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MARKET POWER, ECONOMIC PROFITABILITY AND PRODUCTIVITY GROWTH MEASUREMENT: AN INTEGRATED STRUCTURAL APPROACH

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ABSTRACT

The purpose of this paper is to treat scale economies, profit-maximizing markups, economic profitability, capacity utilization and productivity growth within an integrated structural model, and to assess their interactions empirically using annual two-digit U.S. manufacturing data. Attention is focused on error biases in measuring productivity using traditional accounting procedures. An important conjecture by Robert Hall, that the coexistence of normal economic profits and positive markups of price over marginal cost imply the existence of substantial scale economies and excess capacity, is then examined using this structure.

The empirical results suggest that markups in most U.S. manufacturing firms have increased over time, and tend to be countercyclical. However, procyclical capacity utilization and scale economies tend to offset the short run profit potential from markup behavior. As a result, on average economic profits are normal, but declining profitability is prevalent in most industries since the early 1970s. Also, although cost and revenue shares tend to be approximately equal, the error biases in standard productivity growth measures resulting from input fixity and scale economies are substantial, particularly over business cycles.

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I. Introduction

In the last few years, macroeconomists and students of industrial organization have reexamined relationships among scale economies, markups, economic profitability and productivity growth. Paul Romer [1986] has emphasized the importance of increasing returns for productivity growth at the aggregate industry or economy level. Empirical evidence supporting this has been presented by Robert Hall [1986,1988a,1988b], who reported both significant increasing returns and markups of price over marginal cost in various U.S. industries. Hall also finds that economic profits are approximately normal, suggesting an industrial structure along the classic lines of monopolistic competition. Related evidence on the cyclical nature of markups, suggesting some procyclicality of markup behavior, has been presented by Domowitz, Hubbard and Petersen [1987, 1988].

Analysis of the cyclical characteristics of Robert Solow's [1958] productivity residual provided the basis for these empirical studies. The resulting framework is limited, however, by its dependence on a number of necessarily restrictive assumptions[1]. Each study therefore focuses on a particular issue, with little acknowledgment of linkages among different results and hypotheses. The purpose of this paper is to extend this type of analysis to treat scale economies, profit-maximizing markups, economic profitability, capacity utilization and productivity growth within an integrated theoretical structural model, to assess their interactions empirically using detailed two-digit U.S. manufacturing data, and to examine the generality of findings reported in the earlier studies.

More specifically, using the "new industrial economics" approach outlined by Timothy Bresnahan [1988] in which marginal cost and therefore

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[1]These are outlined somewhat further in Section IV of this paper.

markups are unobserved but estimated econometrically, I specify an integrated cost and demand structure for each industry. The structure is quite general in that (i) markups and returns to scale are permitted to vary over time (they are not constant parameters); (ii) variable and quasi-fixed inputs are distinguished (by explicit recognition of adjustment costs) thereby allowing short- and long-run impacts to differ; (iii) quasi-fixity of both capital and labor is incorporated (to accommodate labor hoarding as well as slow adjustment of capital); (iv) input substitution is not constrained a priori (a generalized Leontief restricted cost function is employed and gross output rather than value-added is used as a measure of output); (v) nonstatic expectations are allowed for (through an instrumental variable estimation procedure); and (vi) the effects of supply and demand "shocks" are directly represented (by specifying and estimating industry-specific cost, input demand and output demand functions). Resulting estimated economic performance indexes therefore reflect the existence of these characteristics of production.

Although measures of scale economies, markups and economic profitability by industry are of interest in their own right, this general specification allows their linkages as well as their impacts on productivity growth to be formalized and measured. In particular, in this paper I focus on implications of these phenomena and their interactions for the measurement and interpretation of multifactor productivity growth in U.S. industries.

Building on my earlier work (Morrison [1986,1989a,1989b,1990]) that dealt with differences between primal- (revenue) and cost-based specifications of productivity growth[2], I consider theoretically and empirically the "error biases" that result in traditional primal multifactor productivity growth measurement by failing to take into account properly the effects of markups,

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[2]This work formalized a framework sketched out by Zvi Griliches [1967].

input fixities, and scale economies. The structural framework used for this analysis facilitates empirical assessment of the important conjecture made by Hall, that since economic profits are normal in most industries and yet markups are considerable, then scale economies and excess capacity must be substantial.

The data I use are similar to those used by Hall, although my focus is on manufacturing rather than on all 1-digit industries. I estimate structural equations for seventeen 2-digit U.S. industries, and aggregated durable, nondurable and total manufacturing industries. The data on which the estimation is based are annual data from 1950 to 1986 from the Bureau of Labor Statistics on prices and quantities of gross output, and capital, labor, intermediate material, energy and purchased services inputs.

I begin my analysis in Section II by outlining fundamental theoretical results linking productivity growth, markups, scale economies and capacity utilization. Then in Section III I compare the generality of the framework motivated by these results with those used in previous literature on productivity growth, stressing implications for error biases in measuring such growth. In Sections IV and V I outline the contributions of the structural model for empirical implementation, and present empirical results.

My principal empirical findings are that markups have been countercyclical and have an upward trend for most industries, and that excess capacity and the potential to exploit scale economies have tended to expand over time. In terms of economic profitability, these characteristics of cost and demand tend to offset each other, resulting in approximately normal profits on average, although declining profitability since 1973 is prevalent for a number of (especially durable manufacturing) industries. These empirical results are consistent with Hall's conjectures. Moreover, they imply that cost and revenue shares, and therefore standard primal and cost-based measures of multifactor productivity growth, are by coincidence rather similar on average. However, I find that these traditional measures of productivity growth may be misleading due to inappropriate assumptions and error biases resulting from input fixities and scale economies.

II. Fundamental Results Used for the Analysis

To motivate formally the theoretical linkages among productivity growth, markups, scale economies and capacity utilization, I will rely primarily on three results. These results can be combined and employed directly to motivate the use of estimated cost and demand elasticities that relax the standard restrictive assumptions. This allows generalization and refinement of productivity growth measures, and determination of how various characteristics of technology and market structure are related. The three results can be summarized and integrated as follows.

First, I will initially base the analysis of productivity change on the traditional output-side specification of productivity growth motivated by the technical change literature introduced by Solow [1958]:

$$\text{1a)} \qquad \frac{\partial \ln Y}{\partial t} = \frac{dY/dt}{Y} - \sum_j \frac{p_j v_j}{p_Y Y} \frac{dv_j/dt}{v_j} = \frac{dY/dt}{Y} - \sum_j S_j \frac{\dot{v}_j}{v_j} = \epsilon_{Yt} ,$$

where Y and p_Y are output quantity and price, v_j and p_j are corresponding input measures, "." denotes a time derivative, and S_j is the revenue share $p_j v_j / p_Y Y$. With perfect competition, instantaneous adjustment and constant returns to scale, this is equivalent (except for a change in sign) to the cost-side specification[3]

$$\text{1b)} \qquad \frac{\partial \ln C}{\partial t} = \frac{dC/dt}{C} - \frac{dY/dt}{Y} - \sum_j \frac{p_j v_j}{C} \frac{dp_j/dt}{p_j}$$

[3]See Ohta [1975] or Morrison [1990] for further elaboration of this equality.

$$= \frac{dC/dt}{C} - \frac{dY/dt}{Y} - \sum_j M_j \frac{\dot{p}_j}{p_j} = \epsilon_{Ct} ,$$

where Y(v,t) is the production function, C(p,Y,t) is the corresponding dual (total) cost function, v and p are vectors of the v_j and p_j values, M_j is the cost-share $p_j v_j/C$, and t represents technology (or the passing of time).

The residual measure of technical progress, representing the growth in output that cannot be attributed to increases in inputs (1a), or, conversely, the diminution of costs not explained by changes in input prices (1b), has been denoted the Solow residual. It is often constructed using only value-added output, and thus only capital and labor inputs. Although Hall uses the value-added approach, more generally this multifactor productivity measure can include other inputs affecting production of gross output, such as energy and intermediate materials. In this study I employ this more complete specification of input changes, thereby permitting, for example, the assessment of substitution of labor for energy after energy price increases.

Secondly, I will exploit information on the relationship between costs and revenues incorporated in the cost and output shares used in the productivity growth computations. If perfect competition, instantaneous adjustment (full utilization) and constant returns to scale (CRTS) prevail, $p_Y Y = C$. In this case revenue and cost shares are identical and thus primal and cost productivity measures are equivalent (as in (1a) and (1b)). However, if any of these restrictions are invalid, differences between revenues and costs will occur. For example, this can arise because imperfect competition implies $p_Y \neq MC$ (where $MC = \partial C/\partial Y$ represents marginal cost), or because nonconstant returns to scale or fixity cause $AC \neq MC$ (where $AC = C/Y$ denotes average cost). I have shown elsewhere (Morrison [1989b]) that recognizing these differences results in the relation

$$2)\qquad p_Y Y = C \cdot \frac{MC \cdot Y}{C} \frac{p_Y}{MC} = C \cdot \epsilon_{CY}/(1+\epsilon_{PY}) \;= C \cdot ADJ\;.$$

This adaptation relies on two elasticity expressions. The cost elasticity $\epsilon_{CY} = \partial \ln C(Y,\cdot)/\partial \ln Y = MC \cdot Y/C$ is defined in terms of the total cost function $C=C(p,Y,t)$. The inverse demand elasticity $\epsilon_{PY} = [\partial p_Y(Y,\cdot)/\partial Y] \cdot Y/p_Y$ is based on the inverse demand function $p_Y=p_Y(Y,\rho)$, where ρ is a vector of shift variables for the output demand function. Equation (2) therefore explicitly captures the dependence of revenue on both the cost- (or supply-) and demand-side elasticities through the adjustment factor $ADJ=\epsilon_{CY}/(1+\epsilon_{PY})$.

Although the $\epsilon_{CY}=MC \cdot Y/C$ equality holds by definition, the equality of the inverse demand elasticity ϵ_{PY} and the markup of output price over marginal cost requires some additional motivation. Essentially this relationship emerges because, for any level of output produced, assuming the profit maximization condition MR=MC holds (where MR is marginal revenue), the markup p_Y/MC can be written as $p_Y/MR = p_Y/(p_Y+Y \cdot \partial p_Y(Y,\cdot)/\partial Y) = 1/(1+\epsilon_{PY})$. Thus, when market power exists from any factor affecting the shape of the demand curve facing a firm, such as product differentiation in the context of monopolistic competition, $\epsilon_{PY} \neq 0$ and the $p_Y Y=C$ equality must accordingly be adapted.

Thirdly, a result based on the ϵ_{CY} elasticity can be used to interpret equation (2) further: the cost elasticity with respect to output $\epsilon_{CY} = \partial \ln C/\partial \ln Y = (\partial C/\partial Y)Y/C=MC/AC$ differs from one if either nonconstant returns (long run fixities) or short run fixities exist. Specifically, I have shown elsewhere (in Morrison [1989b]) that ϵ_{CY} is a combination of the impacts of long run returns to scale and capacity utilization, such that

$$3)\qquad \epsilon_{CY} = \eta(1-\textstyle\sum \epsilon_{Ck}) = \epsilon^{L}_{CY} \cdot CU_c = \frac{MC \cdot Y}{C^*} \frac{C^*}{C}\;.$$

This equality depends on the definitions of (the inverse of) returns to scale ϵ^L_{CY} (where L denotes long run), and a cost-side measure of capacity utilization CU_c. Development of these measures requires a representation of the cost function explicitly incorporating fixed inputs, $C(p,Y,t) = G(p,Y,t,x)+\sum_k p_k x_k$, where $G(\cdot)$ is a variable cost function and x a vector of K quasi-fixed inputs x_k having <u>ex ante</u> rental (market) prices p_k. Based on this representation the associated shadow cost function $C^*=G(p,Y,t,x)+\sum_k Z_k x_k$ can be defined, where Z_k is the shadow value of x_k, $\partial G/\partial x_k$. This forms the basis for defining ϵ^L_{CY} as $\epsilon^L_{CY} = (MC\cdot Y)/C^*$[4] (where $MC=\partial C/\partial Y=\partial G/\partial Y$), and CU_c as $CU_c=C^*/C = (1-\sum\epsilon_{Ck})$ (where $\epsilon_{Ck} = [\partial C(\cdot)/\partial x_k]\cdot x_k/C = [p_k+\partial G(\cdot)/\partial x_k]\cdot x_k/C)$.[5]

Intuitively, equation (3) indicates that the change in costs as output varies is a combination of the potential economies of scale implied by the sloped long run average cost curve (cost changes associated with long run returns to scale) and the constraints faced from input fixity that are reflected in the slope of the short run cost curve (cost changes arising from potential returns to variable inputs in the short run). When long run constant returns to scale exist, $\epsilon^L_{CY}=1$ and all cost changes are associated with short run returns to inputs. When instantaneous adjustment prevails, $\epsilon_{Ck} = (p_K-Z_k)x_k/C = 0$, and cost changes result only from movements along the long run cost curve. This full equilibrium condition is equivalent to saying that $CU_c=1$; capacity (defined in terms of all fixed inputs) is fully utilized.

Putting the second and third results together shows that:

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[4] $1/\eta$ therefore represents the proportional change in output possible from a given percentage change in costs. If this exceeds one, long run average costs decline with a scale expansion so there is potential for proportionately greater output than cost increases.

[5] C^*/C represents capacity utilization since utilization fluctuations arising from fixity of factors imply the marginal valuation (Z_k) deviates from the market price (p_k) for any fixed factor x_k. This expression assumes homotheticity of $Y(\cdot)$, as was shown in Morrison [1986], although a comparable version can be generated for nonhomothetic cases.

4) $$p_Y Y = C \cdot \frac{MC \cdot Y}{C^*} \frac{C^*}{C} \frac{p_Y}{MC} = C \cdot \epsilon^L_{CY} \cdot CU_c / (1+\epsilon_{PY}) \quad .$$

An important implication of this expression is that when $\epsilon_{PY} \neq 0$ from product differentiation or $\epsilon_{CY} \neq 1$ due to either scale economies or fixity, the equivalence of (1a) and (1b) is destroyed. This results both because (i) the assumptions on which these measures are constructed are invalid, so corrections must be made to measure technical change appropriately, and (ii) because the primal (but not the cost) measure includes all returns to cost and market characteristics, so a decomposition may be carried out to identify these impacts separately. This latter deviation arises from (4) because it shows that revenue $p_Y Y$ (and therefore the revenue shares appearing in (1a)) embodies returns to all characteristics of the production process that cause $p_Y Y \neq C$ -- fixity, scale economies and market power. However, costs C (and thus the shares in cost) include only <u>ex ante</u> returns to inputs so (1b) captures the effect of technical change independent of these other effects.

These implications highlight that adapting productivity growth measures to recognize generally neglected characteristics of the technology and the market provides insights into why observed productivity growth fluctuations might occur, and how one might identify their underlying components. For example, if markups are increasing over time, it follows that standard primal productivity growth measures based on (1a) will be increasingly downward biased over time. Technical change advances in this case will be understated because some growth in output will inadvertently be attributed to increases in the price of a unit of output. Similar errors arise if invalid assumptions of CRTS and instantaneous adjustment ($\epsilon_{CY}=1$) are made. These are, however, somewhat more complex to untangle because not only biases but also decompositions are implied. Adaptations to deal with these measurement issues will be formalized further in the next section.

Another useful point arising from consideration of (4) is that if approximately normal profits are observed for a firm or industry, then $p_Y Y \approx C$, which in turn means $ADJ = \epsilon_{CY}/(1+\epsilon_{pY}) = \epsilon^L_{CY} \cdot CU_C/(1+\epsilon_{pY}) \approx 1$. This provides a useful context in which to assess the Hall [1986] contentions that capacity utilization and returns to scale may attenuate the profitability arising from market power. Using (4), in essense this means that the cost characteristics reflected in ϵ_{CY} must counteract the markup p_Y/MC. This could occur since if short or long run fixities (excess capacity) exist, $\epsilon_{CY}<1$, and since markups imply that $p_Y/MC = (1/\epsilon_{pY})>1$, it follows that the ratio of these two factors could be approximately one.

The observation of apparent normal profits not only suggests that the levels of the markup, capacity utilization and returns to scale measures must be such that this condition holds, but also that if ϵ_{CY} declines (due either to decreases in capacity utilization or increases in potential returns to scale), this will support a larger markup without increasing overall profitability. This has significant implications for the cyclical behavior of markups. If CRTS prevails, for example, increases in capacity utilization will be associated with decreases in markups, meaning countercyclical markups will be observed. Hall's [1986] conjecture about the relationship between markups and excess capacity therefore directly implies countercyclical markups.[6] This tendency could, of course, be counteracted by changes in scale economies if the CRTS assumption is invalid.[7]

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[6]A somewhat different argument for countercyclical markups, motivated by industrial organization theory, has been presented by Rotemberg and Saloner [1986].

[7]See Morrison [1988b,1989a] for further analysis of how this might happen when capacity is overutilized.

Issues motivated by consideration of (1) and (4) thus have important implications for the correct measurement of "true" productivity or technical change, and for analysis of the interactions among cost and demand characteristics of the production process. To pursue these implications further, however, the theory underlying adaptation of traditional productivity growth measures for these characteristics must be formalized, and an empirically implementable model must be developed to allow estimation of the appropriate elasticities. These steps are pursued in the next two sections.

III. The Implications of These Relationships for Productivity Growth

Recognizing the impacts of the different cost and market characteristics -- markups, scale and fixity -- has somewhat varied implications for productivity growth measurement. For example, correcting for imperfect competition simply requires recognizing that the denominators of the revenue and cost shares differ due to $p_Y Y \neq MC \cdot Y = C$ (given $\epsilon_{CY}=1$). Since appropriate measurement of aggregate input growth requires weighting input changes by cost shares, adapting for this necessitates an error bias correction to change the share-weights. Correcting for scale economies implies that the deviation between MC and AC must be accomodated; this is accomplished as an error bias correction to change the denominator of the weights on both output and input changes. This also implies a decomposition of the primal measure to isolate true technical change from the combined productivity impact of technical change and scale economies. Allowing for the impact of fixities from $Z_k \neq p_k$ requires one additional step; the numerator of both the primal and cost share-weights for the quasi-fixed inputs, as well as the denominator of the cost shares must be adapted.

More specifically, the deviation between (1a) and (1b) arising from imperfect competition occurs only because $(1+\epsilon_{pY}) \neq 1$ implies $p_Y Y \neq C$; no assumptions are imbedded in the construction of these expressions affecting the cost measures or the numerators of the shares. Thus, reconciling (1a) and (1b) requires recognizing that $(1+\epsilon_{PY})=MC/p_Y=C/p_YY$, so $S_j=M_j(1+\epsilon_{PY})$[8] and $\epsilon_{Yt}=-\epsilon_{Ct}+\epsilon_{PY}\cdot\sum_j M_j(\dot{v}_j/v_j)$. This expression appropriately measures the input shares in terms of costs rather than revenue. Therefore, correcting the ϵ_{Yt} computation for markups requires computing $\epsilon^M{}_{Yt}=-\epsilon_{Ct}=\epsilon_{Yt}\cdot\epsilon_{PY}\cdot\sum_j M_j(\dot{x}_j/x_j)$, where $\epsilon_{PY}\cdot\sum_j M_j(\dot{x}_j/x_j)$ may be considered the "error bias" in the usual primal measurement of productivity growth, and M stands for the "Markup correction". The bias therefore depends on the cost shares, the inverse demand elasticity (or markup), and the growth rates of the inputs.

If scale economies or changes in capacity utilization also exist, the restrictive assumption that $\epsilon_{CY}=1$ must also be relaxed for measurement and interpretation of productivity growth. The additional complexity of adapting productivity growth measures for $\epsilon_{CY}\neq 1$, since this affects the weight on output growth and the numerator as well as the denominator of the shares, motivates the division of the refinement of the productivity growth measurement framework into two parts -- a decomposition in addition to the error bias correction.

To correct for error biases arising from $\epsilon_{CY}\neq 1$, it must be recognized that (1b) is based on the assumption that the cost function can be written as a unit cost function $AC=C/Y=c(p,t)$ so $\epsilon_{CY}=1$ and $d\ln c/dt = d\ln (C/Y)/dt = d\ln C/dt - d\ln Y/dt$. However, if $\epsilon_{CY}\neq 1$ this is not valid; the average cost derivative becomes $d\ln C/dt-\epsilon_{CY}(d\ln Y/dt)$. Application of equation (1b) is therefore incorrect unless this adaptation is made.

More formally, to correct for $\epsilon_{CY}\neq 1$ owing to scale economies, as shown in Morrison [1989b], the residual ϵ_{Ct} must be adjusted to

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[8] Thus $S_j-M_j\epsilon_{PY}=M_j$.

$$5) \qquad \epsilon_{Ct}^{R} = \frac{\dot{C}}{C} - \epsilon_{CY}\frac{\dot{Y}}{Y} - \sum_j \frac{p_j v_j}{C}\frac{\dot{p}_j}{p_j} = -\epsilon_{CY}\frac{\dot{Y}}{Y} + \sum_j \frac{p_j v_j}{C}\frac{\dot{v}_j}{v_j} = \epsilon_{Ct} + (1-\epsilon_{CY})\frac{\dot{Y}}{Y},$$

where R represents "adjusted for Returns to scale", and the last term is the error bias in traditional measures when CRTS is assumed inappropriately. The adaptation in (5) reflects that $\epsilon_{CY} = MC \cdot Y/C = MC \cdot Y/AC \cdot Y = MC/AC$. Thus, the adjustment by ϵ_{CY} restates the change in output in terms of its correct marginal value. The impact of the bias depends on the extent of potential scale economies and the output growth rate.

If instead $\epsilon_{CY} \neq 1$ because $\epsilon_{Ck} \neq 0$ due to fixity and therefore non-optimal capacity utilization, this implies that the valuation of the quasi-fixed inputs at their market prices p_k is erroneous; valuation should instead be in terms of the shadow value, Z_k, reflecting the true marginal product of x_k. This implies an adjustment for the numerator of the share weight on quasi-fixed input changes as well as for the denominator on weights of all inputs and output.

This occurs because (1b) depends on instantaneous adjustment through the use of Shephard's lemma to substitute v_j, the cost minimizing demand for input i, for $\partial C/\partial p_j$, which assumes marginal products always reflect market prices for all inputs. If any input k (x_k) is quasi-fixed, however, this is not valid because the firm will not be able to choose instantaneously a cost minimizing demand for x_k; valuation of the changes in quasi-fixed inputs should be at the shadow value Z_k instead of p_k, and input shares should be measured in terms of C*. Adaptation of the weight on output changes arises in this case also, because variable and total costs do not change proportionately with output in the short run even if long run CRTS prevails. Non-optimal use of the fixed inputs implies $\epsilon_{CY} = 1-\sum_k \epsilon_{Ck} = C^*/C \neq 1$.

The resulting corrected expression for ϵ_{Ct} therefore becomes

$$6)\qquad \epsilon^F_{Ct} = (1-\sum_k \epsilon_{Ck})\frac{\dot{Y}}{Y} - \sum_k \frac{Z_k x_k}{C}\frac{\dot{x}_k}{x_k} - \sum_j \frac{p_j v_j}{C}\frac{\dot{v}_j}{v_j}$$

$$= \epsilon_{Ct} + \sum_k \epsilon_{Ck}\left(\frac{\dot{Y}}{Y} - \frac{\dot{x}_k}{x_k}\right),$$

where F represents "adjusted for Fixity".[9] As before, the last term in this expression can be thought of as an error bias occurring in this case if instantaneous adjustment is assumed when subequilibrium (not being able to reach a full equilibrium because of fixity) really exists; the bias now depends in part on the relative growth rates of output and the quasi-fixed inputs.

Generating a fully adjusted measure of technical change from the cost side, incorporating both fixity and returns to scale, requires combining (5) and (6) as in Morrison [1989b]. This measure, denoted ϵ^T_{Ct} (where T represents the "Total adjustment") accomodates the full error bias in the standard ϵ_{Ct} measure. Similarly, constructing a fully adjusted primal measure to obtain ϵ^T_{Yt} requires recognizing quasi-fixity, and thus valuing the fixed inputs in the ϵ^M_{Yt} computation at their shadow values.

Once these adaptations of standard productivity growth measures are made to correct for invalid assumptions of CRTS and instantaneous adjustment, the relationship between the primal measure of productivity growth and a pure technical change measure can be expressed in terms of a decomposition.

This decomposition is analogous to the treatment of returns to scale motivated by Ohta [1975]. Ohta showed that the $\epsilon_{Yt}=-\epsilon_{Ct}$ equality must be adapted to $\epsilon_{Yt}=-\epsilon_{Ct}/\epsilon_{CY}$ (or $\epsilon^T_{Yt}=-\epsilon^T_{Ct}/\epsilon_{CY}$ in our notation, to account for corrections of the standard measures) when nonconstant returns to scale (NCRTS)

[9] This is developed in more detail in Morrison [1989b].

exist so $MC \neq AC$ and $p_Y Y = MC \cdot Y \neq AC \cdot Y = C$. This implies that the primal productivity growth measure can be divided into a component capturing technical change only and one reflecting the cost changes arising from returns to scale, where by definition ϵ_{CY} is the inverse of returns to scale.

Morrison [1986] showed that an equivalent adjustment is implied when $\epsilon_{CY} \neq 1$ due to short run fixity. When both exist neither ϵ^L_{CY}, showing scale economies, or CU_c, indicating utilization of fixed inputs, are equal to one; thus, $\epsilon_{CY} = \epsilon^L_{CY} CU_c \neq 1$. The associated decomposition of the output-side measure -- including returns to all cost and demand characteristics -- isolates technical change independently from the characteristics captured in the deviation of ϵ_{CY} from one, since it separately identifies the different characteristics that cause $p_Y Y \neq C$ from equation (4).

It should be emphasized that whether the cost or primal productivity growth measure (ϵ^T_{Ct} or ϵ^T_{Yt}) is the appropriate measure for analysis depends on the context and desired interpretation. The point of the decomposition is to highlight the distinct factors reflected in primal productivity growth measures. In some circumstances one might want to identify technical change independently of other factors, in which case ϵ^T_{Ct} would be the relevant measure, but in others returns to scale might be thought of as an important determinant of overall "efficiency" or "productivity", implying that ϵ^T_{Yt} would be a preferable measure for analysis. The decomposition simply accomplishes the desirable goal (for interpretive purposes) of identifying the individual contributions of technical change and other factors affecting economic performance.

It is also important to note that both the error bias adjustments to correct for erroneous assumptions, and the decomposition to isolate the different components of the primal productivity growth measure, may be used to help "explain" fluctuations in standard productivity growth measures. The first adaptation is a pure correction, however, whereas the other facilitates interpretation in terms of the technical determinants of economic performance.

IV. Towards an Empirical Implementation: A Brief Review of Recent Literature

In order to implement the productivity growth framework developed in the last section, and to evaluate the magnitude of and relationships among the different components generally captured in productivity growth measures, a model is required to separately identify and measure the corresponding components. Previous contributions by, among others, Hall [1986,1988a], and Domowitz, Hubbard and Peterson [1987,1988] provided steps in this direction. However, the underlying framework used in these studies is insufficient for a full analysis since it relies on an incomplete specification of the underlying cost and demand relations. Thus it does not distinguish the independent impacts of different cost and demand characteristics on economic performance.

In particular, as indicated in Section I, measurement of markups, scale economies and utilization fluctuations can be accomplished by estimating certain cost and demand elasticities, including the inverse elasticity of output demand (reflecting markup behavior), the long run elasticity of cost with respect to output changes (capturing returns to scale), and the shadow value of fixed factors, or alternatively the short run cost elasticity with respect to output (revealing the impacts of fixity or utilization changes). Measurement of these elasticities, however, requires a complete specification of the production technology and demand structure facing the firm, a goal which was not pursued in the initial Hall study or the subsequent related literature.

Hall [1986,1988a] used the original development of the Solow [1958] residual to motivate his analysis, and measured the markup as a constant parameter using simple parametric methods. Little scope for analysis of the interactions among different components of the production structure exists in this framework, however, since the relationship between the constant markup and the cost characteristics cannot be assessed. In addition, the determinants (or even the trends in) the markup are not specified, so the simplicity of the model limits interpretation of the measured markups. Estimation of only one deviation from the usual maintained assumptions is possible; estimating markups precludes consideration of scale economies, and characterizing returns to scale requires somehow first imputing cost from revenue shares. Problems are also evident from the empirical results generated using Hall's procedures. Both the markup and returns to scale measures reported by Hall [1989,1988a,b] are extremely large and implausible for some industries[10], and the reasons for this are not apparent.

Domowitz, Hubbard and Peterson [1987,1988] included other variables, allowed the markup to vary, and based their analysis on an industrial organization perspective that suggested markups would vary in response to variables like concentration ratios. However, this framework is still based on a fairly simple extension of the "Solow residual equation", and does not allow independent representation of cost characteristics such as capacity utilization and returns to scale. For example, the cyclicality of markups was established by them using a simple regression of markup indexes on published capacity utilization measures.

In Morrison [1989a,b] I instead employed a production theory approach based on estimation of cost and demand functions. The econometric treatment allows computation of a number of indexes and elasticities reflecting not only the level and pattern of markups, capacity utilization, returns to scale and other indicators, but also their dependence on exogenous demand and supply (cost) variables facing the firm.

[10]The results found for the chemical, petroleum and printing and publishing industries are particularly problematic in the manufacturing sector, although those for food and paper also imply that the unit price is more than three times the associated marginal cost.

The framework, although more complex to specify and estimate, provides a far richer structure in which to assess the different cost and demand characteristics facing the firm than those relying only on the Solow equation. It allows, for example, direct estimation of shadow values for fixed inputs, since it is based on an explicit characterization of the variable cost function $G(\cdot)$. The corresponding measures of capacity utilization and scale economies can therefore be easily constructed. Similarly, an inverse demand equation $p_Y(\cdot)$ is incorporated, thereby facilitating direct estimation of the inverse demand elasticity.

The usefulness of this more structural framework is also demonstrated by the results generated using the model; for example, markup, returns to scale and capacity utilization measures for the U.S, Canadian and Japanese manufacturing sectors, and for various Canadian manufacturing industries reported in Morrison [1988b,1989a] respectively are reasonable, and the measured utilization indexes are quite closely correlated to published estimates.

The basic building blocks of my structural model are a Generalized Leontief restricted cost function and a similarly constructed output demand function. The NCRTS Generalized Leontief cost function has the form

$$7)\ G(Y,t,x,\Delta x,p) = Y[\textstyle\sum_i\sum_j \alpha_{ij}\, p_i^{.5}\, p_j^{.5} + \sum_i\sum_m \delta_{im}\, p_i\, s_m^{.5} + \sum_i p_i \sum_m\sum_n \gamma_{mn} s_m^{.5}\, s_n^{.5}]$$

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

where x_l, x_k denotes the fixed inputs (here capital, K, and labor, L), p_i and p_j index the prices of variable inputs (energy, E, intermediate materials, M, and purchased services, PS), s_m, s_n depict the remaining arguments (Y, t, ΔK and ΔL), t is a time counter, and the inclusion of Δx (ΔK and ΔL) allows for internal costs of adjustment on capital and labor. The corresponding inverse demand function for output is specified as

$$8)\quad p_Y(EXP,p_{IM},r,p_{CPI},Y,UN,t) = \left[\frac{\sum_h \beta_{Yh}\rho_h^{.5}}{Y-\beta_{YU}UN-\beta_{Yt}t}\right]^2$$

where h indexes the components of the vector of shift variables ρ of $p_Y(Y,\rho)$, including here consumption expenditures, EXP, a price index for imported goods, p_{IM}, the interest rate, r, a price index for consumption goods, p_{CPI}, and UN is unemployment.[11]

These two functions are used to construct a system of estimating equations including (i) the cost function (7) plus variable input demand equations for E, M and PS derived from Shephard's Lemma ($v_j=\partial C/\partial p_j$); (ii) a short run price setting equation MR=MC using the expressions for marginal revenue ($MR=p_Y+(\partial p_Y/\partial Y)\cdot Y$) and marginal cost ($MC=\partial G/\partial Y$); (iii) two Euler equations to reflect adjustment paths of the two quasi-fixed inputs; and, to complete the system, (iv) the output demand equation.[12]

Once the parameters of this model are estimated, the determinants of costs ($C=G(\cdot)+\sum_k p_k x_k$) and demand ($p_Y(\cdot)$), and thus the derivatives underlying the elasticities representing markups, scale economies, and capacity utilization, are explicitly determined. These indexes may therefore be constructed for evaluation and comparison, and adaptation of traditional productivity growth measures. The results of such procedures are reported in the next section.

[11] These variables were primarily taken from the Economic Report of the President. The rate of return, r, is the Moody Baa bond yield.

[12] For further details, see Morrison [1988a].

V. Empirical Evidence on Markups, Fixities and Productivity Growth Patterns

Va. Data and Estimation

Estimation of this model was carried out using U.S. manufacturing data for 1952-1986 for a number of manufacturing industries. The sectors considered include food and kindred products (FO), textiles (TX), apparel and other textile products (AP), paper and allied products(PA), printing and publishing (PP), chemicals and allied products (CM), petroleum and coal products (PC), rubber and miscellaneous plastics (RB), lumber and wood (LW), furniture and fixtures (FN), clay and glass (CL), primary metals (PM), fabricated metal products (FM), machinery (MC), electric and electronic equipment (EL), instruments and related products (IN), and transportation equipment (TQ). In addition, a total manufacturing category (MA), constructed by aggregating the individual sectors using Divisia indexes, was estimated for comparison.

These data are based on series for prices and quantities of output, capital, labor, energy, intermediate materials and purchased services developed and used by the Bureau of Labor Statistics Division of Productivity and Technology.[13] The capital data were, however, reconstructed to generate an ex ante measure more closely related to the procedures used by Berndt and Wood [1984].[14] Such a recalculation is required because the "residual" method of capital measurement in the BLS data generates an ex post measure of capital

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[13]The data, including detailed data for the capital components, were graciously provided by Michael Harper at the Bureau of Labor Statistics (BLS).

[14]This was accomplished by taking the components of the capital stock used by the BLS and reaggregating using the Moody Baa bond yield instead of the internal rate of return (ignoring the ex post capital gains component). In addition, the capital stock data used here do not include inventories or land, which might be thought to affect production and productivity differently than non-residential structures and producers' durable equipment.

quasi-rents including any returns not reflected in the other input measures. Use of such an ex post measure would be inappropriate, for it includes effects of returns to scale and market power, as well as the quasi-rents accruing to capital.

The model was estimated for each industry separately, using three stage least squares to incorporate the endogeneity of output quantity and price, and to allow for the possibility of nonstatic expectations on input prices as suggested by Pindyck and Rotemberg [1983]. The instruments employed included lagged values of the exogenous variables facing the firm, as well as the world oil price, defense spending, and the political party variables relied on in the Hall studies. The results were quite robust to different specifications of instruments.[15]

The estimated model for each of the manufacturing industries can be used to generate a large number of indexes, elasticities, and other parameter transformations. Since space constraints prohibit detailed analysis of the different sectors, I concentrate here only on the overall evidence of markups, scale economies and input fixity, and their effects on productivity growth and economic profitability. A wealth of additional analyses and comparisons can be made, however, from perusal and manipulation of the numbers provided in the Tables. The interested reader can therefore pursue the analysis substantially further.[16]

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[15] In particular, including or omitting the Hall instruments had little effect on the estimated indexes.

[16] The results are presented in the text for all industries in terms of average annual growth rates computed from the relevant indexes. More complete indexes (from 1960) are presented in the Appendix. Some additional results about correlations and other indexes computed are commented on below. Computations of certain measures underlying these comments can be made directly from the presented indexes. Other results, such as the shadow value ratios underlying the CU_c measures, require direct computation using the estimated parameter values. Further information about these indexes and the parameter estimates are available upon request from the author.

Vb. Productivity Growth

Traditional multifactor productivity growth indexes ϵ_{Yt} based on the K,L,E,M,PS division of inputs are presented in terms of average annual growth rates (AAGR) in Table 1, and in their full form (from 1960 to 1986) in the Appendix Table 1A. These measures are computed using standard primal-side measurement techniques, ignoring the potential existence of markups, input fixity and returns to scale.

Table 1

Traditional Primal-Side Productivity Growth Measures (ϵ_{Yt}), U.S. Manufacturing, (Average Annual %)

ϵ_{Yt} Year	MA	FO	TX	AP	PA	PP	CM	PC	RB
1953-86	1.005	0.762	2.011	0.875	0.920	0.595	2.029	0.699	1.021
1960-86	1.050	0.766	1.779	0.945	1.035	0.325	1.566	0.543	1.069
1960-73	1.610	0.985	1.880	1.285	1.769	1.042	2.788	1.255	1.670
1973-86	0.489	0.548	1.678	0.625	0.300	-0.392	0.345	-0.168	0.468
St. Dev.	1.344	1.255	2.961	1.877	2.450	3.085	3.194	1.081	2.702

	LW	FN	CL	PM	FM	MC	EL	IN	TQ
1953-86	2.035	0.567	0.649	-0.499	0.525	1.891	2.266	1.420	0.890
1960-86	2.039	0.624	0.571	-0.247	0.523	2.443	2.504	1.414	1.067
1960-73	2.886	0.994	1.051	0.730	0.872	2.112	3.145	2.213	1.995
1973-86	1.192	0.253	0.091	-1.224	0.174	2.774	1.864	0.614	0.139
St. Dev.	3.325	2.050	1.774	3.897	1.431	2.646	2.127	2.665	3.244

The AAGR reflect the existence of a post-1973 productivity growth slowdown, even though the dramatic stagnation immediately after 1973 seen in the full indexes is somewhat masked by including the most recent years in the annual average computations. The industries which show a negative growth rate in the post-1973 period are printing and publishing (PP), primary metals (PM) and petroleum and coal refining (PC). The latter two of these are capital- and energy-intensive industries which might be thought to be heavily affected by energy price shocks. This tendency is evident overall; from the full indexes it appears the industries hardest hit in the mid-1970s included PM, FM, MC, CM, PA, and RB, all of which are capital intensive. These industries are also those, however, that experienced relatively intense international competition. Interestingly, the only industry to exhibit an increase in productivity growth over this period was MC, which includes the computer industry.[17]

The traditional productivity growth indexes appear considerably pro-cyclical, with, for example, declines appearing in most industries around 1970, 1974-75 and 1982-83. One indication of the extent of these fluctuations is the standard deviation, which for each industry indicates the deviations of these productivity growth rates from their mean rate. These measures are rather large, particularly for durable goods industries and those nondurable goods industries mentioned above as suffering from productivity growth stagnation and declines.

The fluctuations observed, however, are less systematic it might initially appear, particularly given the emphasis on these relationships in the recent studies by Hall. The correlations of these indexes with indexes reflecting cyclical trends are not very significant. In particular, when this productivity growth measure is correlated with either a standard published capacity utilization measure (the Federal Reserve Board index for

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[17]Semiconductors are included in EL, which also experienced very strong productivity growth over this period, particularly in the late 1970s. The relatively strong performance of the MC industry is driven largely by the enormous productivity growth experienced in 1984-86.

manufacturing, FRB) or the CU_c measure resulting from estimation of my model, the correlations tend to be primarily positive but generally statistically insignificant. Similarly, simple correlations of multifactor productivity growth carried out using the Hall variables -- the world oil price (WOP), defense spending (DEF) and political party in power, were largely insignificant at standard confidence levels.[18]

For example, using a one-tailed test of the hypothesis that the covariance of the productivity residual and WOP was positive, marginal significance levels under five percent were only found for the AP, CM, PC, RB, CL and FM industries. For DEF this was the case for PA, CM, PC, CL, MC and TQ. Hall's results also, however, inferred limited correlation patterns. This was especially true for DEF, which was only correlated at the five percent level with the productivity growth measure for one manufacturing sector, FN. For WOP more correlation was found; the residuals for the FO, PA, CM, PC, CL and EL industries were correlated with WOP at this level of significance. If my results were based on a two-tailed test (a standard t-test of the significance of the slope coefficient), the only significant correlations remaining would be that of the PC productivity residual with both instruments, and of the CM measure with DEF. For Hall, no significant correlations at this level would occur for DEF, and FO and EL would become marginal or drop out for WOP.

It should be noted that my results differ from Hall's for a number of reasons. One disparity is the inclusion of intermediate materials, purchased services and energy costs, and therefore their substitution with capital and labor, in my productivity growth measure. This suggests that using WOP as an instrument may not be very appropriate. One indication that the correlation

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[18]The one outlier for this was PC (petroleum and coal refining) which is intuitively reasonable since energy price shocks affect this industry in a very direct manner.

measures may suffer from some endogeneity is that many of the manufacturing sectors for which correlations with WOP were found use energy as either as an energy or material input. Thus the observed correlations could reflect the treatment of these inputs.

The cyclical fluctuations in productivity that do exist, although not pervasive in terms of statistical significance, influence the interpretation of changes in economic performance. Thus, it is useful to see to what extent these variations might be smoothed, and in this sense "explained", by taking into account cyclically related markup, capacity utilization, and returns to scale characteristics. These characteristics, and the associated adaptations of traditional productivity growth measures, will now be considered in turn.

Vc. Markups

It has been argued that markup behavior might be expected to be cyclical, although controversy remains about whether they are pro- or counter-cyclical.[19] Hall's treatments of the markup do not allow for cyclicality to exist, since in his empirical analysis the markup is simply estimated as a constant parameter. However, his general hypothesis about excess capacity counteracting markups implicitly suggests that increasing markups would be accommodated by additional excess capacity, leading to countercyclicality of markups. Domowitz, Hubbard and Peterson more directly address this issue by allowing for variable markups and assessing the correlation of the markup measure with a published measure of capacity utilization (as mentioned above), and find some evidence of procyclicality.

[19] See Morrison [1988b,1989a] for further elaboration of cyclicality of markups and its determinants.

In this study, the cyclicality and determinants of the markup are directly incorporated into the model.[20] One indication of the cyclicality implied for markup behavior, motivated by the Domowitz, Hubbard and Peterson studies, is a correlation of the markup index with a capacity utilization measure. The relationship of the markup index with other exogenous factors affecting aggregate output in the economy, such as Hall's world oil price and defense spending variables, may also provide some evidence of cyclicality, since output changes largely drive utilization variations.

The estimated markup indexes implied by my model are presented in Table 2 in terms of annual averages, and in Appendix Table 2A in their full form. As found by Hall, significant markups do appear to exist, although the estimates of the markups are intuitively more reasonable than those based on the simpler framework of the Hall studies.[21] The year-to-year variations are also important; although the standard deviations are not large (especially relative to mean markups), clear tendencies do emerge.

A secular increase in markups over time is evident, although significant year-to-year variations occur. This tendency is more clearly apparent from the year-to-year changes appearing in Table 2A than from the overall averages, although it is not as pervasive as found in studies such as in Morrison [1989a,b]. The only industries experiencing a clear downward trend in markups are AP, LW, PC and PM; this is consistent with intuition given the

[20]It should be noted that the impacts of labor hoarding, adjustment costs and other similar characteristics that might affect productivity growth are reflected in these estimates as well as those for the cost elasticity, discussed in further detail in Section Vd. below.

[21]This is particularly true for the CM, FO, PC and PP industries, for which the Hall estimates are clear outliers (with markup ratios of 20.112, 5.291, -139.478 and 14.263, respectively). The estimates here are also comparable to those found using different data in Morrison [1989] where pooled total manufacturing data for the U.S., Canada and Japan were used for estimation, and in Morrison [1989a] which is based on data for Canadian manufacturing industries.

Table 2

Average Annual Markups (p_Y/MC) and Cost Elasticities (ϵ_{CY}), U.S. Manufacturing

$p_Y/MC(=1/(1+\epsilon_{pY}))$

	MA	FO	TX	AP	PA	PP	CM	PC	RB
1953-86	1.188	1.292	1.259	1.283	1.324	1.362	1.608	1.210	1.197
1960-86	1.197	1.298	1.272	1.280	1.363	1.396	1.695	1.237	1.223
1960-73	1.183	1.285	1.261	1.287	1.324	1.350	1.588	1.255	1.198
1973-86	1.211	1.311	1.284	1.273	1.402	1.441	1.803	1.220	1.248
St. Dev.	0.027	0.031	0.048	0.018	0.098	0.095	0.236	0.072	0.073

	LW	FN	CL	PM	FM	MC	EL	IN	TQ
1953-86	1.471	1.192	1.213	1.257	1.179	1.326	1.228	1.317	1.306
1960-86	1.475	1.204	1.220	1.247	1.186	1.359	1.252	1.354	1.318
1960-73	1.507	1.191	1.221	1.268	1.187	1.275	1.203	1.241	1.304
1973-86	1.443	1.217	1.220	1.225	1.184	1.443	1.302	1.467	1.332
St. Dev.	0.074	0.036	0.025	0.050	0.023	0.111	0.078	0.140	0.050

$\epsilon_{CY}(=CU_c\epsilon^L_{CY})$

	MA	FO	TX	AP	PA	PP	CM	PC	RB
1953-86	0.860	0.826	0.743	0.771	0.762	0.773	0.671	0.831	0.832
1960-86	0.835	0.811	0.728	0.756	0.712	0.738	0.626	0.821	0.791
1960-73	0.855	0.832	0.767	0.760	0.759	0.766	0.689	0.793	0.837
1973-86	0.815	0.791	0.689	0.752	0.665	0.710	0.562	0.849	0.745
St. Dev.	0.062	0.042	0.062	0.042	0.120	0.085	0.122	0.039	0.108

	LW	FN	CL	PM	FM	MC	EL	IN	TQ
1953-86	0.667	0.801	0.813	0.773	0.859	0.783	0.848	0.793	0.794
1960-86	0.660	0.779	0.786	0.748	0.846	0.745	0.815	0.756	0.762
1960-73	0.650	0.809	0.827	0.789	0.863	0.804	0.875	0.843	0.793
1973-86	0.671	0.748	0.746	0.708	0.830	0.686	0.756	0.669	0.730
St. Dev.	0.057	0.062	0.078	0.073	0.036	0.101	0.093	0.122	0.079

intensifying international competition in the apparel, lumber and primary metals markets, and the rise in costs of crude materials in the petroleum refining industry which has provided downward pressures on profit margins. Some other industries facing increasing international competition such as CL and FM (and to a lesser extent TX and TQ) appear from the averages to be quite constant. Interestingly, markups in high-technology industries such as CM, EL, MC and IN all increased for 1960-73 to 1973-86.

In general, markups appear to decline during recessions and in that sense seem procyclical. For example for all industries the 1973 and 1979 OPEC shocks are reflected in a downturn in the markup ratio. However, from correlations of the markup with the economic measure of capacity utilization, CU_c, the evidence is overwhelmingly in favor of countercyclicality of markups. The correlations of the reported markups with CU_c (and the full cost elasticity ϵ_{CY}) are negative throughout except for the primary metals industry (PM),[22] and are all statistically significant at the one percent level. For total manufacturing (MA), for example, the correlation[23] is -0.419 with a standard error of .088 The correlations with the published FRB capacity utilization for manufacturing are somewhat more ambiguous, though; although the correlations are generally negative, they tend to be very small and largely insignificant.

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[22] The positive correlation of PM and capacity utilization was also found for Canada in Morrison [1989a]. In the Canadian study FO (and to a lesser extent TQ) were also found to be procyclical. The evidence of countercyclicality in nondurable manufacturing in the U.S. found here is largely dependent on the correlation for FO which is a large proportion of total nondurable manufacturing; the different result is likely the result of a quite different composition of this industry in Canada. In addition, although the correlation for TQ is negative in the U.S., it is also has one of the smallest values.

[23] These computations were carried out similarly to Hall using a simple regression of the markup index on the capacity utilization index and a constant, and the significance assessed in terms of the t-statistic on the slope coefficient.

Correlations of markups with defense spending were often positive, suggesting indicating that expansion due to increased government expenditures has a different effect on markup behavior than a general increase in output. Correlations of markups with the world oil price variable, however, weakly support the conclusion of countercyclical markups since increases in this variable tend to be closely associated with recessions; the correlations were primarily positive but often insignificant

Countercycality of markups has a well defined impact on productivity growth patterns through the error bias $\epsilon_{PY} \cdot \sum_j M_j (x_j/x_j)$. Since $\epsilon^M_{Yt} = -\epsilon_{Ct} - \epsilon_{Yt} - \epsilon_{PY} \cdot \sum_j M_j (x_j/x_j)$, and an increase (in absolute value) in ϵ_{PY} implies a larger markup, an upward trend in the markup will compensate to some extent for a downward trend in the productivity growth rate (as long as inputs in general are increasing). Since this occurs for both secular and cyclical markup fluctuations, countercyclical markups imply that cost-based measures of productivity growth reveal higher levels and less cyclicality of productivity growth.

This correction for demand characteristics can, however, be misleading if cost characteristics such as scale economies exist that should also be accommodated in the measures, particularly given the offsetting cyclical patterns of the indicators. Additional insights about fluctuations in traditionally measured productivity growth can therefore be obtained by considering the impact of explicitly relaxing the assumptions of constant returns to scale and instantaneous adjustment -- incorporating fixity.

Vd. The Cost Elasticity, ϵ_{CY}, and its Components

The cost elasticity ϵ_{CY} reflects a combination of both short and long run fixity, captured as downward sloping short- or long-run average cost curves. This fixity was recognized in the Hall studies as a potential determinant of cyclical swings in measured productivity growth, but was developed in the context of long run returns to scale and the effect measured as a constant parameter. Using my model the effects of short run fixity (capacity utilization) or long run returns to scale (scale economies) may independently be distinguished, and the varying cyclical behavior of such measures incorporated. This distinction is particularly important for providing an assessment of Hall's contention that markups coexist with normal profits owing to excess capacity.

In particular, capacity utilization, which is one component of ϵ_{CY}, is by definition procyclical. Similarly, if scale economies exist, output expansion from upward swings in the cycle cause average cost declines, so this component of ϵ_{CY} will also tend to be procyclical. This procyclicality suggests that increased profitability from countercyclical markups tends to be offset by excess capacity and the existence of scale economies; the Hall correction to change revenue to cost shares will therefore affect measured productivity growth less than if only markups were taken into account. The remaining effect of error bias corrections to accomodate the deviation of ϵ_{CY} from one is not obvious <u>a priori</u> since the bias depends not only on the measure of ϵ_{CY}, but also on the relative growth rates of output and quasi-fixed inputs. However, in general procyclical variations in ϵ_{CY} will result in corrections incorporating $\epsilon_{CY}\neq 1$ to smooth the productivity growth measure, since this procyclicality implies greater output than input changes.

The measured cost elasticity ϵ_{CY} is presented in terms of annual averages in the second panel of Table 2, and in full index form in Appendix Table 3A. These measures suggest short and long run scale economies exist and are quite substantial in a number of industries. Scale economies also appear to be increasing, especially in industries which tend to be more capital intensive and have experienced productivity growth stagnation, such as PA, CM, and PM.

One interesting exception to this is the MC industry, which, as mentioned above, includes the computer manufacturing sector. Although productivity growth in this industry has been strong and actually increasing, scale economies have also risen substantially. Note also that this industry experienced one of the largest jumps in markups during this period, as did CM, where scale economies also expanded. This is in sharp contrast to PM, where a (more modest) increase in scale economies occurred along with a decline in markups. This suggests declining profitability as well as productivity performance, due perhaps to a decline in relative efficiency and increased international competition. To a lesser extent this is true also for AP.

The procyclicality of the ϵ_{CY} measure is evident from the more complete indexes in Table 3A, where, for example, declines are evident for most industries in the downturns of 1969-70, 1974-75 and 1982-83. To a large extent cyclical movements in ϵ_{CY} are driven by utilization fluctuations, since potential scale economies appear to be increasing over time rather smoothly. In turn, the capacity utilization patterns appearing in the CU_c indexes result primarily from changes in capital utilization, although labor hoarding[24], and thus procyclicality from changes in work effort, are also evident from fluctuations in the shadow value of labor.

More specifically, the independent effects of short and long run fixities can be distinguished from the equality $\epsilon_{CY}=CU_c\epsilon^L_{CY}$. The two components of ϵ_{CY} are presented as annual averages in Table 3, and graphically for total manufacturing in Figure 1a. The CU_c numbers in Table 3 show that

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[24]This could be interpreted as reflecting changes in work effort, which will tend to be procyclical, as mentioned by Hall.

Table 3

Average Annual Capacity Utilization (CU_c)
and (Inverse) Returns to Scale (ϵ^L_{CY}), U.S. Manufacturing

CU_c(=C*/C)

	MA	FO	TX	AP	PA	PP	CM	PC	RB
1953-86	0.968	1.002	0.994	0.968	0.989	0.930	1.028	0.971	0.927
1960-86	0.953	0.996	0.996	0.956	0.946	0.898	1.019	0.961	0.898
1960-73	0.955	0.999	1.019	0.959	0.966	0.916	1.032	0.924	0.922
1973-86	0.950	0.993	0.973	0.953	0.927	0.881	1.006	0.999	0.873
St. Dev.	0.042	0.022	0.045	0.042	0.101	0.077	0.043	0.045	0.081

	LW	FN	CL	PM	FM	MC	EL	IN	TQ
1953-86	0.860	0.889	0.946	0.951	0.955	0.952	0.976	0.983	0.957
1960-86	0.861	0.874	0.910	0.926	0.947	0.930	0.958	0.962	0.930
1960-73	0.827	0.889	0.964	0.969	0.966	0.949	0.990	0.994	0.949
1973-86	0.894	0.858	0.855	0.883	0.929	0.911	0.927	0.931	0.911
St. Dev.	0.071	0.045	0.101	0.084	0.030	0.061	0.054	0.065	0.068

ϵ^L_{CY}(=MC·Y/C)*

	MA	FO	TX	AP	PA	PP	CM	PC	RB
1953-86	0.887	0.824	0.747	0.796	0.767	0.829	0.650	0.856	0.894
1960-86	0.876	0.814	0.730	0.791	0.751	0.820	0.612	0.854	0.880
1960-73	0.895	0.833	0.751	0.792	0.785	0.835	0.666	0.858	0.906
1973-86	0.857	0.796	0.709	0.789	0.717	0.805	0.558	0.850	0.853
St. Dev.	0.030	0.028	0.044	0.013	0.047	0.025	0.098	0.008	0.042

	LW	FN	CL	PM	FM	MC	EL	IN	TQ
1953-86	0.776	0.900	0.861	0.812	0.899	0.819	0.867	0.803	0.829
1960-86	0.768	0.891	0.865	0.808	0.894	0.800	0.849	0.782	0.818
1960-73	0.786	0.910	0.857	0.815	0.893	0.846	0.884	0.847	0.835
1973-86	0.750	0.871	0.872	0.802	0.894	0.754	0.815	0.718	0.802
St. Dev.	0.029	0.028	0.013	0.014	0.017	0.062	0.052	0.078	0.036

capacity utilization has been declining in every industry but PC and LW.[25] They also suggest excess capacity virtually everywhere, although overutilization of capacity appears in the CM industry throughout the time period, and in the early years for the textile industry.[26] The excess capacity has been driven primarily, especially in the post-1973 period, by a low shadow value of capital relative to its market price; in most industries a decline in the Z_K/p_K ratio and an increase in Z_L/p_L has occurred post-1973 Note also that the levels of CU_c are less than .9 in the PP, RB, LW, FN, CL and PM industries, indicating that the cost consequences of short-run excess capacity are often greater than 10%.

The bottom panel of Table 3 indicates, however, that scale economies seem to be driving the evidence of a low and declining ϵ_{CY} even more than CU_c. In particular, long run returns to scale (the inverse of ϵ^L_{CY}) are very substantial and increasing, especially in the nondurable industries such as TX, AP, PA and CM. Excess capacity therefore exists even in the long run. Precisely why long-run scale economies are increasing over time in all industries except CL and FM is a fascinating topic for further research.

Ve. Normal Profits

The counteracting effects of markups and utilization/scale are evident from the average annual levels of $ADJ=\epsilon_{CY}{}^L CU_c/(1+\epsilon_{PY})=p_Y/AC$ (where AC is short

[25]This does not explicitly include the impact of adjustment costs, but only of the fixity itself. The following adaptation of the productivity growth measure also ignores this modification. This was simply neglected for the sake of brevity, however; as in Morrison [1989b] the direct adaptation for adjustment costs has a negligible effect on the results.

[26]This is in contrast to indexes measured by Berndt and Morrison [1981] and others for total manufacturing in the U.S. This likely arises because of the explicit recognition of fixity arising from both capital and labor stocks (from adjustment costs), a more complete specification of inputs, and incorporation of nonstatic expectations through the estimation process. This last point is elaborated in Morrison [1985].

run average total cost with the fixed factors values at their <u>ex ante</u> prices) in Table 4 and Figure 1b. ADJ tends to be close to one, suggesting that revenues approximately equal economic costs, and that economic profits are therefore roughly zero on average.

Table 4

Full Adjustment Factor (ADJ),
U.S. Manufacturing (Average Annual Level)

$ADJ = \epsilon_{CY}/(1+\epsilon_{PY}) = p_Y \cdot Y/C$

Year	MA	FO	TX	AP	PA	PP	CM	PC	RB
1953-86	1.021	1.065	0.933	0.988	0.999	1.046	1.052	1.004	0.989
1960-86	0.999	1.052	0.924	0.967	0.966	1.026	1.045	1.014	0.964
1960-73	1.011	1.068	0.963	0.978	1.001	1.031	1.078	0.994	0.999
1973-86	0.987	1.036	0.885	0.957	0.931	1.021	1.011	1.035	0.929
St. Dev.	0.056	0.034	0.049	0.053	0.082	0.051	0.044	0.034	0.073

	LW	FN	CL	PM	FM	MC	EL	IN	TQ
1953-86	0.978	0.953	0.985	0.974	1.012	1.028	1.034	1.028	1.035
1960-86	0.971	0.936	0.959	0.935	1.003	1.005	1.016	1.010	1.002
1960-73	0.977	0.963	1.008	1.001	1.024	1.021	1.051	1.043	1.032
1973-86	0.965	0.910	0.910	0.869	0.983	0.988	0.982	0.977	0.972
St. Dev.	0.062	0.052	0.086	0.122	0.033	0.058	0.057	0.061	0.084

Although short run profits or losses are possible in this model, profit-maximizing markup behavior does not result in high profitability since its countercyclical pattern is accommodated by procyclicality of the output-cost elasticity. Thus the Hall assertion concerning the relationship between markups and capacity utilization, which implies monopolistically competitive markets are predominant in the U.S., is not only possible theoretically but is borne out empirically by my results. Essentially, managers' pricing responses balance the technical and market economic fluctuations encountered, but do not allow for excess profitability on average.

The annual average ADJ measures presented in Table 4 suggest that this balancing act has increasingly resulted in revenues falling short of covering all costs of production, including appropriate returns to capital, in U.S. manufacturing industries.[27] Although for total manufacturing normal profits were approximated on average for the 1960 to 1986 period, a decline in profitability in the post-1973 period is evident for all industries except PC.[28] In particular, although before 1973 only six industries had negative economic profits, post-1973 the number of such industries more than doubled to thirteen. Only four industries experienced a positive economic profit post-1973 (FO, PP, CM and PC), with FO, and PC being the most profitable.

It is interesting to conjecture that these nondurable manufacturing industries were perhaps subject to less intense competition than most of the other industries during this period of international expansion of markets. Other industries, even the MC industry which performed better than other durable industries but still fell short of normal profits by 1% on average, tended to be more internationally competitive as well as more energy and capital intensive.

Overall, these numbers are dramatic confirmation of much recent discussion on the apparent declines in competitiveness of U.S. durable goods and textiles industries. It should be noted, however, that the post-1973

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[27]Recall that the interest rate used in the ex ante opportunity cost of capital is the Moody Baa bond yield.
[28]Note that realized capital gains on equipment and structural assets are not included in the opportunity cost of capital measure here. These gains could possibly add to the profitability implied here.

decline in profitability was reversing toward the end of my sample; more complete indexes show increasing profitability after 1982, with positive economic profits by the end of the sample for the MC industry.

Little variation of the ADJ factor is apparent, but there is a clear downward trend and some procyclicality in the ratio of returns to costs. This is evident from Figure 1b, which illustrates that ϵ_{CY} has a relatively greater impact on ADJ than the markup ratio; markups are not keeping pace with changes in technical factors and competition, so ADJ is declining. This suggests some pattern in the difference between cost and revenue shares. Although the Hall correction to measure input shares in terms of costs instead of revenues will have little impact, since ADJ closely approximates one, a measure based on cost shares will tend to show a somewhat smaller decline in productivity growth over time.

It appears, therefore, that the greatest explanatory clout for productivity growth fluctuations arise from error bias corrections. This seems to be the case from my measures; true technical change is smaller and less volatile than usually measured because of erroneous assumptions about returns to scale and fixity imbedded in the measurement process. I will now turn to this final result.

Vf. The Corrected Technical Change Measure

Productivity growth indexes resulting from adapting standard measures for short and long run fixity are presented in Table 5. Note that these measures implicitly already incorporate adjustments for markups, since they are based on cost-side computations. The first panel of Table 5 includes the impacts of technical change, returns to scale and utilization ($\epsilon^T_{Yt}-\epsilon^T_{Ct}/\epsilon_{CY}-\epsilon^T_{Ct}/\epsilon_{LCY}\cdot CU_c$), and therefore represents a primal-side measure of total productivity growth with error biases removed and the influence of

Table 5

Corrected Cost-Side Productivity Growth (ϵ^T_{Yt}) and Technical Change (ϵ^T_{Ct}), U.S. Manufacturing, (Average Annual %),

$\epsilon^T_{Yt} - \epsilon^T_{Ct} / \epsilon_{CY}$

	MA	FO	TX	AP	PA	PP	CM	PC	RB
1953-86	0.762	0.361	1.717	0.607	0.202	-0.178	0.516	0.163	0.617
1960-86	0.751	0.368	1.354	0.688	0.278	-0.525	-0.129	0.020	0.575
1960-73	0.973	0.582	0.802	0.796	0.774	0.249	0.112	0.246	0.623
1973-86	0.528	0.155	1.906	0.580	-0.218	-1.299	-0.370	-0.207	0.528
St. Dev.	1.058	1.697	3.445	2.343	2.342	3.193	3.394	0.964	2.723

	LW	FN	CL	PM	FM	MC	EL	IN	TQ
1953-86	1.898	0.422	0.359	-0.545	0.407	1.447	1.847	0.563	0.358
1960-86	1.718	0.465	0.362	-0.300	0.364	1.781	1.982	0.368	0.257
1960-73	2.216	0.645	0.512	-0.070	0.346	0.797	2.326	1.192	0.700
1973-86	1.220	0.286	0.211	-0.531	0.382	2.766	1.637	-0.457	-0.187
St. Dev.	4.517	1.736	1.580	3.048	1.197	2.920	2.035	3.170	2.604

ϵ^T_{Ct}

	MA	FO	TX	AP	PA	PP	CM	PC	RB
1953-86	0.655	0.294	1.285	0.451	0.123	-0.056	0.443	0.134	0.523
1960-86	0.625	0.295	0.981	0.505	0.173	-0.348	-0.097	0.011	0.473
1960-73	0.839	0.489	0.631	0.587	0.531	0.221	0.063	0.192	0.583
1973-86	0.411	0.101	1.332	0.424	-0.186	-0.918	-0.257	-0.170	0.364
St. Dev.	0.918	1.392	2.407	1.787	1.750	2.269	2.340	0.813	2.422

	LW	FN	CL	PM	FM	MC	EL	IN	TQ
1953-86	1.278	0.347	0.286	-0.445	0.347	1.038	1.566	0.549	0.338
1960-86	1.140	0.375	0.278	-0.235	0.303	1.267	1.639	0.346	0.249
1960-73	1.444	0.536	0.436	-0.052	0.299	0.657	2.051	0.999	0.600
1973-86	0.836	0.213	0.119	-0.421	0.308	1.877	1.227	-0.062	-0.103
St. Dev.	3.087	1.419	1.311	2.373	1.020	2.138	1.642	2.642	2.138

markups omitted. The second panel isolates the impact of technical change (ϵ^T_{Ct}), provided by a decomposition of the full measure.

A comparison of the indexes in Tables 1 and 5 indicate that correcting for error biases resulting from markups and input fixity is quantitatively important. In general productivity growth appears lower than reflected in the traditional measure for the 1960-73 period, but often is higher after 1973. Thus, the difference between the pre- and post-1973 periods is substantially reduced. For example, for total manufacturing, unadjusted growth rates for 1960-73 and 1973-86 are 1.610 and 0.489, while corresponding fixity-adjusted values are 0.973 and 0.528. This reflects less of a productivity growth slowdown than is generally perceived, and thereby suggests a partial "explanation" of the usually measured slowdown. The entries in Table 5 also suggest that true efficiency growth in some industries, especially in PP, CM, PC, PM and IN, has been very limited even from the early years of the sample.

A further decline in the apparent growth of technical change, especially for earlier years, appears when the impacts of scale economies are removed. This can be seen by comparing the top and bottom panels of Table 5. However, in some industries, notably CL, PM and FN, standard productivity growth measures understate technical change. It is also the case that indications of negative productivity growth are attenuated with this adjustment; some of the declines attributed to productivity change therefore appear to be due to diminished output demand and therefore the potential to take advantage of scale economies.

In total, corrections to standard productivity growth measures tend to somewhat reduce secular and cyclical fluctuations in productivity growth measures. This tendency to "smooth" the productivity growth measure is corroborated by an examination of the year-to-year fluctuations reported in Appendix Table 4A, and the graph of ϵ_{Yt} (traditionally measured), ϵ^T_{Ct} and

ϵ^T_{Yt} for total manufacturing in Figure 1c. The smoothing of fluctuations is evident even though standard deviations for the total productivity growth measure ϵ^T_{Yt} increase for some industries relative to the standard primal measure. It is also consistent with a reduced statistical significance found to correlations of these productivity residuals with the capacity utilization, world oil price and defense spending indexes (except for the MC industry).

In summary, the Hall-inspired correction of ϵ_{Yt} for markups by adapting revenue into cost shares does not significantly affect the evidence of productivity growth, because the offsetting impacts of markups and utilization and scale imply approximate equivalence of cost and revenue shares. However, corrections of productivity growth measures for error biases due to erroneous assumptions about returns to scale and fixity do provide insights into the "explanations" of productivity growth fluctuations.

VI. Concluding Remarks

The issues addressed in this paper about the determinants of productivity growth fluctuations -- in particular the effects of markups and fixities -- are based on a somewhat different perspective than recent studies such as those by Robert Hall. The analysis here is developed in terms of a full structural model allowing formalization and measurement of the relationships among productivity growth, profit-maximizing markup behavior, capacity utilization and scale economies. Such a framework permits consideration of whether these cost and revenue components, usually ignored in productivity growth analysis, are in some sense "responsible" for cyclical fluctuations and secular downturns in productivity growth.

The first "cause" evaluated is the markup of price over marginal cost. Markup indexes embodying a cyclical component have been constructed for a number of U.S. manufacturing sectors. The patterns of these profit-maximizing markups tended to reveal increases in markups over time and in cyclical downturns -- markups appear to be countercyclical. As a result, the traditional primal productivity growth measure, developed in terms of revenue shares and thus implicitly based on the assumption of perfect competition, exacerbates declines over time and in recessionary periods. Thus, adaptation of the measure to be in terms of cost shares provides some "explanatory power" for productivity performance variation, in terms of smoothing observed fluctuations.

However, fixities in both the short and long run also have an impact on observed economic performance. Within my model, short run fixities are represented in terms of changes in capacity utilization, and long run "fixities" are reflected as scale economies. Although capacity utilization is by definition procyclical, I find it also appears to have an upward secular trend. On the other hand, the capability of taking advantage of scale economies seems to be increasing over time. This is consistent with intuition, for in order to obtain normal economic profits, the existence of increasing excess capacity and scale economies must be offset by increasing markups. My empirical results confirm this counteracting effect in U.S. manufacturing industries; I find that economic profits on average have been zero, but have exhibited a downward trend over time.

Together, these forces tend to offset the smoothing effect of adjusting primal productivity growth measures for markups by measuring cost instead of revenue shares. However, incorporating these characteristics still contributes in an important way to "explaining" fluctuations in productivity growth in terms of error biases. Corrections of erroneous assumptions made in traditional computations have a significant smoothing impact on observed trends in productivity growth and technical change.

The framework used here for productivity growth measurement is based on a consistent treatment of interactions among productivity growth, markups and short and long run fixities, and thereby facilitates detailed analyses of economic performance and fluctuations. The conjectures of Robert Hall which form the motivation for this study are largely confirmed, in the sense that markups are significant, and tend to be counteracted by excess capacity and returns to scale, resulting in approximately normal profits. However, the full structural framework of this paper is necessary for assessing empirically the validity of such conjectures; in the Hall model restrictive assumptions preclude such an analysis.

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APPENDIX TABLES

Table 1A

Primal-Side Productivity Growth (ϵ_{Yt}), U.S. Manufacturing (%),

Year	MA	FO	TX	AP	PA	PP	CM	PC	RB
1960	0.079	0.774	1.830	1.983	-1.630	-6.046	0.141	1.638	-1.040
1961	1.135	0.496	0.798	-1.747	1.079	5.698	2.066	1.364	3.972
1962	2.025	1.322	3.232	0.660	0.333	-3.616	3.449	1.128	2.834
1963	2.388	1.141	1.532	1.892	1.328	2.776	3.337	1.302	2.027
1964	2.527	0.222	3.155	-0.656	2.633	3.676	4.522	1.511	2.195
1965	2.460	1.996	1.432	1.841	0.854	0.606	3.208	0.309	1.499
1966	1.489	1.598	2.771	1.740	0.795	1.792	1.798	1.035	0.420
1967	-0.070	0.194	1.398	2.801	-1.698	0.237	-2.054	1.021	0.855
1968	1.146	-0.550	-0.243	-0.454	3.973	-0.335	3.982	2.032	1.360
1969	1.174	0.925	2.316	0.386	3.219	1.747	2.442	0.865	2.247
1970	-0.495	1.172	5.165	-0.911	-1.233	-3.405	2.034	2.623	-2.716
1971	1.868	1.568	1.882	1.309	2.039	0.428	2.611	0.514	3.050
1972	2.791	1.577	1.821	7.529	3.956	2.212	4.525	1.039	1.724
1973	2.493	1.138	-0.814	2.053	5.721	1.728	4.326	1.567	2.247
1974	-1.663	-2.268	-3.322	1.440	-1.138	-0.750	-3.861	-1.761	-3.152
1975	-1.781	0.905	1.503	0.879	-6.222	-0.977	-5.391	-0.562	-1.418
1976	1.881	1.472	4.215	0.480	2.874	0.405	2.859	0.276	-0.826
1977	0.521	-2.040	6.860	0.563	0.923	-0.287	1.053	0.185	1.038
1978	0.470	1.356	-1.372	0.807	1.564	-0.103	0.166	0.087	-0.189
1979	0.627	1.277	3.721	0.796	-0.231	-0.250	1.980	-1.657	-0.792
1980	1.124	1.978	4.915	4.031	-0.274	0.022	-2.510	0.604	2.307
1981	1.851	2.469	2.824	2.676	1.781	2.392	3.719	-0.895	5.499
1982	0.130	2.109	2.336	0.041	4.107	-0.615	0.573	-0.418	0.564
1983	-0.323	-0.901	0.549	-1.322	-0.649	-1.518	1.495	-1.275	0.584
1984	2.063	0.155	0.920	1.529	0.282	-0.255	0.944	1.734	1.890
1985	1.109	2.236	-9.085	-0.292	-1.573	-0.497	-1.168	-0.022	2.364
1986	0.352	-1.630	7.751	-3.501	2.463	-2.662	4.626	1.526	-1.787

Table 1A, contd.

	LW	FN	CL	PM	FM	MC	EL	IN	TQ
1960	-1.462	-2.774	-0.576	-1.980	-0.504	-0.095	2.807	-1.323	1.167
1961	0.466	0.882	2.076	0.567	0.373	1.441	4.032	-2.354	-0.120
1962	1.562	-1.251	0.709	0.364	1.700	3.625	5.609	1.732	4.132
1963	7.437	2.929	3.335	2.329	0.703	1.055	4.494	-0.845	5.435
1964	10.144	1.454	1.718	2.845	1.399	4.960	3.631	4.356	3.213
1965	3.087	2.435	0.636	0.882	1.705	1.461	6.077	6.243	5.764
1966	0.731	0.495	-0.295	2.352	0.431	2.415	2.428	2.989	0.237
1967	4.805	-0.437	-0.991	-2.244	1.504	0.107	0.937	0.103	-1.087
1968	3.128	0.524	1.613	-1.926	0.898	0.366	1.826	3.206	2.932
1969	-2.845	2.351	1.425	-0.525	0.543	1.170	3.816	4.328	-0.360
1970	5.131	-2.333	-1.071	-1.537	-1.789	1.131	-0.741	-1.730	-5.345
1971	-0.314	0.222	-0.057	0.135	0.390	0.326	0.903	4.291	7.201
1972	4.584	5.005	3.004	1.708	1.659	5.764	4.075	4.043	0.868
1973	-0.399	0.641	1.561	4.545	1.823	3.638	3.795	2.411	3.067
1974	1.900	-1.174	-2.329	-1.013	-3.558	-0.612	-1.924	0.760	-1.301
1975	1.842	-0.488	-0.799	-10.887	-2.595	-3.743	-0.842	2.424	0.597
1976	-1.200	2.615	1.382	-0.880	2.912	3.521	3.447	0.510	3.898
1977	-2.838	0.617	-1.905	-4.221	1.221	3.346	6.259	1.388	0.753
1978	-1.836	2.105	0.082	1.731	-0.594	1.656	2.843	-0.276	-0.747
1979	4.062	0.161	-0.616	-0.406	1.159	2.995	2.339	1.797	-1.912
1980	6.390	2.782	0.538	2.770	1.494	3.608	3.774	-1.851	-3.230
1981	0.125	1.192	2.045	2.519	0.943	3.444	1.347	4.501	-1.225
1982	-4.501	0.243	-0.122	-5.775	-0.686	-0.694	2.521	-0.081	1.151
1983	-0.350	-2.670	-0.271	-5.222	0.867	2.782	-2.101	-1.531	3.371
1984	6.274	2.155	3.297	5.725	2.686	7.172	1.563	2.495	2.732
1985	0.180	-0.888	1.842	0.624	-0.100	5.216	3.214	-0.367	0.550
1986	5.448	-3.356	-1.968	-0.878	-1.487	7.369	1.796	-1.790	-2.796

Table 2A

Markups ($p_Y/MC=1/(1+\epsilon_{pY})$), U.S. Manufacturing

Year	MA	FO	TX	AP	PA	PP	CM	PC	RB
1960	1.149	1.277	1.194	1.265	1.203	1.255	1.320	1.148	1.108
1961	1.149	1.278	1.195	1.278	1.232	1.257	1.339	1.161	1.104
1962	1.151	1.264	1.193	1.273	1.241	1.261	1.369	1.179	1.122
1963	1.158	1.271	1.192	1.273	1.258	1.286	1.403	1.197	1.123
1964	1.163	1.283	1.199	1.274	1.263	1.309	1.420	1.209	1.138
1965	1.169	1.266	1.219	1.269	1.280	1.335	1.455	1.219	1.159
1966	1.179	1.256	1.240	1.279	1.306	1.358	1.505	1.239	1.181
1967	1.183	1.277	1.249	1.274	1.318	1.365	1.525	1.254	1.190
1968	1.197	1.300	1.286	1.299	1.352	1.394	1.636	1.265	1.231
1969	1.203	1.304	1.322	1.311	1.373	1.404	1.721	1.282	1.256
1970	1.201	1.323	1.322	1.317	1.397	1.374	1.741	1.327	1.233
1971	1.199	1.325	1.321	1.311	1.385	1.376	1.747	1.316	1.241
1972	1.209	1.309	1.326	1.284	1.402	1.408	1.833	1.320	1.282
1973	1.218	1.248	1.323	1.285	1.408	1.425	1.946	1.346	1.319
1974	1.210	1.246	1.292	1.239	1.356	1.375	1.824	1.256	1.250
1975	1.193	1.266	1.288	1.265	1.327	1.326	1.609	1.222	1.175
1976	1.203	1.299	1.291	1.269	1.351	1.347	1.688	1.217	1.195
1977	1.217	1.308	1.303	1.283	1.368	1.390	1.763	1.223	1.246
1978	1.229	1.298	1.323	1.297	1.388	1.425	1.856	1.253	1.270
1979	1.225	1.287	1.323	1.287	1.389	1.434	1.877	1.220	1.261
1980	1.214	1.297	1.282	1.279	1.380	1.436	1.805	1.191	1.222
1981	1.212	1.319	1.270	1.279	1.398	1.446	1.842	1.179	1.238
1982	1.198	1.341	1.239	1.274	1.416	1.455	1.743	1.173	1.218
1983	1.203	1.340	1.265	1.279	1.446	1.479	1.792	1.174	1.238
1984	1.214	1.330	1.269	1.276	1.448	1.527	1.879	1.203	1.296
1985	1.211	1.346	1.266	1.262	1.460	1.545	1.855	1.207	1.306
1986	1.221	1.362	1.285	1.253	1.503	1.551	1.904	1.336	1.306

Table 2A, contd.

	LW	FN	CL	PM	FM	MC	EL	IN	TQ
1960	1.432	1.146	1.184	1.248	1.144	1.187	1.136	1.184	1.228
1961	1.432	1.140	1.182	1.230	1.140	1.182	1.139	1.179	1.222
1962	1.485	1.154	1.181	1.237	1.150	1.198	1.157	1.176	1.253
1963	1.499	1.153	1.193	1.250	1.156	1.208	1.160	1.175	1.272
1964	1.444	1.163	1.201	1.255	1.163	1.228	1.160	1.180	1.267
1965	1.467	1.182	1.213	1.271	1.180	1.252	1.178	1.197	1.281
1966	1.449	1.199	1.223	1.292	1.197	1.290	1.201	1.222	1.309
1967	1.478	1.198	1.215	1.271	1.205	1.290	1.202	1.232	1.316
1968	1.493	1.208	1.229	1.292	1.220	1.297	1.223	1.258	1.356
1969	1.496	1.218	1.238	1.293	1.219	1.320	1.243	1.288	1.350
1970	1.642	1.201	1.233	1.256	1.195	1.311	1.231	1.281	1.289
1971	1.564	1.198	1.237	1.247	1.188	1.286	1.220	1.280	1.312
1972	1.617	1.231	1.254	1.280	1.201	1.320	1.241	1.307	1.339
1973	1.523	1.235	1.268	1.314	1.222	1.391	1.280	1.359	1.384
1974	1.409	1.205	1.249	1.291	1.199	1.398	1.246	1.359	1.325
1975	1.369	1.164	1.224	1.258	1.169	1.340	1.205	1.326	1.284
1976	1.424	1.144	1.229	1.256	1.181	1.361	1.227	1.357	1.322
1977	1.442	1.208	1.236	1.270	1.192	1.399	1.268	1.399	1.356
1978	1.428	1.229	1.244	1.290	1.198	1.448	1.295	1.448	1.385
1979	1.378	1.230	1.239	1.275	1.201	1.487	1.315	1.475	1.377
1980	1.356	1.220	1.217	1.237	1.191	1.486	1.306	1.487	1.311
1981	1.372	1.219	1.206	1.239	1.185	1.512	1.324	1.520	1.287
1982	1.398	1.195	1.189	1.176	1.166	1.431	1.304	1.526	1.256
1983	1.466	1.210	1.199	1.171	1.169	1.405	1.316	1.516	1.302
1984	1.553	1.247	1.207	1.170	1.181	1.498	1.379	1.564	1.356
1985	1.535	1.250	1.205	1.153	1.183	1.501	1.361	1.559	1.373
1986	1.636	1.255	1.210	1.143	1.181	1.490	1.377	1.535	1.382

Table 3A

Cost Elasticity ($CU_c \epsilon^L_{CY} - \epsilon_{CY}$), U.S. Manufacturing Industries

Year	MA	FO	TX	AP	PA	PP	CM	PC	RB
1960	0.911	0.852	0.809	0.825	0.880	0.853	0.814	0.834	0.946
1961	0.908	0.852	0.815	0.803	0.846	0.852	0.801	0.823	0.940
1962	0.900	40.851	0.839	0.797	0.831	0.856	0.790	0.820	0.930
1963	0.893	0.846	0.847	0.781	0.815	0.822	0.771	0.814	0.930
1964	0.894	0.839	0.852	0.790	0.823	0.812	0.771	0.814	0.917
1965	0.897	0.852	0.820	0.802	0.814	0.799	0.767	0.813	0.903
1966	0.880	0.855	0.800	0.801	0.785	0.777	0.731	0.803	0.877
1967	0.862	0.835	0.771	0.781	0.757	0.764	0.723	0.799	0.869
1968	0.827	0.814	0.723	0.737	0.719	0.726	0.656	0.784	0.805
1969	0.807	0.807	0.693	0.711	0.701	0.713	0.612	0.770	0.772
1970	0.794	0.798	0.697	0.687	0.665	0.709	0.594	0.758	0.743
1971	0.808	0.798	0.700	0.681	0.687	0.713	0.599	0.767	0.744
1972	0.820	0.814	0.708	0.742	0.697	0.707	0.583	0.767	0.732
1973	0.832	0.851	0.701	0.769	0.720	0.706	0.561	0.776	0.725
1974	0.857	0.846	0.714	0.789	0.734	0.728	0.590	0.835	0.776
1975	0.856	0.837	0.685	0.757	0.715	0.753	0.638	0.831	0.818
1976	0.843	0.816	0.686	0.753	0.714	0.750	0.607	0.834	0.804
1977	0.839	0.806	0.709	0.756	0.716	0.745	0.588	0.840	0.778
1978	0.822	0.807	0.673	0.739	0.696	0.730	0.557	0.831	0.759
1979	0.829	0.805	0.681	0.736	0.691	0.726	0.552	0.855	0.761
1980	0.818	0.786	0.690	0.730	0.660	0.701	0.552	0.870	0.748
1981	0.795	0.768	0.691	0.724	0.629	0.681	0.525	0.873	0.704
1982	0.782	0.756	0.688	0.734	0.611	0.666	0.540	0.867	0.699
1983	0.794	0.765	0.697	0.747	0.620	0.678	0.546	0.870	0.711
1984	0.783	0.763	0.699	0.749	0.617	0.675	0.520	0.858	0.689
1985	0.788	0.762	0.663	0.771	0.619	0.687	0.541	0.861	0.705
1986	0.790	0.763	0.687	0.793	0.625	0.702	0.549	0.816	0.733

Table 3A, contd.

	LW	FN	CL	PM	FM	MC	EL	IN	TQ
1960	0.672	0.864	0.874	0.810	0.904	0.911	0.931	0.909	0.871
1961	0.665	0.865	0.877	0.804	0.904	0.905	0.917	0.897	0.858
1962	0.624	0.859	0.887	0.800	0.900	0.879	0.898	0.912	0.842
1963	0.610	0.859	0.889	0.802	0.894	0.866	0.894	0.906	0.830
1964	0.675	0.859	0.890	0.828	0.893	0.856	0.904	0.905	0.830
1965	0.697	0.853	0.888	0.827	0.892	0.849	0.918	0.904	0.843
1966	0.712	0.831	0.854	0.822	0.877	0.813	0.924	0.888	0.808
1967	0.686	0.813	0.832	0.812	0.869	0.800	0.917	0.864	0.787
1968	0.669	0.784	0.797	0.768	0.842	0.767	0.867	0.822	0.751
1969	0.661	0.768	0.769	0.759	0.830	0.739	0.836	0.804	0.735
1970	0.553	0.741	0.738	0.765	0.821	0.742	0.825	0.775	0.754
1971	0.600	0.758	0.761	0.754	0.829	0.760	0.828	0.770	0.767
1972	0.611	0.765	0.781	0.749	0.837	0.751	0.830	0.764	0.765
1973	0.685	0.767	0.783	0.773	0.826	0.719	0.818	0.746	0.740
1974	0.728	0.776	0.781	0.811	0.842	0.714	0.834	0.760	0.769
1975	0.725	0.766	0.751	0.749	0.845	0.732	0.830	0.772	0.797
1976	0.714	0.772	0.767	0.734	0.839	0.715	0.800	0.746	0.773
1977	0.734	0.776	0.778	0.709	0.844	0.709	0.794	0.727	0.752
1978	0.752	0.767	0.778	0.708	0.837	0.684	0.782	0.696	0.727
1979	0.785	0.760	0.776	0.728	0.839	0.668	0.779	0.687	0.717
1980	0.701	0.736	0.728	0.717	0.822	0.650	0.758	0.658	0.720
1981	0.634	0.712	0.693	0.698	0.802	0.625	0.723	0.621	0.709
1982	0.594	0.700	0.665	0.632	0.795	0.646	0.702	0.597	0.721
1983	0.608	0.723	0.709	0.642	0.819	0.698	0.711	0.613	0.730
1984	0.561	0.726	0.725	0.675	0.830	0.669	0.696	0.598	0.694
1985	0.600	0.745	0.758	0.687	0.832	0.683	0.706	0.597	0.688
1986	0.589	0.764	0.787	0.706	0.845	0.723	0.710	0.627	0.695

Table 4A

Corrected Cost-Side Productivity Growth (ϵ^{T}_{Ct}), U.S. Manufacturing (%)

Year	MA	FO	TX	AP	PA	PP	CM	PC	RB
1960	-0.123	0.441	1.743	1.766	-1.819	-6.158	-0.387	0.972	-1.347
1961	1.089	0.215	0.233	-2.337	-0.032	4.642	0.303	0.470	3.866
1962	1.075	0.970	2.073	-0.427	-0.839	-3.604	1.027	-0.105	1.568
1963	1.701	0.560	0.873	1.347	0.186	1.610	1.001	0.193	1.433
1964	1.639	-1.134	1.871	-1.839	1.364	2.437	2.103	0.639	1.221
1965	1.233	1.629	-0.173	1.132	-0.839	-0.690	-0.226	-0.353	0.086
1966	0.142	1.315	0.926	0.570	-1.084	0.385	-1.439	-0.170	-0.741
1967	-0.827	-1.138	0.548	2.422	-2.280	-0.486	-4.449	-0.170	0.233
1968	0.124	-1.306	-2.203	-1.320	2.301	-1.187	0.277	0.698	-0.863
1969	0.559	0.586	0.616	0.477	1.876	0.606	-0.026	0.049	1.068
1970	0.077	0.581	4.326	-0.138	-0.933	-2.331	1.373	1.366	-1.939
1971	1.544	1.131	0.198	0.863	1.621	0.443	0.983	0.007	1.881
1972	1.262	0.888	-0.303	6.187	1.870	0.306	-0.340	0.033	-0.635
1973	1.290	2.059	-0.784	0.687	3.696	0.746	0.235	-0.163	0.394
1974	-1.634	-3.007	-2.053	3.420	-1.184	-0.288	-4.448	-0.781	-1.931
1975	-0.004	0.965	2.211	0.436	-2.462	0.138	0.251	-0.201	2.609
1976	0.716	-0.722	2.202	-0.690	0.280	-0.384	-1.509	-1.031	-1.955
1977	-0.514	-2.397	3.559	-1.318	-0.781	-1.995	-2.648	-1.143	-1.427
1978	-0.437	0.813	-1.149	0.152	0.292	-1.597	-1.926	-0.413	-0.770
1979	0.219	1.442	3.034	1.834	-0.778	-1.040	0.780	-1.509	-0.259
1980	1.701	1.726	4.973	3.302	0.111	-0.758	0.096	2.204	2.722
1981	0.977	1.788	2.018	1.519	0.784	0.840	1.871	-0.539	2.481
1982	1.594	1.761	3.510	-0.464	3.810	-1.405	3.213	0.467	0.791
1983	-0.065	-0.537	-0.730	-1.359	-1.307	-0.868	-1.031	-1.239	0.802
1984	0.571	-0.147	0.226	0.865	-0.709	-1.693	-1.006	1.404	-1.008
1985	1.505	1.720	-6.292	0.371	-0.751	-0.611	0.083	0.271	3.002
1986	0.716	-2.089	5.808	-2.550	0.278	-2.273	2.937	0.298	-0.320

Table 4A, contd.

	LW	FN	CL	PM	FM	MC	EL	IN	TQ
1960	-1.455	-2.273	-0.405	-2.486	-0.674	-0.003	2.044	-1.654	1.417
1961	0.209	1.052	2.048	1.284	0.618	1.839	3.302	-1.857	0.604
1962	-0.091	-1.703	0.168	-1.149	0.729	2.188	3.781	1.408	0.869
1963	5.089	2.998	2.215	1.067	0.303	-0.018	3.783	-0.925	3.827
1964	8.629	0.926	0.790	1.121	0.547	2.664	3.127	3.321	3.001
1965	1.450	1.604	-0.583	-1.232	0.278	-1.179	4.511	4.242	3.630
1966	0.707	-0.352	-0.973	0.321	-0.998	-1.122	-0.219	0.435	-2.759
1967	2.395	-0.189	-0.434	-1.125	0.542	-0.308	-0.203	-1.484	-2.430
1968	1.609	0.098	0.618	-2.665	-0.290	0.326	1.079	1.678	0.017
1969	-3.076	1.251	0.779	-0.972	0.439	-0.353	2.792	2.535	-0.421
1970	1.243	-1.793	-0.423	0.124	-0.070	1.496	-0.208	-0.773	-1.200
1971	-0.119	0.211	-0.415	0.992	0.714	1.532	1.222	3.646	4.192
1972	0.521	2.390	1.347	-0.285	0.542	2.291	2.142	1.244	-1.633
1973	0.201	0.469	0.531	1.846	0.535	-0.815	1.550	-0.484	0.103
1974	4.350	-0.080	-1.968	-1.977	-2.817	-2.606	-1.789	-1.352	1.081
1975	5.607	1.514	1.010	-6.182	-0.329	0.105	1.388	4.008	1.632
1976	-3.794	1.282	0.842	-0.885	1.748	1.650	1.929	-1.648	1.662
1977	-5.320	-0.267	-2.165	-4.000	0.178	0.762	3.177	-1.069	-1.132
1978	-2.432	0.843	-1.029	0.062	-1.119	-1.666	1.305	-2.635	-2.349
1979	4.144	-0.010	-0.772	-1.022	0.669	0.309	0.493	0.132	-1.578
1980	7.044	1.730	1.493	4.532	2.420	3.061	3.360	-2.645	0.255
1981	-0.317	-0.485	1.021	0.148	0.566	1.903	0.695	3.174	-0.902
1982	-3.081	1.325	0.547	-0.225	0.660	4.373	3.422	0.054	1.849
1983	-1.527	-1.458	0.480	-1.849	1.077	3.677	-1.946	-1.002	0.998
1984	3.556	0.207	1.375	2.706	1.549	1.476	-1.192	0.172	-0.159
1985	0.631	0.171	1.972	2.078	-0.054	4.265	3.803	-0.543	-0.086
1986	2.009	-1.996	-1.257	1.138	-0.549	7.093	1.310	-0.632	-2.610

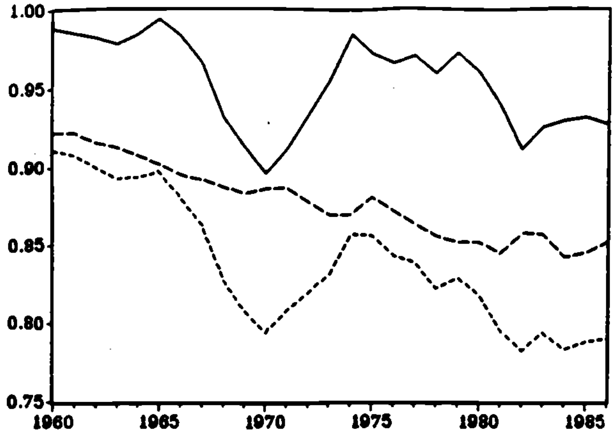

Figure 1a

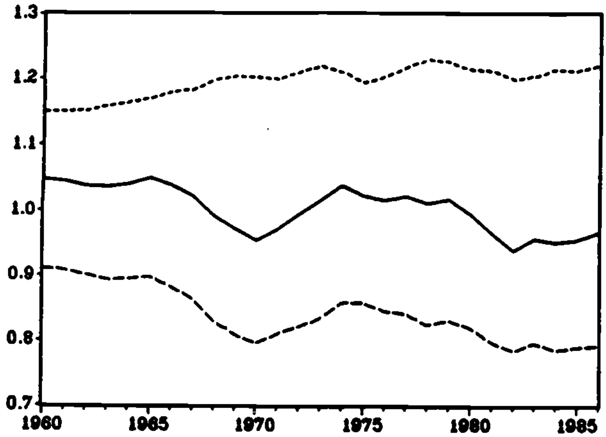

Figure 1b

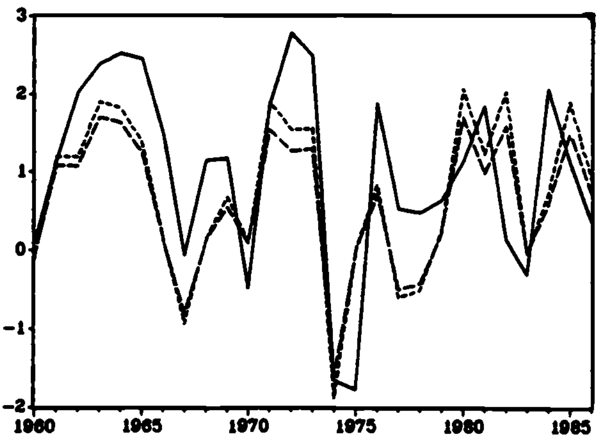

Figure 1c