WORKING PAPER
ALFRED P. SLOAN SCHOOL OF MANAGEMENT

PRODUCTIVITY AND ITS MEASUREMENT
A STRATEGIC PERSPECTIVE

by

Zenon S. Zanetos
and
Ming-Je Tang

September 1986

MASSACHUSETTS
INSTITUTE OF TECHNOLOGY
50 MEMORIAL DRIVE
CAMBRIDGE, MASSACHUSETTS 02139
PRODUCTIVITY AND ITS MEASUREMENT
A STRATEGIC PERSPECTIVE

by

Zenon S. Zannetos
and
Ming-Je Tang

September 1986  1792-86
PRODUCTIVITY AND ITS MEASUREMENT, A STRATEGIC PERSPECTIVE *

Zenon S. Zannetos, Professor
Sloan School of Management
Massachusetts Institute of Technology
50 Memorial Drive
Cambridge, MA 02139
(617-253-7164)

Ming-Je Tang, Assistant Professor
Department of Business Administration
University of Illinois at Urbana-Champaign
Champaign, IL 61820
(217-333-2504)

* The authors wish to acknowledge the contribution of Dr. Themis Papageorge to this research and the partial financial support of the Hyundai Corporation.
I. **INTRODUCTION**

Strategy is formulated based upon trends in the environment which may create the threats and opportunities a firm will face in the future. The competitive environment is probably one of the most important sub-environments to a firm's strategy. Consequently, a firm needs to capture the trend of its relative competitive position through environmental scanning. Given the abundance of available information bounded rationality and problemistic search (Cyert and March, 1963) the question is not whether to scan a firm's environment but which signals the firm should pay attention to and how. Very little research has been performed in this area. Aguilar (1967), Kefalas and Schoderbek (1973), and Hambrick (1981a, 1981b, 1982) have described the process through which environmental scanning is conducted at different management levels. Very few studies focus on the "content" of environmental scanning with empirical evidence. This paper attempts to develop an empirical measure of productivity which serves as a strategic signal to management by indicating the long-term trend of the relative competitiveness of an industry. The measure should be also used at the firm level and compare the productivity of firms within an industry. It, in effect, should perform a dual role.

Although a great deal of excellent research has been conducted on productivity, the work has been mainly concentrated at the macro-economic
level and as a result, it has not provided meaningful information to the managers who are in a position to improve productivity through strategic and policy decisions.

In an attempt to fill the vacuum, this study focuses on productivity at the level of the firm rather than the economy as a whole. Our goal is to structure company data in an associative context that is not only feasible to obtain, but which is also meaningful as well as effectively useful for decision makers. To this end, the methodology should, as much as possible, (1) relate symptoms with causes; (2) point to appropriate remedies for the identified problems; and (3) be feasible as well as effective.

More specifically, the particular measure of productivity found to possess these attributes is value added over payroll and benefits (VA/PB). The numerator, value added, reflects how a firm's output is accepted in the market, which represents the effectiveness of the firm. The denominator reflects the amount of homogenized labor input. The ratio reflects a firm's relative efficiency of achieving value in the market; and thus its relative competitive position.

In this paper, we will address the development of this productivity measure and demonstrate its application. We will start by reviewing existing literature concerning approaches to productivity analysis and develop criteria for evaluating and choosing productivity measures. Several productivity measures will then be tested against the developed criteria using data from the U.S. automobile industry. Finally, we will discuss the relationship between the preferred productivity measure and other commonly used performance measures such as return on sales, absolute earnings, and earnings per share.
II. LITERATURE REVIEW

Productivity describes the efficiency of the process with which inputs are converted into output(s). Thus, productivity is measured as the ratio of output to input. If only one of several input factors is included in the denominator, the resulting productivity measure is a "single factor productivity." If, on the other hand, all input factors are counted in the denominator, the resulting measure is "total factor productivity." When multiple outputs or inputs are involved in productivity measures, researchers face the critical issue of how to aggregate the outputs and inputs. The major differences among the several approaches to productivity analysis reside in the weighting schemes used to aggregate outputs or inputs and in the choice of single factor productivity or total factor productivity as the focus of analysis.

III. Approaches to Productivity Analysis

Our literature review revealed four basic approaches to productivity analysis: (1) production function; (2) econometric; (3) growth accounting; and (4) behavior science. The production function and growth accounting approaches deal with total factor productivity, while econometric and behavior science approaches largely deal with single factor productivity. This literature review does not intend to be exhaustive. For a comprehensive review please see Nelson [1981].

1. Production Function: Researchers using the production function approach assume that the growth of output can be attributed to a growth of input and to technological progress (Solow, 1956; Gallop and Jorgenson, 1980; Fraumeni and
Jorgenson, 1981). To identify the contribution of input factors, a specific production function or its dual, a cost function, is assumed. Techniques, such as econometrics, are used in estimating the parameters of the production function or cost function. The difference between actual output growth and calculated output growth is defined as productivity growth or technical change. A translog production function with constant returns to scale, a flexible form of production function, is commonly assumed.

2. **Econometric Approach**: In contrast, those using the pure econometric approach do not restrict themselves to the factors used in the production function approach [Mansfield 1980; Kopcke 1980]. They believe that other factors such as R & D expenditures and technology may make direct and significant contributions to productivity growth and therefore, should be directly incorporated in the model. In the econometric models, the dependent variable is productivity and the independent variables are factors believed to affect it. Hypothesized relationships are tested by examining the statistical significance of the coefficients of the independent variables. By means of this approach correlation can be established but causality cannot necessarily be implied.

3. **Growth Accounting**: The third approach, growth accounting, is based upon the assumptions that (a) the production function is differentiable; (b) the relevant markets are competitive; and (c) the earnings of each factor of production, when fully employed, equal the value of its product Denison 1974, 1979 (1); Kendrick 1961; Kendrick and Grossman 1980. The contribution of each individual input is measured by its market return and its share in specific output value. Specific output growth is then related to input, by weighting
the growth of physical inputs by their respective shares in specific output value. As in the case of the production function approach, the output growth which cannot be explained by inputs growth is attributed to technological progress or productivity growth.

The three approaches reviewed above reveal important aspects of macro-productivity, may be theoretically and intuitively appealing, especially for the field of public policy formulation, but very difficult to support empirically. Even for policy decisions, the support derived from the models is symptomatic and not causal-diagnostic. Furthermore, the averaging process, which permits stability of behavior through aggregation, conceals valuable information relevant to the identification of causes as well as the measurement of productivity.

4. The final approach we categorize as behavioral science Hall and Dickson 1975, Horwitz and Sherman 1980. In contrast to the other approaches, the unit of analysis is at the level of the firm and of the individual. Instead of focusing on structured or economic factors, behavioral science focuses on firm-specific and individual-specific variables such as motivation, organizational structure, and group dynamics. The methodologies used with this approach vary considerably, but often include questionnaires, surveys, interviews, and observations. While much of the data are "soft," this approach often provides pertinent information or insights, regarding the behavior of those who make decisions, that are not found in other approaches.

As mentioned earlier, in this paper we will deal with productivity at the level of the firm and the industry, and with the measurement of such. Our goal is to provide information useful for managerial decisions. We are in
effect claiming, and this should not escape the reader, that it is the combination of resources through use that adds value and not the possession of resources. As a result, the starting point should be unique managerial decisions, which derive from the use of the firm's technology and aimed at the final product or service as well as the use of resources for effectively marketing it.

To accomplish the goal, we will develop criteria for evaluating productivity measures; contrast various measures against the criteria developed; apply some measures, including the one we propose, to the U.S. automobile industry; and present some strategic implications of our research for productivity growth.

IV. CRITERIA

To establish pragmatic criteria for evaluating productivity measures, we identified three main areas of concern: (1) theoretical and statistical soundness; (2) feasibility; and (3) usefulness. It should be noted that the criteria we will use to assess the desirability of measures are not independent of one another. Theoretical purity and feasibility are often incompatible and, as a result, it is often necessary to devise tradeoffs, especially at the margin.

Theoretical and Statistical Soundness

Productivity may be defined as the output per given level of input, where both output and input can be measured in terms of physical units, value, or in the case of output, value-added. Although the choice of the terms of measurement is to a certain extent arbitrary, the measure chosen should be consistent, homogeneous, robust, and valid.
(1) By consistent, we mean that the measure should be as free of interdependencies as possible, should have clearly stated assumptions, and be free of the measurement process. Furthermore, causal relationships implied in the measure should be explicitly stated. A particular measure is meaningful when it reflects not only the assumptions but also the cause-effect relationships. It is the latter which provides the associative context in which data are used and by means of which meaning is generated. It is critical that these relationships be clearly delineated for decision-making purposes, such as the hypotheses implicitly proposed in the usage of a particular measure.

(2) Homogeneity is the quality of being uniform or having common properties deriving from the same genus, both at any moment in time and over time. Aggregating heterogeneous inputs and outputs by their physical units is meaningless unless some homogenization mechanism is imposed. In an efficient market, the price contains all necessary information and thus price is normally used as the mechanism for homogenization. However, the use of price is not free from problems. Information impactedness, uncertainty, and inflation may all mitigate the effectiveness of price as a homogenization mechanism.

(3) Another statistical concern is whether or not a measure is robust in terms of its ability to represent the distribution of variance in a given population of data. Statistically speaking, a strong argument can be made for using an estimator that is reasonably efficient for any kind of population shape. Efficiency is defined in the general case as the ratio of the mean square error of two estimators. An estimator which is free of the assumption
that the population distribution is normal, and is therefore reasonably efficient compared to a normally distributed estimator, is called robust, distribution-free, or nonparametric.

(4) A test is said to be valid if its probability values and confidence intervals are correct as specified. In our test we employ mean and variance out of the population of residuals. Since the total number of residuals will be small (we chose a period of 25 years), the student distribution is more appropriate than the normal distribution for the determination of probability $P_i$, for $i = 1, 2, \ldots, k$. Therefore, we decided to use the student distribution for the calculation of $P_i$. The methodology used to examine the robustness and the validity of various productivity measures is presented in an earlier working paper (Zannetos et al., 1981).

B. Feasibility

The second area of concern is the practicality of the measure, for what is theoretically attractive may be impractical or impossible to calculate. Thus, the following criteria are utilized:

(1) The elements of the productivity measure must be measureable, and the unit of measurement must be independent of the item being measured. They must be reasonably quantifiable.

(2) The measure should utilize data that are feasible to collect. Of course, the best situation is one where data are already available, but in any case the measure should not call for data which are by nature unavailable or prohibitively expensive to gather.

C. Usefulness

The final criterion concerns the usefulness of the measure. The measure chosen may be theoretically attractive, as well as feasible, yet it may convey no effectively-useful information to interested parties.
(1) The measure should be useful for inter-firm, intertemporal, and inter-industry analysis. For this reason, national aggregative measures are not useful for our purposes. Furthermore as we have already stressed, that the averaging and standardization processes which are inherent in the generation of macro data, hide critical information useful for intra-firm, inter-firm, and inter-industry analyses. Disaggregation without loss of consistency, homogeneity, and robustness is a very desirable attribute of a measure.

(2) The measure should provide strategic signals to decision makers. Too often measures indicate a change taking place but provide no meaningful information as to exactly what has occurred and what corrective actions might be appropriate. According to the causal relationships hypothesized in the measure mentioned above, interested parties should be able to monitor certain indices in order to identify critical changes in the internal as well as external environment of the firm or industry, as well as in the probable causes of these changes. These signals provide useful feedback and as such should become part of a firm's (or industry's) control system. They should also derive from data generated by the on-going information system of the firm if the organizational intelligence is to be captured in the context (Zannetos 1986).

(3) The measure should not only be useful but also must be usable. In other words, the measure must not only be contextually associated with the decision-maker's frame of reference, but also must be easy to use; otherwise, it will never be used.

(4) The measure must yield information which contains prognostic
powers. Unfortunately this attribute can only be tested ex post facto, although it can be used in an ex ante basis, in order to verify the opinion of the experts, once confidence in the measure is established.

(5) Finally, the measure must be cost-effective, in the sense that the value of information generated must be greater than its cost.

From the previous discussion, we can see that it will be difficult to find a single measure which will meet all criteria, especially since some are at cross-purpose with others. Thus, priorities must be set among the criteria. While the first two criteria are certainly important, if we have to err, we will do so in favor of usefulness. In an era of research, innovation, exploding information technology and specialization, all of which destroy the determinism of normal market behavior, the decision makers need more information but fewer data. They need a filter which derives from the context of the user. What determines meaning and usefulness is the associative context of the manager, and there upon also rests his/her comparative advantage. (Zannetos, 1973; 1986)

V. **EVALUATION OF PRODUCTIVITY MEASURES**

In this section, we will briefly examine the most commonly used productivity measures in the light of the criteria developed in the previous section.

First, consider the production function and the growth accounting approaches. Both deal with total factor productivity and productivity growth is defined as the portion of output growth not explained by input growth. Productivity growth is simply a residual and is not explained by the production function specified or the growth accounting equation. Since the underlying causes of the changes in the productivity growth are not known,
these measures fail to meet our first criterion, that of consistency. Secondly, it is almost impossible to find a satisfactory mechanism for homogenization of capital goods because the prices of used capital goods such as structures and machinery and equipment are difficult and often impossible to obtain. Another critical issue in measuring capital input is whether the latter should be adjusted for utilization and if so how. Different adjustment mechanisms for capital inputs result in significant variations in the total-factor-productivity growth calculated from the production function and the growth accounting equation. Thus, the heterogeneity of capital goods and the lack of proper homogenization mechanisms make the results derived from these two approaches unreliable. More importantly, these two approaches are more applicable at the national level to facilitate public policy decisions and are of limited value for managerial decisions at the firm level. Since total factor productivity measures are deficient in several aspects of our criteria, we turn our attention to single factor productivity measures.

The most widely used single factor productivity measure is the Bureau of Labor Statistics (BLS) measure, value added per man-hour. The output measure, value added, is homogeneous in the sense that the price mechanism is used to homogenize outputs. Also, since value added is sales minus the cost of materials purchased, it eliminates double accounting for suppliers' contributions to output. However, labor input is not homogeneous because hours worked by skilled and unskilled workers are equally weighted without regard for differences in their contribution. Moreover, data on hours worked cover only production workers. However, from a managerial point of view, all workers—support as well as production—are part of the cost function of the firm and the industry. We suggest that the price mechanism be used to
homogenize labor input and that all labor including the president of the firm, be included. The resulting productivity measure is total value added to the goods and services produced by the total payroll and benefits utilized for the period, per dollar of the total payroll and benefits. Value added has four components: payroll and benefits, total depreciation, interest, and profit before taxes in the total production. The productivity measure, VA/PB becomes:

\[
\begin{align*}
\text{VA/PB} &= \frac{\text{VA}}{\text{P & B}} \\
&= \frac{\text{P & B} + \text{D} + \text{I} + \text{PBT}}{\text{P & B}} \\
&= 1 + \frac{\text{D} + \text{I} + \text{PBT}}{\text{P & B}}
\end{align*}
\]

Where: VA/PB = Total Value Added to the goods and services, produced during the period by the total payroll of the period, per dollar of total payroll and benefits.

VA = Total Value Added
P & B = Total Payroll and Benefits
D = Depreciation and other Amortizations
I = Interest
PBT = Profit before taxes on total production for the period.

In addition to homogeneity, this measure is also free of interdependencies in several aspects.

1. Unless productivity increases the measure it is not affected by the substitution of indirect labor for direct labor because both the numerator and the denominator include both labor classes. So a simple accounting shift or
reclassification of direct labor to indirect labor will not affect the measure. If on the other hand an effective reorganization occurs which changes the direct to indirect labor ratio, with a resultant increase in productivity, the latter will be reflected in an increase in the measure because of an increase in PBT.

2. The measure is free from the effects of substitution between different labor classes. As price is used to homogenize labor input, net effects of substitution between skilled and unskilled workers will be reflected in the VA/PB. As the U.S. industries gradually shift toward skilled labor and white collar workers, the productivity measure will indicate how successful its skilled laborers substitute for unskilled laborers.

3. Since both the denominator and the numerator are in nominal dollars and inflation will increase both of them by roughly the same percentage, the measure has an advantage of mitigating the effects of inflation. To put it another way, and subject to item 6 below, the equipment will be the only historical cost that will not possibly change with inflation. However, to the extent that (a) technology with its concomitant increase in productivity and reduction of maintenance will be incorporated in subsequent models of manufacturing equipment and (b) even if technology has not changed, the demand for equipment and the imputation of value through the markets, will result in neutralizing the effects of inflation.

4. As vertical integration increases both value added and payroll and benefits, increase or decrease accordingly. If we further assume that the increase or reduction of integration is a conscious management decision, there must be some intermediary market for the output of the process added or dropped, to evaluate its contribution.
5. If a fair price of the output is available, the VA/PB measure could be applied to the plant level and even to any stage of production.

6. This measure also reflects the monopoly power of the firm relative to that of the union. Since the exit cost of labor is low and the opportunity cost of labor to the firm is relatively high, there is a great chance that a union can win a raise even though physical labor productivity does not increase accordingly. As a result, VA/PB decreases. However, if the firm obtains some monopoly power through technological advancements of its product, the technological superiority allows the firm to raise its price to the "functional equivalent value" of the product minus the necessary switching costs. This capability permits the firm to pass along its cost increases to the consumer and the net result may be an increase in VA/PB. In other words, other things being equal, if the firm's monopoly power is higher than that of its union, the firm may be able to pass along the increases in terms of higher prices using some of its "monopoly rent".¹

The proposed productivity measure is superior to traditional profitability measures such as accounting return on investment (AROI)² return on sales (ROS), return on equity (ROE), absolute earnings (E) and earnings per share (ERS) adjusted for inflation or not. Enough has been written in the professional literature about the last three measures, however, to motivate us to concentrate on the first two. By implication all the arguments presented for the AROI and ROS apply to the other three. First, the denominator of AROI is capital invested which is strongly affected by price fluctuations and the time the investment is made. Thus, the ROI may be misleading in comparing the performance between different firms formed in different years and investing in a different time-related pattern. Although indices of capital goods are available and adjustments are feasible, they are
too aggregate to reflect the price levels of particular supplying industries a firm faces. The more unique the firm is the more specialized the capital and the more difficult it is to obtain a market measure for capital goods adjustment. And uniqueness is what determines monopoly rent.

Turning now to ROS both numerator and denominator of VA/PB are in constant dollars, ROS therefore avoids this problem of price instability. However, ROS is not a consistent measure of production efficiency due to the effect of vertical integration. Consider two firms with the same level of efficiency and sales, but different levels of vertical integration. The firm with a higher degree of vertical integration will on average have larger operating profits than the less vertically integrated firm. As a result, the less vertically integrated firm has a lower return on sales even though both firms are as equally efficient for the common part of the manufacturing process. Thus, the trend of ROS is measuring changes in both efficiency and vertical integration. In sum, AROI is not free from price level changes and ROS is not free from the degree of vertical integration. Similar arguments may be made for ROE, E, and EPS.

Despite these desirable features of the proposed productivity measure, one may say that it is not free from certain misleading consequences of labor--capital substitution. If, for example, a firm substitutes capital for labor and wage rates per hour remain unchanged, total labor costs will be lower and depreciation will be higher. Profits will increase (or fall) depending on whether the reduction in labor costs exceeds (or is less than) the increase in depreciation. However, we can think of cases where VA/PB increases and profitability decreases.

Obviously, a drop in profits, under normal conditions may be undesirable. Therefore, an analysis of the reasons must be carried out. This can be done
by analyzing the components of value added. It could be that the profitability drop is due to short-run phenomena and not because of a management misjudgment. For example, it could be because a lot of start up costs were charged to operations instead of capitalizing them. Alternatively, the reduction in profits may be due to accelerated depreciation. Of course, a decision on a project that comes very close to the refusal value may no be wise for management but the proposed measure can raise these questions.

In summary, the proposed measure combines several desirable attributes in that it (1) is homogeneous, (2) compensates for relative substitution between direct and indirect labor and between different labor classes, (3) compensates for relative inflation, (4) reflects the relative degree of vertical integration, (5) can be applied at any level in the value-added chain and (6) indicates the relative monopoly power of the firm to pass along the cost increase versus that of labor to extract higher renumeration.

The next criterion of concern is the robustness of the measure. Using the U.S. automobile industry, the proposed productivity measure and other similar measures have been tested for robustness at both the firm level and industry level. At the firm level, sales and value added have been used as output measures and (a) cost of goods sold, (b) cost of goods sold plus depreciation and amortization, (c) cost of goods sold plus capital expenditures, and (d) payroll and benefits have been used as input measures. At the level of industry (SIC 3717: Motor Vehicle and Parts and SIC 3715: Truck), wages of production workers hours of production workers, and payroll are used as input measures and value added used as the output measure.

The statistical test of the robustness of the productivity measures is too involved to present here. We instead refer you to an earlier working paper [Zannetos et al 1982], where it is shown that value added over payroll and
benefits is consistently a robust measure while others are not. Thus, the ratio VA/PB satisfies the soundness criterion best. Having identified a measure that is theoretically and statistically sound, we now will evaluate its usefulness. The concept of usefulness is a relative one. Thus, we will compare the relative usefulness of the proposed productivity measure with other commonly used performance measures.

VI. Usefulness of the Productivity Measure as Compared to Common Performance Measures

We use market share of imported cars as an indicator of the health of the U.S. auto industry. Exhibit 1 shows that the market share of imports has been increasing since 1964 and reached 27.9 percent in 1982. Although the imports share declined somewhat in 1983 and 1984, this decline can be attributed to import quotas. Considering the long-term decline of the U.S. auto industry, we ask: What measures can provide managers with early warning signals?

Many criteria are commonly used by management to evaluate company performance and to provide signals for strategic changes, including return on sales (ROS), return on stockholders' equity (ROE), return on total accounting investment (AROI), net income (NI) and earnings per share (EPS). The term "return" can be based on either net income or as operating income before taxes, interest and extraordinary items. Since net income is affected by "financial operations" such as the debt-equity ratio, extraordinary items and
taxes which have nothing to do with the production efficiency of a firm, operating income is theoretically superior to net income in measuring efficiency. Therefore, operating income is used to calculate return in this paper. We will compare the usefulness of these performance measures to that of VA/PB.

The VA/PB of GM is shown in Exhibit II. Exhibit III through VII present these performance measures for GM from 1955 to 1984. (Since GM has more than 60 percent of the share of the U.S.-made car market, it is representative of the U.S. auto industry)\(^3\). Observe that only VA/PB and ROS give any indication of declining health in the industry. Neither ROI nor ROE indicate the trend of decline in the industry, while both net income and EPS actually show the industry progressing with positive trends for the fifteen years after the market share of imports begins climbing. Thus, only VA/PB and ROS have predictive power on the decline trend of the U.S. auto industry. Regressing VA/PB and ROS against market share of imports from 1958 to 1979 yields Pearson correlation coefficient of -0.895 and -0.886 respectively\(^4\). In other words, the VA/PB can explain up to 80 percent of the variance of the import market share. Using the U.S. steel industry as another sample, the Pearson correlation coefficient between VAPB and the import market share between 1949 and 1983 is -0.824, indicating a strong relation between VA/PB and international competitiveness.

---

INSERT EXHIBITS II through VII ABOUT HERE
Although ROS also explains a significant amount of the variance of the import market share, as stated earlier, ROS is not a consistent measure of production efficiency because of vertical integration. To reflect the efficiency of a firm, ROS must be adjusted for vertical integration. The Pearson correlation coefficient between adjusted ROS and the market share of imports drops to -0.862 and is lower than that of VA/PB. Also, although the correlation coefficient cannot show the direction of causality, one may reasonably argue that the low ROS is likely to have been caused by rising imports. Thus, we conclude that VA/PB has greater predictive power than ROS and other commonly used performance measures and those commonly used measures may provide wrong signals. However, if VA/PB is not readily available, adjusted ROS may be used as its surrogate.

We have already observed correlations between ROS, VA/PB and imports' market share, we now attempt here to establish the causality of these three variables. As the productivity of GM started declining, it gradually lost competitiveness, imports started gaining, and its economic monopoly power disappeared. As a result, the auto maker could not pass on all increases in costs to the consumer. This can be shown by the decline of the ratio of new car price index over the producer price index of the motor vehicle industry (Exhibit VIII). In the same period, as the productivity of auto makers declined, it became advantageous to buy materials rather than to produce and thus GM lowered its degree of vertical integration. The effect of the price-cost squeeze is reflected in the decline of ROS. Thus, the root of the decline of the profitability of the U.S. automobile industry and the inroads of imports is the decline in productivity as reflected in the measure VA/PB. Therefore, the decline in VA/PB not only resulted in intra-firm substitution (a vertical integration), but also inter-firm substitution (declining market
shares). These empirical results reveal that VA/PB, although a short-term measure, has long-term implications.

In conclusion, the proposed productivity measure is theoretically sound, technically feasible and most importantly, it is useful to provide strategic signals. Furthermore, based on the measure VA/PB we may derive implications for the strategy of the firm and for the management information systems.

Strategies for Productivity Growth

Recognizing the impact of declining productivity, we ask: What are the strategies to reverse the trend? Since productivity is a ratio of output to input, the answer lies in either reducing input (i.e., labor cost and material cost) or increasing output (i.e., value added). Although the cost reduction strategy is commonly prescribed and is intuitively appealing, however, for the U.S. auto industry which is facing fierce competition from Japan, and in the future from Korea, the value creation strategy is more effective in the long run. First, labor and capital costs in the U.S. are significantly higher than those in Japan and for sure higher than those of Korea. Even if the U.S. automakers successfully imitate Japanese strategies and increase productivity to the same level as the Japanese automaker, the cost differences due to wage and interest differentials cannot be eliminated. Since the Japanese have the cost advantage and it is highly unlikely that this advantage can be eliminated, it leaves the U.S. with no choice but to focus on the value creation strategy, e.g., product differentiation. Secondly, as argued in an
earlier paper [Zannetos et al 1982], low marginal cost is prohibitive to adopting product and process innovations. Since investment in process innovation aiming at cost reduction leads to lower marginal costs at the present time, it will also impede future adoption of product and process innovations. Thus, the common prescription of investment in process innovations to improve productivity may be dangerous in the long run especially in an era characterized by rapid technological changes. Therefore, the cost reduction strategy not only is futile (i.e., cannot solve the problem of cost differences), but also is vulnerable to future technological changes.

Finally, the value creation strategy fits the strength of the U.S. industry. This strategy can be implemented through effective product innovations. If such product innovations are proprietary and not easily matched, the innovator is insulated from price competition and can extract monopoly rents and thus increases its value added. This product innovation strategy requires technological superiority which is the strength of the U.S. Therefore, in the long run, it is advantageous for the U.S. auto industry to adopt the value creation strategy rather than the cost reduction strategy.

**Implications to Management Information System**

As shown before, the proposed productivity measure is a short term measure with long term implications and can be used to evaluate performance at the company or the plant level. As the measure incorporates a certain level of intelligence, it could be used as part of a decision-making system to aid performance evaluation and strategic planning. Although the information needed to calculate the productivity measure is readily available from accounting systems, it can not be directly obtained from profit and loss statements. This is mainly because profit and loss statements are generated
based upon goods sold, not goods produced, but value added of a firm should be based upon goods produced which is the total contribution of employees in a particular period. Thus, adjustment for the difference between goods sold and goods produced is necessary.

The difference between goods sold and goods produced is the difference between this year's and last year's inventory. If goods sold exceed goods produced, inventory will decrease and vice versa. Here, for the inventory change, we exclude raw materials and include only finished and semi-finished goods because the firm has not created any value on raw materials.

Basically we have two alternatives for making adjustments for inventory changes: i) adjust the denominator, payroll and benefits, or ii) adjust the numerator, value added. If inventory increases (decreases), the method of adjusting the denominator is to subtract (add) the payroll and benefits charged to the inventory increase (decrease) from total payroll and benefits. The second alternative is to adjust value added by adding (subtracting) the profit portion of inventory increase (decrease) to (from) the value added. The profit portion is the difference between the market value of inventory change and the cost of inventory change which is the profit margin. As previously explained we prefer the value added approach because that is the value generated by the utilization of resources.

**Conclusion**

We have examined various approaches to productivity analysis and showed that value added per dollar of payroll and benefits is a better measure in terms of theoretical and statistical soundness. Using the U.S. automobile industry as an example, it is shown that the productivity measure proposed is a better predictor of the health of the industry than traditional performance
measures such as AROI and ROS. To regain international competitiveness, we suggest that the U.S. auto industry adopt a value creation through product innovation strategy instead of a cost reduction through process innovation strategy. Our work has been limited to the U.S. auto industry, future research is needed to analyze industries such as the steel, semiconductors and computer industries to examine the generalizability of the conclusions derived from this paper.
FOOTNOTES

1. Monopoly rent is defined as the average rate of return that the firm enjoys over and above that of the industry. However, that does not imply that this is permanent, as we will show shortly.

2. This should not be confused with R.O.I. which is an ex ante project control measure. After the initial evaluation is made and the investment is initiated then normally complex operations revert to fiscal controls.

3. A similar analysis for Ford and Chrysler indicates that VA/PB reached a peak for Ford in 1960 and for Chrysler in 1958.

4. The reason for this closeness is that there is a "clearning" of inventory at the end of the year as they change models. For industries that build and liquidate inventories the difference will be greater.

5. Hourly wage rates of the auto workers in Japan are roughly half those in the U.S. and in Korea about 10%. If the problems of quality are conquered by Korea, then we will have another Japan in the making.
Bibliography


