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Special Issue on Productivity

Bureau of Business and Government Research
Midwestern State University
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BUREAU OF BUSINESS AND GOVERNMENT RESEARCH
MIDWESTERN STATE UNIVERSITY
WICHITA FALLS, TEXAS

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In this issue

FOREWORD

Garland R. Hadley, Director
Division of Business Administration
Midwestern State University

This is the second issue of the **Midwestern Business and Economic Review.** I am especially honored to present this issue because the editors have been kind enough to include an article by me as the lead article.

This issue deals with the topic of productivity. This is an extremely important subject at the present time because our rates of increases in productivity are closely related to the competitiveness of American industry in world markets; and it is increases in productivity that make possible increases in our real incomes and advances in our overall standard of living.

During the last few years there has been a great deal of concern because rates of increase in productivity have fallen. Why this has happened and the possible consequences of this decline are of special interest at this time. Hopefully the articles that follow will help provide a better understanding of productivity and its important role in our society.

There are five articles featured in this issue. They are:

"Have Real Income Been Declining?" by Dr. Garland R. Hadley, Director, Division of Business Administration;

"The U.S. Productivity Problem: An Introduction" by Dr. Yoshi Fukasawa, Associate Professor of Economics and Director of the Bureau of Business and Government Research;

"Productivity and Quality Circles" by Mr. Bruce Robertson, Division Facilitator for Quality Circles, Howmet Turbine Component Corporation;

"Productivity and Statistical Quality Control" by Mr. Ron Barnes, Training Coordinator, Cryovac Division, W.R. Grace & Company; and

"A Synopsis: Question and Answer Session" by Dr. Charles D. Ramser, Professor or Management.

Of these, the last four were presented at a seminar on productivity hosted by the Bureau of Business and Government Research at Midwestern State University in 1983.

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Herbert R. Smith

Herb Smith, Chairman and President of the investment counseling firm of Herbert R. Smith, Incorporated, was born April 14, 1932. He is married to Mary Jane Kolp Smith and they have two children, Sara and Russell.

Mr. Smith has been in the investment banking and investment counseling professions since graduation from Harvard Graduate School of Business Administration in 1959. At Harvard, he specialized in security analysis and investment courses and served as president of the student body. He also holds an A.B. degree in economics from Williams College where he was a member of the Senior Honor Society and active in varsity athletics.

For several years prior to forming Herbert R. Smith, Incorporated, he was a partner in a major regional investment banking firm (J. Barth & Co., San Francisco) where he developed an extensive background in equity and fixed income securities.

He is author of a quarterly economic and money market letter, a lecturer on market analysis and portfolio administration, and has instructed an MBA program and various banking industry advanced education programs.

Herbert R. Smith, Incorporated, serves as investment counsel to a significant number of banks in Texas and surrounding states, as well as a number of corporate pension funds, endowment funds and foundations.

Mr. Smith is a member of the Board of Trustees of the First United Methodist Church. He is serving, or has served on the boards of the MSU "M" Club, Wichita Falls Museum and Art Center, Wichita Falls Symphony, Theater League, Airport Advisory Board and United Fund.

IKARD SMITH

Ikard Smith

Mr. Ikard Smith, President of McClurkans, Inc., was born on August 25, 1919. He is married to Ann Smith, and they have several children and grandchildren.

Mr. Smith attended New Mexico Military Institute and the Wharton School of Finance at the University of Pennsylvanis, Philadelphia, PA. He also served with the 13th Airborne Division of the U.S. Infantry from 1941 to 1945. He held the rank of Major.

Mr. Smith has made significant contributions to the business and civic community in Wichita Falls. He is a former President of the Wichita Falls Chamber of Commerce, the Wichita Falls Industrial Foundation, Wichita Falls Midtown Now, Inc., YMCA and the Wichita Falls Board of Education. He has served on the Board of Regents of Midwestern State University and the Wichita Falls Symphony as well as on the Woman's Forum Advisory Board and Bethania Hospital Lay Advisory Board. He is also a member of the Board of Directors of First Wichita National Bank since 1954.

Mr. Smith was named Outstanding Salesman of the Year for Wichita Falls in 1977 by the Sales and Marketing Executives. He is a board member of the American Retail Federation and the Independent Stores of the National Retail Merchants Association.

Mr. Smith has served as co-chairman of the Employee Division of the United Fund and co-chairman for the March of Dimes. He has served as President of the Wichita Falls Council of Churches and is the former Chairman of the Board of the Floral Heights Methodist Church.

HAVE REAL INCOMES BEEN DECLINING?

Garland R. Hadley, Director of Division of Business Administration,
Midwestern State University

INTRODUCTION

For a number of years, Americans have taken for granted that their real incomes are increasing. A person who worked hard could expect to be better off each year. Even if his own skills did not improve much, rising capital investment and the increases in productivity that normally accompany added capital investment would cause wages to rise relative to prices, and his real income would increase.

During the past decade that trend seems to have disappeared. The most recent *Economic Report of the President* shows that Median Family Income in constant 1981 dollars had fallen from $24,633 in 1973 to $22,308 in 1981[16]. Estimates of incomes for 1982 and 1983 suggest some slight improvements, but they appear short of being strong enough to return the average family to the growth path it has enjoyed for the past 40 years.

Two independent research organizations concerned with the effect of taxes on personal disposable (after-tax) income have also issued reports showing that after-tax incomes appear to be falling. The Tax Foundation reported that from 1973 to 1983, before-tax income for a "protypical" American family (one earner employed full-time, year-round, with two dependent children) rose from $11,895 to $24,100. However, when direct Federal taxes (income taxes and social security taxes) were subtracted from the incomes of the "protypical" family and the results adjusted for inflation by the Consumer Price Index, it was found that the family's after-tax income had fallen from $10,168 to $8,832--a decline of $1,333 in constant 1973 dollars over the past 10 years[20].

Another group, the National Taxpayers Legal Fund, noting a significant shift away from the one-earner family (a decline of 14 percent since 1973), made similar estimates to determine whether the two-earner family had fared any better. After adjusting for taxes and inflation, the NTLF estimated that the two-earner median family, in terms of 1973 dollars, had experienced a loss in real disposable income of $902--from $11,459 in 1973 to $10,557 in 1983[4].

Thus, three separate organizations have recently issued reports, all containing data that suggest that the historic trend in increases in real income seems to have halted--or at least faltered. The real income of the average working person, or family, in 1983 does not appear to be any more than it was in 1973. If anything, it may be lower.

The principal purpose of this article is to examine this reported slowdown in growth of real earnings, and it will discuss possible explanations for some of the recent changes observed in the relationship between productivity and earnings.

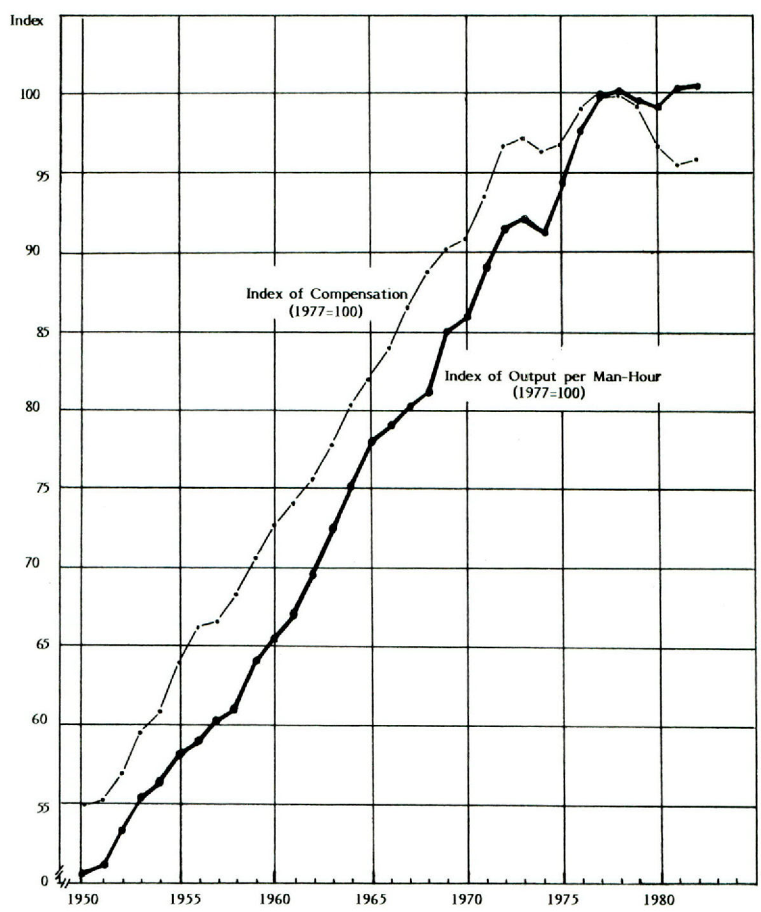
TRENDS IN REAL EARNINGS AND PRODUCTIVITY

The general level of salaries and wages can vary from country to country and from one period to another within the same country. Real earnings in the United States are considerably greater than in most other countries. This does not mean, however, that American producers are at a disadvantage because they pay higher salaries and wages. Labor productivity must be taken into account. Labor in the United States possesses higher skill levels (because of more education, training, and experience) and works with large amounts of capital equipment (due to high levels of investment in American plants). Thus in many cases, particularly in capital-intensive industries, the greater productivity of American workers more than offsets the higher level of salaries and wages.

One of the principal determinants of the general level of salaries and wages is labor productivity--output produced per worker per hour. When the amount produced per worker per hour is high, real earnings will be high. And if labor productivity is increasing over time, then real earnings will increase over time.

Figure 1 illustrates the relationship between real compensation per hour and output per worker from 1950 to 1982. What this figure shows is a plot of indices. One is an Index of Real Employee Compensation for non-farm, business sector workers using 1977 as the base year. The data are based upon hourly wages and salaries paid to employed people plus employers' contributions for social insurance and private benefit plans. They also include an estimate of wages, salaries, and supplemental payments for the self-employed.

Figure 1



Notes: Compensation refers to real compensation, nonfarm employee, in business sector (1977=100). Output per man-hour is output per worker per hour, nonfarm (1977=100).

Source: Economic Report of the President, 1983, Table B-40, p. 208.

The Index of Real Employee Compensation shows that real earnings experienced uninterrupted growth from 1950 to 1973, nearly doubling the standard of living enjoyed by Americans. Then in 1974, real earnings fell for the first time since the Great Depression. Real earnings rose again from 1975 to 1978, but fell again for three consecutive years--1979, 1980, and 1981. These data confirm the findings of the studies cited at the beginning of this article--they show real earnings in 1981 and 1982 are below the 1973 level.

The second plot shown on Figure 1 is an index of productivity. It shows an index of the real value of the gross domestic product originating from the non-farm sector per worker per hour with 1977 = 100. Here again, this index shows an uninterrupted growth of productivity (output per worker per hour) from 1950 through 1973. Throughout this period there is a close relationship between productivity and earnings.

The close relationship between the amount produced and real earnings should not be surprising. Real income and real output are simply two different ways of viewing the economic pie. One measures what is consumed and the other what is produced. As long as the share of the pie going to employee compensation remains constant, then a close relationship between real earnings and productivity will exist. In 1950, 81 percent of national income went to employee compensation and proprietorship income. That share has not changed significantly during the past 30 years[3].

What is surprising is the dramatic change that began to occur in 1974. From 1974 through 1978, real output per worker per hour grew more rapidly than real earnings. From 1978 through 1982, productivity tended to level off while employee compensation fell dramatically. Figure 1 shows the two indices crossed in 1977 as a result of a relatively stronger performance of output per worker per hour than of employee compensation. (No particular significance should be attached to the year in which these indices crossed; that is simply a matter of 1977 being the base year where the value of each index equals 100. If another year had been chosen as the base year, then the indices would have the same value for that year).

The data presented in Figure 1 suggest that a dramatic change is occurring in the relationship that has historically existed between real earnings and productivity. This occurrence raises some important questions. Among these are:

(1) Why is this change occurring?
(2) Is this a temporary anomaly or a new economic fact of life with which Americans must cope?

To attempt to answer these questions is to venture into an area where there is no general agreement. Thus, the discussion that follows will contain considerable conjecture and speculation and will deal with a number of issues that are still being debated.

Three of the more plausible explanations will be discussed here. One is the argument that America has been experiencing a declining capital-labor ratio, thus inducing a price adjustment between these factors of production. Some point to foreign competition and suggest that cheap foreign labor is forcing down the salaries and wages of American workers; while others suggest that inadequacy of government data makes the problem look a lot worse than it really is. Hopefully, each of these arguments and their possible consequences will be made clearer in the discussion that follows.

Declining Capital-Labor Ratio

It has been suggested that rising oil prices, governmental regulations, changes in demographic factors, and labor-force participation rates have simultaneously caused a shrinkage in the economically efficient productive capital stock and a dramatic growth of our labor force, thus resulting in a declining capital-labor ratio[5]. This argument becomes clearer with the following observations:

(1) The increase of oil prices decreased the present value (both in terms of productive capacity and real market value) of some of the old energy-intensive capital stock. In a sense this means that a portion of the nation's capital stock was made obsolete and idled. The results of a recent study by Norsworthy and Malmquist seems to support this idea. They report, "...both energy productivity and capital productivity declined in the four-year period following 1973[12]. Other support is the fact that the United States consumed a smaller quantity of oil following the price increases. For example, following the Iranian oil curtailments in the first half of 1979, the consumption of petroleum products declined from 37.8 quads in 1978 to 37.0 quads in 1979 and 36.5 quads in 1980[15].

(2) During the 1970's the United States experienced the highest levels of unemployment since the Great Depression. In an effort to combat high unemployment, it appears that government officials turned to the Keynesian tonic that had appeared to be effective in the past. The Government, especially at the federal level, pursued expenditure, taxation, and regulatory policies geared to stimulating current consumption, somewhat at the expense of capital investment. These policies evidenced themselves in terms of increasing deficits, taxation policies unfavorable to long-term investments, mandated expenditures for environmental abatement and worker safety, and increasing transfer and entitlement payments. As Herbert Stein has shown, while these policies were effective in stimulating consumer spending, they were ineffective in inducing the private investment in capital needed to create new jobs and expand the nation's output[13]. These policies stimulating consumer spending without a corresponding increase in production led to excess demand that was answered in part by increased imports and in part by inflation. The effects of these policies were a growing lack of confidence, increased uncertainty, and high interest rates--all of which contributed to inhibiting long-term investments.

(3) Government regulations also forced a growing portion of expenditures labeled "investment" to be channeled into purchases of equipment for pollution control and worker safety. The Department of Commerce has estimated that the net capital stock devoted to reducing air and water pollution subtracted from the net capital stock in manufacturing lowered the growth in manufacturing capital from 4.5 to 4.2 percent per year[10]. To the extent that these expenditures "crowded-out" true additions to productive capital, productive capital stock failed to grow as rapidly during the last decade.

(4) Because of the bulge in the growth of the labor-force age population, the natural consequence of the post-World War II baby boom, the labor force underwent an appreciable expansion. This natural growth of the labor force age population was also accompanied by a dramatic increase of labor-force participation, especially by women who had not been in the job market previously, as shown in Table 1.

These observations lend support to the idea that growth in capital stock slowed during the same period that growth in the labor force accelerated. In this case, the capital-labor ratio in the United State would be declining.

In order to properly appreciate the significance of a falling capital-labor ratio, it is useful to review some basic concepts. Economic efficiency depends on the prices of all the factors used in the productive process as well as the price of the product itself. Economic efficiency is optimized when the price of the product times the marginal product of each factor used to produce the product is equal to the price (or cost) of the factor. In general, if the price of a factor increases relative to other factors, the amount of that factor used will decrease relative to the other factors. And as the supply of a factor used in production increases, its price will tend to fall relative to other factors and more of it will be used in the production process.

Table 1
Total Labor Force by Sex and Age
Selected Years, 1965-1995

Sex and age (16 years and older)	Number in thousands 1975	1985	1995	Average annual rate of change (percent) 1965-75	1975-85	1985-95
Total, both sexes	94,793	115,043	124,583	2.06	1.94	0.80
Total, male	57,706	64,951	68,398	1.24	1.18	0.52
Total, female	37,087	50,091	56,185	3.46	3.00	1.15

Source: U.S. Department of Commerce, Bureau of the Census, Social Indicators III: Selected Data on Social Conditions and Trends in the United States, (Government Printing Office Washington, D.C., 1980) Table 7/6, p. 351.

Now the declining capital-labor ratio argument can be summarized. Sharp increases in oil prices led to an increase in the cost of using energy-intensive equipment. That increased cost led to an idling of some equipment--and the workers associated with that equipment found themselves unemployed and in less demand than before. At the same time, a growing labor force and increased labor-force participation rates increased the abundance of labor relative to capital. The economic consequences of such a shift in the capital-labor ratio is that real salaries and wages paid to workers must fall in order to fully employ this larger labor force.

Competition from Cheap Foreign Labor

As noted above, it is not the absolute level of salaries and wages that is of concern in discussing the idea that cheap foreign labor may be forcing down salaries and wages in the United States; labor productivity must be taken into account. If productivity is high enough to offset the differential in wages, then higher paid workers can compete successfully with lower paid workers.

Leontief, a Nobel Prize winning economist, first suggested the superiority of American labor[11]. This observation was confirmed later by empirical studies conducted by Kreinin[9] , Kehen[7], and Baldwin[1]. The ideas developed by these writers are relatively simple. Human capital is created by investing in education and training. Human capital, like physical capital, is a produced means of production. That is, it requires an investment of time and resources to produce it. Once produced, the skills and expertise resulting from education and training last several years and tend to increase the productivity of the labor force substantially for a long period of time. Because of the abundance of education and training in the United States, this country has a comparative advantage in, and exports, skill-intensive commodities and services.

Others have developed more specific theories to explain areas in which the United States has a comparative advantage[2]. Underlying most of these theories are three key concepts: The size and uniqueness of the American market, technological leadership, and the availability of capital.

Due to the high income in the United States and the size of the American market--relative to others--unique consumption patterns and markets for new products are created. Entrepreneurs in the United States tend to have the first opportunities to identify new demands and to respond to these budding markets. The size and uniformity of the market allows profitable production of many products and services that could not be successfully produced for smaller markets. Once they begin to respond to this market, producers enjoy a temporary world-wide monopoly with easy access to foreign markets. However, such advantages are short-lived as other countries begin to imitate the innovation. A continuing advantage in this area depends upon a constant stream of innovations resulting in new products and services[8].

It is also often argued that America has a comparative advantage for certain classes of products and services due to its leadership position in technology[17]. This is currently evidenced in the advocation of high-tech industry as the wave of the future. Three factors are often cited to support this theory:

(1) The production of technology-based products and services requires much skilled labor which is relatively abundant in the United States.

(2) Because labor costs are high in the United States, there is greater incentive to use new technology to develop labor-saving production processes that increase labor productivity, and

(3) The development of new technology-based products frequently requires high investments in research and development (R&D) and requires large capital-intensive plants. American business has access to large amounts of capital, and it has the ability and willingness to undertake large-scale ventures.

The relationship between R&D activity and export performance is well established[6;17]. Market and technological innovation seem to play central roles in maintaining our competitive position in world markets. Without a continuing stream of new products and services, better production methods, and/or superior industrial organization, it does appear possible that foreign producers could make sufficient inroads into American markets to force our industry to lower salaries and wages in order to remain competitive in world markets.

While the United States has lost some ground to Japan, Germany, and France in certain areas, it remains a strong competitor. According to recent data reported by the Brooking Institution for example, the output per employee in U.S. manufacturing in 1980 was about 16 percent higher than in Japan, 21.7 percent higher than in Germany, and 31.3 percent higher than in France[11]. Some areas in which America appears to have fallen behind were highlighted in a 1981 *White Paper On International Trade* issued by the government of Japan. According to this report, Japanese productivity levels in 1979 were above those of the United States in steel (108 percent above U.S. levels), general machinery (11 percent higher), electrical machinery (19 percent), transportation equipment (24 percent), and precision machinery and equipment (34 percent)[10].

Much has been said about the miraculous growth of productivity in Japan. Recent research has begun to dispel the aura of mystery surrounding it. As Norsworthy and Malmquist point out, "...in the main, the rapid growth in the capital stock--which can be viewed as raising the workers' capacity to process a greater volume of materials--is a major source of Japanese growth[12]". Another consideration is the willingness of the workers in Japan to accept and accommodate new technology. Zabola argues that this willingness is a necessary part of realizing the cost savings that new capital is designed to achieve[19].

In this context, it can be seen that the "cheap foreign labor" argument is not completely unrelated to the "declining capital-labor ratio" argument. Indeed it might be argued that, within this framework, a country facing increasing competition from abroad might have the option of either reducing salaries and wages or increasing R&D expenditures and capital investment (or some combination) to remain competitive in the world market.

Inadequacy of Government Data

This leads to the last and final argument. It basically is an argument that the apparent decline in real salaries and wages, relative to productivity, is due to the inadequacy of government data--especially the Consumer Price Index adjustments--to accurately adjust for the effects of the high rates of inflation that plaqued the United States economy during the past decade. Many economists believe that the Consumer Price Index often overstates the rate of inflation. The two errors most often cited are (1) the failure to account for consumer substitutions away from goods that rise in price, and (2) the overstatement in housing costs[3].

The Consumer Price Index assumes that consumers purchase a given (fixed) market basket of goods and services. Over time, some goods rise in prices faster than others. Under these circumstances, consumers will frequently use less of the product, the price of which is rising, or shift to another product which has not risen as rapidly in price. Thus foregoing purchase of high price goods or substitution of goods will lessen the effect of rising prices on real incomes.

More serious is probably the treatment of home ownership costs in the Consumer Price Index. The home ownership component accounts for nearly 25 percent of the market basket on which the index is based. The government treats the price of a house and the mortgage interest payments of the house as two separate transactions. The price of the house is counted once when it is purchased and again as the interest rate component on the mortgage. The effect is the same as the assumption that all homeowners refinanced their mortgages each month. In times of inflation and rising interest rates, this can introduce a considerable discrepancy into the Consumer Price Index.

The "inadequacy of government data" argument says that the Consumer Price Index adjustments overstate the actual effect of inflation on real salaries and wages. In other words, real salaries and wages may not have fallen (or risen as slowly) in the past few years as much as government data indicate because of the discrepancies introduced into the Consumer Price Index by inflation and rising interest rates.

FUTURE OUTLOOK FOR REAL INCOMES

How one feels about the future outlook for real incomes is largely determined by what he or she perceives the causes of the changes discussed earlier and what will happen to those factors responsible for the changes. By now it should be clear that the factors determining our standard of living are not simple to analyze or to predict. It is not clear what the future trends in productivity, foreign competition and government policy will be; therefore any predictions are based as much on speculation as analysis.

Capital-labor Ratio

In the preceding discussion it was suggested that a growth in the supply of labor relative to capital has resulted in a declining capital-labor ratio, thus causing real salaries and wages to fall. To the extent this is true, a reversal in that trend would in a similar fashion provide pressure for real earnings to rise.

On the capital side of the ratio there appears to be reason to anticipate growth in the nation's capital stock at a faster rate than in the past. First, oil prices have fallen, and barring some international incident, are not expected to rise in the near future[19]; therefore the shrinkage of capital stock resulting from rising energy prices should abate. Second, mandated expenditures related to environmental protection and worker safety appear to be becoming a smaller share of capital budgets; thus the "crowding-out" effect should lessen. Third, capital investment appears to be increasing sharply, Since a low point in October 1982, orders for capital goods have increased 37 percent; and the rise in the second half of 1983 was considerably greater than in the first half[14].

A factor that may adversely affect the United State's ability to increase its capital stock is the level of interest rates. If the United States has been experiencing a declining capital-labor ratio, then it would be expected that the price of money (interest rates) would increase because it is more scarce relative to labor. However, other factors also seem to be contributing to the record real interest rates that now prevail. Those most frequently mentioned are uncertainty about the future, tight money policies, and the financing of high government deficits.

High interest rates of course make it more costly to increase the capital stock. Certain investments that are feasible at low interest are not profitable to undertake at higher rates. If expectations of inflation subside and confidence in the American economy strengthens, then one would expect real interest rates should begin to fall, making a number of new investments more attractive.

Now attention will turn to the labor side of the ratio. Table 1 reflects the total labor force by sex and age for selected years from 1965 through 1995. These data are provided by the U.S. Department of Labor. As these data show, the rapid growth of the labor force is beginning to slow. The labor market has already absorbed most of the baby boom population, and the rate at which women are entering the job market is beginning to subside. On the average, about 1,000,000 fewer people are expected to be entering the work force each year in the 1985-95 decade than during the 1975-85 decade. This represents a substantial slowdown in the rate of growth of the labor force. It may be worth noting that all the new people who entered the work force during the past 10 years will be maturing, more experienced, and better trained for their jobs during the next decade; thus, on the average the work force of the next decade should be more productive than they were in the one just passed[18].

From these discussions, one can see that a number of things suggest that the rate of capital formation may increase in spite of high interest rates. At the same time, growth of the labor force is almost certain to slow. Thus, with these two adjustments taking place simultaneously, the capital-labor ratio should stop its decline and possibly begin to increase.

Competition from Abroad

At the present time the United States is experiencing record level trade deficits. The United States Current Account balance grew to a deficit of $43 billion in 1983, and according to the Organization for Economic Cooperation and Development could exceed an $80 billion deficit in 1984[14]. An analysis of the causes and possible adjustments to this situation is far beyond the scope of this article; the discussion here will be limited. However, these data do imply that the United States can continue to expect aggressive competition from abroad.

Hopes for improving America's position in world trade appear to rest upon increasing investment in R&D and technology-based enterprises. According to Brookings Institution data, R&D spending is rapidly recovering from the much publicized decline of the 1970s. While the number of scientists and engineers employed in industry R&D grew at 1.6 percent between 1960 and 1973, growth from 1973 to 1980 averaged 3.2 percent per year[10]. The strong position Americans enjoy in science and technological expertise also supports the view that the United States is likely to see an improvement in the efficiency of its capital and in productivity. This is not to say that the United States will, or should, seek to regain markets in areas where it has lost ground. Indeed, it appears that future growth is more likely in the "high tech" areas where America presumably has comparative advantage because of its scientific and technical resources.

SUMMARY AND CONCLUSIONS

Based upon the data examined in this article, it does appear that the historic trend of increases in real income enjoyed by the average American family since 1950 had halted--or at least faltered. The real income of the average working person, or family, in 1983 does not appear to be any more than it was in 1973--possibly slightly lower.

Possible explanations for this slowdown include (1) a declining capital-labor ratio and/or (2) competition from cheap foreign labor. The "declining capital-labor ratio" argument suggests an adjustment has occurred in the relative prices of these two factors of production--i.e. wages have fallen relative to prices. The "cheap foreign labor argument" suggests that in order for American industry to compete with foreign producers, American workers must either accept lower wages or become more productive. The recent slowdown in productivity may have created a lag that resulted in many American workers being forced to choose between unemployment and lower wages.

It is also possible that the effect of this slowdown may not have been as severe as the data would suggest. The Consumer Price Index used to adjust for the effects of inflation may actually overstate the effect of inflation on real salaries and wages.

While the future trends in real incomes are not completely clear, it does appear that a number of factors affecting our real earnings are changing in such a way as to encourage a positive rate of growth. It appears that the capital-labor ratio will improve, increased capital investment should spur some increases in productivity, and increased expenditures for R&D and investments will hopefully strengthen the United States' competitive position in world markets. However, it is likely that continued high interest rates will inhibit capital formation, at least in the short run, and foreign competitors will continue to compete aggressively in both domestic and foreign markets. Hence, while there are several positive signs that standards of living may begin to improve again, there is reason to doubt that it will grow at as great a rate, at least in the near term, as it has in the past.

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THE U.S. PRODUCTIVITY PROBLEM: AN INTRODUCTION

Yoshi Fukasawa*, Associate Professor of Economics and Director of the Bureau of Business and Government Research, Midwestern State University

Public concern for the less-than-satisfactory performance of the U.S. economy has been growing. Stagflation, simultaneous existence of high inflation and unemployment, was a major problem in the 1970's. Today, increasing attention is being directed toward the sluggish productivity growth in the U.S.

This paper presents an introduction to the U.S. productivity problem. It provides some definitions and measurements of productivity. Comparisons of the U.S. productivity performance with those of other industrialized countries are made. The economic consequences and some often-mentioned causes of the productivity slowdown in the U.S. are discussed. The paper then examines the productivity behavior in the 1981-82 recession, followed by some concluding remarks.

Productivity

Productivity pertains to the relationship between output and inputs in a production process. Output can be measured in relation to an individual input such as labor with a given amount of other inputs (single-factor productivity), or to two or more inputs combined (multi-factor productivity).

Productivity is often referred to as output per employee or output per man-hour worked. Frequent reference to labor productivity arises for the following reasons: First, labor constitutes the largest component of the cost of production. At the national level, for example, compensation to employees ($1.9 trillion) accounted for approximately three quarters of the net national product at factor cost ($2.6 trillion) in 1983.[1] Secondly, labor, unlike capital and raw materials, directly affects the macroeconomic goal of full-employment. Finally, labor is relatively homogeneous in the sense that quantity can be readily determined without detailed specifications and classifications.

The use of labor productivity does not imply, however, that productivity growth is solely or mainly due to labor. Overall productivity improvement reflects not only the labor contribution but also an increase in capital stock, a greater intensity in the use of existing capital, technological improvements, more efficient use of material inputs, better application of managerial and organizational concepts and others.

Table 1 shows an international comparison of productivity performance among six industrialized countries. The U.S. still enjoys the highest level of productivity, measured in terms of gross domestic product (GDP) per employed person. West Germany and Japan, countries well-known for an economic miracle in the postwar period, reached 94.0 percent and 71.5 percent, respectively, of the U.S. productivity level in 1981.

TABLE 1

Level and rate of growth in productivity, Selected Countries 1950-81

Country	Productivity Level[1] 1981	Productivity Growth[2] 1950-81	1965-73	1974-81
Canada	93.3	1.9%	2.4%	0.1%
Japan	71.5	6.3	8.2	2.9
France	93.2	4.1	4.6	2.4
Germany	94.0	4.5	4.3	2.5
United Kingdom	64.3	2.2	3.2	1.3
United States	100.0	1.6	1.6	0.2

Note: Relative level in gross domestic product (GDP) per employed person (U.S. = 100)

Average annual percentage increase in real gross domestic product per employed person.

Source: U.S. Department of Commerce, Productivity and the Economy: A Chartbook, Bulletin 2172 (June 1983), p. 20 and p. 69.

Productivity is a dynamic concept that must be evaluated on the basis of growth over time. In this regard, the U.S. fell behind all the countries by a significant margin. During the 1950-81 period, Japan had the highest average productivity growth rate of 6.3 percent per year, followed by West Germany with 4.5 percent, while productivity in the U.S. increased at only 1.6 percent per year.

Productivity growth has declined substantially for all the countries since 1973. Japan experienced the sharpest decline of 5.3 percentage points, followed by the 4.5 percentage-point decline for West Germany.

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Yet, even in the 1973-81 period, productivity growth rate in the U.S. was surpassed by those of all the countries, except Canada. A review of such statistics may have prompted William Batten, Chairman of the New York Stock Exchange, to issue the following statement: "In 1960, the typical American worker in manufacturing annually produced as much as four Japanese workers or two French or German workers. Today, the American's output is matched by 1½ Japanese and by 1¼ Germans or Frenchmen. If the trend continues, all three will be outproducing us by the end of the next decade."[2] It is important to examine the consequences and causes of such a dismal productivity performance of the U.S. economy.

Consequences of Productivity Decline

Productivity growth is an important factor for economic well-being at the national as well as at the firm level. At the aggregate level, productivity reflects an advance in the overall standard of living, more stable prices, greater employment opportunities, and a more favorable trade balance with other countries.

Improvement in the standard of living in economics usually refers to an increase in the amount of goods and services available to each member of our society. Increases in productivity, more output per unit of input, are the main source of an advance in economic well-being of a country. Productivity growth affords the greater availability of goods and services and leisure time simultaneously.

An increase in productivity also provides greater job opportunities. Kendrick observed that when a productivity increase accelerates, unemployment rates are lower than the average, because stronger productivity growth is associated with higher rates of investment which in turn stimulates the growth of demand, output, and employment.[3]

Productivity growth also contributes to an effort to control inflation. Improvement in productivity tends to increase wage rates and to reduce the prices of goods and services. When labor producttivity grows faster than real wage rates, labor costs per unit of output tend to fall, thus reducing the pressure placed upon prices to rise. On the other hand, the inflation problem is aggravated by excessive wage increases over productivity to the extent that some or all the rising unit labor costs tend to be passed on to consumers in the form of higher prices.

A rising unit labor cost in the U.S. in the relation to those of other countries also contributes to the U.S. balance-of-payments problem. Prices in the U.S. rising faster than those in other countries tend to make domestically produced goods relatively less attractive compared with foreign goods, thus inducing a rise in imports greater than exports.

At the firm level, labor productivity relates to the profitability of businesses. For most businesses, labor constitutes the largest component of the cost of production and distribution of goods and services. Slower growth in productivity in relation to wage increases means a higher cost per unit of output over time. Some or all of the cost increase may be passed on to consumers in the form of higher prices or absorbed by the firm. The former tends to depress sales and eventually profits, and the latter directly shrinks profits; thus reducing incentives for the firm to expand production and employment, resulting eventually in lower wages for workers. On the other hand, an improvement in productivity tends to reduce the unit cost of production, resulting in improved profitability, increased production, greater employment, and eventually higher wages for employees.

The foregoing discussions can be brought to a sharper focus with the use of data shown in table 2. On the basis of the timing of shifts in the average productivity growth rates in the U.S., the postwar period (1948-83) is divided into three subperiods: 1948-65, 1966-73, and 1974-83.

TABLE 2

U.S. Productivity and Related Date, 1948-83 (Average Annual Percent Change)

	1948-65	1966-73	1974-83
Total output[1]	3.9	4.0	2.0
Productivity[2]	2.7	2.1	0.8
Hours[3]	1.2	1.8	1.1
Weekly hours[4]	-0.4	-0.7	-0.5
Employment[5]	1.7	2.5	1.8
Compensation per hour[6]	4.8	6.7	8.6
Real compensation per hour[7]	2.8	2.2	0.2
Inflation rate[8]	2.0	4.4	8.5
Unit labor cost[9]	2.1	4.4	7.8

Note: [1] Total output refers to gross domestic product originating in the nonfarm business sector in 1972 dollars.

[2] Productivity refers to output per hour of all persons in the nonfarm business sector.

[3] Hours of all persons engaged in the nonfarm business sector.

[4] Average weekly hours for production or nonsupervisory workers in private nonagricultural civilian labor force.

[5] Number of employed persons as a percentage of the nonagricultural civilian labor force.

[6] Wages and salaries of employees plus employer's contributions for social insurance and private benefit plans and estimated compensations for the self-employed.

[7] Hourly compensation divided by the consumer price index for all urban consumers.

[8] Inflation rate is calculated as a year-to-year percent change in consumer price index, all items, for urban consumers.

[9] Unit of labor cost is found by dividing compensation per hour by productivity.

Source: Council of Economic Advisors, Economic Report of the President 1984, p. 254, p. 264, p. 267 and pp. 282-3.

The annual rate of growth in total output, measured in terms of gross domestic product originating from the nonfarm business sector, increased from 3.9 percent in 1948-65 to 4.0 percent in 1966-73, but declined to 2.0 percent in 1974-83, as shown in table 2. The increase in the growth rate of output between the periods 1948-65 and 1966-73, however, resulted from an increase in the total hours worked rather than a productivity increase. During the periods, productivity declined by 0.6 points while the total hours increased by the same percentage points, as shown in table 2.

The total hours worked increased because more workers were on the job, although each worker spent fewer hours on the job. Employment increased from the annual rate of 1.7 percent in 1948-65 to 2.5 percent in 1966-73. On the other hand, hours worked per employee per week declined by 0.3 percentage points during the period.

Comparisons of the 1966-73 period with 1974-83 show the growth rate for total output declined because of a deceleration in both productivity and total hours worked. The growth rates in productivity and total hours worked declined by 1.3 percentage points and 0.7 percentage points, respectively. Furthermore, the decline in growth of total hours worked in the 1974-83 period was due to a fall in employment growth as well as to a further decline in the average workweek.

Growth in compensation per hour, measured in terms of wages and salaries and other labor-related payments, accelerated over this time period in the U.S. The rate of growth in compensation per hour increased from 4.8 percent per year in 1946-65, to 6.7 percent in 1966-73, and to 8.6 percent in 1974-83, as shown in table 2. However, growth in real compensation per hour, the nominal compensation per hour adjusted for inflation, declined by 0.6 percentage points between the periods 1948-65 and 1966-73, and further by 2.0 percentage points between 1966-73 and 1974-83.

A close relationship exists between the growth rate of productivity and that of real compensation per hour. Using real compensation per hour as a proxy, it can be stated that the sluggish productivity increase slowed the improvement in the standard of living in the U.S. in the post-war period.

Unit labor costs are related directly to compensation per hour and inversely to productivity. A rise in compensation per hour and/or a fall in productivity causes unit labor costs to increase. As noted earlier, compensation per hour and productivity grew at the rate of 8.6 percent and 0.8 percent, respectively, resulting in the 7.8 percent-per-year increase in unit labor costs in the 1974-83 period.

Causes of U.S. Productivity Decline

Several factors contribute to the decline in the growth rate of productivity in the U.S. Some of the same factors may also apply to other countries. No single factor can explain the entire phenomenon of the recent U.S. productivity slowdown, but often-mentioned causes include:

(1) Inadequate Investment

Capital formation is an important ingredient for productivity growth over time. More and better equipment and plants tend to make a worker more productive.

The rate of growth in investment has slowed markedly since 1973, a decline that is particularly significant in relation to growth in the labor force over the time period. Investment, measured in terms of net private domestic fixed non-residential investment in constant (1972 = 100) dollars, increased at the rate of 5.8 percent per year in 1948-65 and 6.9 percent in 1966-73, as shown in table 3. Investment, however, declined at an average rate of 1.4 percent per year in the 1974-81 period. During the period, the civilian labor force increased at an annual rate of 2.2 percent. It follows that investment per worker on the job or actively seeking a job fell at the rate of 3.6 percent per year in 1974-81.

TABLE 3

Some Factors Affecting the U.S. Productivity 1948-83

	1948-65	1966-73	1974-83
Investment[1]	5.8	6.9	-1.4
Civilian Labor Force	1.3	2.3	2.2
R & D Expenditures[2]	2.8	2.6	2.3
Labor Participation Rate[3]			
Females, 20 years and over	35.9	42.5	49.6
Young, 16-19 years old	48.8	50.0	55.5
Sectoral productivity[4]			
Farm	5.3	5.2	3.4
Manufacturing	2.6	2.7	1.7
Trade	2.4	2.6	1.0

Note: [1]Investment refers to net private domestic investment, non-residential, in 1972 dollars, average annual percentage increase.

[2]Expenditures for research and development as a percent of gross national product (1981-1982).

[3]Civilian labor force as a percent of noninstitutional population in group specified.

[4]Average annual percent change in output per hour.

Sources: Council of Economic Advisors, Economic Report of the President 1984, p. 239 and p. 258.

U.S. Department of Commerce, Productivity and the Economy: A Chartbook, Bulletin 2172 (June 1983), p. 10 and p. 80.

The decline in the capital-labor ratio may have been due to an excess supply of labor in the economy. Rapid growth in the civilian labor force, mainly due to the postwar baby boom and rising labor participation by women, lowered the relative prices of labor to capital. Producers responded to the excess labor supply by substituting away from capital-intensive techniques to labor-intensive methods of production. This shift tended to reduce labor productivity by lowering the capital-labor ratio. According to Tatom, the fall in investment per worker translated into the 0.64-percentage-point productivity decline per year in the 1973-80 period from the 1948-73 trend.[4]

Several other reasons can be suggested for the slow or even negative growth in capital formation. Among usual explanations are: the extent of slack in the use of existing capital; diversion of funds from investment to expenditures on health, safety, and pollution controls; large federal budget deficit; inflation; tax disincentives.

(2) Falling R&D Expenditures

Research and development (R&D) is a major source of technological advance, which in turn allows for innovations in a production process. An improvement in the quality of equipment and plants and of a production method in general tends to increase the productivity of workers engaged in the process.

The R&D expenditures as percentages of GNP have steadily declined in the U.S. from 2.8 percent in 1948-65 to 2.6 percent in 1966-73 and further down to 2.3 percent in 1974-83, as shown in table 3. Kendrick estimated that the decline in the advance in knowledge, realized mainly through R&D, contributed to the U.S. productivity decline by 0.3 percentage points in 1973-77 when compared to the 1966-73 trend.[5]

(3) Changing Labor Force

Age and sex composition of the U.S. labor force has changed in the past decades. Approximately one out of every three females, 20 years old and over, participated in the labor force during the 1948-65 period, as shown in table 3. In 1974-83 approximately half of all the females in the same age group were on the job or actively seeking a job.

A similar but less drastic increase in the labor force participation rate is observed for the youth. Labor participation rate for 16-19 years old, both sexes, increased from 48.8 percent in 1948-65 to 55.5 percent in 1974-83.

Perry argued that growth in the proportion of women and the young who have relatively less experience in the job market contributed temporarily to a slowdown in the U.S. productivity in the past.[6] As their experience accumulated, the young and women are expected to contribute to the improvement in the overall productivity in the future.

There is also a growing concern for educational quality in the U.S. in recent years. Inadequate and inappropriate skills and training of current and future workers would have an adverse effect on productivity growth.

(4) High Energy Costs

Energy price developments evolving around the OPEC cartel have affected output, product prices, and productivity. Average posted price of Saudi Light Crude, for example, increased from $1.80 per barrel in 1970 to $11.45 in 1974 and further to $28.67 in 1980.[7]

A rise in energy prices relative to those of other inputs and outputs tends to reduce the productivity of labor. The adverse effects may result from two sources: First, higher energy prices induce firms to substitute more labor-intensive methods of production for energy-intensive techniques. A shift toward a more labor-intensive method to produce the same level of output causes a reduction in output per man hour. Secondly, a higher production cost resulting from a rise in energy costs tends to increase the price of a product. The rise in price, in turn, tends to discourage consumption and thus production of the product. Labor productivity is reduced to the extent that a reduction in employment tends to be more rigid than a fall in output.

Taking into account the entire impact of rising energy costs, Tatom estimated that in 1973-81 overall productivity grew 1.2 percentage points per year lower than the average of 1948-73 in the U.S.[8]

(5) Government Regulations

Proliferation of government regulation affects the economy's productivity by diverting real resources from the production of measured output. Denison calculated that increased costs of pollution abatement since 1967 and employee safety/health programs since 1968 reduced productivity growth by an average of 0.22 percent per year over the period 1969-75 in the U.S.[9]

(6) Service-Oriented Economy

Annual productivity growth rates averaged 5.3 percent for farm, 2.6 percent for manufacturing, and 2.4 percent for trade in the 1948-65 period in the U.S. as shown in table 3. Rapid urbanization of American cities moved employment opportunities from rural to urban areas in the 1950's and 60's. The U.S. has also moved toward a more service-oriented economy in terms of relative share of employment in recent years.

Recognizing such a shift in employment and the sectoral differences in productivity, it can be considered that urbanization and the move toward a service-oriented economy contributed to a lower overall productivity growth. Bailey, however, found that only 0.02 percentage points of the total reduction, excluding construction, of 1.90 percent per year in the 1973-81 period from the 1948-73 trend could be attributed to the shift in output (not employment) share.[10]

(7) Weakening Work Intensity

Productivity growth is also affected by a myriad of social and psychological factors. Weisskopf, Bowles, and Gordon examined attitudinal determinants of productivity. Strike activity and the incidence of industrial accidents are regarded by the authors as an indicator and a cause of worker unrest, respectively. They argued that the level of work intensity, which cannot be measured directly, is determined by the intensity of supervision and the probability and the cost of job loss. Using proportion of supervisory workers, duration of unemployment, change in the growth of real spendable earnings, industrial accident rate, and other variables as proxies, the authors estimated that declining work intensity accounted for 0.6 percentage points of the 2.0-point decline in productivity growth rate in the U.S. nonfarm business sector between 1948-73 and 1973-79.[11]

(8) Managerial and Organizational Inefficiency

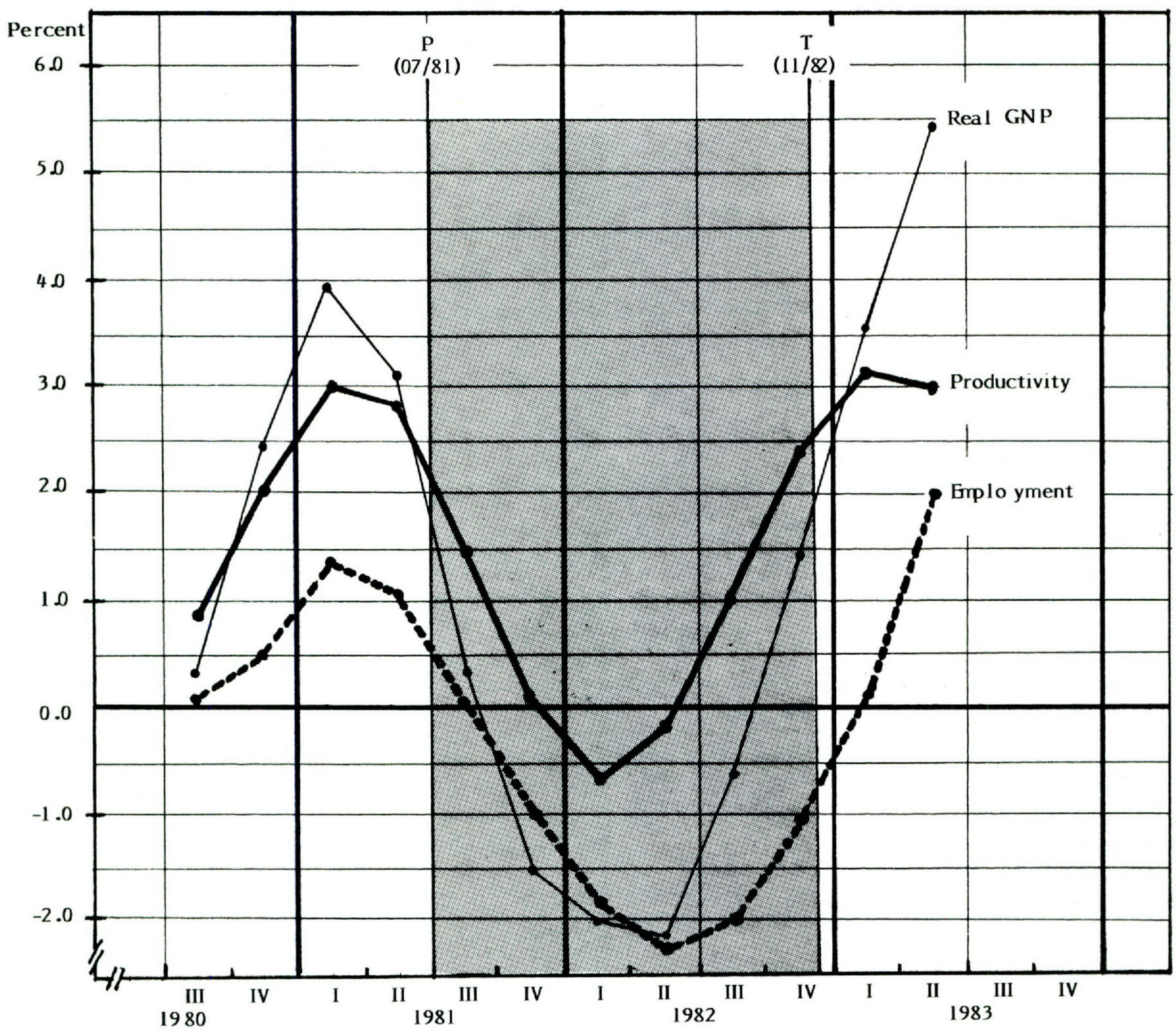
American management practices and organizational structure have recently been under close scurtiny as a factor contributing to the productivity problem. For example, Hayes and Abernathy attributed American management failures to their preference for methodological elegance over the insight that comes from "hands-on" experience in strategic decision making and for short-term cost reduction rather than long-term development of technological competitiveness.[12] The study did not, however, provide the quantitative measurement of the impact of management failures on productivity.

Productivity in the 1981-82 Recession

According to the National Bureau of Economic Research, the most recent U.S. recession lasted 16 months beginning July 1981 and ending November 1982. Figure 1 depicts quarterly percentage changes in productivity, employment, and real GNP from the third quarter of 1980 to the second quarter of 1983. All the data are adjusted by the four-quarter centered moving-average method for smoothing.

Note that productivity fell last and rose first in relation to real GNP and employment. Productivity began to fall in the first quarter of 1982 (reference point a). On the other hand, the rate of growth in real GNP and employment turned negative in the fourth quarter of 1981 (points b and c, respectively). As a recovery approached, real income and employment began to rise in the fourth quarter of 1982 (point b') and in the first quarter of 1983 (point c'), respectively. Productivity showed an improvement some months before the general economic recovery began to unfold. The rise in productivity began in the third quarter of 1982 (point a').

FIGURE 1
Productivity in the 1981-82 Recession



Notes: Productivity refers to output per hour, private business sector. Real GNP is GNP in 1972 dollars. Employment is nonagricultural payroll employment, establishment survey. All the data are adjusted by the four-quarter centered moving average method for smoothing.

Source: Survey of Current Business, various issues.

This cyclincal behavior of productivity can be explained by the "labor hoarding" practice of businesses.[13] In the face of slowing or falling output in the beginning stage of a recession, firms typically tend to be slow to dismiss employees, especially those essential to the operation of firms such as highly skilled workers and management personnel. Firms tend to hoard workers to avoid the relatively large rehiring costs in a subsequent expansion. Output tends to fall faster than employment, resulting in a lower or negative productivity rate as or just before the recession begins. Conversely, as a recovery approaches, output increases are usually achieved by increasing the utilization of labor at a given employment level, improving productivity. Productivity growth continues in the early stage of expansion, where output to meet newly spurred demand tends to increase at the rate faster than employment. The productivity level of 101.9 at the end of the recession in the fourth quarter of 1982 thus exceeded the level of 98.9 at the beginning of the recession in the third quarter of 1981.[14]

The labor hoarding practice makes the behavior of employment less volatile than that of output in a business cycle. Magnitudes of variability of employment and real GNP, as measured by the variance, were 1.54 and 6.53, respectively, during the period between the third quarter of 1980 (the terminal trough of the 1980 Recession) and the fourth quarter of 1982 (the terminal trough of 1981-82 Recession).

Concluding Remarks

Reversing the downward productivity trend of the past decades is one of the most pressing economic challenges facing the U.S. in the 1980's. Standard of living in the U.S. cannot be improved without adequate growth in productivity. Sluggish productivity growth tends not only to deteriorate U.S. competitiveness in international markets but also to make it increasingly difficult to achieve the domestic macroeconomic goals of price stability and full employment.

At the firm level, productivity growth is related directly or indirectly to the profitability of businesses. The success of American businesses today depends largely on controlling the growth of the unit production cost by carefully balancing wages and productivity.

Although productivity improved significantly as the recovery unfolded in the U.S. in 1983, it appears to be a cyclical gain. The U.S. productivity problem is a complicated issue with a myriad of contributing factors. The often-cited causes include inadequate investment, falling R&D expenditures, changing labor force, higher energy costs, proliferation of government regulations, service-oriented economy, weakening work intensity, and managerial/organizational inefficiency. Most factors are long term in nature, and deserve careful considerations. Economic goals of our society will be better met in the 1980's by successfully mastering the challence of productivity growth.

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PRODUCTIVITY AND QUALITY CIRCLES

Bruce Robertson, Division Facilitator for Quality Circles,
Howmet Turbine Components Corporation

Productivity growth is the concept I want to discuss with you today. I have observed this phenomenon in the past fifteen years working at Howmet Turbine Components Corporation. Having had the opportunity to work as a hands-on laborer during the summertime between college semesters and to eventually achieve fulltime status in various manufacturing responsibilities with Howmet, I can draw upon the experiences gained at our Michigan, Virginia, and Texas facilities.

There has been a lot of productivity growth at each of these Divisions, but it can not compare to the productivity growth that has been experienced in the last year and a half in the Wichita Falls Division.

From an industrial perspective on today's economy, the concern for productivity growth is essential. Anything that can improve productivity will find a hot market among industrial corporations. However, I think that a distinct or specific approach has to be the focus at this stage in our industrial history. Many corporations have a basic problem with those "anything" programs to improve productivity. There are two reasons for their failures; first, there is a definite lack of quality efforts for the product; and secondly, and perhaps the major cause of failure is an inefficient and short-run management philosophy that has been incorporated within the organization. The following articles illustrate and contrast two reasons for a failure: "The West is in serious trouble with respect to product quality." A major reason is the immediate threat posed by the Japanese revolution in quality. This comment was written by Dr. Joseph Juran:

> "Things will get worse before they get better. Beyond the 1980's my prediction is much more optimistic. The West is now clearly on the defensive but its competitive position in matters of quality is not at all as severe as that faced by Japan in the early 1950's. Moreover, the West has enormous natural resources as well as the managerial and technological skills required to harness those resources to the needs of industrialized societies. Historically the industrial West has demonstrated that once it sets clear priorities and goals it can accomplish astounding results. In my opinion, the West will, during the 1980's, clarify its priorities and during the 1990's those astounding results should be forthcoming."

Another article refers to the problem of management philosophy. This article appeared in *The Wichita Falls Times and Record News* and was authored by A.R. Chowdhury, Professor of Manufacturing Technology at Bowling Green State University. He stated:

> "I have a simple answer for solving the problems of American business--fire most managers. Most industries are guided by people ignorant of science and technology, abrasive or apathetic toward blue-collar workers, obsessed with short-term profits and slow to invest in modernization. Most managers and corporate leaders, the decision makers, are technologically illiterate. They don't understand science and engineering and don't try to. As long as they have that 2 percent profit or 3 percent profit coming, they're happy."

Management philosophy must change. Experienced workers with over twenty years service can help management solve its problems. But in most companies the workers are generally ignored. One may ask: "How can you promote quality and productivity when people are not motivated?" With their current treatment, blue-collar workers go to work and collect a paycheck, but have little interest in their jobs. We are drowning in resources--natural resources, human resources, economic resources--that are not being used effectively. When you look at what other countries are doing with what little they have--Japan, Korea, Taiwan, Brazil, and Argentina--we are lagging behind.

"Buy American?" Why should we if America can't produce a quality product? People say to me that I'm not patriotic. That's ignoring the issue unless you merely want to manipulate the consumer.

Ways to revitalize industry are fairly simple--involve people. First, get the blue-collar worker interested in his job, get him involved in the decision-making, and productivity will be improved. When people are led intelligently and with sincere consideration, layers of bureaucracy are not needed to solve problems that shouldn't come up in the first place. Secondly, industry must modernize, retrain workers to employ new skills in order to boost productivity. We must do more with less and encourage the new investment necessary to stimulate new growth.

Our new investment at Howmet is a program called "Quality Circles." Quality Circles is a new and trendy subject which has fostered the writing of many articles, but there is still more that can be learned from this unique concept.

This program has stimulated enthusiasm and motivation at Howmet. It has resulted in a highly sought-after condition, namely, growth in plant productivity.

This basic and simple program that began at our facility in the fall of 1981 is based on implementation steps that adhere to long-term goals, to help the number one asset in our Division--our people. It is a program that builds the teamwork concept that was made by our former General Manager David Squier, now a Vice-President at our Corporate level. He stated:

> "Quality Circles are not just another program dreamed up by management to cut costs; they are a proven method of involving employees in the identification and solutions of the problems. Quality Circles are becoming a way of life in industry because they work. Too often, management has thought they have had the answers, when in fact they may not have even known the problem. Quality Circles change this by asking experts, the employees, for their input and active participation in improving quality and operating performance."

The program is having a great impact on today's industrial society. The Quality Circle concept was conceived in Japan in the year 1961. Actually it was an implementation of American ideas to improve Japanese quality following the end of World War II. Following the war, General Douglas MacArthur had a goal to get Japan back on its feet and he believed the best way was to introduce American experts to help their country in all aspects.

He called upon two key people, Dr. Edward Demning, a statistical expert in Quality Control, and a name which I quoted earlier, Dr. Joseph Juran, a management expert in Quality Control. With their expertise along with the theories of behavioral scientists, Maslow, Herzberg, and McGregor, they formed what I call a Steering Committee. Dr. Ishikawa (Father of Quality Circles in Japan) formed the leadership role in their organization. The third part of their system was the J.U.S.E. (Japan Union of Scientists and Engineers), who formed the nucleus of the Circle activities within Japan.

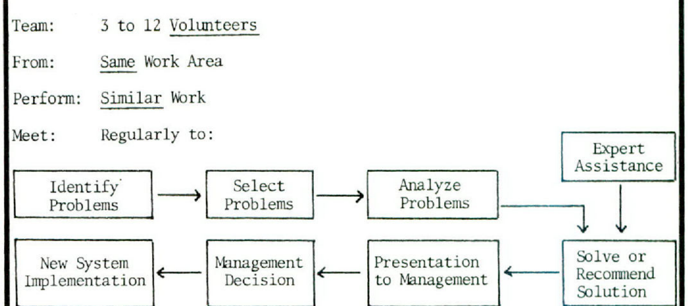
What have been the results of Japan's program. In 1945, Japan was a world leader--a world leader of poor quality. You probably shared the problems I had buying their products: missing parts, or the product would often break before you got it home.

In 1983, with improved productivity, Japan has become a world leader of quality products in high technological items such as automobiles, cameras, computer chips, electronics, the list goes on and on. Every year, every day, Japan is capturing more world markets. The amazing part of this whole concept is that Japan has accomplished this with limited natural resources. For the past thirty-eight years the only natural resource Japan depended on was their people, and with their people they have done it!

What is a Quality Circle? Figure 1 is a schematic presentation of a Quality Circle program. It is a team of 3 to 12 volunteers who come from the same work area and who are doing similar work. They meet regularly once a week for an hour to identify their problem. They select their problems and analyze them; then, at this stage, they can call in experts if additional information is needed. It is their choice to do this. They get together and solve or make recommended solutions to those problems. They package their recommendations in form of a presentation to management. A decision is made by management and the new system or proposal may be implemented into the respective areas within the plant. All the training that each member receives is done by a leader who teaches all the Quality Circle techniques for problem solving.

Figure 1

A Quality Circle



Consider what I call "measurements of our Quality Circle program." Figure 2, the Visual "Inclusion" Reject Report, will show what this program is doing at Howmet. There was a definite improvement that started developing shortly after the program was started. It was noticed during March of 1982. Some of our major division reports show this basic trend. The visual "inclusion" reject report shows 220 inclusion problems in January

1982. that problem continued at a high level until March at which time our first Quality Circle groups began brainstorming problems and ideas in the Circle meetings. The inclusion problems started to decrease in March and in the following months to reach all time lows.

Figure 3 shows our ZYGLO (FPI) product yields; this Division Control Chart shows a similar trend to Figure 2. Likewise, beginning in March the product yields began improving and went above target line.

Figure 4 is a very important one; it is our Scrap Chart. Scrap results from not producing the product right the first time and losses can mount rapidly. In March our scrap began decreasing. Our scrap levels continued to decrease to totals that exceeded expectations. Many of our older, more experienced divisions had never seen their scrap levels to this low.

Figure 2
Visual "Inclusion" Reject Report
Wichita Falls Division, 1982

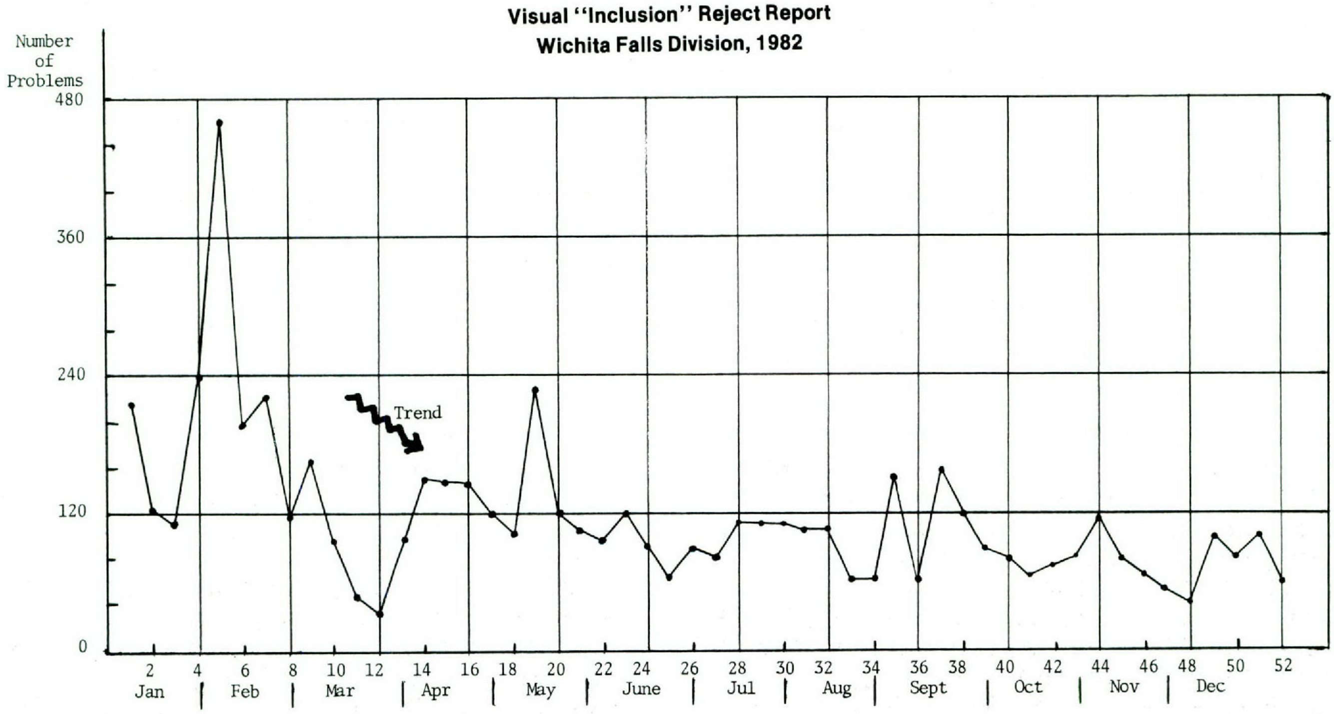


Figure 3
Zyglo (FPI) Product Yields
Wichita Falls Division, 1982

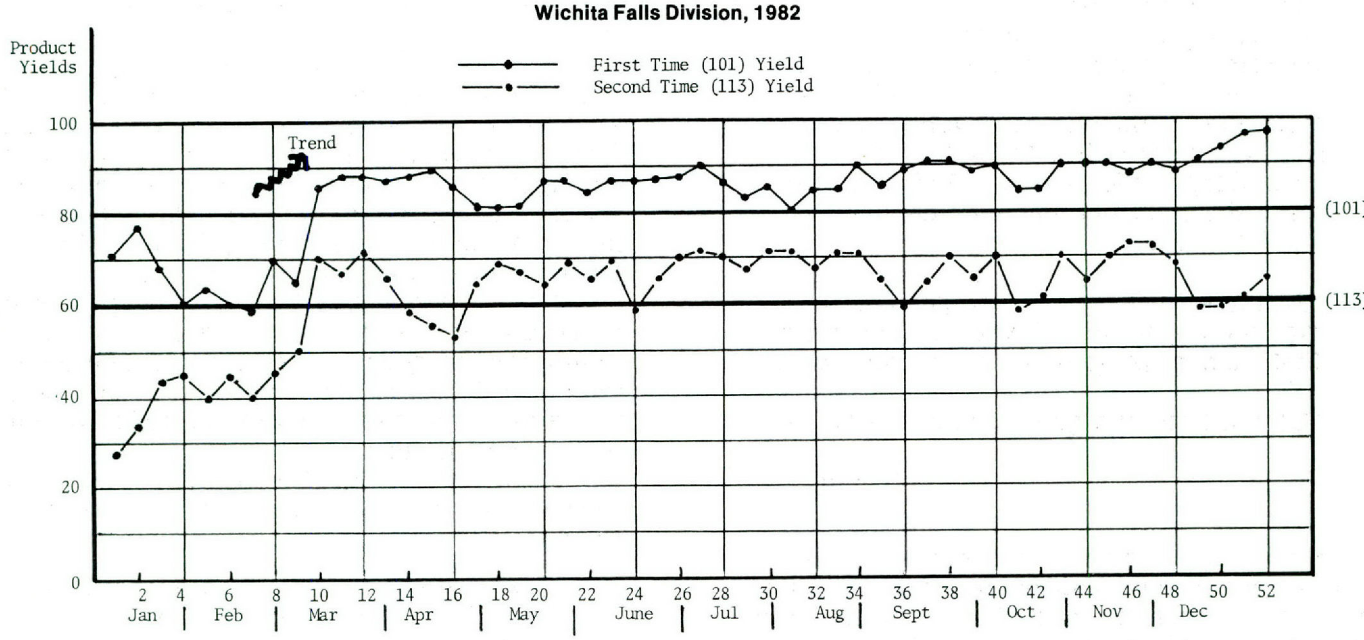
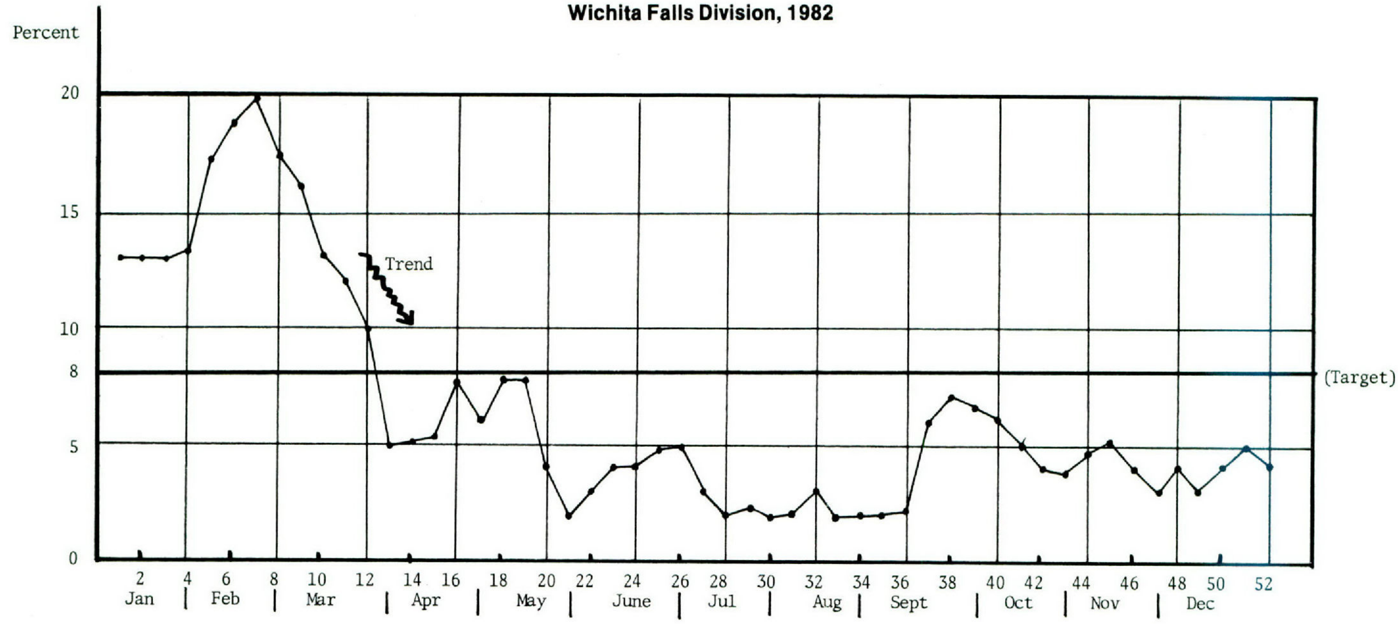


Figure 4
Scrap Prevention Control
Wichita Falls Division, 1982



What forces were at work that were having this overall impact on our yields? The Quality Circle concept was at work on both motivational and technological aspects of performance.

Another very important item dear to all our interest was profitable operations. Ironically it was during March 1982, that another major milestone was reached as this letter from Mr. Eberly, Corporate Office Vice-President, to Mr. Squier, former Wichita Falls Division General Manager, will attest. The memo reads:

> "April 12, 1982
>
> "I would like to congratulate you and the Wichita Falls Team for your outstanding performance achieved during March 1982. Making the Division profitable in the face of declining and constantly changing markets has certainly made your task extremely difficult. The way WFD has responded to the many and varied challenges encountered is admirable and we all have every confidence that WFD will operate in the black during the balance of 1982 and future years.
>
> "Please extend my heartfelt personal congratulations to all of your Management Staff and employees for a job well done.
>
> "Best wishes and good luck in the future.
>
> "R. Eberly"

We turned a profit for the first time! The Wichita Falls Division has continued to make money each month since that time. Quality with profitability has been the basic trend since the first use of Quality Circles.

We are sometimes asked, "How much time does your Quality Circle program use in comparison to plant operation hours?" All the people involved directly or indirectly with the program spend only 3.1 percent of their time, on the average, in activities within the Quality Circle program.

This program has been successful. At the end of 1981, Howmet had 459 employees; that total decreased by 16 percent to 385 by the end of 1982. Job products increased 35 percent and employee efficiency jumped 12 percent from 80 to 91. Employee turnover, which is a real indicator of success, went down 34 percent during the same period. Another indicator of possible success has been reported by our Personnel Manager. He has received calls from 20 of the 38 employees who want their old job back.

Regardless of what type of program a firm adopts, the basic requirement is that it pay for itself and provide some profit--the old ROI ballgame! Projected savings of the new proposals made at the Management Presentations is $245,000 for our Division, as shown in Figure 5. The actual savings implemented for 1982 were $50,000. The money spent in the program has totaled $98,000.

An interesting point is that today over 4,000 corporations are currently realizing a six-dollar return from every dollar invested into their program. With over-19-month experience with our program, the ratio of dollar returned to our dollar invested is almost unbelievable.

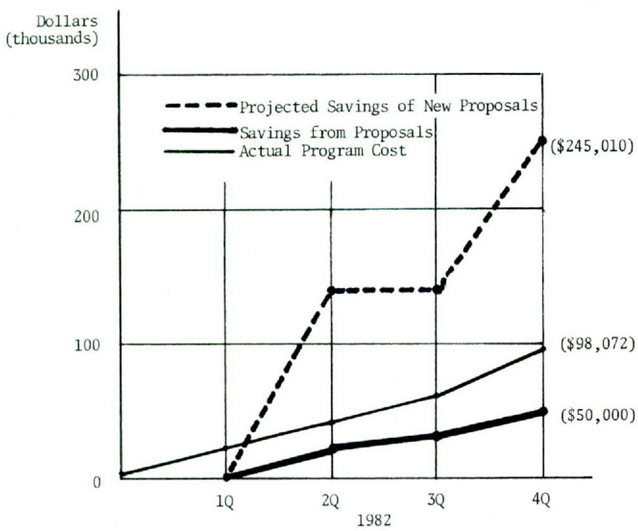
A list of the results which have been seen at our Division stemming directly from the Quality Circle Program includes:

- Management has learned we can afford to take the time to implement the program.
- The "we-they-him" concept has changed into the working "us" unit.

- Volunteers have identified over 550 problems or suggestions--and **they** are working on the solutions.
- There is improved communications throughout the Division.
- Information from Circle members in the Wichita Falls Division has been utilized at other Howmet Divisions.
- Each employee is recognized as the expert in his area.
- There is better understanding of work areas and Division activities.
- Volunteers are involved in changing the "standard" working procedures to improve methods the "Wichita Falls Way."

Figure 5

Cost Reduction Status of the Quality Circle Program
Wichita Falls Division, 1982



The Quality Circles Program at our plant has met a reaction from the overall organization which has emerged through three phases: surprise, appreciation, and then respect.

There is yet another example of the impact of our Quality Circle Program. Each time a potential customer visits our plant he is introduced to our program. The customer gains an interest in and develops a respect for what we do.

A letter from one such customer speaks for itself:

> "The Quality Circle program provided a very strong feeling of confidence in the attitudes of your employees--these are important facts in indicating quality of workmanship. You can be assured that when our decision is to be made, your company will receive a high rating."

We got the business!

At each of the meetings of the Quality Circle meetings, members take their own minutes. I want to share with you an example of minutes taken from a recent meeting:

"Thursday, December 16, 1982, started out like most any working day at Howmet. With a minor difference being-- The Guillotine Gang was a nervous wreck. This was the day chosen for our management presentation. The time seemed to drag by. But 1:30 p.m. finally arrived. The next two hours were tension filled, but as expected, the Guillotine Gang came through like champs. We presented our ideas, including slides and video to help us demonstrate. Management approved of our ideas and felt we have some worthwhile ambitions. As a result, we will be seeing a few changes in our department including lowered working benches, new chairs, new improved twist and bending fixtures, and last but not least, we have a new Kodak Ektragraphic Audio Viewer Projector. With this we will make a library of training methods. Each job assignment will be clearly defined, taped, and recorded showing each step in the process of gauging and repairing the parts. With this uniform training method, a reduction in cracks and faster, more efficient production should be evident."

What has been the response from our Management personnel to employees creating such a powerful motivation within the Division? Two examples reflect our Management's feelings. Both came from our former Division General Manager, David Squier:

> "Your presentation demonstrated to me that the X-ray Department is definitely 'work smarter'. You have developed a solution to a real problem and improved organization, safety, and a considerable labor savings will result. By copy of this memo I'm asking Jerry Cedrone, Quality Control Manager, through the PMS's, to see that this idea is disseminated to the X-ray Departments at our other casting locations. I congratulate you on your fine presentation. You are a perfect example of what Quality Circles are all about."

> "I am very proud of the job you have done in preparing for and presenting your novel and effective ideas. You have done a professional job in all respects. You have identified some real problems and implemented solutions which will make your work more effective and save the company thousands of dollars. Management accepts your recommendations and will underwrite the cost for universal straightening fixtures. Orders will be placed for the fixtures as soon as competitive quotes are received and analyzed. Again, congratulations on a job well done. Who can better contribute to problem identification and solution than the man or woman actually doing

the work? This is the theory behind the Quality Circle program. You have tested and proven the theory."

Productivity growth in action has developed from our Quality Circle Program. Our program is like a tidal wave that begins with ripples that will grow bigger and better.

In summary, I would like to direct my final comments directly to the students in attendance today. If you choose a job in business or any occupation, one element I can share with you is my fifteen years of work experience. I recommend that you use your investment in quality learning by investing in a company that offers a Management Employee Participation Program like Quality Circles. That investment should enable you to do more things than have been previously done in United States industry. And I think that you will share, like we share at Howmet, productivity growth within your choice of occupation.

PRODUCTIVITY AND STATISTICAL QUALITY CONTROL

Ron Barnes, Training Coordinator, Cryovac Division, W.R. Grace & Company

In order to tie this presentation in with the major topic of this seminar, productivity growth, I will quote Dr. Grayson from the American Productivity Center, who defines the essence of productivity as: "Productivity is getting more out for what you put in."

We need to look at what some of those inputs are and what the outputs are. Figure 1 is a schematic presentation of a production process. As Dr. Fukasawa mentioned earlier, labor, (in terms of man hours), capital (in terms of equipment), and dollars (to keep the labor working, keep the capital running, and furnish the materials and supplies that are needed to keep the process running) are your three major inputs. All other inputs can be broken down into one of those three major categories. The inputs are manipulated through some type of a process until they come out as goods and services.

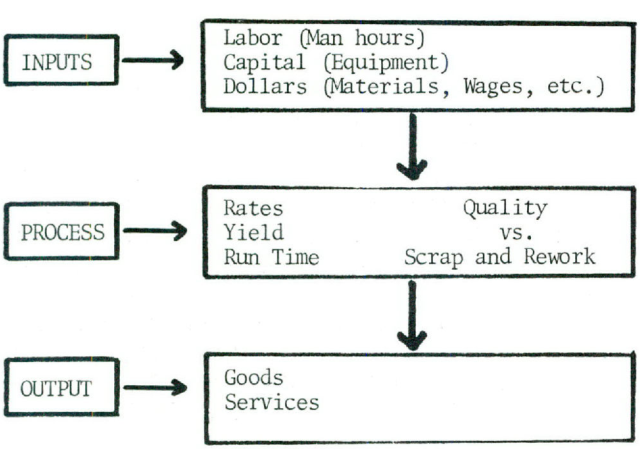


Figure 1
A Production Process

Most of us affect the inputs or the outputs at the processing level. Normally we look at rates, yield, and run-time in all of our processes.

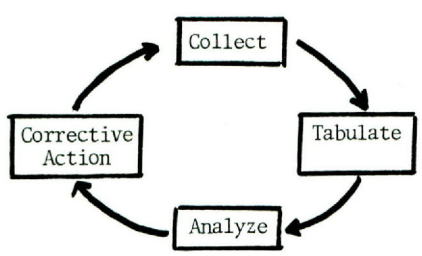
1. What are we getting out for what we are putting in?
2. What are we getting out of each hour?
3. How much of the material we started out with came out as finished product?
4. How long has the machine been running?
5. Do we have to shut the machine down to rework another piece of material?

Through the process we can expect to get one of two things. We can get quality output or we can get scrap and rework. If we end up with scrap or rework, we have reduced our productivity. If we can reverse that and turn the scrap and rework into a quality product, then we will increase productivity. I would like to add a little bit to Dr. Grayson's definition by describing output a little more narrowly. Many of us are guilty of counting all **through put** as output. We know what we put in, we got a number of items out and we counted them all as production. But, if they weren't quality goods, if they couldn't go on to the consumer, or did not perform the function for which they were designed, they are not output. Only quality goods should ever be counted as output.

Quality is a nebulous term; it means different things to different people. But the one thing it should mean to all of us is that "a quality good or service meets or exceeds the needs of customers." As producers, we have a responsibility to fill any promises that we have made to our consumers. In order to accomplish that, our products should necessarily conform to some engineering specification. How do we know whether or not our products conform? Statistical quality control tools allow us to know whether or not we are meeting the specifications. Let us take a look at just what statistics is. According to Dr. Thomas Shahnazarian, statistics is "The analysis of data required for effective problem solving and decision making."[2] The term effective is very important. We often make decisions based on erroneous or missing data, and the decision may not be effective; therefore, it is very important that we follow a proper data collection procedure. Dr. Shahnazarian defines this process or procedure as Data Cycle, as shown in Figure 2

The data cycle is a process that facilitates the making of accurate decisions. First, we collect data. After we have collected it, we must tabulate it. After it is tabulated, we must analyze it. After it has been analyzed, we react. Reacting may include making adjustments, or other corrective action. But we don't stop here. We must go back and collect data again to see if we have really done what we thought we were going to do and see if we got the impact we expected. After data has been collected again, we must tabulate and analyze it to detemine if more corrective action is needed.

Figure 2
Data Cycle



The cycle is continual, when you start a program of statistical quality control, plan to do it for the rest of the process cycle life. It does not end until the process dies. Companies have gotten into trouble by starting a statistical quality control system, and, when everything is working well they stop collecting and analyzing. Once their data cycle has been terminated, they don't know where they are and, within a few months, they may start getting rejects back from customers. if they start up the control charts again, they will likely see why. The process has gotten out of control. So once you start the quality control process you must continue it.

The failure to control the quality of its products is a major cause for this country falling behind Japan Incorporated. Japan did not develop quality control, they did not invent it. Doctors Juran and Demning, from the United States, were very instrumental in the use of statistical quality control in Japan. The Japanese have made use of the tools that were developed in the U.S. in the 1920's. Dr. Walter Shewhart, working for Bell Laboratories, developed the procedures (which Japan has been using since the 1940's) for statistical quality control. Shewhart's methods, which include charting techniques and process capability studies, have the objective of determining whether the results (i.e. quality of product) obtained today are equal to those that were obtained previously, thus allowing us to determine whether or not the process is stable. If it is stable, it should be repeatable. The control charts signal whenever a particular process makes a statistically significant shift. Dr. Shewhart based his system on the concept of a "constant cause system" which hypothesises that no two products or units of production are exactly alike, there is always some variation.

The Four M's

There are four major factors that affect all variables or attributes. These are referred to as the four M's:

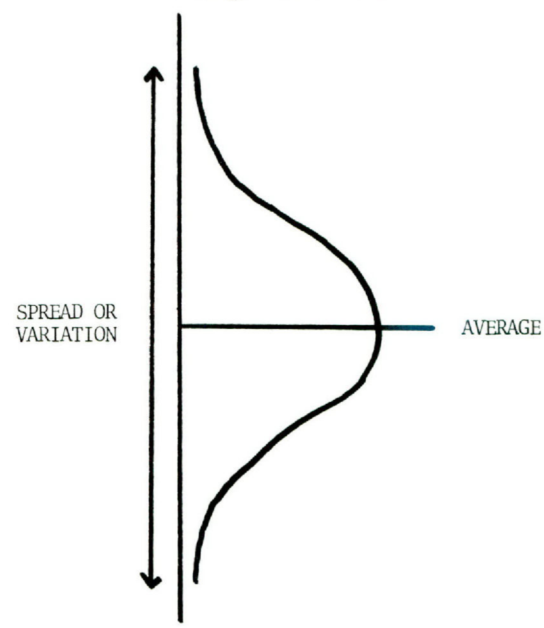
1. Man
2. Methods
3. Machines
4. Materials

When we talk about man we speak about the differences in the way humans see and do things. One man may adjust a knob and read it one way, and another person may come along ten minutes later and get a different reading from the same adjustment.

Methods include standard operating procedures and standard operating conditions. they can vary from shift to shift, from person to person, from plant to plant.

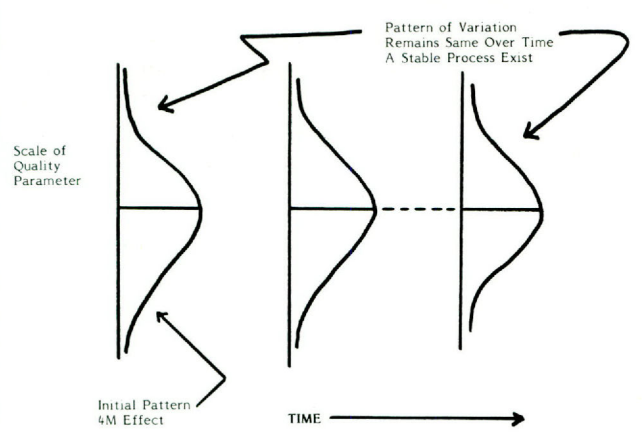
The machine, itself, may be built in the same machine shop, and may be designed to perform the same function, but they all have slight differences. Matherials consist of raw materials, semi-finished goods, supplies and etc. Figure 3 shows the pattern of normal variation, a bell curve.

Figure 3
Average and Variation



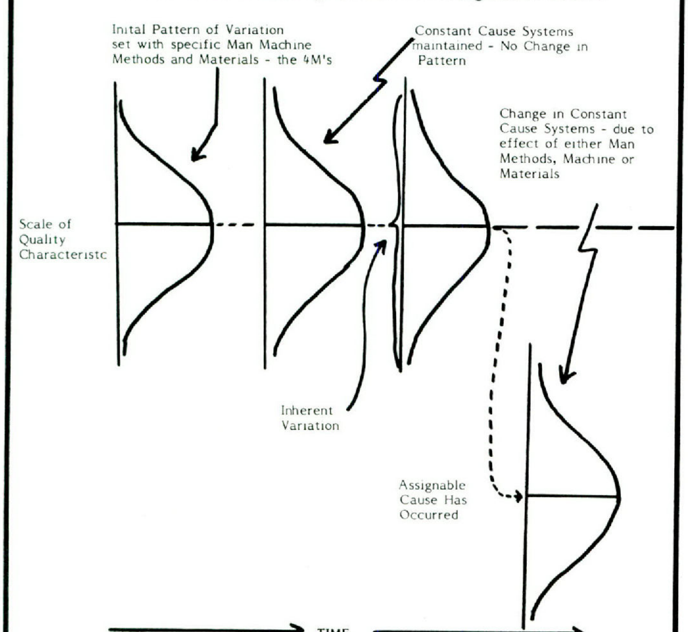
Most industrial applications will follow the normal distribution. However, the first step should always be to construct a histogram to find out whether or not your data pattern follows a normal distribution. Most will; but, if one of the four M's change, it will change the distribution pattern. When this happens, the constant cause system is disrupted and we can say that we have had an assignable cause. Let us look at the ways that can occur. To check for a constant cause system, we will take a series of observations to form some distribution that will have a mean and some measure of dispersion. If the system is a constant cause system, we can go back later and take another sample of the same number of observations and we should get the same type of pattern with "statistically" the same mean and the same distribution. This should continue through time until one of the four M's change. Figure 4 shows a constant cause system.

Figure 4
The Constant Cause System



If one of the four M's change, it may shift the average, as shown in Figure 5. When such a shift in the curve occurs, there is an assignable cause. Remember, we must know we have a constant cause system before we can determine whether or not we have assignable causes. With enough work, we can find the assignable cause and correct it. The shift does not necessarily take place in the average. Other factors which may shift will be discussed later in this article.

Figure 5
The Constant Cause System & An Assignable Cause



How do we begin to use a system like this? What do we have to do first? Basically there are four steps to achieving statistical control.

1. First, you must determine capability. Does your machine or process have the capability of being controlled statistically? Capability is a very narrowly defined word and will be discussed later.
2. After you determine capability, any assignable causes must be corrected.
3. When the assignable causes are corrected, central limits can then be established.
4. With the control limits in place you can continue to operate within the control limits. Using the control limits as a signal you will be able to determine when adjustments are necessary and when they are not necessary.

One of the major problems in manufacturing processes is over-adjustment by the operating people. Using this system, adjustments will be made only when some type of control chart must be developed in order to detect the need for adjustments.

Control Charting

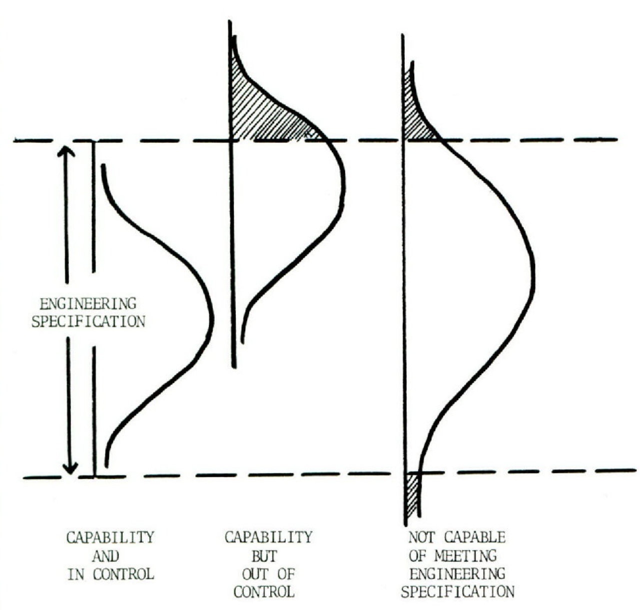
The control chart is based on an average (or arithmetic mean), as shown in figure 3. Henceforth this average will be referred to as the "$\bar{X}$ (X-bar)" which is the measure of central tendency chosen for use in this procedure. Either the "r" (range) or the "σ" (sigma or standard deviation) as the measure of variation about the average.

There are two major types of charts used. The $\bar{X}$ chart of process averages and either a range chart or a sigma chart. To determine whether to use a range or sigma chart, use the following rule. Range charts are accurate when nine or fewer observations make up a sample. For ten or more observations per smple use the sigma chart because range charts experience reduced validity at a sample size of ten. Range charts are much easier to use in that they are easier for operating people to work with and facilitate the computation of control limits which provide the bases for their use in Dr. Shewhart's development.

The $\bar{X}$ chart and the r, or σ chart are used first to determine capability. Later in this article, an example of charts which show capability and those that do not will be shown after which the same types of charts are used to control a process if it has shown capability. In that context, these illustrations will allow you to detect any out of control conditions. These charts will provide confidence that the process is in control and thus will eliminate any doubt as to whether the product should be scrapped or should be sent to the customer. This is to say that if your measurements are getting outside of the control limits developed for your control charts, you are manufacturing scrap for your customers. However, if the measurements remain within the control limits, you know it. This ability to detect the degree of process control provides a great deal of confidence in the process and, as we mentioned earlier, stops necessary adjustments to the process.

It was noted earlier in this article that the term "capability" would be defined. In the terms of statistical control, "capability" is very narrowly defined. The process has capability if it can meet engineering specifications. Conversely, if it cannot meet specifications, it does not have capability, as shown in Figure 6. Three examples are considered: In the first example, the process being measured has capability and is in control. The second example illustrates a process that is operating outside the specification levels. Any material which falls outside of the specification levels will have to be discarded or reworked. The spread is identical to that of the first example, which tells us this process is out of control but it **probably** has capability. If the average computed for this process can be returned so as to conform with the engineering specifications, then the process can be controlled. In its present condition, however, this process is out of control. The third example illustrates a process that does not have capability. Three alternatives are available which will provide this process with capability:

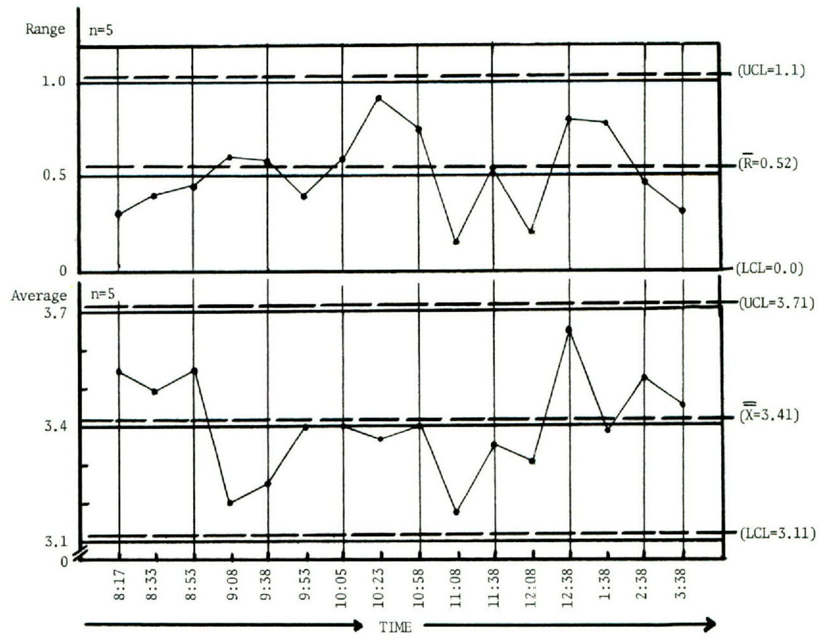
Figure 6
Process Capacity



1. It could perhaps be controlled at the demonstrated level. If it is elected to control it at that level, it will result in defective materials that either must be thrown away or reworked.
2. The process can be examined to determine if an assignable cause can be detected and make corrections that narrow the spread. This will give the process the capability of meeting specifications.
3. Finally, customers' needs can be examined. Are customers specifications realistic or are they spurious? If there is an opportunity to broaden those specifications and still make a product that will satisfy customers' needs, then there is still possibility that this process has capability (at the new specification level) and thus can be controlled.

Figure 7 is an example of an $\overline{X}$ chart and an r (range) chart showing a process that has been statistically controlled and has capabilty. How can this be determined? The r chart has an upper control limit and there is also a lower control limit which in this case is zero. At no time does the range of the data go outside the range of those control limits so it can be said that process range is in control. Looking at the control limits of the $\overline{X}$ chart and the $\overline{\overline{X}}$ (average of averages) the process is not exceeding the control limits. The fact the product measurements remain within the control limits of both charts indicates that this process is in statistical control and has the capability of meeting specifications established if they are greater than the control limits. Any variations noted between the control limits is accepted as normal variation. The operator evaluating this process would not make any adjustments so long as the averages stay within the $\overline{X}$ control limits and the range is within the r control limits.

Figure 7
r and $\overline{X}$ Charts: Process In Control



An examination of Figure 8, indicates that at ten o'clock, the range of measurements went outside the control limits, thus indicating that the process is out of control and adjustments to the process are required. In addition, the average readings were out of control also so that there are definite signs for some period of time that some actions by the operator were needed. Process capability was being studied. A machine needed a die cleaning. It was known to need a die cleaning but was allowed to run. Production data for the machine was recorded. A few days after cleaning was completed, measurements of output from the machine were examined with results as recorded on Figure 9. All readings shown on Figure 9 are within the specified control limits. there was a problem, which was that the operator did not have the gauge set up properly so the readings were not within the control limits. But the machine remained in control for that period of time. In a situation like this, in order to come back to normal, the operator must make the adjustments as required. In this example it would be a machine speed adjustment.

Figure 10 is another example of how the data

Figure 8

r and $\bar{X}$ Charts: Process Out Of Control

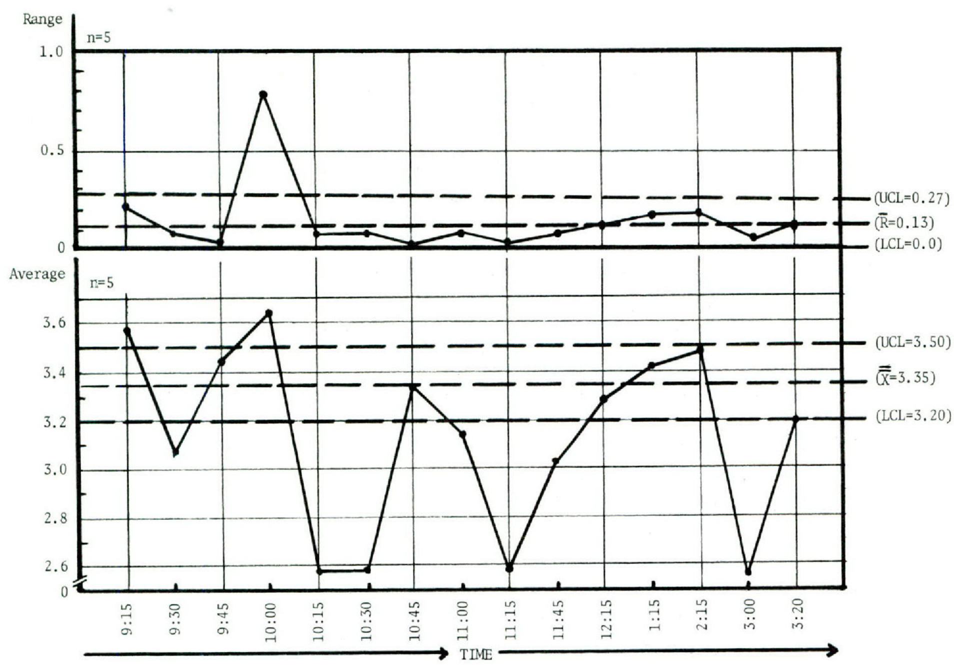


Figure 9

r and $\bar{X}$ Charts: Process After Adjustments

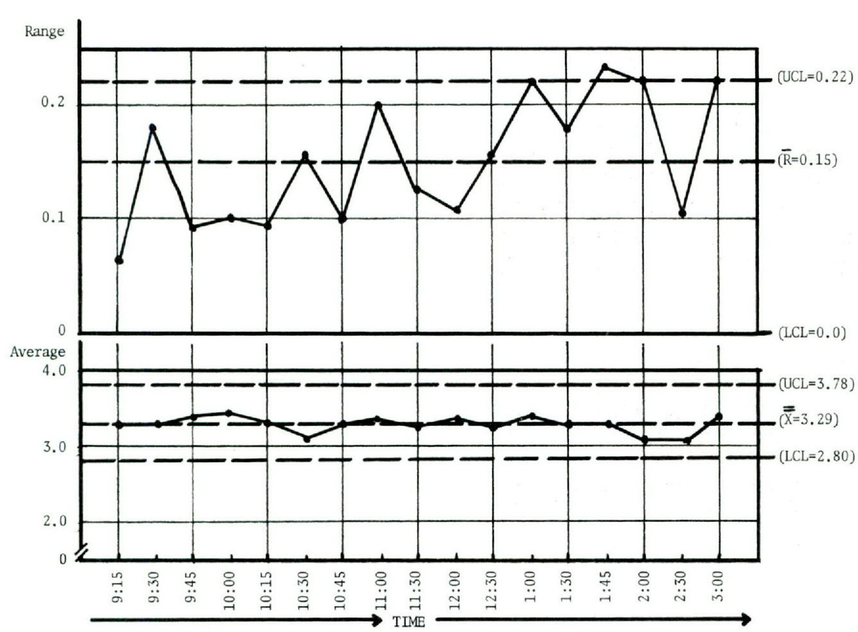
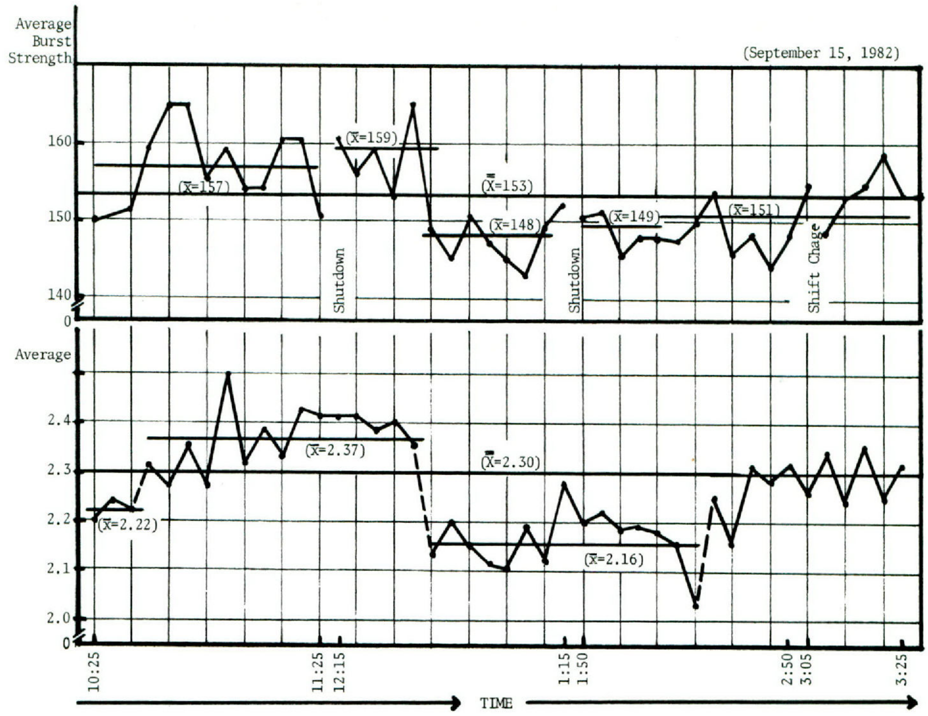


Figure 10

Average Burst Strength After Start-Up



can be used. Cryovac produces flexible plastic packaging for industry. If the bag doesn't have a seal at the end, it just isn't a bag. Thus, one of the most important variable that must be measured is the strength of that seal. It was noted that if one of the controls were properly adjusted before a machine was shut down, seal strength would be maintained when the machine was restarted. This is illustrated on the chart by the data before 11:25 and data after the lunch break (12:15). From this chart the impact of an outside variable (in this case the thickness of incoming semi-finished goods) on the seal strength can also be seen. In this case, it was noted that when the thickness decreased, so did the seal strength. That finding resulted in further study by another department that produces semi-finished goods.

In summary, it should be remembered that once a statistical control program is begun, it provides the opportunity of recognizing a multitude of potential problems. It is often found that the factors once thought to be problems were not and that the factors never recognized as problem areas actually become assignable causes.

1. Dr. C. Jackson Grayson, Jr., "The Productivity Payoff", 1979 American Productivity Center, Inc., 123 N. Post Oak Lane, Houston, TX 77024
2. Dr. Thomas E. Shahnazarian, "Statistical Methods for Quality Control", Technical Seminars, Box 22, New Canaan, CT 06840
3. Ibid
4. Ibid
5. Ibid
6. Ibid

A SEMINAR SYNOPSIS: QUESTION AND ANSWER SESSION

Charles Ramser, Professor of Business Administration, Midwestern State University

This workshop is for you. You may have come here looking for an answer to a problem. You may be wondering if America has a productivity problem. If nothing else has happened in the last hour and a half, I bet you can appreciate the fact that there is a challenge here. It is not simple and American industry is going to have to view the problem from several perspectives, including the perspective of today's worker. I think that we can clearly see in both of these presentations, that these two fine area companies are doing something to reduce this problem.

Robertson's presentation offers optimism through an approach to improving both productivity and employee fulfillment--namely the "Quality Circle". The importance of improving productivity in national and world terms is stressed by Robertson, as well as its significance to the firm and to the individual. The big gap between just having a job performed and motivated employee input is at least partially bridged for Howmet by quality circles. Genuine employee involvement results in greater quantity and quality of product output. In the long run, it also results in an improvement in overall production technology and in the reward of even more significant involvement for the workers. Quality Circles, as both a program and a philosophy, must ultimately pay off in ROI terms--something which Howmet and Robertson appear to keep in mind.

Barnes deals with a specific quality control perspective involving statistics applied directly at the work place. It fits beautifully into a quality circle program. Quality control goes right to the essence of productivity. Product specifications which are out of control do not qualify as output for productivity calculations. The significance of using statistics--X-bar charts, and the like--to chart product and process characteristics is convincingly documented and presented in his paper. The benefits in added productivity are evident at the Cryovac Division of W.R. Grace Company.

I know that you have a reaction to these fine presentations while we have these experts here. I would like from you, the audience, a question or comment that you would like to direct to either Mr. Robertson or Mr. Barnes.

Question: What percentage of the local work force actually takes part in the quality circle program?

Answer: (Mr. Robertson) Right now, we have 35 percent directly involved in our program, and probably double that are indirectly involved. I hope that the 385 people we have today at one point in time in the future will have a QC group of their own.

Question: Do you have a problem of having too many volunteers for the program and having to select a limited number?

Answer: (Mr. Robertson) We had that situation in a couple of departments where we had 20 some people volunteer and whereas the group size runs generally from 10 to 12. So we tried to afford the opportunity for as many as possible to be involved.

Dr. Ramser: We get the impression that quality circles are swimming against the old tide. As far as what American workers have always been led to believe, they ought to be treated like passive entities at work. We have heard of the Japanese challenge and how it has been so effective there. Now we're seeing that management is really moving over and making room for this America. We have the impression, Mr. Robertson, that management in your place is moving over to make room for workers to be thinkers and that things have moved ahead there. Is your management comfortable with all this change?

Response: (Mr. Robertson) It is an adjustment no matter who your management is. It may be a shock to alot of them at first, but once your program gets going and you see enthusiasm, motivation, you name it, it just takes over and it proves day after day the concept of self help. Really it does not leave much to management to say yea or nay to. Dr. Ramser had the opportunity to be at our facility back a few years ago so he had seen, I guess you could say, the before and after from the management supervisor's perspective of this concept. He and Dr. Fukasawa, about three or four weeks ago, were in a presentation of one of our groups. I think there is a big difference from before and after.

(Ramser): It was a night and day difference in two ways. The workers felt like they were somebody and the managers accepted that and were very comfortable with the role of listener. I think they were very satisfied that the workers had ideas, could think, and showed that they had something between their ears.

I bet the students in the audience are shocked still from the fact that Mr. Barnes' presentation sounded in some ways like a statistics class, and yet he was saying that some of those things studied in statistics classrooms are the answer to his problem of productivity lag. That those techniques when put on charts and graphs and shown to workers really have an effect on them. Are the workers able to understand those bar charts and similar graphs, better than I can? Are workers actually doing statistical computations complete with plotting and charting?

Response: (Mr. Barnes) Yes, basic statistical computations.

Comment: (Dr. Ramser) Don't you think that since the things we teach in basic statistics classes in college are really out there, that people ought to try to learn them while they are here in college?

Question: Imagine the operator does not touch the machine as long as the range stays in control. I was wondering, in certain processes, doesn't the physical control chart limit improvement?

Response: (Mr. Barnes) The first thing that has to be done is the proper capability study. Once that is accomplished, you have already determined what the variation of that process ought to be. And as long as it is not varying any greater than normal pattern variation you don't touch it. The operator understands that, it makes it much easier for him to do his job, and to do it with confidence and what he is doing is not going to get him into trouble. We have a good example of that in one of the plants. We had been running a capability study and the machine was in control as showing capability and then the shift changed. A new operator came on, and of course, he was a better operator than anybody in the whole wide world and he knew how to set that machine up. So he immediately changed everything on that machine and the machine was out of control. It took them five hours to get it back into control. During that time we are generally capable of making about four or five thousand bags per hour. So, you see that we had 20 to 25 thousand questionable bags run during that time limit trying to get that machine back into control. Now that is not satisfying to the operator nor is it satisfying to management. It would be much more satisfying for the operator to know the materials that he produced were going to be quality materials and he's not going to hear from management.

Question: What if the production employee has a good idea?

Response: (Mr. Barnes) If he has a suggestion for improvement, we are willing to work with him to verify whether or not his improvement is viable, and rerun the product capability studies with the improvement in place. And when we have done that it does prove to be a statistically valid improvement then we will incorporate it in all operations and reconstruct the control limits and control charts to reflect that.

Question: Talking about quantity and quality, I get the impression that you project that as you are increasing the quantity, you are also increasing the quality. Normally, there is sort of an adversarial relationship in industry between these variables. Have you gone to where your quality program depends on your output, not through-put but output?

Answer: (Mr. Barnes) We haven't yet, but there may be a point where that occurs. The main reason we have not done that is the material that would have been scrap or would have been rework is not part of your output so you actually increase the output at the same time that you improve quality. A statistical approach obviously works best for us simply and most directly on the one machine. In effect, I know you are not going to agree with this but you are making the operator a better part of the machine because he's got his own performance feedback by operating his own machine. It gets to the point where he is basically part of the machine.

Question: The quality circle approach seems to be more adaptable or seems to be more suitable to a flexible production environment; however, I wouldn't think that your quality control statistical checking approach would work in a non-production environment. (Street Department)

Answer: (Mr. Barnes) To make it last as a normal process would be difficult. But certainly a quality circle approach by itself could be applied in that aspect. I think there is alot of difference between the two; quality circles and statistical sampling.

Question: How do your employees react to control? I could see where some employees could be very resentful on this and your guy comes around with those damn charts again and every time I get this thing working this guy starts taking his samples. I was just curious about that...how do your workers react to this?

Answer: (Mr. Barnes) Let me tell you one thing first; there is not the difference that you're seeing. The physical control method that was used in Japan by Duran, et. al. eventually led to quality circles there. This needs to be in place for your quality circles to be more effective. That is a valuable tool that your people will use to do their quality circle work. The chart that they operate from tells whether the quality circle is effective. These are some basic tools that we talked about on our control charts.

Question: (Dr. Ramser) Then the charts are not viewed negatively in a quality circle environment?

Response: (Mr. Barnes) In some of our departments out there we do not have the operator input as part of the strategy in as great of a quantity as it is in some other departments. Once you have charts in place, and you have the manpower in place, you try to take the charts out. As soon as they are taken out, the operator can watch a deteriorating performance occur. Shortly after that quality falls off and the charts are back up. If there is a quality circle environment, or even if there isn't, the operators like them and managers like them too.

Question: (Dr. Ramser) Do either of these techniques suggest higher unemployment? I know that, Mr. Robertson, your figures show the smaller plant census now than before. Is that because of quality circles?

Response: (Mr. Robertson) No, because as you can see, I think we had 109 people voluntarily quitting an operation.

Question: Well then, does the quality control atmosphere result in people so productive that you don't need as many of them?

Answer: (Mr. Robertson) That's a good question. There might be particular areas where because we found new ways of doing things that is true. I think that maybe the x-ray department is nearly like that. It has not actually reduced....alot of people are needed to do the operations at a more efficient, faster pace. So I don't view it as reduction. I would like to add one thing here kind of interesting because our quality circle concept is now entering a stage where we are in a process of re-doing a statistical package implementation. We already really have two circles, our gauging crew and our x-ray group, that are doing some monitoring with the use of statistics. So our plan is to implement statistical control within the operation where-ever and on what-ever it can be used. The two programs we are tying together.

Question: In the quality circle program, you were talking about the leader of the quality control circle. How do you pick the one you want for the job?

Answer: (Mr. Robertson) What we did when we first started is that we had nine pilot volunteers. After I came back from my training facilitator schooling, it was my responsibility to train all of our future leaders. We started a volunteer approach. A person volunteers from the floor for QC leader. We have not had one person drop out yet if they are not chosen to be a leader. In the literature I have read that will happen. Maybe at one time we will have that experience where they choose not to deal with it.

Dr. Ramser: The productivity problem in the United States is complex and significant. The productivity trend of recent years must be reversed for both national and international reasons. At the firm level, wages and productivity must be in line. Mr. Barnes and Mr. Robertson have presented progressive approaches to factory work which are being taken by their firms to meet the challenge of productivity growth.

On that note, our conference is concluded. On behalf of the Midwestern State University Bureau of Business and Government Research, let me thank both Mr. Barnes and Mr. Robertson for their presentations today. Also thanks to you, the audience, for your kind attention.

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