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Sectoral Labor Markets, The Long-Run Phillips Curve, and Implicit Contracts

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I. Introduction

The sectoral labor market approach was introduced by Lipsey [8] as an explanation of Phillips loops—the apparent shifting of the Phillips curve over the business cycle. Lipsey argued that, in an economy with a set of sectoral Phillips curves, the degree of dispersion of unemployment across sectors would affect the location of the aggregate Phillips curve. While this role for the sectoral model in Phillips relationships has largely been superseded by greater attention to expectations, several authors have utilized the sectoral model in attempts to establish the existence of a non-vertical long-run Phillips curve. Notable efforts have been the articles by Baumol [3], Brechling [4], and Tobin [11]. Common to these papers is the stochastic multi-sectoral model, in which each sector's excess demand for labor is subject to exogenous random shocks.

As is well known, full feedback of correct expectations leads to a long-run, natural rate solution in a multi-sector labor market and to the irrelevance of the inflation rate in the determination of real magnitudes. (The rate of inflation itself is determined typically by the growth of the money supply.) Modifying this result requires different assumptions about microeconomic behavior in the multi-sectoral model, which can then be aggregated to obtain the desired macroeconomic implications. The current paper has two objectives: first, it examines the assumptions needed by Baumol and Tobin to derive a negatively-sloped, aggregate long-run Phillips curve. We conclude that Baumol [3] and Tobin [11] each depends implicitly on very similar assumptions. An assumption sufficient for a long-run trade-off is that workers receive some real wage protection from adverse states of nature, but that the protection is incomplete; furthermore, the degree of such protection must depend negatively upon the general rate of inflation.

Second, we examine the consistency of this assumption with optimizing behavior of the economic agents. To do so, we develop an implicit contracts model which is modified to allow for incomplete protection. Our model differs from the standard approaches of Azariadis [1] and Baily [2] primarily in that we suppose that contracting occurs with current workers vis-a-vis next period's wage and employment strategy. Under this formulation, the wage rate might be a function of the state of nature either to attract new workers or to induce current workers to leave. Imper-

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fect mobility arises here from the fact that different prospective workers evaluate the non-pecuniary benefits at the firm differently. As part of the analysis, we show that Tobin's assumption of wage floors (albeit real, not nominal, floors) is particularly plausible. Finally, we argue that the degree of protection might depend upon the general rate of inflation, either due to an interest rate effect (real interest rates being lower under high permanent inflation) or due to contracts (such as mortgages) with fixed nominal payments over the life of the contract. We assume throughout that the rate of inflation is known as well as that workers are free of money illusion. In the Baumol and Tobin models, this is consistent with non-neutrality, due to the functional role of inflation in reducing the amount of real wage protection chosen.

In the next section, the basic multi-sectoral model of the labor market is set up. Section III analyzes the assumptions underlying Baumol's and Tobin's models. The fourth section develops an implicit contracts story in which to situate the Tobin-Baumol result. Section V summarizes the analysis.

II. The Basic Multi-Sector Labor Market Model

In this section we consider the basic sectoral model, following largely the analysis by Brechling [4] in formulation and notation.

We adopt the following notation for the n-sector economy:

- w $(n \times 1)$ vector of sectoral wage-inflation rates
- X $(n \times 1)$ vector of proportionate excess-demands for labor ((labor demand-labor supply)/employment)
- a $(1 \times n)$ vector of employment weights defining average wage-inflation by aw
- B $(n \times n)$ wage-adjustment matrix
- C $(n \times n)$ expectations-feedback matrix

Wage-adjustment is described by a standard Walrasian adjustment mechanism with a feedback term on expected wage-inflation:

$$w = BX + Cw^e \tag{1}$$

where w^e is the expected wage-inflation vector.[1] For simplicity, B and C will be taken to be diagonal matrices. The basic notion is that firms in a given sector predict the 'going' or reference wage which is relevant to their sector and then adjust their wage (relative to the reference wage) for demand conditions. The growth rate of the reference wage for each sector is dependent upon expected wage-inflation in that and other sectors as specified below.

There are three remaining areas of specification to complete the model:

i. the long-run equilibrium conditions (including the matrix C).
ii. the expectations-generating process embodied in the wage-pattern or reference wage matrix H, where $w^e = Hw$ in the long-run.[2]
iii. the nature of matrix B.

The standard approach to the long run would be to suppose that C was the identity matrix so that full feedback of inflationary expectations occurs. Assuming also in the long run that expectations are correct ($w^e = Hw$), we get the general long-run equation:

$$w = BX + IHW = BX + Hw \tag{2}$$

$$(I - H)w = BX \tag{3}$$

[1] The analysis is simplified by following Phelps and others in dropping direct price-inflation effects from the Phillips wage-adjustment equation. Changes in the price level retain their influence on the demand for labor and hence indirectly on wage-adjustment.

[2] The reference wage for a given sector could depend upon: (i) the wage in that sector alone; (ii) the average wage in the economy; or (iii) some sector-specific weighting of the wages in the given sector and other sectors. The nature of intra- and inter-sectoral mobility determines which of the three cases obtains.

Now consider the expectations-generating process:

(a) If each sector forms its expectations independently of wage trends elsewhere in the economy, then H is the identity matrix. Hence, irrespective of the specification of B, each sectoral labor market must clear in the long-run.

(b) If, however, each sector takes account of other sectors in forecasting the inflation rate of its own reference wage, then one obtains a modified natural rate solution. Unlike (a) above, long-run equilibrium is consistent with $X \neq 0$. Moreover, even aggregate excess demand may be non-zero in the long run. Consider the simple case which each sector uses as its reference wage the average wage in the economy. Thus, H is a non-diagonal matrix of the form:

$$H = (a\, a \ldots a)'$$

To aggregate equation (3), premultiply it by a:

$$a(I - H)w = aBX \tag{4}$$

Since each row vector in H sums to unity, $a(I - H)$ is the zero vector. Therefore:

$$aBx = 0 \tag{5}$$

If and only if the adjustment speed matrix B is scalar does the following condition hold:

$$aX = 0 \tag{6}$$

This is the traditional natural rate solution defined by aggregate vacancies equaling aggregate unemployment. If, however, B is non-scalar, perhaps due to asymmetric wage-setting on the excess supply and excess demand sides, then condition (5) holds but the natural rate solution (6) does not. Provided continuous shocks maintain disparate sectoral demands, the dispersion of labor demand would affect the aggregate state of excess demand in long-run equilibrium.

III. The Baumol and Tobin Approaches

For the solution of the sectoral model to be a long-run Phillips curve, the algebra dictates that the product CH not be the identity matrix. If expectations are properly formed, so that the H matrix displays the row-sums of unity property discussed above, the long-run Phillips curve is dependent upon C not being the identity matrix; moreover, for inflation to be negatively related to unemployment in the long-run, components of the C matrix must on balance be less than unity. Baumol [3] and Tobin [11] present arguments as to why the full feedback of an identity C matrix might be abridged, without the presence of money illusion.

The traditional notion is that in an industry or sector with zero excess demand for labor, the wage must rise at the same rate as the reference wage to allow maintenance of the work force. Similarly, the rate of inflation of the reference wage should be the benchmark from which to lower or raise wages in accord with the excess demand for labor in a sector. Suppose, however, that a firm has an expected excess demand for labor of zero, but is subject to exogenous shocks in demand in both directions, and that optimal wage adjustment in a case of excess demand is greater than in a case of excess supply (the asymmetry assumption). In that scenario, if the firm followed the formula for wage-setting:

$$w_i = b(X_i) + w_i^e \tag{6}$$

wages in the sector (on an expected value basis) would constantly be rising above the reference wage even though expected excess demand is zero. One way of handling this difficulty, the course Baumol follows, is to assume:

$$w_i = b(X_i) + cw_i^e \quad c < 1 \tag{7}$$

If this equation is applicable generally to distributions of stochastic excess demands, a long-run Phillips curve can be derived meeting the condition that expected wages in each sector rise with the reference wage. Further, if prices in the economy follow a mark-up over wages, this approach preserves the expected real-wage, and is thus (by Baumol's contention) consistent with rational long-run behavior.

The difficulty with this argument is seen more clearly in the related Tobin formulation, so we will consider the problem only after discussing that model. The Tobin approach removes the full feedback link only for sectors with extreme excess supply of labor, providing a floor on wage declines.

Tobin states his major assumption:

> A rather minor modification may preserve Phillips tradeoffs in the long run. Suppose there is a floor on wage change in excess supply markets, independent of the amount of excess supply and of the past history of wages and prices.

Let us make the somewhat weaker assumption that firms with positive excess demands or modest negative excess demands for labor adjust wages normally in reference to expected wage-inflation, but that firms in a third condition, with extreme excess supplies of labor, are constrained by a floor which partially adjusts for inflation:

$$w_i = \max\,[bX_i + w^e, \mu + \lambda w^e] \qquad \mu < 0 \quad 0 \leq \lambda < 1 \tag{8}$$

Depending upon the magnitude of λ, the wage in sectors constrained by the floor adjusts for inflation to a greater or lesser degree. Aggregating our sectors according to the three demand conditions—positive excess demand, excess supply, and extreme excess supply, the wage-adjustment equation takes on the form:

$$w = B_f X + FHw$$

where

$$B_f = \begin{bmatrix} b_1 & 0 & 0 \\ 0 & b_2 & 0 \\ 0 & 0 & \mu \end{bmatrix} \quad F = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & \lambda \end{bmatrix} \tag{9}$$

$$W = [I - FH]^{-1} B_f X$$

and the average rate of wage-inflation (aw) is obtained by pre-multiplying by a. This variable is now determinate. Expanding in the case where H is the matrix defined by $(a\,a \ldots a)'$, so that the reference wage in each sector is the average wage;

$$aw = b_1a_1X_1 + b_2a_2X_2 + a_3\mu + (a_1 + a_2 + \lambda a_3)aw$$

$$aw = (b_1a_1X_1 + b_2a_2X_2 + a_3\mu)/(1 - \lambda)a_3 \tag{10}$$

The aggregate feedback coefficient on expected inflation ($a_1 + a_2 + \lambda a_3$) is less than unity whenever some sectors are in the constrained condition.[3]

This form of the floors assumption on the surface does not appear to too objectionable. Given that average price inflation equals average wage-inflation (in the long-run), a natural interpretation is that the floor arises as workers buy protection from adverse states of nature. This sort of floor should reasonably be indexed to inflation and in our assumption it is—in the worst conceivable excess supply situation, wages must rise in that sector at some proportion of the general rate of inflation. Thus one important feature of the assumption that must be defended by an optimization rationale is that wages are somewhat but not completely insured against inflation and excess supply in a sector.

A second feature of the assumption however, displays a difficulty shared with the Baumol approach as well—the degree of protection declines with the general inflation rate. Under our assumption embodied in (8), wages of sectors in condition 3—extreme excess supply—are changing relative to the average wage by:

$$d(W_3/aW)/dt = (W_3/aW)\,[\mu + (\lambda - 1)aw] \tag{11}$$

where W_3 is the wage level of sectors in condition 3 and aW is the average wage level. The bracketed term is simply the proportionate growth rate of the ratio, (W_3/aW). As the general inflation rate (aW) increases, this ratio declines at a rate $(\lambda - 1)$. By contrast, constant protection independent of the rate of inflation would require $\lambda = 1$. In that case, the long-run Phillips curve would disappear. To support these models, then, we must be able to argue that less real (or reference) wage protection is chosen at a higher inflation rate.

IV. The Relation to Implicit Contracts Theory

The basic assumption common to the Baumol and Tobin approaches, we have seen, is that there is incomplete wage protection and a degree of protection inversely related to the general level of inflation. In the current section we consider to what extent this assumption is consistent with the implicit contracts approach to wage insurance as developed by Azariadis [1] and Baily [2].[4]

Incomplete Wage Protection

To provide a framework for the analysis that readily incorporates our arguments vis-a-vis incomplete wage protection, we adopt a somewhat different approach to the contracting mechanism. We suppose that the firm contracts with current employees wage rates and levels of employment in each possible state-of-nature.[5] These states of nature refer to draws from an excess demand for labor density (relative to the current number of associated workers), the X of the earlier sections. Workers as a group are concerned with the expected sum of individual utilities, and an efficient contract is one that maximizes profits subject to the constraint that:

$$E\Big[\sum_k U_k\Big] = \overline{U}$$

where k indexes the associated worker

Workers are heterogenous and each gains an expected period utility:

$$U_k = \sum_i (\tilde{U}(W_{ie}) + \theta_k]\pi_{ie}\pi_i + \sum_i \tilde{U}(W_{iu})\pi_{iu}\pi_i \qquad \tilde{U}' > 0 \quad \tilde{U}'' < 0$$

[3]Tobin's model does not require that the floor on wage-changes in excess supply sectors be permanent. Temporary floors are sufficient, if stochastic shocks are continually driving some sectors into excess supply.

[4]It should be noted that our concern here is with uncertainty vis-a-vis the state of nature affecting a specific sector, possibly the relative price of its output, and not uncertainty in the general rate of inflation. As such, the partial indexation properties determined by Gray [7] and Fischer [5] are not applicable. The reason we cannot rely upon their results is that we require a feedback coefficient less than unity, in some sense, on expected general inflation; the less than unity indexation in the cited papers would be on the deviation from the mean.

[5]This contracting can be viewed as arising from institutional features; it is in any case implicit since the workers cannot observe the state of nature facing the firm. More generally, this sort of approach is justified by the presence of mobility costs, since prospective workers are concerned not just with the current wage offer but with future expected utilities (pertaining to continuing workers) at the firm.

where $\tilde{U}$ is common across workers but each worker gains a specific non-pecuniary benefit from working at the firm in the amount θ, which is not observable by the firm. W_{ie} is the wage in state of nature i when employed and W_{iu} the corresponding income when unemployed, due either to unemployment compensation or welfare (or temporary employment) or, alternatively, the wage received from employment in a new firm net of search and mobility costs. π_{ie} is the probability of being employed in a state of nature i and $\pi_{iu} = 1 - \pi_{ie}$, the probability of being unemployed; π_i is the probability of the given state of nature. We suppose that a normal work week prevails so that partial unemployment is not a way of allocating a given amount of work (in contrast to the arguments presented by Mortensen [9]).

Under this construction, we can obtain the standard implicit contracts results of a constant (over states of nature) wage when the following conditions prevail:

i. mobility costs are so high that no worker chooses to become separated whatever the wage rate
ii. the desired work force never exceeds the inherited associated work force.

Since the firm cannot observe θ, any layoffs must be random. Thus for a given employment strategy ($N_i < N$, where N is the number of inherited associated workers), the problem becomes a cost minimization calculation:

$$\min \sum_i W_{ie}\pi_{ie}\pi_i N \qquad (13)$$

with respect to W_{ie} each i

subject to

$$\sum_i \tilde{U}(W_{ie})\pi_{ie}\pi_i N = k, \quad k \text{ a constant}$$

which has the solution of a constant wage. This follows since the $E(\Sigma\theta_k)$ is unaffected by the choice of wage rates. Relaxation of either condition (i) or (ii) can lead to a non-constant wage rate.

Condition (i) is pertinent when the firm desires a work force less than the inherited level N. It is possible that by setting a lower wage the firm can induce those with relatively low non-pecuniary benefits to leave voluntarily, in which case the unemployment is more efficiently allocated. Condition (ii) is relevant for high demand periods, and presupposes that due to heterogeneity of prospective workers, it may be necessary to raise the wage to entice new associated workers to the firm. To analyze these possibilities, we begin with the benchmark solution of the standard implicit contracts result, and ask separately whether for a particularly favorable or unfavorable state of nature denoted j, it might pay to adjust the wage.

Since the two cases are not symmetrical, we will begin with the case of a particularly favorable state of nature in which the firm inherits from the previous period N continuing workers but would desire more. The policy over the other states of nature is taken to be unchanged with respect to employment levels, and will still entail a fixed wage in those other states.[6] Since full employment would occur for continuing workers in the favorable state j whether or not the wage is raised in that state, the effect of a higher wage is a downward adjustment in the fixed wage paid in the other states. For a discrete wage change in state j in the amount of W,

[6]Strictly, the adoption of the variable wage strategy due to profit maximization rather than cost-minimization considerations would affect the expected labor force size due to a lesser need for labor hoarding (from the ability to raise the wage to adjust the work force to a favorable demand situation) and a lower cost of maintaining a given force (due to the lower average wage cost of a given aggregate expected utility when layoffs are more efficiently allocated by wage lowering).

the adjustment is the amount δ defined by:

$$\tilde{U}'\delta + \frac{\tilde{U}''}{2}\delta^2$$

$$= -\left(\pi_j\pi_{je}\Big/\sum_{i\neq j}\pi_i\pi_{ie}\right)\left(\tilde{U}'W + \frac{\tilde{U}''}{2}W^2\right) \qquad (14)$$

in a second-order Taylor approximation. (The wage change W is defined as $W_j - W$.) If the firm offered the 'normal' wage in the favorable state of nature j, it seems reasonable to suppose it could employ not just the inherited workers N, but some additional number willing to join for the 'normal wage'. Denoting this total N^*, suppose that additional workers require a premium (which must be uniformly paid to all workers) in the form $\omega(N^0 - N^*)$. The firm will then raise the wage marginally if:

$$MP_j(N^*) - W_i - \omega'(N^* - \overline{N}) > 0 \qquad (15)$$

where MP_j is the marginal product, W_i is the normal wage, and $\overline{N}$ is average (over states $i \neq j$) employment. The concavity of the utility function has no effect on the marginal decision, although it does affect the ultimate level to which the wage is raised, that meeting the condition:

$$MP_j(N^0) - (W_i + \omega) - \omega'(N^0) + \delta'\overline{N} = 0$$

where δ' is calculated from the total differential of equation (14), and is positive but diminishing with ω due to the concavity of the utility function.

In the adverse state of nature case, lowering the wage can cause a more efficient allocation of employment since those with the lowest nonpecuniary evaluations will voluntarily separate. Assuming that the firm keeps the same employment levels in each state of nature whether or not the wage-lowering policy is utilized, and adopting the voluntary separation function:

$$S = S(\omega) \qquad (16)$$

where ω is now defined[7] $\omega \equiv W - \tilde{W}$ and $\tilde{W}$ is the average wage (weighted for employment and state of nature) with an average non-pecuniary evaluation for those voluntarily separating:

$$\theta^0 = \theta^0(\omega) \qquad (17)$$

which entails an average non-pecuniary evaluation for those remaining in the pool:

$$\tilde{\theta} = \tilde{\theta}(\omega) \qquad (18)$$

the firm would seek to cost-minimize:

$$\sum_i W_i N_{ii} \quad \text{subject to } E\left[\sum_k \text{U}_k\right] = \overline{U} \qquad (19)$$

This minimization will entail a constant wage in all states of nature $i \neq j$, where j is the particular adverse state under consideration. Unlike the case of a favorable state of nature, due to the mobility costs (and the fact that the wage-lowering, if it occurs, is for the current period only), we suppose that a discrete fall in the wage from the normal wage is necessary to achieve any voluntary separations. As such, for the policy of wage-lowering to be utilized, this 'fixed cost' from the concavity of the utility function must be covered, unlike the wage-raising case above where the marginal condition does not contain a concavity element.[8] There would have to be an ω such that the number of separations, S, does not exceed $(N - N_j)$ and it must meet the conditions:

$$(\tilde{\theta} - \overline{\theta}) + \frac{\tilde{\text{U}}''}{2}\left[\omega^2\frac{\sum_i \pi_{ie}\pi_i}{\sum_{i\neq j}\pi_{ie}\pi_i}\right] > 0 \qquad (20)$$

This possibility depends on the one hand on the curvature of the utility function, and

[7]We re-define ω for simplicity in calculation.
[8]As workers would normally be doing some self-insuring through wealth holdings, the concavity of utility would seem most pertinent for severe downward shocks.

secondly upon the distribution of non-pecuniary evaluations encompassed in equation (18).

Under our presumption that a discrete change in the wage (downwards) is necessary to induce voluntary separations, but that the normal wage allows for new recruits into the workforce, we are more likely to see upward wage adjustments than downwards, as the concavity of $\tilde{U}$ bears greater weight on the latter. A further argument can be adduced for this 'wage floor' phenomenon, that workers are more concerned with wages falling below the norm than above, since the normal imperfection of the capital market is the difficulty of borrowing against future labor income. These arguments would lend validity to the wage floors approach adopted by Tobin, although it should be noted that everything here is framed in terms of real wages, not nominal wage floors.

Inflation and the Degree of Protection

While we have argued for some wage flexibility in response to sectoral conditions, that incomplete wage protection is consistent with the basic neo-Walrasian adjustment equation:

$$w = bX + p^e \tag{21}$$

For the formulation utilized by Baumol and Tobin we must consider why the amount of real wage protection should be dependent in degree upon the general rate of inflation. We consider two arguments, one relying upon the 'Tobin effect' of decreased real interest rates at higher inflation levels, and the second depending upon nominal commitments. Other effects of inflation, as surveyed by Fischer and Modigliani [6], would similarly affect the degree of real wage protection, so our conclusions are tentative.

First, consider again workers and firms agreeing on a contract about next period's wage and employment strategy. If an adverse state of nature were to occur ($X < 0$), firms would want to induce quits, thus permitting a more efficient allocation of employed labor. To induce more voluntary mobility, firms would have to lower the real wage in this state of nature. Will workers accept this, *ex ante?* In general workers will accept less real wage protection, the higher the rate of inflation is. This conclusion relies on Tobin's argument that, due to the fixed nominal interest rate on money, an increased long-run rate of inflation leads to a shift towards real assets and a lower real interest reate. The quit decision, of course, entails foregoing current income in anticipation of higher expected (discounted) income achieved through search. The lower the real interest rate, the higher the worker's valuation of future income relative to current income. While this tilts the marginal worker toward quitting, the mobility costs we have assumed inhibit her taking this step. The only way more voluntary mobility will occur is if the firm lowers its real wage (in this adverse state of nature). Thus, the degree of protection (downwards) should be less when long-run inflation is higher.

Our second argument relies upon loans correctly predicated upon the long-term rate of inflation but still requiring constant nominal payments. (An example is a residential mortgage with fixed monthly nominal payments although, *ex ante,* they depend upon the nominal interest rate, a market variable.) Higher inflation causes a twist or downward tilt in the schedule of real commitments, as argued in Fischer and Modigliani [6], the extent of the twist increasing with the inflation rate. Specifically, the real interest payment per period would decline over time with higher inflation. As an alternative to taking out such a loan for purchasing durable assets, though, workers usually can rent durables at a rate roughly equal to the average real repayment on the loan plus a premium. In an adverse state of nature, workers may well prefer to rent rather than buy these durable assets. If the expected inflation rate should rise, then the rental price of these assets (e.g., houses) should decline relative to their capital price because their owners are getting capital gains on them. As long as this appreciation is not capitalized into the prices of the durables immediately, workers should be able to arrange lower rental payments for the period. This ability to reduce real expenditures (temporarily) this depends upon the rate of inflation in the direction we desire—the higher the rate of inflation, the greater the workers's ability to lessen real commitments on durable goods and hence the less real wage protection they may require.

In the current section, then, we have established an argument for incomplete real wage protection (and why this is likely to take the form of wage floors, although that is not strictly necessary for the analysis), and presented some suggestions as to why the degree of protection might vary with the rate of inflation. This assumption is, as earlier shown, sufficient to establish a long-run Phillips curve along the lines suggested by Baumol [3] and Tobin [11].

V. Summary

In the current paper, we have shown that efforts by Baumol [3] and Tobin [11] to establish a long-run Phillips curve depend implicitly on a similar assumption—there is incomplete real wage protection for workers (with respect to the state of nature affecting a particular sector) and that the degree of protection depends negatively upon the rate of inflation. We have developed a model of implicit contracts that allows for such behavior.

If inflation is to have real costs (or benefits), it must be operating through the behavior of individual agents. The model we have suggested shows one way inflation can modify behavior, in this case leading to what might be considered a beneficial result, an increase in employment. Whether one wants to rely upon this effect as a basis for a long-run Phillips curve is a separate question.

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