The Cyclical Behavior of Marginal Cost and Price (Revised)

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Abstract

I examine the cyclical behavior of price/marginal cost margins for U.S. manufacturing since World War II. Shortrun marginal cost is markedly procyclical. This is primarily due to procyclical overtime payments, incurred because employment is not perfectly flexible. In most industries output price fails to respond to the cyclical movement in marginal cost; so price/marginal cost margins are markedly countercyclical.

My results contradict business cycle theories that explain low production in a recession by a high real cost of producing; they support theories that explain low production in a recession by the inability of firms to sell their output.

I. Introduction

First principles state that demand shocks are partially smoothed in the shortrun by upward price movements along a supply curve. The shortrun supply curve is strictly upward sloping because some factors are fixed with remaining factors subject to diminishing returns. Therefore shortrun marginal cost is increasing in output. This applies as well to aggregate demand shocks. A generally high level of demand should be associated with a general rise in the real price of outputs, where by real price I mean relative to input prices (a low real wage) as well as relative to surrounding periods (a high real interest rate). Such price movements should partially stabilize cyclical movements arising from demand shocks. This is one basis for classical economists' view of the macroeconomy as largely self calibrating. The other is the belief that input prices respond reasonably quickly to variations in their demands (wage flexibility). Keynes in the General Theory diverged from the flexible wage view, but kept faithful to the classical view that prices move procyclically relative to wages (countercyclical real wages).[1] A long empirical literature, however, has failed to find countercyclical real wages. (Geary-Kennan, 1982, review much of the evidence.)

An obvious explanation for procyclical real wages is that the cycle largely reflects aggregate supply shocks. This is a centerpiece of many "new classical" models (e.g., Kydland-Prescott, 1982). If productivity or input supplies are procyclical then marginal cost will be countercyclical and real wages procyclical.

The purpose of this paper is to examine whether shortrun marginal cost is procyclical and, if it is, whether output prices respond to the cyclical movements in marginal cost. Traditionally capital has been the factor viewed as fixed in the shortrun. More recently, however, a number of studies (beginning with

Oi, 1962) recognize that labor may be costly to adjust. I examine shortrun marginal cost allowing employment to be quasifixed. Using two-digit-level manufacturing data, I estimate that a shortrun increase in production-worker employment of 10 percent is associated with an increase in marginal cost of between 2.5 and 3 percent. Most of the rise in marginal cost is due to overtime payments, incurred because employment is not perfectly flexible. The same 10 percent expansion is found to have little effect on output price (where output price is the industry-specific GNP deflator). Together these results show that price/marginal cost margins decrease by almost 3 percent for a 10 percent expansion.

My results do not contradict either the disequilibrium or equilibrium views of the business cycle; they do, however, strongly contradict leading versions of each.

My results are incompatible with Keynesian theories based on a fixed shortrun labor demand curve (e.g., the General Theory). These assume that nominal wages are less flexible than prices. When prices increase (faster than expected) the real cost of labor falls, decreasing marginal cost and causing employment and output to expand, thereby tracing out the Keynesian aggregate supply curve. The evidence, however, is that marginal cost relative to price is high, not low, in a boom. The results are not inconsistent with disequilibrium models which allow price as well as wage rigidity (e.g., Barro-Grossman, 1971), because it is cost, not price, movements which generate the cyclical movements in markups.

The finding is also incompatible with competitive equilibrium stories of the cycle, as they require a constant price/marginal cost ratio (equal to one). In particular, if the cycle is primarily the response of the economy to supply shocks then marginal cost should behave countercyclically. The evidence is clearly consistent with market-clearing models in which the elasticity of goods demand behaves procyclically. Kalecki (1938) noted that the cyclical behavior of wages and prices for the United Kingdom might be explained by a procyclical elasticity of demand. A number of theoretical justifications for procyclical elasticity are possible (e.g., Pigou, 1927, Rotemberg-Saloner, 1984, Bils, 1985).

II. Approach to Calculating Marginal Cost

A necessary condition for cost minimization is that the relative marginal products of inputs be set equal to their relative costs. This implies that, at the cost-minimizing choice of inputs, the marginal cost of increasing output can be calculated simply as the cost of increasing input i, where we are free to choose i, to produce the marginal increase in output. For my purposes it is convenient to think in terms of varying average hours of work for production workers, holding employment of production workers and all other inputs constant at their optimal levels. Marginal cost is:

$$(1)\quad MC = (\delta Costs/\delta H)(\delta H/\delta Y)\,|_{Y^*,H^*,N^*,etc.^*} \quad ,$$

where Y is output, N is employment of production workers, H is average hours worked for production workers, and etc. are other inputs. The * on Y implies it is chosen with regard for some overall objective (e.g., profit maximization).

I assume throughout the paper that the productive technology has the form:

$$(2)\quad Y = H^{\alpha} f(\text{everything but } H) \quad ,$$

which is slightly less restrictive than Cobb-Douglas. I note in particular that productivity shocks are allowed; however, they must be multiplicative with respect to average hours. This production function implies:

$$(1') \quad MC = (1/\alpha)(H^*/Y^*)(\delta Costs/\delta H)\big|_* \quad ,$$

where the * is shorthand for at the optimum.

The standard macroeconomic approach is to set the marginal cost of an hour of labor equal to a wage rate W; and the cost of increasing average hours to employment, N, times that wage rate. (There are exceptions, including Abel, 1978, Shapiro, 1984, and Bernanke, 1985.) Note, however, that this requires the marginal cost of an hour of labor to be invariant to the level of hours, H. Within manufacturing this cost increases significantly with hours because firms are required to pay an overtime premium of 50 percent for hours above 40 per week (Fair Labor Standards Act of 1938). Even in industries not required to pay overtime premium, the marginal disutility of work presumably increases with the level of hours. If firms must compete for labor, it is necessary that compensation reflects this higher disutility at higher hours.

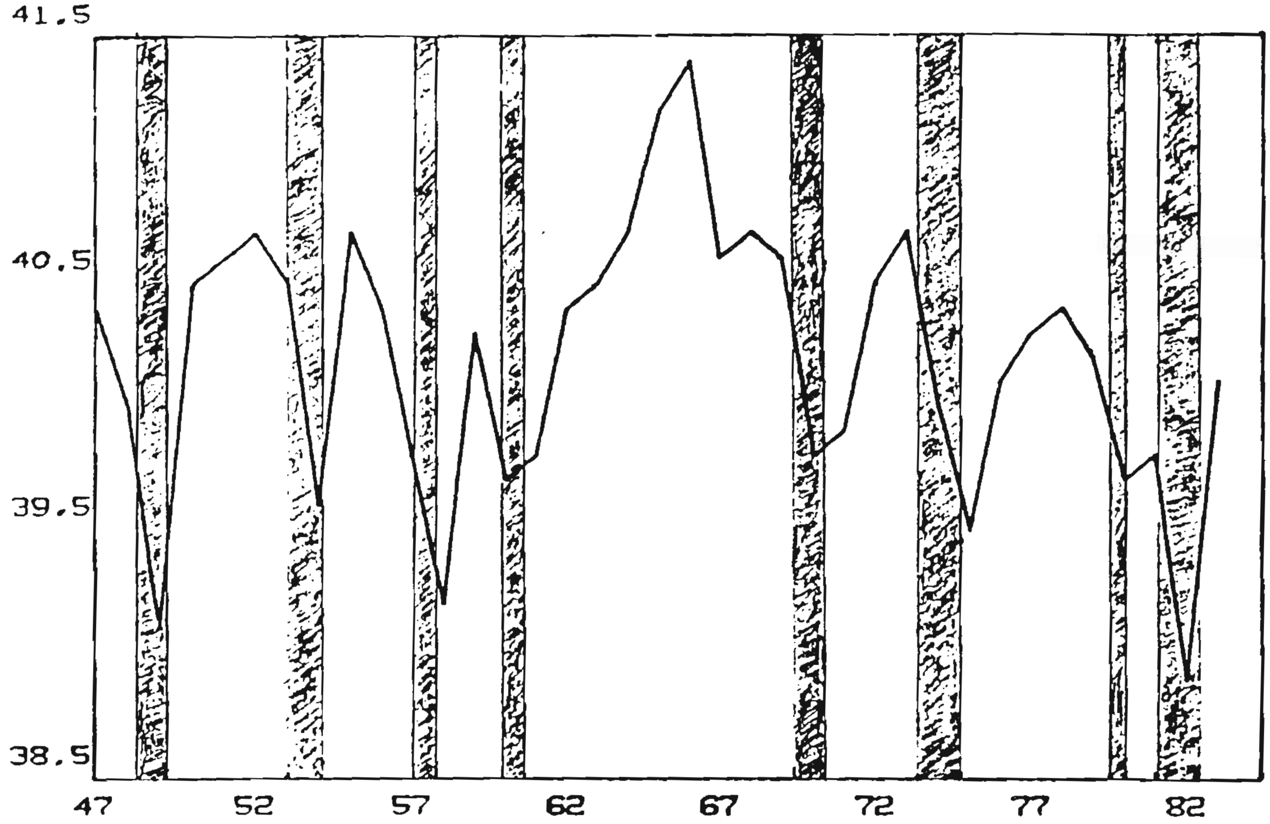
This suggests viewing the effective cost of an hour of labor, W, as being a function of the number of hours worked, W(H). Marginal cost of output then becomes:[2]

$$\begin{aligned}(3) \quad MC &= (1/\alpha)(H^*/Y^*)[W(H^*)N^* + W'(H^*)N^*H^*] \\ &= (1/\alpha)(N^*H^*/Y^*)\widetilde{W}(H^*) \\ &\text{where } \widetilde{W}(H^*) = W(H^*) + W'(H^*)H^* \quad .\end{aligned}$$

$\tilde{W}(H)$ is interpreted as the "marginal wage schedule". For calculating marginal cost it is clearly the marginal wage that is relevant. The arguments above predict $\tilde{W}(H)$ is increasing in H. If hours are procyclical then this is potentially an important procyclical component in marginal cost. Average hours for production workers in manufacturing are given in Figure 1. The data source is the Bureau of Labor Statistics (BLS) Employment and Earnings. NBER defined recessions (peak to trough) are shaded. Hours are markedly procyclical.

If the marginal wage increases significantly with hours, then the question arises of why variations in hours would be observed. That is, why would not firms keep hours constant and vary labor input by varying employment? The answer must be that employment is less than perfectly flexible. If firms view large variations in employment as costly it will be optimal for them to bear some costs of having hours away from their optimal longrun value. Quasi-fixity of labor is studied in a number of papers (Oi, 1962, Nadiri and Rosen, 1969, Brechling, 1975, Sargent, 1978, Pindyck-Rotemberg, 1983, Shapiro, 1984). For empirical purposes it is captured by including a convex function (typically quadratic) of change in employment in the firm's overall cost or profit function. The theoretical case for such adjustment costs is rarely made. For capital convex adjustment costs have been justified on the grounds that increases in capital become increasingly difficult for the firm to absorb (Treadway, 1971), or, alternatively, that the cost of capital goods is an increasing function of the rate of investment (Gould, 1968). With regard to labor, the convex function of change in employment can probably be better viewed as simply proxying for the fact that, for any of several good reasons, firms prefer a steady level of employment. Variations in employment require hires and fires (or recalls and layoffs), which firms may view as costly. The existence of firm specific

Figure 1 : Average Hours in Manufacturing



skills causes firms to prefer steady employment levels because decreases in employment cause trained workers to leave or have their skills depreciate, requiring additional training when employment is expanded. Because workers prefer stable employment, varying employment is also costly to a firm by hurting its reputation in the labor market.

Equation (3) gives marginal cost in terms of the cost of marginally increasing average hours holding other inputs, including employment, at their cost-minimizing values. Marginal cost can equivalently be viewed as the cost of marginally increasing employment holding other inputs, including average hours, at their cost-minimizing values. One component of this cost will be the marginal adjustment cost of increasing employment, given that employment is quasifixed. Each of the rationales for quasifixity of employment made above implies that this marginal adjustment cost will be high when employment is high relative to surrounding years. Thus the earlier statement that marginal cost will be high when hours are high can be reinterpreted as marginal cost is high when employment is relatively high.

III. The Marginal Wage

In the calculation of marginal cost in (3), α is a constant parameter and thus has no cyclical effect on marginal cost; and (NH/Y) is data.[3] Therefore, the problem of estimating cyclical movements in marginal cost reduces essentially to estimating the shape of the marginal wage schedule, $\widetilde{W}(H)$. This is the major focus of the paper. Allowing for an overtime premium, the effective wage a firm faces is:

$$(4) \quad W(H) = w[1 + p(V/H)] \quad ,$$

where w is the straight-time wage, p is the overtime premium, and V is the average number of overtime hours per production worker. The marginal wage with respect to hours is:

$$(5) \quad \tilde{W}(H) = w[1 + p(dV/dH)] \quad .$$

For manufacturing industries (which constitute the present data) law dictates that an overtime premium be paid for hours above 40 per week. If all workers work an identical number of hours then the relationship between average overtime hours and average hours would be very simple. V would equal H minus 40, or zero, whichever is larger. The change in overtime hours for a change in hours (dV/dH) would be equally simple, equalling zero when H is less than 40 and one when H is greater than 40. Provided the overtime premium is significant (such as the legal 50 percent rate) the implied marginal wage is very procyclical as hours typically move from below to above 40 during an expansion (note Figure 1).

However, the assumption that all workers work an identical number of hours is probably very poor. For instance, within a firm where workers average 40 hours per week one would expect to find some workers working more than 40 hours per week and some working less because of bottlenecks of one sort or another. Assuming that all workers work the same number of hours is particularly misleading when applied to data that is aggregated across time or firms, such as that used below. In a firm that averages 40 hours per week over a year (or quarter or month) there is probably part of the period spent above 40 hours and part below; and in an industry averaging 40 hours per week there are probably some firms above 40 hours and some below.

For this reason, my approach in calculating the marginal wage is to assume there is some variance in hours across workers. This implies overtime hours are a smooth function of average hours. It remains true that the change in overtime hours for a change in hours (dV/dH), and therefore the marginal wage, should be increasing in H, and thus procyclical. When average hours are low they can presumably be increased without much need for overtime hours; but when H is already high a further increase in H will be difficult to achieve without a corresponding rise in overtime hours because virtually everyone will be working 40 or more hours per week. This implies a marginal wage that is continuously increasing in average hours rather than jumping at 40 hours per week.

Proceeding, a firm's overtime hours per worker can be exactly written as a function of the firm's average hours per worker and the higher moments of the distribution of hours across workers, Z.

$$(6) \quad V = f(H,Z) \quad .$$

How many moments must be included in Z depends on the nature of the distribution of hours. V would be increasing in H and also increasing in the variance of hours across workers. The firm could clearly reduce its overtime costs by reducing the variance of hours across workers to zero. Presumably firms arrive at an optimal variance by trading off overtime costs against the inconvenience (or bottlenecks if workers have differing assignments) of scheduling hours so that all work the same number. Fortunately, I need not consider this portion of the firm's problem explicitly, because I can calculate marginal cost in terms of increasing average hours given the firm's choice for the variance in hours across workers.

Of primary interest is the derivative of overtime hours with respect to average hours. Following the arguments above, I specify this derivative to be increasing in average hours. I assume:

$$(7) \quad dV/dH = a(i,t) + b(H-40) + \chi \quad .$$

By writing a(i,t) I allow the parameter a to vary across industries (indexed by i) and across time (indexed by t). The parameter b, however is required to be a constant.[4] χ is a a potential error term in the relationship. I try three estimators of equation (7) below. The first requires χ exactly equal to zero; the second allows χ to be nonzero, but requires it be uncorrelated with H; the third allows χ to be nonzero and potentially correlated with H. This issue is discussed further below. Given (7), the marginal wage schedule is:

$$(5') \quad \tilde{W}(H) = w[1 + pa(i,t) + pb(H-40) + p\chi] \quad .$$

This marginal-wage specification is virtually equivalent to those of Abel (1978) and Shapiro (1984). It has the convenient property that it linearly aggregates.

Values for (dV/dH) presumably (though not necessarily) lie between zero and one. For sufficiently extreme values of H equation (7) will not satisfy this. For this reason, below I also try the specification:

$$(7') \quad dV/dH = a(i,t) + b(H-40) + c(H-40)^2 + d(H-40)^3 + \chi' \quad .$$

This nonlinear specification suffers the drawback that it cannot be linearly aggregated. The data are aggregated at the two-digit industry level. Therefore, in using specification (7') I must implicitly assume that two digit manufacturing industries can be adequately represented as a single firm. I find extending equation (7) to (7') has no impact on the results or conclusions of this paper. The results using specification (7') are discussed in notes (7) and (13).

To this point I have treated the overtime premium, p, as a parameter to be determined. This may seem curious given that law prescribes a premium equal to 50 percent. It may be incorrect, however, to equate the effective premium for overtime hours with the 50 percent rate firms must pay by law.[5] Several papers, most notably Hall (1980), have pointed out that if a long-term relationship exists between employer and employees then it is not correct to equate the effective wage rate with the wage payment being made at any single point in time. If a firm pays its workers in excess of the marginal disutility of labor in one period, it may well be tied with paying them less than the marginal disutility of labor in another period. With regards to overtime payments the problem is the following. The wage a firm pays takes a very large jump of 50 percent at 40 hours per week due to the overtime premium. Workers' disutility of working is presumably smoothly increasing in hours. This implies workers would strictly prefer working some overtime hours to working 40 hours per week (in fact, overtime hours are rationed in many instances). By offering workers overtime hours, therefore, a firm may incur some goodwill which allows it to lower compensation in another form, if not then, at some point in time. The implication is that the effective cost premium of an overtime hour may be less than the 50 percent explicit payment.[6]

In the next section I use two separate approaches to estimating the marginal wage. The first estimates the effect of hours on overtime hours directly. To arrive at a marginal wage, I then must presume the effective overtime premium equals 50 percent. The second approach estimates the shape of the marginal wage schedule indirectly from observing the cost minimizing choices firms make for employment and average hours. This approach estimates the effect of hours on overtime hours and the overtime premium simultaneously. Therefore, it is not necessary to presume the effective overtime premium equals 50 percent; and the second approach is much less subject to the criticism just raised. I find the two approaches give extremely simlilar estimates for the shape of the marginal wage. This suggests the effective overtime premium is actually very close to 50 percent.

Even estimating the marginal wage by the second approach requires assuming that variations in hours affect compensation through an overtime premium. If the model of labor payments as "installment payments" is taken to its logical end then this assumption will be false. The effective cost of an hour of labor will be the marginal disutility of an hour of labor; the distinction between straight-time and overtime hours becomes irrelevant and my estimates of the marginal wage below fail to be identified. This is not as dire a problem as it sounds, however. If the effective marginal wage equals the marginal disutility of labor, then its shape can be inferred from prior studies' estimates of labor supply elasticities. To obtain a marginal wage that is less procyclical than I find below requires that the elasticity of labor supply be greater than 0.67. This is above most estimates in the literature. Therefore, redoing the present paper equating the shape of the marginal wage to the shape of workers' work/leisure indifference curves would imply an even more procyclical marginal cost and more countercyclical markup than I purport to show.

IV. Estimating the Marginal Wage

As mentioned, I try two separate approaches to estimating the marginal wage. The first estimates the relationship between overtime hours and hours. Given a value for the overtime premium of .5, this implies the marginal wage. The second estimates the shape of the marginal wage schedule from observing the cost minimizing choices firms make for hours and employment. I find the two approaches yield very similar estimates for the shape of the marginal wage schedule.

(A) Approach 1

The goal here is to estimate (dV/dH) directly. In turn, this will identify the marginal wage schedule, assuming an overtime premium equal to .5. Totally differentiating equation (6) gives:

$$(8)\quad dV = (dV/dH)dH + (dV/dZ)dZ \quad ,$$

where all variables are as previously defined; and it is understood that all variables refer to a given time period t. Substituting from (7):

$$(8')\quad dV = [a(i,t) + b(H-40) + \chi]dH + (dV/dZ)dZ \quad .$$

I intend to estimate this equation in order to identify the parameters a and b. The error term χ is problematic here because it yields a nonconstant parameter for (dH) (beyond that captured by a(i,t) varying over i and t). Therefore, for this subsection only I impose that χ be equal to zero. The higher moments of the distribution of hours, Z, are unobservable. This creates problems in estimating (8') only to the extent (dZ) is correlated with (dH). I proxy for (dZ) with a constant, time trends, and the rate of growth in employment. This obviously does not capture all of (dz); but I assume the remainder of (dZ) is uncorrelated with (dH). Substituting in (8') yields:

$$(8'')\quad dV = [a(i,t) + b(H-40)]dH + g(t) + k\mathrm{Ln}(N/N_{-1}) + \varepsilon \quad .$$

The error term, ε, reflects the uncaptured effect of (dZ). In addition to varying across industries, I allow the parameter a to depend on t and t^2. The parameter g is also allowed to depend on t and t^2.

I estimate (8") using BLS Employment and Earnings data on annual averages for overtime hours, hours, and production-worker employment for each of the 21 SIC classified two-digit manufacturing industries for each year from 1956 to 1983. (BLS collection of overtime data began in 1956.) The 21 industries are listed in Table 5. (Transportation equipment is broken into motor vehicles and equipment, and the remainder of transportation equipment. For these two industries the coverage begins with 1958.) Several variables require first differencing the data; so the coverage is actually for 1957 to 1983. For hours, H, I use the average of hours in years t and t-1.

The results of estimating (8") by OLS appear in Table 1. The estimate for the parameter a (using the mean across industries as of 1956) implies that an increase in average hours from 40 to 41 hours per week is associated with an increase in average overtime hours of .400 hours. The key parameter is b. The estimate for b implies that, whereas an increase in average hours from 40 to 41 increases overtime hours by .400 hours, an increase from 41 to 42 hours

Table 1: Estimates of Equation (8")
(t-statistics in parentheses)

$\bar{a}(i,t)$	=	.4004	+	.0350 (t-1956)	−	.00112 $(t-1956)^2$
		(11.91)		(6.02)		(-5.65)
b				.0936		
				(5.42)		
g	=	.00568	+	.00732 (t-1956)	−	.000345 $(t-1956)^2$
		(0.24)		(1.85)		(-2.50)
k				1.260		
				(8.26)		
R^2				.91		
D-W				2.29		
F				200.3		
n				563		

increases overtime hours by .494 hours. Given an overtime premium of 50 percent, this translates into about a 3.9 percent higher marginal wage at 41 hours than at 40. (Recall Figure 1 showed post-WWII recessions to be associated with a fall in average hours of about one hour.) By contrast, the increase in overtime hours between 40 and 41 hours per week would only raise an average wage rate approximately 0.5 percent (or one-eighth the rise in the marginal wage). Over the range of 36 to 44 average hours per week, which is approximately the range observed in the two-digit industry data, (dV/dH) increases from .026 to .774.[7]

This first approach to estimating the marginal wage has the virtue of being very simple and straightforward. Its has two drawbacks. It does not allow an error in the relationship between hours and overtime hours (equation 7). More importantly, it requires that the effective overtime premium equal the explicit premium of 50 percent.

(B) Approach 2

The shape of the marginal wage schedule can be inferred from the choices firms make for hours and employment. For estimating the absolute value of marginal cost it is necessary to know the absolute value of the marginal wage schedule; but for estimating relative cyclical movements in marginal cost all that is needed is the shape of the marginal wage schedule.

I consider the firm's problem of choosing employment and average hours to minimize the cost of its desired quantity of production-labor, L*. For a firm to minimize its overall cost function or to maximize profits it is necessary that it minimize this cost. Therefore, the problem is more general than profit maximization or cost minimization.[8]

Because I wish to allow for the possibility that employment is quasifixed, I actually consider the firm's dynamic problem of minimizing the expected present-discounted value of the costs of procuring its expected future stream of production-labor demands. This problem is:

$$(9)\quad \min_{N_t, H_t} \quad E_t \sum_{\tau=t}^{\infty} R_{t,\tau} \{W_\tau(H_\tau)N_\tau H_\tau + F_\tau N_\tau + l w_\tau N_\tau H_\tau [Ln(N_\tau / N_{\tau-1})]^2\}$$

$$\text{subject to} \quad E_t\{N_\tau H_\tau^{\beta} - L_\tau^*\} = 0 , \quad \text{for } \tau = t, t+1, \ldots, \quad .$$

E_t is the expectations operator, conditioned on information known at time t. I choose an infinite horizon for simplicity. $R_{t,\tau}$ is the nominal rate of discount between periods t and τ.

W(H)NH is the wage cost of production labor. FN captures production-labor expenses which increase with employment, but are fixed with respect to average hours, such as unemployment insurance and vacation pay. The real-world distinction between hours-related and not-hours-related expenses is discussed at length below. (9) assumes that firms possess no monopsony power with respect to employment; however, the effective wage firms must pay is affected by their choice of hours.

Fixity of employment is introduced, similarly to other works, by incorporating a convex function of change in employment. The costs of adjustment are of the external variety. (A discussion of various forms for adjustment costs is contained in Soderstrom, 1976.) Adjustment costs are often specified as quadratic in changes (i.e., $(N_t - N_{t-1})^2$). The formulation here makes the marginal adjustment cost linear in percentage changes, rather than absolute changes in employment. This is desirable because the two-digit industries vary considerably in size; and it does not seem reasonable that an increase in employment of 1 million in a large industry such as primary metals would have the same relative effect on costs as a 1 million increase in a small industry such as leather goods. The adjustment costs are multiplied by the straight-time wage to account for nominal movements (as in Pindyck-Rotemberg).[9]

The constraint in (9) requires that hours and employment be sufficient to satisfy the labor input demand, L^*. The effective amount of labor is given by NH^{β}. This specification does not require that employment and hours enter multiplicatively in production. I have not set β equal to one because several studies have found that increasing hired labor by increasing hours has a greater impact on output than an equal increase in hired labor achieved by increasing employment.[10]

To meet (11), firms must satisfy a dynamic first-order condition that the marginal cost of an hour of effective labor (NH^{β}) obtained by increasing average hours, H, equal the marginal cost of an hour of effective labor obtained by increasing employment, N, including a marginal adjustment cost. This first-order condition can be written:

$$(10) \quad E\ \{\ W(H) + (F/H) + l[wLn(N/N_{-1}) - Rw_{+1}(N_{+1}/N)Ln(N_{+1}/N)]\ \}$$
$$= \quad (1/\beta)\tilde{W}(H) \quad .$$

Time period t subscripts have been dropped for convenience. By estimating this condition I obtain an estimate of the marginal wage up to the multiplicative constant $(1/\beta)$.

For reasonably small changes in employment, such as those observed in the annual, two-digit-industry data used below, $[(N_{+1}/N)Ln(N_{+1}/N)]$ can be closely approximated by $[Ln(N_{+1}/N)]$. Making this simplification, substituting for the marginal wage from (5'), and rearranging gives:

$$(10') \quad E\,\{Ln(N/N_{-1}) - R(w_{+1}/w)Ln(N_{+1}/N)\} = (-1/l)[(W(H)/w) + (F/wH)] + (1/l)(1/\beta)[1 + pa(i,t) + pb(H-40) + p\chi] \quad .$$

Examining (10') it is clear that none of the parameters β, p, a, or b are identified. The value of pb relative to (1 + pa) is identified, however, and this gives the shape of the marginal wage schedule.

Equation (10') as stands cannot be estimated because it includes an expectational term. Substituting the actual value for the expected gives:

$$(10'') \quad Ln(N/N_{-1}) - R(w_{+1}/w)Ln(N_{+1}/N) = (-1/l)[(W(H)/w) + (F/wH)] + (1/l)(1/\beta)[1 + pa(i,t) + pb(H-40)] + \mu \quad .$$

$$\text{where,} \quad \mu = (p/l\beta)\chi + (Rw_{+1}/w)Ln(N_{+1}) - E\{(Rw_{+1}/w)Ln(N_{+1})\} \quad .$$

μ is a composite error term. The first component reflects a potential error in the relationship between hours and overtime hours, (dV/dH). The second component is an expectational error. If expectations are rational it will be uncorrelated with all variables of which firms have knowledge at time t, including the right-hand-side variables. Thus, if there is no error in the (dV/dH) relationship (χ equals zero), or if the error is orthogonal to the right-hand-side variables in equation (10"), then equation (10") can be consistently estimated by ordinary least squares. More generally, we should expect the error term χ to be correlated with the right-hand-side variables.[11] Therefore, I estimate (10") both by OLS and by instrumental variables (described more fully below).

I estimate (10") using annual, post-WWII, two-digit manufacturing data. The source for employment, N, average hours, H, average hourly wage, W(H), and average straight-time wage, w, is the BLS Employment and Earnings.[12]

The variable (F/wH) requires some discussion. Since 1951 the U.S. Chamber of Commerce has surveyed firms biannually on their annual fringe payments and legally required payments to workers. There is not a direct relationship between all such payments and F because some payments, such as FICA payments, vary with hours as well as employment. By deleting such payments a measure of F is obtained. The Appendix contains the 1981 Chamber survey as well as a description of how payments are divided between those considered hours-related and those considered not hours-related. The Chamber survey gives fringe payments as a percentage of wages for all workers. By using their figures I implicitly assume that (F/wH) for production workers can be represented by (F/wH) measured for all workers. The Chamber survey gives fringe payments as a percentage of wages. (F/wH) is fixed payments in terms of straight-time wages. Therefore I put the Chamber's figures in terms of straight-time wages by multiplying by (W(H)/w). Although the Chamber's survey covers all manufacturing industries, it does not give figures separately for each industry (as seen from the Appendix). Lumber is combined with furniture and with paper, instruments with miscellaneous manufactures, textiles with apparel, foods with tobaccos, and rubber and plastics with leather goods. Nevertheless, there are 14 categories with 16 biannual observations for each (1951 to 1981), for a total of 224 observations. The other variables in equation (10") were aggregated into the same 14 categories in order to be consistent with the variable (F/wH).

I assume a constant real interest rate of 5 percent annually. This could be relaxed, however variations in (Rw_{+1}/w) are trivial relative to variations in $Ln(N_{+1}/N)$.

The results of estimating equation (10") by OLS appear in the first column of Table 2. The parameter estimates are in accord with the framework above and are statistically significant. The estimate for the adjustment-cost parameter, l, implies that when employment is 10 percent above surrounding years the marginal adjustment cost of an additional worker is approximately 513 dollars in 1967 (using the mean wage and hours for manufacturing). In 1967 annual compensation in manufacturing averaged about $7480; so the marginal adjustment cost is about 6.8 percent of annual compensation. Of central interest is the estimated shape of the marginal wage schedule. The relative steepness of the schedule is given by the value of (pb) divided by (1 + pa). Its estimate (using the mean industry value for a as of 1956) is .0375. This implies the marginal wage is about 3.7 percent higher for each hour increase in average hours. This is virtually equivalent to the corresponding estimate of .0390 from the first approach assuming an overtime premium of .5.

The similarity of the estimates from the two separate approaches supports the assumption that the effective overtime premium equals .5. The first approach gives direct estimates of the parameters a and b. Using these estimates together with the estimate here of (pb) divided by (1 + pa), it is possible to recover an estimate for the effective overtime premium, p. This estimate is .477. Going further, taking the parameters a, b, and p as identified above, it is possible to recover an estimate for the production parameter β. This estimate is 0.990. Thus there is also indirect support for assuming employment and average hours enter multiplicatively in production.

As advertised, I reestimated equation (10") by instrumental variables. The instruments are (H-40) and [(W(H)/w) + (F/wH)] each lagged two years, the rate of growth in domestic consumer credit in years t and t-1 (source is Board of Governors of the Federal Reserve System), and the rate of increase in energy

Table 2: Estimates of First-Order Condition (t-statistics in parentheses)

		OLS	IV
1		.8925 (4.30)	.6192 (4.02)
$(1/\beta)[1+p\bar{a}(i,t)]$	=	1.2027 (154.80)	1.2000 (172.50)
		− .0100 (t-1956) (-1.89)	− .00747 (t-1956) (-1.50)
		+ .000989 $(t-1956)^2$ (4.07)	+ .000863 $(t-1956)^2$ (3.89)
$(1/\beta)pb$		.0451 (3.96)	.0504 (3.86)
$\frac{pb}{1+\bar{a}(i,t)}$		.0375 (3.97)	.0420 (3.87)
R^2		.42	.42
D-W		2.34	2.04
F		8.84	8.21
n		224	210

prices for total manufacturing in years t and t-1 (source is Berndt-Wood, 1984). The credit and energy price variables are intended to reflect aggregate demand and aggregate supply shocks respectively.

The results are presented in the second column of Table 2. The estimated adjustment cost parameter is reduced by about 35 percent. The estimated marginal adjustment cost of an additional worker when employment is 10 percent above surrounding years is now only 356 dollars in 1967, or about 4.7 percent of annual compensation. The estimated marginal wage schedule is slightly steeper. The estimate of (pb) divided by (1 + pa) has increased from .0375 to .0420; so an increase in average hours of one hour is associated with about a 4.2 percent higher marginal wage. Using the estimates for parameters a and b from approach 1, the recovered estimate for the overtime premium p is .547, and the estimate for the production parameter β is 1.015.[13]

The alternative estimators appear to reach a consensus on the shape of the marginal wage schedule. In the next section I find that cyclical movements along this marginal wage schedule are large relative to cyclical movements in straight-time wage rates or output prices.

V. The Markup

Given an estimate of the marginal wage, calculating marginal cost is straightforward. Substituting in (5) for $\widetilde{W}(H)$ from (7") gives:

$$(11) \quad MC = w[1 + pa(i,t) + pb(H-40) + p\chi](NH/Y)(1/\alpha) \quad ,$$

where *'s have been dropped for convenience. Taking logs and approximating gives:

$$(12) \quad \mathrm{Ln(MC)} = \mathrm{Ln(w)} + \frac{\mathrm{pb(H-40)}}{1 + \mathrm{pa(i,t)} + \mathrm{p}\chi} + \mathrm{Ln(NH/Y)}$$

$$+ \text{ (intercept \& trend terms)} \quad .$$

The error effect, $p\chi$ is unobservable because it is combined in the estimates above with the expectational error. The similarity of the OLS and instrumental variable results, however, suggest that this term is either small in variance or cyclically insensitive. Therefore I ignore it in calculating marginal cost. Three potential estimates for [pb/(1+pa)] were presented in the previous section. For substituting in (12) I choose the OLS estimate from the first-order condition. The alternative estimates give slightly steeper marginal wage schedules, and so would give results slightly more favorable to my conclusions.

Of principle interest is the price/marginal cost markup. Given (12), this is estimated by:

$$(13) \quad \mathrm{Ln(P/MC)} = \mathrm{Ln(P)} - \mathrm{Ln(w)} - \widehat{\frac{\mathrm{pb(H-40)}}{1 + \mathrm{pa(i,t)}}} - \mathrm{Ln(NH/Y)}$$

$$- \text{ (inter. \& trend terms)} \quad ,$$

where the hat (^) signifies the OLS estimate from the first-order condition. I examine the cyclical behavior of markups by regressing the measure (13), component by component, on a measure of the business cycle. Because I use industry-level data, I need an industry-level measure of the cycle. (As opposed to aggregate measures such as the NBER reference cycles.) The measure I use is production worker employment relative to the four surrounding years: $\mathrm{Ln(N)} - .25\ \mathrm{Ln}(N_{-2}N_{-1}N_{+1}N_{+2})$.

The data are annual averages for each of the 21 two-digit manufacturing industries listed in Table 5. The sample period is 1949 through 1981. (This incorporates data for 1947 through 1983 on N, as the cyclical measure absorbs two leads and two lags.) As before, N, H, and w are from the BLS Employment and Earnings. Y is the industry-specific GNP from the U.S. Commerce Department, and is thus a value-added measure. P is the industry-specific GNP deflator.[14]

The results of regressing each component of the markup from equation (13) on the measure of the business cycle appear in Table 3. The regressions also include trends (t, t^2, t^3) and industry specific constants. The regressions employ a Cochrane-Orcutt AR(1) correction. Looking at Table 3, beginning with row 2, straight-time wages show a very small countercyclical movement. A 10 percent shortrun increase in employment is associated with a 0.2 percent decrease. Most of the action, however, is within the wage schedule W(H). Looking at row 3, a 10 percent increase in employment increases the marginal wage 2.0 percent by moving up the marginal wage schedule. This component of the markup shows the most dramatic cyclical movements.

Productivity is slightly countercyclical. A 10 percent shortrun increase in employment is associated with a 0.8 percent increase in (NH/Y). My finding of coutercyclical productivity may seem surprising given that procyclical labor productivity is a noted empirical feature of cycles (see Zarnowitz, 1985). In calculating marginal product, however, I have defined productivity differently than most studies of labor productivity. My measure of labor is more procyclical because it includes variations in average hours. Furthermore, I examine only production-worker labor; production labor is much more cyclical than nonproduction labor. By disaggregating I reduce the apparent procyclicality of productivity. Industries which decline most in recessions are those with higher labor pro-

Table 3: Regressions of Marginal Cost and Price on Business Cycle
(T-statistics in parentheses, n = 693)

Component	Estimate
Ln(P)	-.0232 (-0.90)
Ln(w)	-.0227 (-2.55)
$\frac{pb(H-40)}{1 + p\hat{a}(i,t)}$	.2024 (16.48)
Ln(NH/Y)	.0831 (3.33)
Ln(P/MC)	-.2881 (-9.92)

ductivity. Therefore aggregate productivity is more procyclical than disaggregate.

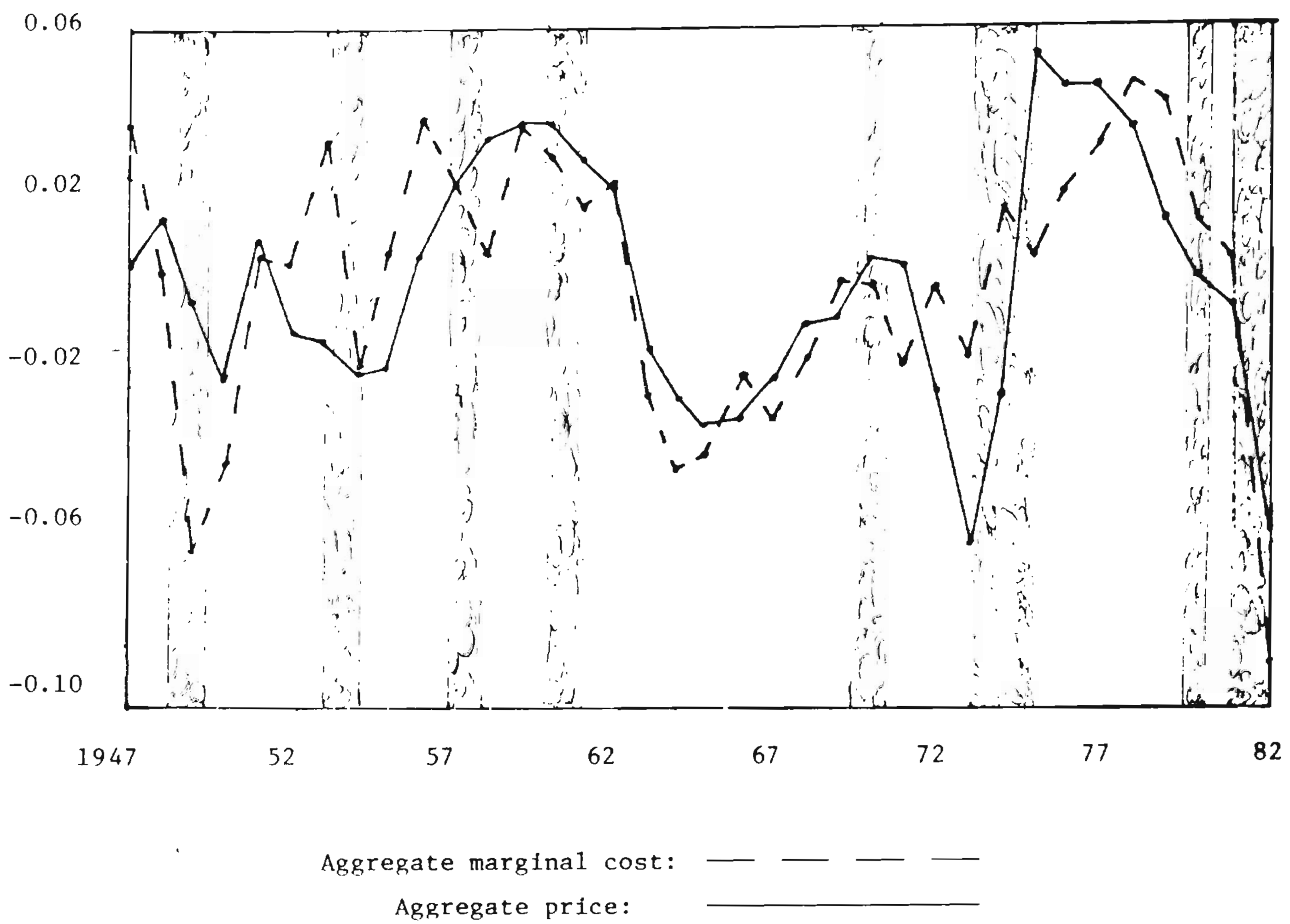
Marginal cost (combining rows 2, 3, and 4) is procyclical, increasing by 2.6 percent with the 10 percent shortrun increase in employment. A large share of this procyclical movement is from the impact of average hours on the marginal wage.

Table 3 also gives the behavior of prices (GNP deflators). Prices are very slightly (and statistically insignificantly) countercyclical. Prices decrease by 0.2 percent for a 10 percent shortrun increase in employment. Of primary interest, price/marginal cost margins are countercyclical. Margins decrease by about 2.9 percent for the 10 percent increase.

Figure 2 graphs price and marginal cost for aggregate manufacturing. Aggregate marginal cost is constructed by aggregating the marginal costs for the individual industries, giving each industry a weight equal to its share in manufacturing value added in 1965 (the midpoint of the sample). Aggregate price is constructed by aggregating industry-specific deflators in an identical fashion. Constant and trends (t, t^2, t^3) have been eliminated. NBER defined recessions (peak to trough) are shaded. Aggregate marginal cost declines considerably relative to trend with each recession (by almost 10 percent for the 1949 and 1982 recessions). Aggregate price declines relative to trend for 5 of the 8 recessions. The markup increases considerably with each recession.

The price data (GNP deflators) I use are constructed from sellers' reported prices. If price discounting is more prevalent in recessions then this will be a biased measure of cyclical price variability, with actual transaction prices being more procyclical than my data appear. The most extensive study of this issue, to my knowledge, is by Stigler and Kindahl (1970). Stigler and

Figure 2: Aggregate Marginal Cost
and Aggregate Price, 1947-82.



Kindahl collect purchase-price data for a large number of industrial goods for the years 1957 to 1966. They find movements in their transaction prices differ considerably from movements in BLS Wholesale Prices (an index constructed from sellers' listed prices) at a monthly frequency. At a cyclical frequency, however, their prices and the BLS prices behave roughly similarly. Results from their study are reprinted in Table 4. Stigler-Kindahl transaction prices decline more than BLS prices in recessions, but actually increase somewhat less in expansions. Although the correlation between Stigler-Kindahl price changes and BLS price changes is only .38 at a monthly frequency, at a 6 month frequency the correlation is .73. At an annual frequency (the data frequency here) the correlation is presumably even higher. My conclusion is that the failure of prices to move with marginal cost probably cannot be explained by failure of reported prices to move with transacted prices.

The cyclical behaviors of the components of price over marginal cost are given separately by industry in Table 5. (Again the equations are estimated by the Cochrane-Orcutt procedure, and include a constant and trends t, t^2, t^3.) Straight-time wages show little cyclical movement in any industry. Changes in average hours, on the other hand, are an important procyclical component in marginal cost in almost all industries; the exceptions are the food and tobacco industries. The cyclical behavior of productivity varies considerably across industries. Productivity is very countercyclical in miscellaneous manufactures, foods, tobaccos, printing, chemicals, and fuels; it is particularly procyclical in paper products, primary metals, and motor vehicles. In many industries the GNP deflator shows little cyclical movement. Lumber products and textiles, however, have very procyclical deflators. Foods, apparel, paper products, fuels, and leather goods have very countercyclical deflators.

Table 4 -- Stigler-Kindahl Results.

(Note: NBER prices are Stigler-Kindahl prices.)

Comparison of the Comprehensive BLS Index with the Corresponding NBER Index for All Industrial Commodities

	BLS		NBER
Trend			
Monthly Percentage Rate of Increase	−.026		−.060
Cycle			
Average Monthly Percentage Rates of Change			
Peak to Trough	−.129		−.205
Trough to Peak	.118		.079
Average Monthly Percentage Rates of Change Corrected for Trend			
Peak to Trough	−.082		−.140
Trough to Peak	.117		.111
Short Run			
Correlation of First Differences of Logarithms			
Monthly		.378	
Quarterly		.576	
Semiannually		.728	
Variances of First Differences of Logarithms	.202		.042

Source: Stigler-Kindahl, p. 82.

Table 5: Regressions of Marginal Cost and Price on Cycle, by Industry. (T-statistics in parentheses)

	Ln(P)	Ln(w)	$\frac{pb(H-40)}{1 + pa(i,t)}$	Ln(NH/Y)	Ln(P/MC)
Lumber & wood products	.550 (3.7)	.0007 (0.02)	.136 (3.3)	.295 (2.1)	.133 (1.6)
Furniture & fixtures	-.198 (-2.3)	-.061 (-1.6)	.280 (5.5)	.022 (0.2)	-.467 (-6.6)
Stone, clay, & glass prods.	-.035 (-0.4)	-.008 (-0.2)	.253 (5.3)	.103 (1.1)	-.380 (-4.0)
Primary metals	-.165 (-1.7)	-.038 (-0.9)	.343 (4.6)	-.240 (-3.1)	-.189 (-1.6)
Fabricated metals	-.130 (-1.3)	-.064 (-1.9)	.243 (5.5)	.129 (2.0)	-.424 (-6.5)
Machinery except electrical	-.053 (-0.9)	-.024 (-0.9)	.300 (4.9)	.131 (2.1)	-.483 (-5.6)
Electrical machinery	-.094 (-1.4)	-.079 (-2.7)	.132 (4.1)	.227 (3.0)	-.382 (-5.7)
Motor vehicles & equipment	.010 (0.1)	.018 (0.6)	.254 (4.2)	-.207 (-2.4)	-.058 (-0.6)
Other transp. equipment	.052 (0.9)	.029 (0.5)	.107 (3.4)	.241 (2.9)	-.351 (-3.6)
Instruments & related prod's	-.071 (-0.9)	-.051 (-1.4)	.220 (4.4)	.195 (2.8)	-.482 (-4.4)
Miscellaneous manuf's.	-.204 (-3.3)	-.038 (-1.0)	.142 (2.9)	.382 (3.4)	-.699 (-6.0)

(Continued)

Table 5--Continued

Food & kindred prod's	-.986	-.051	.096	.831	-1.729
	(-1.6)	(-0.3)	(1.0)	(2.0)	(-4.3)
Tobacco prod's	.006	-.169	-.008	.449	-.322
	(0.03)	(-2.1)	(-0.08)	(1.9)	(-1.4)
Textile mill prod's	.434	.076	.344	.284	-.276
	(1.9)	(1.2)	(3.9)	(1.4)	(-1.7)
Apparel & related prod's	-.250	-.059	.263	.106	-.503
	(-1.5)	(-0.7)	(4.0)	(0.6)	(-4.0)
Paper & allied prod's	-.350	-.109	.299	-.604	.144
	(-1.7)	(-2.2)	(3.8)	(-3.0)	(0.8)
Printing & publishing	-.054	-.191	.251	.472	-.575
	(-0.3)	(-2.2)	(3.0)	(1.8)	(-2.9)
Chemicals & allied prod's	-.058	-.073	.163	.358	-.403
	(-0.3)	(-1.1)	(3.5)	(1.7)	(-2.0)
Petroleum & coal prod's	-.258	.070	.299	.565	-1.339
	(-0.5)	(0.7)	(3.8)	(2.2)	(-2.2)
Rubber & misc. plastic prod's	-.070	-.019	.221	.106	-.346
	(-0.8)	(-0.5)	(3.8)	(0.9)	(-2.5)
Leather & leather prod's	-.561	-.071	.287	-.037	-.463
	(-2.5)	(-1.1)	(3.1)	(-0.1)	(-2.1)

This countercyclical behavior probably reflects procyclical intermediate-input prices, rather than countercyclical final-output prices.

Price markups over marginal cost are very countercyclical in all industries except lumber and wood products, motor vehicles, and paper products. This behavior holds for durables and nondurables alike. It also does not appear to be related to an industry's average four firm concentration ratio.[15]

VI. Summary

Marginal cost is very procyclical. Using two-digit manufacturing data, I find a 10 percent shortrun increase in production worker employment is associated with about a 2.6 percent increase in marginal cost. The cause is that employment is not perfectly flexible. In booms firms must incur a high "adjustment" cost if they expand employment, or considerable overtime pay if they expand hours per worker. Prices do not respond to the cyclical movement in marginal cost. Thus markups over marginal cost decline by almost 3 percent with a 10 percent expansion. The finding of a very countercyclical markup holds across most two-digit industries.

This evidence is clearly inconsistent with a perfectly competitive view of manufacturing. It is also inconsistent with the view that wage stickiness is an important cause of the business cycle. Even if wage schedules are not cyclically sensitive, there is much cyclical variation in the marginal cost of labor due to variation in average hours.[16] This implies that imperfections in goods markets play a primary role in the cycle.

Appendix

The results of the Chamber of Commerce survey for 1981 for manufacturing are given in Table A1 as an example. The survey has information on 22 types of payments, which are then subsumed into 5 major categories.

The first major category is legally required payments. These payments increase with earnings for a given worker up to a ceiling, at which point they become fixed with respect to hours. FICA taxes and workers' compensation payments have ceilings that are considerably higher than average earnings. Therefore, I consider these payments to increase with hours and do not include them in F. (For instance, for 1979 the ceiling for FICA payments equaled 178 percent of average earnings, and workers' compensation had effectively no ceiling. The source here is Hart, 1984, p. 15.) Unemployment compensation has a ceiling considerably lower than average earnings. Therefore, I consider these payments to be unrelated to hours and include them in F. (For 1979 the ceiling equaled 47 percent of average earnings.) The final type payment in the first category, Railroad Retirement taxes, is of no significance. I treat it as hours related.

The second category includes private pension plans, and insurance and other benefits. I consider these to be unrelated to hours and include them in F.

The third and fourth categories are payments for time not worked, primarily paid lunch or break time, paid sick leave, and paid vacation time. I consider these to be unrelated to hours and include them in F.

The final major category is other items. These are primarily profit-sharing payments and special bonuses. I consider these payments to be either hours related or not relevant to production workers. In neither case do I include them in F.

Table A1: Employee Benefits as a Percent of Wages, by Type of Benefit and Industry, 1981

Type of benefit	Total, all manufacturing	Food, beverages, and tobacco	Textile products and apparel	Pulp, paper, lumber, and furniture	Printing and publishing	Chemicals and allied products	Petroleum industry	Rubber, leather, and plastic products	Stone, clay, and glass products	Primary metal industries	Fabricated metal products (excluding mach. and trans. equipment)	Machinery (excluding electrical)	Electrical machinery, equipment, and supplies	Transportation equipment	Instruments and miscellaneous manufacturing industries
Total employee benefits as percent of payroll	38.2	37.5	31.1	36.2	36.8	43.4	44.6	37.1	38.0	43.3	37.9	38.5	37.6	38.8	35.1
1. Legally required payments (employer's share only)	10.1	10.3	9.9	10.6	9.0	9.2	7.9	11.4	10.6	12.1	10.3	10.0	9.5	9.5	9.8
a. Old-Age, Survivors, Disability, and Health Insurance (FICA taxes)	6.4	6.5	6.5	6.5	6.4	6.4	6.1	6.4	6.5	6.5	6.4	6.4	6.4	6.4	6.4
b. Unemployment Compensation	1.5	1.5	2.0	1.4	1.4	1.1	0.6	1.9	1.4	1.7	1.6	1.4	1.7	1.2	2.0
c. Workers' compensation (including estimated cost of self-insured)	2.1	2.3	1.4	2.6	1.1	1.7	1.2	3.0	2.7	3.8	2.3	2.1	1.3	1.9	1.3
d. Railroad Retirement Tax, Railroad Unemployment and Cash Sickness Insurance, state sickness benefits insurance, etc.**	0.1	***	***	0.1	0.1	***	***	0.1	***	0.1	***	0.1	0.1	***	0.1
2. Pension, insurance, and other agreed-upon payments (employer's share only)	12.9	12.2	8.5	10.9	11.5	14.9	17.0	11.0	13.3	15.9	12.8	13.6	12.1	14.0	10.6
a. Pension plan premiums and pension payments not covered by insurance-type plan (net)	4.5	5.0	2.3	3.5	5.4	6.5	9.4	3.4	4.3	5.7	4.4	4.7	3.9	4.7	2.8
b. Life insurance premiums; death benefits, hospital, surgical, medical, and major medical insurance premiums, etc. (net)	6.9	5.7	5.4	6.3	5.0	6.8	5.8	6.6	7.6	8.6	7.3	7.5	6.7	8.0	6.6
c. Short-term disability	0.5	0.5	0.3	0.5	0.4	0.5	0.4	0.3	0.5	0.7	0.5	0.4	0.4	0.5	0.5
d. Salary continuation or long-term disability	0.2	0.2	0.1	0.1	0.1	0.3	0.3	0.2	0.1	0.1	0.1	0.2	0.2	0.1	0.2
e. Dental insurance premiums	0.4	0.4	0.1	0.3	0.3	0.6	0.6	0.1	0.3	0.5	0.4	0.5	0.6	0.6	0.3
f. Discounts on goods and services purchased from company by employees	0.1	0.2	0.3	***	0.2	***	0.1	0.1	***	***	***	***	***	***	0.1
g. Employee meals furnished by company	0.1	***	***	0.1	***	0.1	0.2	***	***	***	***	0.1	0.1	***	***
h. Miscellaneous payments (vision care, prescription drugs, separation or termination pay, moving expenses, etc.)	0.2	0.2	***	0.1	0.1	0.1	0.2	0.3	0.5	0.3	0.1	0.2	0.2	0.1	0.1
3. Paid rest periods, lunch periods, wash-up time, travel time, clothes-change time, get-ready time, etc.	3.4	4.0	3.4	3.3	2.9	4.5	3.4	3.7	3.5	3.2	3.6	2.9	3.9	3.1	3.3
4. Payments for time not worked	9.8	9.1	7.6	9.0	10.2	11.1	11.6	9.6	9.5	10.5	9.3	10.1	10.0	11.1	9.0
a. Paid vacations and payments in lieu of vacation	5.1	4.8	3.9	5.0	5.6	5.5	6.0	5.3	5.4	5.9	4.9	5.1	4.8	5.5	4.3
b. Payments for holidays not worked	3.5	3.0	3.0	3.2	3.1	3.7	3.4	3.4	3.3	3.6	3.7	3.9	3.7	4.2	3.4
c. Paid sick leave	0.9	1.2	0.5	0.6	1.3	1.5	1.9	0.7	0.6	0.7	0.5	0.8	1.2	1.1	1.0
d. Payments for State or National Guard duty; jury, witness, and voting pay allowances; payments for time lost due to death in family or other personal reasons, etc.	0.3	0.1	0.2	0.2	0.2	0.4	0.3	0.2	0.2	0.3	0.2	0.3	0.3	0.3	0.3
5. Other items	2.0	1.9	1.7	2.4	3.2	3.7	4.7	1.4	1.1	1.6	1.9	1.9	2.1	1.1	2.4
a. Profit-sharing payments	1.1	0.8	1.0	1.1	2.4	1.8	1.4	0.9	0.4	0.9	0.9	1.2	1.2	0.3	1.4
b. Contributions to employee thrift plans	0.3	0.2	0.2	0.2	0.2	1.0	2.9	***	0.1	0.2	0.2	0.1	0.1	0.4	0.1
c. Christmas or other special bonuses, service awards, suggestion awards, etc.	0.4	0.7	0.4	0.6	0.5	0.5	***	0.4	0.1	0.3	0.6	0.4	0.6	0.1	0.5
d. Employee education expenditures (tuition refunds, etc.)	0.1	0.1	***	0.4	0.1	0.1	0.1	***	***	0.1	0.1	0.1	0.1	0.1	0.3
e. Special wage payments ordered by courts, payments to union stewards, etc.	0.1	0.1	0.1	0.1	***	0.3	0.3	0.1	0.5	0.1	0.1	0.1	0.1	0.2	0.1

*Includes research, engineering, education, government agencies, construction, etc.

**Figure is considerably less than legal rate, because most reporting companies had only a small proportion of employees covered by tax.

***Less than 0.05%.

Notes

1. In light of empirical evidence, Keynes (1939) later acknowledged there may be reasons output prices do not respond to procyclical movements in marginal cost. This view had been expressed earlier by Pigou (1927).

2. I ignore any potential adjustment costs for hours. A priori such costs seem unimportant for manufacturing because shifts and overtime hours appear easily adjustable. Moreover, studies which have examined adjustment costs for hours (Sargent, Shapiro) find them to be very insignificant.

3. The data on hours, H, are for hired hours, whereas what is ideally needed are data on utilized hours. Given shortrun fixity of some factors, it will in general be optimal to utilize hired labor more intensively in booms; so hired hours will be less procyclical than utilized hours. Therefore, by using data on hired hours rather than utilized hours I cause productivity to appear more procyclical, and marginal cost less procyclical, than is true. Thus the bias works counter my conclusions.

4. This is restrictive. For example, if hours are distributed normally across workers then the coefficient b is approximately equal to $(1/\sigma)$, where σ is the variance of the distribution. Therefore a constant b would require a constant variance.

5. Beyond the discussion in the text, the effective premium would be less than 50 percent if firms circumvent the legally required premium. This does not appear to be an issue. A 1965 survey of workers found that among laborers in manufacturing 83.3 percent of those working overtime received premium pay (U.S. Department of Labor, Special Labor Force Report No. 72). More importantly, the data on overtime hours I use below, which is gathered by the BLS, defines

overtime hours as those weekly hours which exceed regular hours and for which overtime premium is paid.

6. At a sufficiently high level of overtime hours workers will presumably disapprove of any increase in hours, despite the overtime pay. At this point the effective premium would exceed 50 percent.

7. Results of estimating the nonlinear specification (9') are:

$$\frac{dV}{dH} = \underset{(10.75)}{.4077} + \underset{(5.23)}{.1218}\,(H-40) - \underset{(-0.59)}{.00339}\,(H-40)^2 - \underset{(-1.51)}{.002693}\,(H-40)^3 .$$

The estimate of b is higher; so the marginal wage schedule is steeper near 40 hours per week. Overall, however, the responsiveness of overtime hours to hours is very close to that estimated with the linear specification. Over the range of 36 to 40 hours per week (dV/dH) increases from .038 to .668.

8. Looking at the firm's broader cost minimization problem would provide further first-order conditions for capital, nonproduction labor, materials, and other inputs. Although estimating a set of conditions theoretically should yield more efficient estimates, it is unlikely that these further first-order conditions can be consistently estimated. Estimating conditions for capital and nonproduction labor is difficult because accurate measures of shortrun movements in <u>utilized</u> capital and nonproduction labor are not available. Because capital and nonproduction labor are largely fixed in the shortrun, it will generally be optimal for firms to utilize these factors more intensively in a boom. Therefore, data on hired capital and nonproduction labor will have a considerable cyclical bias. A further problem with estimating first-order conditions for capital, nonproduction labor, or materials is that it requires that these factors can be substituted for each other, and for other factors. This seems questionable for the shortrun. The assumption of shortrun substitution

between hours and employment of production workers, on the other hand, is not stringent. A practical reason for focusing on employment and hours is that data for inputs other than labor are not, to my knowledge, available at the two-digit level. Thus any potential efficiency gains from estimating further equations would probably cause greater efficiency loss by requiring use of more aggregate data, as well as possibly causing aggregation bias.

9. I ignore any adjustment costs for hours. See note (2).

10. For instance, Shapiro (p. 47) finds hours has about a 6 percent higher marginal product than employment.

11. A possible source of disturbance to the (dV/dH) relationship would be shocks to the <u>elasticity</u> of labor supply with respect to hours. Standard shocks to labor supply (in which labor supply shifts out proportionately so that workers are willing to accept a lower real wage at any given level of hours) are already captured by the straight-time wage. An increase in elasticity would correspond to workers being willing to work longer hours without a corresponding rise in overtime premium. This would imply a negative value for the error term χ, and would presumably lead firms to expand H. (Such shifts in elasticity are, however, irrelevant if firms treat the legal premium as the effective premium.)

12. Data on overtime hours, and therefore straight-time wages, exist only for 1956 and after (1958 and after for motor vehicles and equipment). For earlier years I use a prediction of overtime hours. Using post-1956 data, for each industry I ran the regression:

$$\text{Overtime hours} = l_0 + l_1\text{time} + l_2\text{Hours} + l_3\text{Hours}^2 ,$$

where the variables are industry averages. I used the results to predict overtime hours for pre-1956. I constructed average straight-time wages for pre-1956 from predicted overtime hours and the BLS data on average wages.

13. I reestimated first-order condition (10") using the nonlinear specification (7') for (dV/dH). The results relevant for judging the steepness of the marginal wage schedule are:

	OLS	IV
$\frac{pb}{1 + pa(i,t)}$	.0510 (3.56)	.0557 (2.76)
$\frac{pc}{1 + pa(i,t)}$	-.00292 (-1.28)	-.00043 (-0.10)
$\frac{pd}{1 + pa(i,t)}$	-.000986 (-1.09)	-.00209 (-0.81)

The OLS and IV estimates each give marginal wage schedules that are steeper at 40 hours per week under the nonlinear specification. Overall, however, the estimated schedules are only slightly steeper than those estimated with the linear specification.

14. I thank Michael Burda for making this data available.

15. These ratios appear in Rotemberg-Saloner.

16. The focus here has been on the marginal wage firms face. The results, however, also imply workers perceive a very procyclical marginal wage. This is indirect support for an equilibrium view of the labor market; and is consistent with the conclusion Bernanke (1984) draws from disaggregate pre-WWII data.

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