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ABSTRACT

In this paper a production theory-based model of firms' markup behavior is constructed. The theoretical structure is based on variants of generalized Leontief cost and expenditure functions. This structure yields a full specification of behavior from which the impacts of both supply and demand shocks on firms' markup behavior can be assessed through elasticities. Adjustment costs on both labor and capital and economies of scale are incorporated. Estimation is carried out using manufacturing data for the U.S. and Japan from 1960 through 1981. The empirical results suggest that markups for manufacturing firms in the U.S. and Japan have increased over time, but tend to be procyclical in the U.S. and countercyclical in Japan. This difference stems primarily from differential investment behavior. In addition, capacity utilization and especially returns to scale tend to counteract the short run profit potential from markup behavior, so that markups measured assuming constant returns may be biased downward. Finally, both supply and demand shocks appear to have a significant systematic impact on markups.

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I. Motivation

Recently there has been renewed interest in factors affecting the levels and cyclical behavior of short run markups of price over marginal cost. Hall [1988a], for example, has addressed the markup behavior of firms in a number of industries and comes to the conclusion that markups exist and are large. According to Hall, in manufacturing firms prices exceed the costs of added inputs by approximately 63%. Hall [1988a, 1988b] has also suggested, however, that profitability implied by these markups may be counteracted by excess capacity or returns to scale.

Other researchers such as Rotemberg and Saloner [1986], Bils [1987a, 1987b] and Domowitz, Hubbard and Petersen [1987] have considered more explicitly the behavior of the markup over the cycle. Some suggest that markups are countercyclical because in booms marginal cost increases more rapidly than price with the expansion of production, while the reverse occurs with downturns. Others find that although this holds for some types of goods, markups overall are procyclical. This implies important interrelationships not only between markups and capacity utilization, as suggested by Hall, but also between their cyclical variations.

These studies provide important implications about short run pricing behavior. However, they do not assess the structure of the production technology underlying this behavior and are therefore limited in their interpretation about factors affecting the markup. For example, the Hall study is nonparametric and ignores the dependence of markup levels on changes in market conditions from supply and demand shocks, which Shapiro [1987b] recognizes as important. Although other studies such as Bils [1987b] and Domowitz et al. [1987] relax some of these restrictions, they still essentially use nonparametric or simple regression models for estimation of the pattern of markups. In all these cases, since the measures are not founded on an explicit optimization model, the impact of changing economic factors on production decisions and thus the markup cannot be determined within the model. If an optimization process is built in, however, the impact on markups of demand and supply shocks can be considered more directly.

Empirical implementation of existing models is also restricted by the number of inputs considered. Although many studies recognize the fixity of capital, most studies except those of Domowitz, Hubbard and Peterson consider only one variable input, labor, and in some cases only production labor. Although this facilitates theoretical analysis, it must be recognized that cyclical changes in short run marginal cost depend also on costs of other factors such as intermediate materials and energy.

Even more importantly, constraints on the production process resulting from fixity of inputs must be included explicitly to assess their cost impacts. For example, labor hoarding may have a considerable impact on markup trends if it causes average variable cost to increase as marginal cost decreases in a downturn.[1] Slow adjustment of capital and labor from costs of adjustment must therefore be carefully modeled to determine the influence of these characteristics of the production structure on firm decisions and thus markup behavior. In addition, if the firm faces fixities other than those based on slow capital adjustment and labor hoarding, to isolate the impact the resulting curvature of the long run average cost curve must be recognized.

Explicitly modeling these characteristics of the technology -- which determine capacity utilization and returns to scale -- allows direct assessment of Hall's hypothesis that excess capacity utilization or returns to

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[1]Domowitz et al mention this possibility. Bils also emphasizes the potential importance of quasi-fixed labor.

scale could counteract the profitability of firms resulting from market power. If this is the case, overall economic profits remain negligible even with high markups, which appears consistent with empirical observation. Assessing these relationships and how they might vary when exogenous variables change provides very important information to facilitate the interpretation of markup trends and their determinants.

The purpose of this paper is to analyze the markup behavior of firms using an applied production theory approach. The model allows characteristics of the production structure such as adjustment costs and returns to scale, as well as potential for markup pricing behavior, to affect firms' decisions. The structure does not restrict the number of fixed or variable inputs which may be taken into account. It also permits independent identification of the effects of supply and demand shocks on the short run optimization process of the firm. Based on this framework, markup indexes and associated endogenous economic performance indicators and elasticities are measured for the U.S. and Japanese manufacturing sectors. Capacity utilization and returns to scale indexes are computed to assess the impacts of these characteristics of the production technology on markups. Although some of these measures may be difficult to interpret in the aggregate, the estimates appear to reflect very important characteristics of the production process, since their values are significant and reasonable. Elasticities with respect to both supply (cost) and demand shocks are employed to compute impacts on price and cost fluctuations and accompanying utilization and profitability variations. These measures suggest both supply and demand shocks, particularly investment rates, have important impacts on markups.

II. The Model

The theoretical model for this study is a dynamic profit-maximizing factor demand model with imperfect competition in the output market. The technology is assumed to be represented by a restricted cost function, G, which is a function of J variable input prices p_j (or vector p), K quasi-fixed inputs x_k ($\mathbf{x}$), output Y, the state of technology t, and net investment in quasi-fixed inputs $\Delta x_k = dx_k/dt$ ($\Delta\mathbf{x}$); $G=G(Y,p,\mathbf{x},t,\Delta\mathbf{x})$. This function can also be written as $G(Y,\psi)$, where ψ is a vector of the shift variables or "supply (cost) shocks" for the firm. In the short run the level of quasi-fixed inputs $\mathbf{x}$ is fixed for the firm, as is the state of technology and p. Investment and output or output price are, however, endogenous to the full optimization process of the firm, because the firm is faced with adjustment costs with respect to additional investment and a demand curve for its output.

In particular, adjustment costs are reflected by the incorporation of $\Delta\mathbf{x}$ in the cost function, with $\partial G/\partial|\Delta x_k|>0$ for all k. This formalizes the notion that investment in fixed inputs causes increased variable input use and therefore internal costs of production at a given output level. In addition, market power in the output market is included by assuming the firm maximizes net revenues subject to a downward sloping demand curve for its output, represented by the demand function $Y=D(p_Y,\phi)$ or the inverse demand function $p_Y = D^{-1}(Y,\phi)$. In this specification, ϕ is a vector of shift variables affecting demand which reflect "demand shocks".

The firm's intertemporal profit maximization problem is therefore to

$$1)\ \text{Max}_{\mathbf{v},\Delta\mathbf{x},Y} \quad R(0) = \int_0^\infty e^{-rt}\,(p_{Yt}Y_t - \textstyle\sum_j p_{jt}v_{jt} - \sum_k a_{kt}z_{kt})\,dt\ ,$$

subject to the constraints represented by the demand function $D(p_Y,\phi)$, the restricted cost function $G=G(Y,\psi)$, the definition of gross investment

$z_k=\Delta x_k+\delta_k x_k$, the vector of depreciation rates δ, and the asset purchase prices of **x**, **a**.

This optimization problem is solved in three steps. Variable costs are minimized, given **x**, Δx and Y; the maximum (instantaneous) variable profit obtainable at time t is derived, subject to the variable cost function obtained in the first stage and conditional on the levels of **x** and Δ**x**; and then the present value of total net receipts are optimized over the quasi-fixed inputs.

Minimization of variable costs is incorporated by specification of $G(Y,\psi)$;[2] by definition this restricted cost function captures minimum variable costs conditional on **p**,**x**,Δ**x** and Y. The function G has two important properties. From Hotelling's Lemma $\partial G/\partial p_j = v_j$ and $-\partial G/\partial x_k = Z_k$, where v_j is the short run cost minimizing input level and Z_k is the normalized user cost or marginal shadow value of the stock of x_k.

Given the cost minimizing variable input demands embodied in G, profit maximization conditional on the quasi-fixed inputs requires maximizing $D^{-1}(Y,\phi)\bullet Y-G(Y,\psi)$ with respect to Y.[3] The solution to this problem can be characterized by the standard equality of short run marginal revenue (MR) and marginal cost (MG)

$$2)\quad MR = D^{-1}(Y,\phi) + Y\bullet\partial D^{-1}(Y,\phi)/\partial Y = \partial G(Y,\psi)/\partial Y = MG\ ,\quad \text{or}$$

$$p_Y = -Y\bullet\partial D^{-1}/\partial Y + \partial G/\partial Y = -Y\bullet\partial p_Y/\partial Y + \partial G/\partial Y\ .$$

The final step in the maximization process, determining the path of the quasi-fixed inputs, requires substituting the optimized values for output price and input quantities into the maximization problem:

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[2]The process of constructing this dual cost function is outlined in Berndt, Fuss and Waverman [1980] or Morrison and Berndt [1981].
[3]This approach has been used by Appelbaum [1979], Diewert [1984], and Morrison [1982], among others.

$$3)\ \mathrm{Max}_{\mathbf{x},\Delta\mathbf{x}}\bar{R}(0) = \int_0^\infty e^{-rt}(p_Y(Y,\phi)\cdot Y - G(Y,\psi) - \sum a_k\delta_k x_k)dt$$

$$- \int_0^\infty e^{-rt}a_k\Delta x_k\ dt$$

and expressing the solution to this problem in terms of the Euler necessary conditions (in terms of continuous time):

$$4)\quad -G_{\mathbf{x}} - rG_{\dot{\mathbf{x}}} - p_{\mathbf{x}} + G_{\dot{\mathbf{x}}\dot{\mathbf{x}}}\ddot{x} + G_{\mathbf{x}\dot{\mathbf{x}}}\dot{x} = 0 \quad ,$$

where $\ddot{x}$ denotes the second derivative of x with respect to time, and p_x is the vector of normalized user costs for quasi-fixed inputs $p_k = a_k(r+\delta_k)$.

The solution to the overall profit maximization problem therefore is represented by a system of equations including the optimized level of variable input demand reflected by $\partial G/\partial p_j = v_j$, the profit maximizing output price from (2) and the path of $\mathbf{x}$ and $\Delta\mathbf{x}$ captured in (4). Thus, to implement this model empirically one must next specify the inputs under consideration and the forms of $G(Y,\psi)$ and $D(Y,\phi)$.

I assume there are four inputs, capital (K), labor (L), energy (E), and non-energy intermediate materials (M). Capital is considered quasi-fixed, as is standard for short run models. Energy and materials are assumed to be variable because it is reasonable to hypothesize that they can be obtained rapidly in response to fluctuations in the supply or demand conditions facing the firm. The fixity of labor is unclear. For both the U.S. and Japan some fixity has been noted by researchers, although the extent of the fixity and how it differs between the U.S. and Japan is not certain.[4] For the current application, therefore, labor was specified to be quasi-fixed. This makes the

[4]For a recent overview of this debate, see Tachibanaki [1987].

speed of adjustment endogenous, thus permitting tests of the existence of fixity or hoarding based on the importance of adjustment costs.

The restricted cost function G is assumed to be approximated by a nonconstant returns to scale generalized Leontief (GL) restricted cost function developed by Morrison [1988a]:[5]

$$5)\quad G = Y\bullet[\textstyle\sum_i\sum_j \alpha_{ij}\, p_i^{.5}\, p_j^{.5} + \sum_i\sum_m \delta_{im}\, p_i\, s_m^{.5} + \sum_i p_i \sum_m\sum_n \gamma_{mn}\bullet s_m^{.5}\, s_n^{.5}]$$

$$+\; Y^{.5}\bullet[\textstyle\sum_i\sum_k \delta_{ik}\, p_i\, x_k^{.5} + \sum_i p_i \sum_m\sum_k \gamma_{mk}\bullet s_m^{.5}\, x_k^{.5}] + \sum_i p_i \sum_k\sum_l \gamma_{lk} x_k^{.5} x_l^{.5}\ .$$

where x_l, x_k represent K and L, p_i and p_j index the prices of E and M, and s_m, s_n denote Y, t, ΔK and ΔL.

Hotelling's lemma is used to specify short run cost-minimizing demand equations for E and M for estimation purposes:

$$6)\quad v_i = \frac{\partial G}{\partial p_i} = Y\bullet[\textstyle\sum_j \alpha_{ij}\, (p_j/p_i)^{.5} + \sum_m \delta_{im}\, s_m^{.5} + \sum_m\sum_n \gamma_{mn}\, s_m^{.5}\, s_n^{.5}]$$

$$+\; Y^{.5}\bullet[\textstyle\sum_k \delta_{ik}\, x_k^{.5} + \sum_m\sum_k \gamma_{mk}\bullet s_m^{.5}\, x_k^{.5}] + \sum_k\sum_l \gamma_{lk} x_k^{.5} x_l^{.5}\ ,\quad i=E,M\ .$$

These are the first two estimating equations in the system.

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[5]The properties of this function are outlined in greater detail in Morrison [1988a]. Note that unless there are proportional movements in relative sectoral growth, the computation of a level of returns to scale for an entire industry using this function does not reflect a level of returns for any particular firm. Although constant returns is often assumed to circumvent this problem this seems too limiting. Preliminary empirical investigation of the data with constant returns imposed resulted in implausible results. In addition, estimates from this study as well as previous work by Berndt and Khaled [1979] and Hall [1988a, 1988b] suggest that returns to scale estimates are significant. This significance, in addition to the reasonable size of the estimates found in the current study and Berndt and Khaled, suggest that something important is being picked up from the data by the scale parameters, so they have been retained. Further consideration of markups and returns to scale using more disaggregated data is found in Morrison [1988b].

Elasticities of the markup and its price and cost components with respect to changes in the exogenous variables, can now be clearly interpreted as reflecting responses to demand and supply "shocks". Constructing these elasticities is somewhat complex, however, because a standard elasticity measure requires evaluation at a given quantity or price of output. By constrast, in this case the simultaneous determination of price and output must be taken into account. To allow for this endogeneity, the formulas for price and marginal cost incorporate the solved value of output from the price determination equation. The resulting equations then reflect the full short run optimization process.

More specifically, the price equation used for elasticity construction is the inverse demand equation as a function of the solved value of output from (2). To compute this, Y can be solved from (2) as $Y=f(\phi,\psi)$ and substituted back into the left hand side of the equation to represent the chosen price-output combination. Then elasticities of price with respect to components of the ϕ vector, such as ϕ_1 for example, can be computed as $\partial \ln D^{-1}(\phi,f(\phi,\psi))/\partial \ln \phi_1$. This effectively computes the output price elasticity as $d\ln p_Y/d\ln \phi_1= [\partial p_Y/\partial\phi_1 + \partial p_Y/\partial Y\bullet(\partial f/\partial\phi_1)]\bullet\phi_1/p_Y$, allowing for both price and output adjustments with a shift in demand. Analogous reasoning holds for changes in the cost function with a variation in an element of ψ and corresponding movements along the demand curve that yield a new optimized p_Y, Y combination.

In this model the specification of the cost and demand equations do not allow an analytical solution for the $f(\phi,\psi)$ function. In this case, instead of the explicit solution, the implicit function $0=\phi(Y,\phi,)$ may be used. Then $\partial \ln D^{-1}(\phi_1,f(\phi_1,\psi))/\partial \ln \phi_1$ becomes $[\partial D^{-1}/\partial\phi_1 - \partial D^{-1}/\partial Y\bullet(\partial\phi/\partial\phi_1)/(\partial\phi/\partial Y)]\bullet\phi_1/p_Y$ using the chain rule and implicitly computing $\partial f/\partial\phi_1$ as $-(\partial\phi/\partial\phi_1)/(\partial\phi/\partial Y)$.[7]

This resulting indicator of price changes with exogenous shocks can be compared to cost changes by computing the elasticity of marginal cost with respect to a change in a demand or supply argument. The impact of supply shocks, for example, can be measured in terms of elasticities such as $d\ln MC/d\ln \psi_1$ once $f(\phi,\psi)$ is substituted to represent marginal cost at the chosen output level similarly to p_Y above. Marginal cost is thus a function of demand shocks as well as supply shocks through the function $f(\phi,\psi)$.

Given these expressions it is straightforward to construct the markup elasticities. Using the definition of markup of price over marginal cost as $p_Y/MC=PRAT$ it is easy to show, for example, that

12) $$\frac{d\ln (p_Y/MC)}{d\ln \phi_1} = \frac{d\ln p_Y}{d\ln \phi_1} - \frac{d\ln MC}{d\ln \phi_1},$$

which allows a simple computation of the markup elasticity with respect to any supply or demand shock.

From (12) it is clear that both the size and the sign of the price and marginal cost elasticities are important in determining the markup elasticity. If costs dominate price setting, for example, as has been argued by some researchers[8], then elasticities with respect to the components of the ϕ vector will be small or insignificant, or the p_Y elasticity and MC elasticity will counteract each other and the elasticities with respect to ψ variables will dominate. In addition, with profit maximization the markup ratio can be written as $PRAT=p_Y/MR=1/(1+\epsilon_{pY,Y})$, which is analogous to the standard result that the Lerner index, a simple transformation of the price ratio, is synonymous with the inverse price elasticity.[9] Finally, this relationship

[7] This is discussed by Brown and Christensen [1981] in a slightly different context. Note that this adjustment process also applies to the long run elasticities, suggesting that long run elasticities in this framework with two multiple quasi-fixed inputs could become very complex. The long run elasticities are discussed further in Morrison [1988b]

suggests that the price ratio elasticities can be envisaged as elasticities of the demand elasticity itself with respect to exogenous variables; if the price ratio increases with a shock this is analogous to an increase in the inverse demand elasticity or decrease in the usual output price elasticity.[10]

The analysis so far has been based on the premise that imperfect competition is an important characteristic of market structure. Likewise, the dynamic structure suggests that fixity of capital and labor hoarding may also be important. Hypothesis tests can be constructed to assess these assumptions. If imperfect competition is important, for example, the inverse demand elasticity will differ significantly from zero. This significance can be tested by constructing the inverse demand elasticity measure from (9a) and evaluating its standard error. This is equivalent to testing the null hypothesis of perfect competition, a focus of the Appelbaum [1979] and Hall [1988] studies of market power. The importance of adjustment costs can be similarly assessed by computing (11) and determining whether this measure significantly differs from zero.

This last test is related to evaluating the cost capacity utilization measure, $C^*/C=CU_c$, where C^* is the shadow cost function $G+\sum_k Z_k \bullet x_k$ and C is total costs $G+\sum_k p_k \bullet x_k$.[11] Such a measure reflects the extent of joint fixity of inputs, because if adjustment costs are zero (so fixity would not be an issue) instantaneous adjustment would cause CU_c to equal one. Evaluation of the degree of fixity can therefore be accomplished by determining the statistical significance of the deviation of CU_c from one, where a value of one represents the steady state. In the current model non-optimal utilization

[8] See Rotemberg and Summers, among others.

[9] This relationship and many related issues are discussed in Bresnahan [1988].

[10] Note that this requires evaluation of the elasticity at the new point. In

of both capital and labor is permitted, so any deviation is a combination of these two impacts. In addition, the impact on the utilization patterns of supply and demand shocks may be assessed in terms of elasticities by constructing an expression for CU_c and computing $d\ln CU_c/d\ln \phi_1$ using processes analogous to those outlined above for markup elasticities.

Finally, returns to scale can be measured by evaluating the slope of the long run average cost curve. This requires computing a long run elasticity of cost with respect to output, ϵ^{LR}_{CY}, which turns out to be equivalent to the ratio of the short run cost elasticity, $\epsilon_{CY}=\partial\ln C/\partial\ln Y$, and CU_c, because $\epsilon_{CY}=\epsilon^{LR}_{CY}\bullet CU_c$. This results from the long run cost elasticity expression, $\epsilon^{LR}_{CY}=\epsilon_{CY}+\epsilon^{LR}_{CY}\bullet\sum_k\epsilon_{Ck}$, where $\epsilon_{Ck}=\partial\ln C/\partial\ln x_k$ and k denotes the quasi-fixed inputs K and L, as developed in Morrison [1986, 1988c]. This measure can be computed, its statistical significance tested, and the impacts of exogenous shocks on it calculated, similarly to those for markups and capacity utilization discussed above.

These indexes of capacity utilization and returns to scale are important for evaluating markup behavior. In particular, Hall [1988a, 1988b] suggests that markup behavior and excess capacity or returns to scale trade off in generating profits. In the current model the impacts of both capacity utilization, and returns to scale on profitability of returns to scale, can be independently identified and assessed.

More specifically, Morrison [1988c] has recently shown that an adjustment factor (ADJ) can be developed that decomposes the difference between revenues and costs when fixity, returns to scale and imperfect competition exist; $C\bullet ADJ=p_Y\bullet Y$ where $ADJ=\epsilon_{CY}/(1+\epsilon_{pY})=\epsilon^{LR}_{CY}\bullet CU_c\bullet PRAT$. The first component of this adjustment factor reflects returns to scale, CU_c captures

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the current context, if the impact of the elasticity in turn determines the markup, the full adjustment is the relevant computation.

capacity utilization and PRAT indicates market power. This decomposition of the deviation of revenues from costs, or profits, facilitates assessment of the Hall [1988a] hypothesis that markups may be consistent with zero profits because profits generated by market power are counteracted by excess capacity with respect to capital.

To formalize this argument, assume constant returns to scale and one fixed input (capital) that determines capacity utilization. The deviation of revenues and costs then becomes $ADJ=CU_c \bullet PRAT$ where $CU_c=(G+Z_K \bullet K)/(G+p_K \bullet K)$. Thus, Hall's argument can be expressed as the hypothesis that ADJ=1, so costs are equal to revenues, even though profits are generated from market power. This is obviously equivalent to the hypothesis that $1/CU_c=PRAT$; CU_c and the price ratio are inversely related, which is plausible since one might expect PRAT always to exceed one[12], and with excess capacity CU_c falls short of one so $1/CU_c$ also exceeds one. The interpretation also makes intuitive sense, because CU_c falling short of one means the firm is overcapitalized, so profits are not as high as they might be with full long run optimization. Whether or not this is true empirically can be determined by comparing the capacity utilization and markup values.

Unfortunately for this argument, a common finding of many researchers computing economic capacity utilization indexes for models with fixed capital is that CU_c measures not only span one, but often exceed one for the U.S.[13] In this case, as long as PRAT>1, the argument cannot hold. However, two other possibilities in the model proposed in this paper suggest that an extended version of the Hall hypothesis might bear fruit.

[11]Morrison [1985] contains an overview of this measure.

[12]The optimized p_Y/MC ratio can be rewritten as $1/(1+\epsilon_{PY})$ since MR=MC implies $MC=p_Y+Y \bullet \partial pY/\partial Y$. $p_Y/MC>1$ suggests, for negative ϵ_{PY}, that ϵ_{PY} evaluated at a given price and output level is in the inelastic range, so ϵ_{YP} is elastic. This must be the case for optimization because only then

First, with labor quasi-fixed the impact of labor hoarding on firm behavior can be modeled. This will affect the capacity utilization measure and potential profits because if too much labor is being held, even if capital is at the correct short run level, full capacity utilization will be lower than one and the firm will be employing more labor than it would with full optimization. This could help rationalize the capacity utilization argument if it pushes capacity utilization measures below one.

Second, the full adjustment measure depends not only on capacity utilization and markups but also on returns to scale, reflecting other fixities that affect production. If returns to scale are permitted, to evaluate the potential profitability of the firm even with market power the full ϵ_{CY} measure is the relevant one to compare to PRAT. Since most studies incorporating returns to scale have found fairly large returns exist, this could further reduce ϵ_{CY} sufficiently to counteract the profit margins available from market power. This profitability hypothesis can be assessed by comparing the indexes of capacity utilization, returns to scale and the markup. The impacts of supply and demand shocks on profitability in turn can be assessed in terms of elasticities of these measures.

III. Measurement of the Determinants of Markup Behavior

The data used for empirical implementation of the model are annual time series for the U.S. and Japanese manufacturing industries, 1960-81. Data for the U.S. were provided by Ernst R. Berndt and David O. Wood [1984], and those for Japan were constructed by Takamitsu Sawa at Kyoto University using a similar methodology. The data were pooled for estimation by including country-specific dummies for the β_{EE}, β_{MM}, α_K, α_L and β_{YY} parameters.

will marginal revenue exceed zero.

[13]See Berndt and Morrison [1981], for example.

Estimation was carried out by three stage least squares with once-lagged variables as instruments to allow for the endogeneity of output, output price and investment and for the unobserved expected prices of the inputs.

The first set of results to consider are the parameter estimates reported in Table 1.[14] The pooling parameters that are included (β_{EJ}, β_{MJ}, γ_{KJ}, γ_{SJ}, and β_{YYJ}) are significantly different from zero. This suggests some differences in the production and demand structure between the two countries, although additional pooling parameters included in preliminary estimation to identify other differences in interactions between inputs and output were insignicant. The extent of pooling in the model suggested by the data implies some similarity of production functions facing manufacturing firms in the two countries. It is likely, however, that even if the available technology is similar, the two countries would choose to produce at different points on the function, given varying resource availabilities and flexibility of adjustment. The significance of the scale parameters (α_{KY}, α_{LY}, $\dot{\gamma}_{KY}$, $\dot{\gamma}_{LY}$, α_{EY} and α_{MY}) also has important implications because restriction of the cost function to constant returns to scale resulted not only in a rejection of constant returns, but also yielded implausible indexes and elasticity estimates.[15] The significance of these interactions clearly reflect an important aspect of the technology that should be included in the model.

The R^2's, squares of the simple correlation between actual and fitted values, are all greater than .6, and those for the p_Y and $G(Y,\psi)$ equations are greater than .92. This suggests the model is providing a good representation

[14]Parameter estimates which were statistically insignificant were deleted, unless symmetry between variable or fixed inputs required retaining them.
[15]An interesting pattern that arises when constant returns to scale estimation is carried out is that markups and adjustment costs both appear smaller and adjustment costs often are insignificantly different from zero. It appears, therefore, that the additional flexibility allowed with the scale parameters is important for the representation of markup behavior even though interpretation of returns to scale in the aggregate is problematic.

of the technology, particularly since the cost equation was not estimated and many of the equations do not have an intercept. Estimation of alternative systems with intercepts appended to the equations were attempted, but did not result in substantive changes in results, although the R^2's were higher.

From these parameter estimates performance indexes and elasticities for the two countries were computed. Consider the markup indexes in the first two columns of Table 2. These indexes, computed as the price ratio p_Y/MC=PRAT, suggest that price margins in the U.S. and Japan have varied both across countries and time.[16] The markup of price over marginal cost in the U.S. has remained in the relatively small range of 11% to 23%, generally increasing over time.[17] The markup for Japan is only slightly larger on average than that for the U.S., but it varies substantially more, ranging from 7% in the beginning of the sample to 48% at the end. The markup is also statistically significant; the standard error for 1976 is .009 for the U.S. and .02 for Japan.

[16]This is true also of average cost measures computed with this model, although there is a large difference between the markup of price over marginal and over average cost. This suggests that previous methods that do not well distinguish marginal from average costs, or assume they are the same may contain serious biases that fluctuate over time. The estimates suggest a declining markup over average cost over time. Combined with the PRAT measures above this implies that average costs are increasing relative to marginal cost over time. Since $MC=AC+Y \cdot \partial AC/\partial Y$, this implies a decrease in $Y \cdot \partial AC/\partial Y$ if increasing returns to scale exist so $\partial AC/\partial Y$ is negative. Thus cost curves may be shifting to the right over time so available returns to scale are increasing. This is consistent with evidence on returns to scale outlined below.

[17]This contrasts with estimates generated in studies like Hall [1986] using nonparametric methods. Most of this deviation can be attributed to the gross output as contrasted to value added framework used here since Domowitz, Hubbard and Peterson have shown that including materials should reduce the estimated margin by a factor of $(1-\alpha_M)$ where α_M is the share of materials in output. Since α_M is approximately 60%, this implies a value-added markup of approximately 45% to 60% which is in the range of the Hall estimates. Such a comparison is not strictly applicable, however, since both capital and labor are quasi-fixed in the current model.

In addition to the secular trends in these indexes, cyclical trends are evident. For example, in some recession years, especially those after the OPEC price shocks of 1973-74 and 1979-80, the price ratios decline. These trends are not, however, as strong as the trends over time, especially in Japan. For example, the drop in the price margin between 1973 and 1974 in the U.S., from 19% to 14%, is only slightly lower than the gap between the 1960 and 1981 markup measures. However, the decline in the markup in Japan of 34% to 30% in 1973-74 was not only smaller than that in the U.S. but also much less dramatic than the change over the whole time period.

Also, the recovery from impacts on the markup is faster in Japan. In Japan, for example, by 1975 the markup already exceeded that in 1973, and it continued to rise until 1978, when the subsequent (perhaps OPEC-inspired) setback experienced until 1980 was again accommodated by 1981. In the U.S., by contrast, the decline became worse through 1975 and then turned around slowly, with the markup just reaching the pre-OPEC level of 1973 by 1981 and never reaching that attained in 1970-71.

Further information about the trends in markups and their responses to supply (cost) as compared to demand shocks can be obtained using the price, marginal cost and price ratio elasticities presented in Table 3. For example, the $\epsilon_{PY,pE}$, $\epsilon_{PY,pM}$, $\epsilon_{MC,pE}$, and $\epsilon_{MC,pM}$ elasticities show that if the price of energy or intermediate materials increases, both price and marginal cost increase. Although both components of the total price ratio change are statistically significant, the magnitude of the response is much larger for materials, as would be expected from the more substantial cost share for materials than energy. The response to materials price changes is also slightly larger in Japan than in the U.S., although for energy it is smaller in Japan.

The combined effects on the price ratio, reflected by $\epsilon_{PRAT,pE}$ and $\epsilon_{PRAT,pM}$, are that increases in the input prices decrease the markup ratio, more for energy in the U.S. and more for materials in Japan. This is consistent with the implications observed in the computed index for responses to energy price changes; the larger energy price elasticity in the U.S. implies that OPEC would have had a more substantial downward impact on the markup ratio in the U.S. The magnitude of this change is also substantial; even with only a .04% change in the ratio for a 1% change in energy prices, the doubling and tripling of energy prices experienced in the 1970s would clearly have caused significant declines in the price margin. This suggests that supply shocks based on input prices are important and in aggregate could appear as procyclical variations in price margins.

Similarly, increases in the levels of capital or labor, which could arise due to any relaxation of the constraint but could potentially be a result of declines in their prices and corresponding investment behavior, cause decreases in both p_Y and MC and a corresponding increase in PRAT. This impact appears even larger for capital than for labor, which is consistent with the larger markups found in Japan over time when investment in capital was phenomenally high.

A final cost side change -- the last component of the ψ vector -- is technical change. The $\epsilon_{PY,t}$, $\epsilon_{MC,t}$, and $\epsilon_{PRAT,t}$ elasticities suggest that if the state of technology improves price decreases, but marginal costs decrease even more so the price ratio increases slightly. Since this price ratio response is larger in Japan than in the U.S. it appears that technical change is more beneficial to Japanese firms than U.S. firms, or possibly that the extra capital that has been accumulated in Japan embodies more recent technology and thus supports a higher price margin.[18]

Demand side short run changes stem from shifts in the demand function due to variations in the components of the ϕ vector. Increases in all of these variables except EXP have positive impacts on both p_Y and MC. Most of these price impacts are smaller for Japan than the U.S., but all are significantly different from zero. Each of the impacts is also small for MC, and, in fact, is insignicantly different from zero, especially in Japan. This suggests slightly more price rigidity in response to demand shocks in Japan as compared to the U.S., and a correspondingly smaller movement along the marginal cost curve, which also is likely flatter than that for the U.S. This latter implication is supported by the low $\epsilon_{MC,Y}$ elasticity reported at the bottom of the Table.

Overall, both demand and supply shocks have an important impact on PRAT. All the elasticities are statistically significant and both supply shocks (particularly capital investment and materials price changes) and demand shocks (especially expenditure per capita and cost of living changes) have rather large influences on markup behavior. Note also that in all cases the PRAT response to cost shocks is reversed from that of the price and marginal cost elasticities. This stems from the larger marginal cost than price elasticity. The reverse holds for demand shocks because the price effect dominates. This is consistent with what might be expected; shifts in curves rather than the corresponding movements along curves dominate price setting behavior.

The degree of market power, in the sense of the deviation of price from marginal cost, appears from these indexes and elasticities to be significant both statistically and in magnitude, and changes both secularly and cyclically

[18]This interpretation is, however, difficult to justify explicitly since embodied technical change is not directly modeled.

in response to various exogenous shocks. Additional evidence about the importance of market power can be obtained from the implied output price or demand elasticity. This $\epsilon_{Y,PY}$ elasticity is the inverse of the $\epsilon_{PY,Y}$ elasticity reported in Table 3; -8.326 for the U.S. and -3.640 in Japan, which is within the range suggested by Hall [1988a] for the U.S. This elasticity is quite large for the U.S., suggesting more competitiveness in the U.S. than in Japan in 1976. The elasticities for the remainder of the sample, however, indicate a larger demand elasticity in Japan than for the U.S. earlier in the sample, consistent with increasing market power over time, as is implied by the relationship $PRAT=1/(1+\epsilon_{PY,Y})$. The inverse demand elasticities are significantly different from zero in all years so there is statistical support for the importance of the downward slope of the demand curve for manufacturing output. This conclusion again coincides with the evidence of significance of the price ratio from one. These results suggest that the hypothesis of perfect competition can clearly be rejected. Although it is more difficult to interpret the level of markups as that experienced by individual firms unless extensive implicit collusion is assumed, the level is reasonably consistent with estimates computed by other researchers. Finally, this discussion suggests that PRAT elasticities can be interpreted as changes in the demand elasticity with changes in the exogenous variables.

In addition to markup measures, indexes indicating the extent of input fixity may be used to evaluate the importance and impacts of these constraints on production. As discussed in the previous section, the extent of fixity is represented by the capacity utilization measure CU_c. This measure, which reflects a combination of the costs of capital and labor fixity, is presented in the second two columns of Table 2. The CU_c index is greater than one for most of the time sample for the U.S., only indicating excess capacity for the

1977-1978 period. This is similar to measures constructed by Berndt and Morrison [1981], among others, and is consistent with observations of strong investment in manufacturing even in years of relatively slow growth.

By contrast, in Japan excess capacity became available as early as 1970 and the amount of excess capacity increased from that time. This was a result primarily of the extensive investment in new capital carried out by Japanese manufacturing firms in the 1970s, so that excess capacity in capital was available from 1970. Capital investment in the U.S., even post-OPEC, was small enough that it fell short of that implied by profit maximization. The impacts of labor fixity partially counteract this, since the shadow value to market price ratio for labor is less than one from 1964 through 1974 and 1976 to 1980 for the U.S. and from 1971 through 1979 for Japan with the values for 1975 and 1976 very slightly exceeding one.

The importance of fixity of factors can be determined by considering the statistical significance of the deviation of the capacity utilization measure from one. The individual shadow price ratios can also be evaluated. For CU_c the standard error tended to be between .01 and .015 for most years. Thus, for 1976 CU_c was significantly different from one for Japan but not for the U.S. This arose primarily because of the deviation of capital from its optimum level; for a Z_K/p_K value of 1.21 in the U.S. and .72 in Japan, the standard errors are .10 and .06, suggesting at least marginal statistical significance from one. For labor, the analogous index yields values of .954 in the U.S. and 1.026 for Japan with standard errors of .03 and .05.[19]

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[19] It is possible also, however, to compute the significance of adjustment costs to ascertain the impact of fixity. These computations provide quite different implications; they suggest adjustment costs for capital are marginally significant in the U.S. and insignificant in Japan. For labor, however, adjustment costs were generally positive and significant for both countries, supporting Solow's [1968] suggestion that labor fixity may be even more important than capital fixity for representation of the technology. This evidence of adjustment costs suggests that the enormous

Returns to scale can be measured by inverting the long run cost elasticity with respect to output changes to obtain $1/\epsilon^{LR}_{CY}$. The cost elasticity is presented in index form as the fifth and sixth columns in Table 2. This elasticity indicates that estimated returns to scale in 1976 are 1.186 for the U.S. and 1.261 for Japan. A cost increase of 1% supports a larger output increase in Japan so returns to scale appear larger in Japan; Japanese manufacturing firms are on a steeper portion of the long run average cost curve. The corresponding standard errors were estimated to be .012 for the U.S. and .017 for Japan, clearly indicating statistical significance of the measure from one for both countries. This evidence plainly conveys evidence of returns to expanding output production, even though it is difficult to interpret these results as indicating returns to scale for individual firms. The indexes suggest that returns to scale are increasing over time, possibly due to an outward shift of the long run average cost curve as larger networks cause reduced costs of inputs such as capital, labor, energy and intermediate materials.

Finally, these measures of fixity and returns to scale can be used to motivate assessment of the hypotheses that fixity (Hall [1988a]) or returns to scale (Hall [1988b]) may counteract price markups so firms effectively have zero profits. As suggested in the previous section, this requires computing the adjusted indexes $ADJ_1 = CU_c \cdot PRAT$ to assess the impact of fixity of capital and labor, $ADJ_2 = \epsilon^{LR}_{CY} \cdot PRAT$ to determine the relationship between markups and returns to scale, and $ADJ_3 = CU_c \cdot \epsilon^{LR}_{CY} \cdot PRAT - \epsilon_{CY} \cdot PRAT$ to ascertain the combined effect of capacity fluctuations and scale economies on the profitability of firms. These indexes are presented in Table 4.

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expansion in capital stock in Japan with a fairly constant labor force has a basis in the fixity of labor relative to capital.

A glance at the indexes for both countries shows that the simple hypothesis that capacity utilization alone can attenuate the excess profitability implied by the gap between price and marginal cost is not supported. This arises because overutilization of capital in an economic sense is not sufficiently counteracted by underutilization of labor to cause the total capacity utilization measure to fall short of unity, so the effect of the adjustment is to push the combined ADJ_1 measure farther from one. However, it is also clear that the availability of long run economies of scale, possibly arising from some other fixity the firm faces, does attenuate the markup; the values reported in the third and fourth columns are very close to one in most years, and drop below one in the later years of the sample for the U.S. This suggests that although excess profitability existed to some extent in the early years of the sample, since 1970 the "excess capacity" from potential scale economies reduced profitability even with a larger markup.

The importance of returns to scale in attenuating excess profitability implies that models that impose constant returns to scale on the data likely underestimate markups. This arises because if ϵ^{LR}_{CY} is assumed to equal one, PRAT (and CU_c) must absorb the impact of scale economies, so their estimates will be biased. Estimation of the current model imposing constant returns confirms this. In fact, markups decrease by nearly fifty percent from those estimated when nonconstant returns to scale are allowed. This is also consistent with the lower markups estimated by Appelbaum [1982] in a similar model with constant returns to scale imposed; Shapiro [1987a] argues that forcing the equality of marginal and average costs causes these markup estimates to be biased downward.

This development provides a perspective on the cyclicality of markups since the question of cyclical price margins has typically been considered in the literature[20] as the question of whether the correlation between capacity utilization and markups is negative or positive. If the Hall hypothesis is to be correct, this implies that CU_c, or ϵ_{CY} in the generalized problem with returns to scale, must be inversely related to the markup since $PRAT \cdot CU_c = 1$ implies $PRAT = 1/CU_c$. This imposes a countercyclical variation in the markup by definition if this correlation is thought to be the relevant interpretation of the cyclicality question. In the U.S. the correlations as well as the levels of CU_c are inconsistent with the Hall hypothesis, but when returns to scale are also taken into account some confirmation is found; the simple correlations of the price ratio with CU_c, ϵ^{LR}_{CY} and ϵ_{CY} are .009, -.65 and -.47, respectively. The relationships in Japan are quite different; for Japan the correlations are -.945, -.981 and -.975. For the U.S. only, therefore, the result for capacity utilization is consistent with the Domowitz, Peterson and Hubbard [1987,1988] finding of slightly procyclical markups.

The interactions between PRAT, CU_c and ϵ^{LR}_{CY} can be further explored using elasticities of these values to see how they change with exogenous supply and demand shocks. The elasticities with respect to CU_c, ϵ^{LR}_{CY} and their combination ϵ_{CY} presented in Table 5 can be compared with the PRAT elasticities in Table 2. This comparison suggests some very interesting relationships between the indicators. For example, for the U.S. the impact of input price shocks and of technology on the price ratio and CU_c appears to be very similar. Thus, the dramatic energy price shocks of the 1970s not only caused PRAT to decline but caused ADJ_1 to decrease even more substantially; the trends are in the same rather than opposite direction. This supports procyclicality rather than the countercyclicality implied by the hypothesis that capacity utilization is a buffer for profitability from markups.

[20]See Domowitz, Hubbard and Peterson [1986, 1988], for example.

The response to capital, and particularly labor adjustment, is somewhat different. Although the CU_c ratio increases with investment[21], it does not rise by as much as the price ratio. For labor, by constrast, increases in employment cause the price ratio to increase but the capacity utilization ratio to decline slightly. Overall, therefore, for the U.S., all cost shocks except changes in employment cause the price ratio and capacity utilization to move in the same direction.[22]

For Japan the story is quite different. Although input price changes cause PRAT and CU_c to move in the same direction, the impact on CU_c is less than half that on PRAT. In addition, the effects of investment and labor force expansion on CU_c are both negative, whereas the impact on the price ratio is positive, particularly for capital. This suggests some profit potential for investment in Japan that is not found in the U.S., possibly from more technology embodied in capital. More simply, it may be that the Hall hypothesis that high price margins support excess capital capacity is more applicable to Japan. Technological change also appears to have pushed PRAT up in Japan by more than capacity utilization, or than PRAT in the U.S.

Demand shocks appear to have a rather similar impact on capacity utilization and the price to marginal cost ratio in both countries; the direction of the impact is the same for all variables except POP but the magnitude of the capacity utilization responses as compared to the price ratio movement is considerably larger in the U.S. and similar for Japan.

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[21]Note that this elasticity, similarly to the other elasticity computations, allows a full optimization change to occur rather than holding output constant. Otherwise, an increase in K should by definition increase capacity and decrease the utilization rate for a given output.

[22]Since adjustments in appear to be countercyclical, restrictions in labor are consistent with procyclicality, similar to the Keynesian view of the impacts of labor hoarding on cyclicality of productivity.

The overall effect of these different shocks is that demand shocks tend to be procyclical for both countries, and have a larger impact on capacity utilization in the U.S. Supply shocks exhibit more variation. They are primarily procyclical in the U.S., and also in Japan for the variable input price changes. Labor force changes may attenuate somewhat the general procyclicality of markups for both countries. More importantly, on balance the response to capital investment differs substantially; the significance of the countercyclicality found in Japan as compared to the U.S. appears to stem from the large growth in the capital stock during this period.

IV. Concluding Comments

This paper has developed and implemented empirically a model of firms' markup pricing behavior using a production theory framework based on output demand and restricted cost functions. My framework allows evaluation of important determinants of production structure and thus firm decision making, such as market power, returns to scale and capacity utilization with quasi-fixed capital and labor hoarding. The procedures used allow explicit consideration of the effects of supply (cost) as compared to demand shocks on pricing behavior. The resulting rich structural model permits assessment of a number of important issues that have been raised in the recent literature on the pricing behavior of firms.

The model has been implemented by applying it to pricing behavior in the manufacturing sectors of the U.S. and Japan. The estimated markup indexes suggest that price margins are statistically signicant and lie in the 11% to 48% range, that they have increased over time, especially in Japan, and that they tend to be slightly procyclical in the U.S. and countercyclical in Japan. Potential profitability from market power, however, is attenuated by a combination of capacity utilization and economies of scale -- primarily the latter. Both supply and demand shocks appear to have important impacts on pricing decisions and their cyclical nature, particularly prices of the variable inputs, capital accumulation, and the cost of living. In addition, the fixity of labor seems to be an important constraint on firm behavior in the short run because adjustment costs are significant, and nonconstant returns appear important to take into account.

An interesting feature of this study is the U.S.-Japan comparison. Overall, these countries appear to have a similar production structure statistically, since most pooling parameters included in the model were insignificant, although some important differences arise. The major difference is the size and extent of time trend of the markups. This appears primarily to arise from the investment behavior observed in Japan; although in the U.S. investment has not been large enough to provide a profit-maximizing level of capital capacity, the enormous level of investment in Japan caused excessive capital to be available from the early 1970's, supporting the large observed price margins.

Another potentially illuminating comparison is between different industries. Although disaggregation from the manufacturing level was not pursued here, some important differences have been noted in particular for durable as compared to nondurable goods by Bils [1987a] and Domowitz et al [1987]. Applying the rich structural model of this study to more disaggregated data will be a useful future extension.

Table 1
Three Stage Least Squares Parameter Estimates
(asymptotic t-statistics in parentheses)

β_{EM}	5.2540 (3.489)	$\ddot{\gamma}_{KK}$	-1.5206 (3.199)	α_{Mt}	-19.326 (2.865)
β_{EE}	183.70 (3.189)	$\ddot{\gamma}_{LL}$	.6283 (2.471)	δ_{ML}	-300.03 (7.699)
β_{EJ}	-12.342 (7.629)	$\dot{\alpha}_{Kt}$	-.6939 (2.793)	δ_{MK}	-220.84 (3.674)
$\dot{\delta}_{EK}$	-16.879 (4.839)	$\dot{\alpha}_{Lt}$	.1511 (1.307)	α_{MY}	-156.16 (3.724)
$\dot{\delta}_{EL}$	-1.6726 (1.155)	$\dot{\alpha}_{KY}$	6.0140 (4.332)	β_{YCPI}	22.416 (9.508)
α_{Et}	-18.496 (3.409)	$\dot{\alpha}_{LY}$	-.8797 (2.439)	β_{Yr}	.7335 (5.199)
δ_{EK}	19.988 (.336)	γ_{KY}	-19.840 (1.239)	β_{YPIM}	2.4240 (6.096)
δ_{EL}	-139.63 (3.932)	γ_{LY}	7.7189 (1.031)	β_{YEXP}	-6.6938 (3.910)
γ_{KK}	64.560 (4.949)	α_{EY}	-3.7124 (.098)	β_{YY}	-.6591 (17.452)
γ_{KJ}	-13.298 (8.711)	$\dot{\gamma}_{KL}$	.9849 (2.187)	β_{YYJ}	.01981 (5.042)
γ_{LL}	.8704 (.114)	$\dot{\gamma}_{LK}$	6.8782 (7.351)		
γ_{LJ}	28.669 (16.191)	β_{MM}	1154.1 (18.234)		
γ_{KL}	-26.716 (2.477)	β_{MJ}	-31.614 (9.386)		
α_{Kt}	-3.2943 (1.456)	$\dot{\delta}_{MK}$	-19.897 (5.318)		
α_{Lt}	10.033 (4.214)	$\dot{\delta}_{ML}$	-2.508 (3.484)		

R^2's	
P_Y	.9962
ΔK	.6889
ΔL	.8771
E	.6053
M	.7512
G	.9273

Table 2

Markup Ratio, Returns to Scale and Capacity Utilization Measures

	PRAT		CU_c		ϵ^{LR}_{CY}		ϵ_{CY}	
	U.S.	Japan	U.S.	Japan	U.S.	Japan	U.S.	Japan
1960	1.110	1.069	1.074	1.178	0.894	0.940	0.961	1.108
1961	1.110	1.072	1.068	1.135	0.893	0.933	0.954	1.060
1962	1.115	1.096	1.058	1.130	0.890	0.926	0.943	1.046
1963	1.130	1.114	1.060	1.125	0.885	0.918	0.938	1.033
1964	1.133	1.131	1.050	1.107	0.882	0.912	0.927	1.010
1965	1.141	1.152	1.042	1.100	0.878	0.905	0.915	0.996
1966	1.148	1.165	1.034	1.097	0.873	0.900	0.903	0.988
1967	1.167	1.176	1.040	1.074	0.865	0.896	0.900	0.962
1968	1.189	1.204	1.039	1.060	0.856	0.887	0.890	0.941
1969	1.205	1.230	1.043	1.030	0.850	0.876	0.888	0.903
1970	1.228	1.250	1.055	0.999	0.842	0.866	0.888	0.866
1971	1.224	1.300	1.051	0.982	0.840	0.850	0.883	0.835
1972	1.203	1.336	1.032	0.980	0.844	0.839	0.871	0.822
1973	1.194	1.337	1.026	0.961	0.843	0.834	0.866	0.802
1974	1.150	1.305	1.007	0.901	0.847	0.817	0.854	0.736
1975	1.138	1.352	1.010	0.923	0.844	0.801	0.853	0.739
1976	1.136	1.378	1.005	0.943	0.843	0.793	0.847	0.748
1977	1.138	1.406	0.992	0.951	0.838	0.784	0.832	0.746
1978	1.156	1.481	0.999	0.927	0.830	0.776	0.830	0.720
1979	1.161	1.472	1.017	0.920	0.822	0.769	0.836	0.708
1980	1.178	1.426	1.051	0.910	0.804	0.750	0.846	0.683
1981	1.205	1.481	1.085	0.930	0.787	0.729	0.854	0.678

Table 3

Price, Marginal Cost, and Markup Ratio Elasticities
(Reported for 1978, t-statistics in parentheses)

	U.S.			Japan		
ψ	$\epsilon_{PY,\psi}$ −	$\epsilon_{MC,\psi}$ =	$\epsilon_{PRAT,\psi}$	$\epsilon_{PY,\psi}$ −	$\epsilon_{MC,\psi}$ =	$\epsilon_{PRAT,\psi}$
P_E	.0378 (5.963)	.0782 (6.079)	-.0404 (6.188)	.0234 (6.825)	.0513 (6.804)	-.0279 (6.746)
P_M	.3627 (7.874)	.7502 (8.075)	-.3875 (8.262)	.4096 (11.567)	.8967 (12.429)	-.4872 (13.021)
K	-.0868 (9.105)	-.1796 (9.401)	.0928 (9.683)	-.1255 (9.984)	-.2748 (10.558)	.1493 (10.949)
L	-.0305 (2.872)	-.0631 (2.877)	.0326 (2.882)	-.0312 (2.372)	-.0683 (2.373)	.0371 (2.372)
t	-.0021 (4.086)	-.0044 (4.084)	.0023 (4.080)	-.0033 (4.902)	-.0073 (4.867)	.0040 (4.824)
ϕ	$\epsilon_{PY,\phi}$	$\epsilon_{MC,\phi}$	$\epsilon_{PRAT,\phi}$	$\epsilon_{PY,\phi}$	$\epsilon_{MC,\phi}$	$\epsilon_{PRAT,\phi}$
CPI	.6774 (8.097)	.1939 (1.567)	.4835 (7.289)	.6430 (9.124)	.0590 (.620)	.5840 (9.618)
EXP	-.2025 (3.785)	-.0580 (1.422)	-.1445 (4.068)	-.1975 (3.916)	-.0181 (.6032)	-.1794 (4.286)
r	.0446 (5.016)	.0128 (1.552)	.0318 (4.468)	.0402 (4.921)	.0037 (.6226)	.0365 (4.921)
P_{IM}	.0800 (5.623)	.0229 (1.618)	.0571 (4.385)	.0813 (5.867)	.0075 (.6311)	.0738 (5.088)
POP	.0206 (1.721)	.0426 (1.712)	-.0220 (1.704)	.0143 (.642)	.0313 (.639)	-.0170 (.637)
Y	$\epsilon_{PY,Y}$ −	$\epsilon_{MC,Y}$ =	$\epsilon_{PRAT,Y}$	$\epsilon_{PY,Y}$ −	$\epsilon_{MC,Y}$ =	$\epsilon_{PRAT,Y}$
	-.1201 (17.530)	.0515 (1.406)	-.1716 (5.178)	-.2747 (20.349)	.0330 (.606)	-.3076 (6.309)

Table 4

Adjustment Factors

	$CU_c \bullet PRAT$		$\epsilon^{LR}_{CY} \bullet PRAT$		$\epsilon_{CY} \bullet PRAT$	
	U.S.	Japan	U.S.	Japan	U.S.	Japan
1960	1.193	1.259	0.993	1.005	1.067	1.184
1961	1.185	1.218	0.991	1.001	1.059	1.137
1962	1.181	1.239	0.993	1.015	1.052	1.148
1963	1.199	1.254	1.001	1.023	1.061	1.151
1964	1.190	1.253	1.000	1.032	1.051	1.143
1965	1.189	1.268	1.002	1.043	1.045	1.148
1966	1.188	1.278	1.003	1.049	1.037	1.151
1967	1.215	1.263	1.010	1.054	1.051	1.132
1968	1.237	1.277	1.019	1.068	1.060	1.133
1969	1.258	1.267	1.025	1.079	1.070	1.111
1970	1.296	1.250	1.035	1.083	1.092	1.083
1971	1.286	1.277	1.029	1.105	1.082	1.086
1972	1.242	1.309	1.016	1.121	1.048	1.099
1973	1.226	1.286	1.007	1.116	1.034	1.073
1974	1.159	1.175	0.975	1.067	0.983	0.961
1975	1.150	1.248	0.962	1.083	0.972	1.000
1976	1.143	1.300	0.958	1.093	0.963	1.031
1977	1.130	1.338	0.955	1.104	0.947	1.050
1978	1.155	1.373	0.960	1.150	0.960	1.066
1979	1.181	1.355	0.955	1.133	0.971	1.043
1980	1.239	1.298	0.948	1.071	0.997	0.975
1981	1.307	1.377	0.949	1.080	1.030	1.004

Table 5

Capacity Utilization and Returns to Scale elasticities

(t-statistics in parentheses)

	U.S.			Japan		
ψ	$\epsilon_{CU,\psi}$ +	$\epsilon_{RTS,\psi}$ =	$\epsilon_{ECY,\psi}$	$\epsilon_{CU,\psi}$ +	$\epsilon_{RTS,\psi}$ =	$\epsilon_{ECY,\psi}$
p_E	-.0256 (1.851)	-.0097 (.5924)	-.0353 (5.034)	-.0135 (1.262)	-.0422 (3.480)	-.0556 (11.855)
p_M	-.4065 (4.263)	.1460 (1.327)	-.2604 (5.272)	-.1413 (2.461)	.1224 (1.526)	-.0189 (.3984)
K	.0487 (2.260)	-.1032 (6.181)	-.0544 (4.482)	-.0850 (2.290)	-.1382 (4.924)	-.2233 (13.320)
L	-.0284 (1.878)	-.0100 (.5904)	-.0384 (2.969)	-.0291 (1.595)	-.0075 (.4254)	-.0367 (1.873)
t	.0017 (1.982)	-.0016 (3.238)	.0001 (.2674)	.0015 (1.616)	-.0022 (4.404)	-.0007 (.9336)
ϕ	$\epsilon_{CU,\phi}$ +	$\epsilon_{RTS,\phi}$ =	$\epsilon_{ECY,\phi}$	$\epsilon_{CU,\phi}$ +	$\epsilon_{RTS,\phi}$ =	$\epsilon_{ECY,\phi}$
CPI	.9039 (6.776)	-.1540 (1.102)	.7498 (7.840)	.5877 (6.968)	-.0910 (.920)	.4967 (6.190)
EXP	-.2702 (3.862)	.0460 (1.100)	-.2241 (3.739)	-.1805 (3.826)	.0279 (.9204)	-.1526 (3.439)
r	.0595 (4.440)	-.0101 (1.078)	.0493 (4.876)	.0368 (4.579)	-.0057 (.9068)	.0311 (4.490)
p_{IM}	.1067 (4.831)	-.0182 (1.077)	.0885 (5.568)	.0743 (5.066)	-.0115 (.9055)	.0628 (5.122)
POP	.1987 (7.030)	-.0339 (1.076)	.1649 (15.347)	.3116 (7.956)	-.0482 (.904)	.2634 (10.194)
Y	$\epsilon_{CU,Y}$ +	$\epsilon_{RTS,Y}$ =	$\epsilon_{ECY,Y}$	$\epsilon_{CU,Y}$ +	$\epsilon_{RTS,Y}$ =	$\epsilon_{ECY,Y}$
	.2399 (5.855)	-.0409 (1.132)	.1990 (5.476)	.3287 (8.089)	-.0509 (.954)	.2778 (5.480)

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