g_S - g_L = g_a/\alpha$.

In one respect our model was not neoclassical. Its goods and money markets cleared alright, but its labor market did not. The model had room for involuntary unemployment: $0 < \lambda < 1$. It had infinitely many solutions, i. e., for a given employment fraction $\lambda$ one for each value of the inflationary potential $p$, and for each value of the inflationary potential $p$ one for each employment fraction $\lambda$. As a result, public policy had scope for a tradeoff between unemployment and inflation.

## FOOTNOTE

[1]Friedman added another definition: "The 'natural rate of un-
employment,' in other words, is the level that would be ground
out by the Walrasian system of general equilibrium equations,
provided there is embedded in them the actual structural char-
acteristics of the labor and commodity markets..." Thus defin-
ed, is Friedman's natural rate unique?

Surveying the Phillips-curve literature, Santomero and
Seater (1978), 515, found "a common albeit unverified assump-
tion" that Walrasian general equilibrium is unique. Few macroecon-
omic writers offer general equilibria well enough specified to be
shown to be unique!

Few of those who believe that labor markets will clear,
demonstrate why. Those who do, usually apply search-theoretical
explanations. As Tobin (1972), 6-9, points out, in such explana-
tions all unemployment is voluntary. Do Walrasian equations,
"provided there is embedded in them the actual structural char-
acteristics of the labor and commodity markets," rule out invo-

luntary unemployment? Friedman does not offer general equilibria well enough specified, let alone modified, to answer such a question.

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