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Economics Group

Special Commentary

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What Really Drives Growth in the Industrial Sector?

Executive Summary
Although U.S. manufacturing employment has declined by 40 percent since its peak in 1979, the volume of industrial output in the United States has nearly doubled over the past 30 years. How have manufacturers been able to expand output so much, while significantly reducing headcount? Although an increase in the capital stock has helped, the most important contributor to output growth has been total factor productivity (TFP), which is defined as improvements in the technology that is used to combine capital and labor.

Our analysis, which disaggregates overall industrial output into 19 industries, shows there is a significant relationship between the amount of information technology (IT) used in each industry and the rate of TFP growth. In addition, industries that experience the shock of a sudden decline in profitability tend to boost TFP growth in subsequent years. Thus, the recent strength in IT spending and the collapse in profits during the recent downturn argue that TFP growth in the American industrial sector should remain solid for the foreseeable future. Although a significant increase in manufacturing employment in the years ahead does not seem very likely, U.S. manufacturers should continue to be viable competitors if, as we expect, TFP growth remains strong.

Despite Marked Drop in Labor Input, Industrial Sector Is Alive and Well
There is a widely held belief that the American manufacturing sector is dying, and that perception may be accurate from the perspective of a blue collar worker. The number of manufacturing jobs in the United States peaked at nearly 20 million in June 1979, which represented more than 20 percent of the workforce at that time (Figure 1). After 30 years and four recessions, the rise of some developing countries as manufacturing powerhouses, and restructuring among U.S. manufacturers, there are less than 12 million manufacturing jobs today, a paltry 9 percent of nonfarm payrolls at present.

Industrial output has doubled since 1979 despite a 40 percent decline in manufacturing jobs.

In terms of factory output, however, the U.S. industrial sector is alive and well. Even as the number of manufacturing jobs has dropped by 40 percent since 1979, manufacturing output has nearly doubled over that period. Despite the widespread perception that "everything" is made in China, the United States remains the world's largest industrial producer. According to the United Nations, value added in the U.S. manufacturing sector in 2008 totaled $1.83 trillion. The comparable figure in China was $1.79 trillion.[1]

A sharp decline in manufacturing employment coupled with a sizable increase in output implies a marked rise in labor productivity in the industrial sector.[2] Indeed, labor productivity in the

[1] **As a percentage of total value added, however, China is in a league by itself. According to the United Nations Statistical Division, manufacturing accounts for 43 percent of total value added in China. The comparable figure in the United States is only 17 percent. Moreover, at current growth rates China will soon overtake the United States as the world's largest manufacturer in terms of the value of manufacturing output.**

[2] **Labor productivity is commonly defined as output per worker or output per unit of labor. Productivity growth is simply the change in output per the change in units of labor. See N. Gregory Mankiw, Macroeconomics, 7th Edition, Worth Publishers, New York, 2010.**

manufacturing sector has more than doubled since 1987, significantly outpacing productivity growth in other sectors of the U.S. economy (Figure 2). So how have U.S. manufacturers been able to significantly increase labor productivity over the past few decades? One way to increase productivity is to give each worker more and/or better capital. Have manufacturers employed more capital to increase output per worker or have they relied on other techniques to drive labor productivity higher? What does the future hold for productivity growth in the manufacturing sector in the years ahead? We endeavor to answer these questions in the remainder of this report.

Figure 1

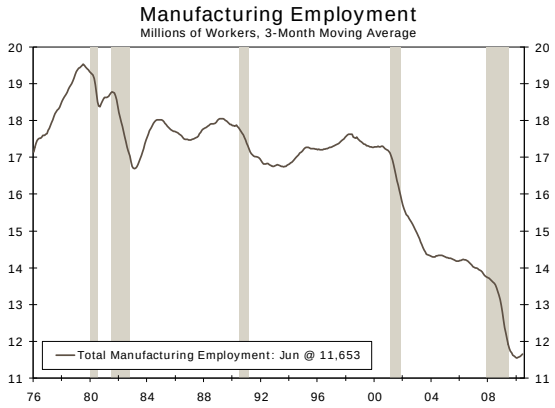
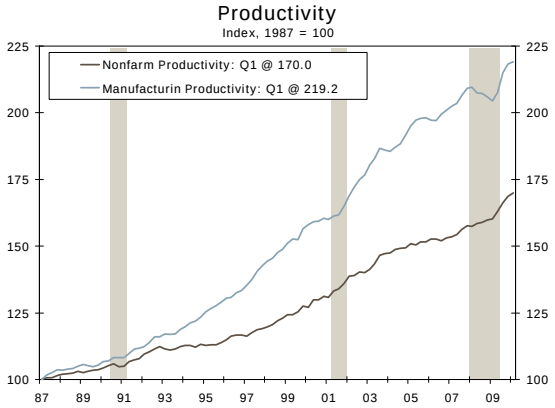


Figure 2



Source: U.S. Department of Labor and Wells Fargo Securities, LLC

Total Factor Productivity: The Crucial Driver of Industrial Growth

Increases in the capital stock have contributed positively to output growth.

According to economic theory, output is produced via labor, capital and the technology employed to combine those inputs into output.[3] In general, increases in labor and capital and improvements in technology will lead to higher output. This theory is certainly supported by the experience of the U.S. manufacturing sector over the past few decades. Since 1947, the volume of manufacturing production in the United States has risen nearly eightfold as the capital stock in the manufacturing sector has increased about fivefold (Figure 3). At the same time, the amount of aggregate hours worked in the manufacturing sector has declined more than 20 percent on balance since 1947. Thus, the increase in labor productivity in the manufacturing sector in the post-World War II era has been driven, at least in part, by additions to the capital stock.

Indeed, the index of capital employed in the manufacturing sector and the index of manufacturing output rose more or less in tandem until the mid-1980s. Between 1948 and 1986, growth in manufacturing production averaged 3.9 percent per annum as the capital stock grew at an annual average growth rate of 3.5 percent. However, the relationship between manufacturing output and capital employed in the manufacturing sector began to change beginning in the mid-1980s. Between 1987 and 2000, manufacturing production grew at an annual average growth rate of 4.2 percent even though growth in the capital stock slowed to 2.0 percent per annum. The change in the relationship became even more pronounced during the past decade. Although the capital stock edged down slightly between 2003 and 2007, manufacturing output rose at an annual average growth rate of 2.4 percent. Meanwhile, the amount of aggregate hours worked fell more than 1 percent per annum between 2003 and 2007.

Clearly, manufacturers have been relying on a factor other than more labor and capital to increase output. As noted earlier, improvements in the technology that is used to combine capital and labor can also lead to more output, and economists attribute the increase in output that occurs with unchanged inputs of capital and labor to an increase in TFP. It appears that growth in TFP

[3] In today's world, computer hardware and software spring to mind when the word "technology" is used. As defined in Webster's dictionary, however, technology is more generally defined as "the practical application of knowledge especially in a particular area."

has been extremely important, especially over the past few years, in driving growth in manufacturing production.

Figure 3

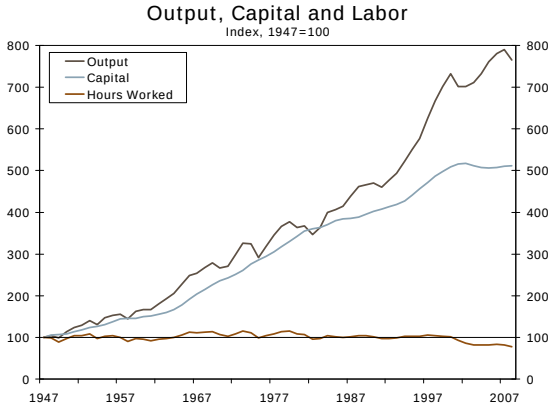
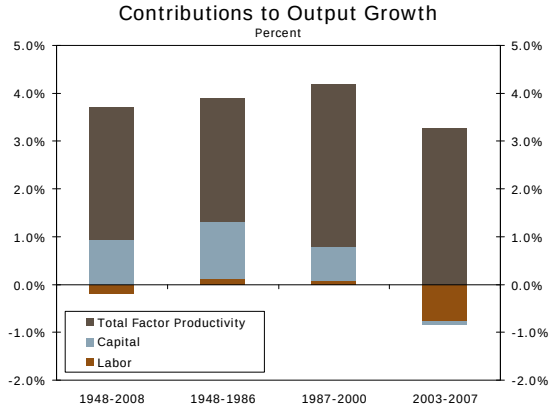


Figure 4



Source: U.S. Department of Commerce, U.S. Department of Labor and Wells Fargo Securities, LLC

Figure 4 decomposes growth in manufacturing output into contributions from various sources.[4] For example, over the entire 1948-2008 period, manufacturing output grew at an average rate of 3.5 percent per annum, which is shown by the overall height of the leftmost bar in Figure 4. The 20 percent contraction in total hours worked over that 60-year period exerted a 0.2 percentage point drag on the annual growth rate in manufacturing output. In contrast, the increase in the capital stock provided a 0.9 percentage point contribution to growth in manufacturing output. Growth in TFP accounted for the remainder (2.8 percentage points) of the annual average increase in manufacturing production.

Growth in total factor productivity accounts for the lion's share of growth in output.

Figure 4 also shows the decomposition in a few sub-periods. In both the 1948-1986 and 1987-2000 sub-periods, growth in the aggregate number of hours worked and growth in the capital stock made positive contributions to the growth rates in manufacturing output that were achieved. As in the entire post-World War II era, however, growth in TFP accounted for the lion's share of output growth in both sub-periods. The stunning finding from the 2003-2007 sub-period is that growth in TFP accounted for all of the growth in manufacturing output that was recorded during those years. The bottom line is that manufacturers have achieved significantly higher levels of output over the past few decades, especially during the past few years, primarily via growth in TFP.

What Drives Total Factor Productivity Growth?

Because growth in TFP is so important, it is imperative that we have a good understanding of how it is achieved. The academic literature has found a direct correlation between industries, both goods producing and service providing, that are intensive in the use of information technology (IT) and growth in total factor productivity.[5] Our research has confirmed this finding for the manufacturing sector. The Bureau of Economic Analysis disaggregates the manufacturing sector into 19 sub-industries, which is a breakdown we follow. We calculated growth in each industry's TFP between 2003 and 2007, and we expressed each industry's IT capital stock as a percentage of its entire capital stock, which we refer to as IT capital intensity. Figure 5 shows that there is a

[4] **The contribution of an input to growth in output can be calculated by multiplying the growth rate of the input by its share in the production process. Calculating an input's growth rate is straightforward. We proxy shares in the production process by value added paid to capital (the operating surplus) and to labor (wages and salaries). See Dale Jorgenson, Mun Ho and Kevin Stiroh, "A Retrospective Look at the U.S. Productivity Resurgence," Journal of Economic Perspectives, Winter 2008, p. 3-24**

[5] **See Dale Jorgenson, Mun Ho, Jon Samuels and Kevin Stiroh, "Industry Origins of the American Productivity Resurgence," Economic Systems Research, September 2007, p. 229-252 and Stephen Oliner, Daniel Sichel and Kevin Stiroh, "Explaining a Productive Decade," Finance and Economics Discussion Series #2007-63, Federal Reserve Board, 2007.**

statistically significant relationship between TFP growth between 2003 and 2007 and IT capital intensity in 2002, the year in which the IT capital stock peaked before it underwent a two-year downturn.

There is a statistically significant relationship between IT intensity and TFP growth.

The statistically significant relationship between IT intensity and TFP growth implies that there is something "special" about IT capital that is not possessed by other forms of capital. That "special" factor, however, is not well understood. Some researchers have hypothesized that information technology, especially when used among nonmanagerial employees, helps firms to reorganize production processes in a more efficient manner. In addition, IT may help to give workers, who arguably are more intimately familiar with the production process, more power in day-to-day decision making.[6] Whatever the link, there appears to be a strong relationship between IT intensity and TFP growth.

Figure 5

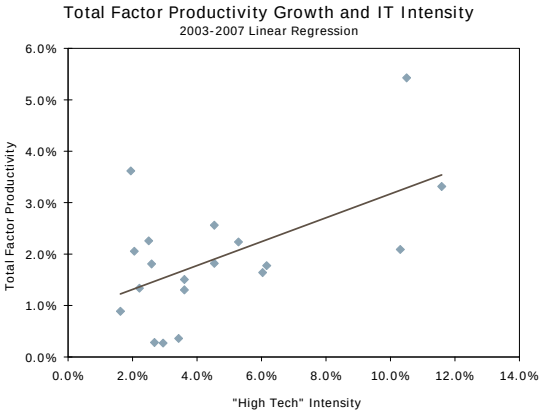
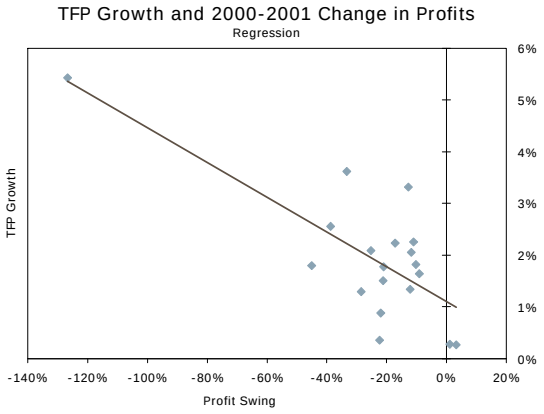


Figure 6



Source: U.S. Department of Commerce and Wells Fargo Securities, LLC

There is also a statistically significant relationship between changes in profits and TFP growth.

IT capital intensity may not be the only factor that has driven TFP growth. For example, when faced with a challenging environment, businesses may need to raise TFP growth to survive. Recognizing this fact of business life, some researchers have suggested industries that experienced the biggest decline in profits during the 2000-2001 downturn should be expected to have the strongest TFP growth in subsequent years.[7] To test this hypothesis, we regressed industry TFP growth on the percentage change in industry profits between 2000 and 2001, and the results illustrated in Figure 6 show that there is a statistically significant relationship between the two variables. That is, the industries that experienced the largest percentage decline in profits between 2000 and 2001 tended to have the strongest rates of TFP growth in 2003-2007.

Close examination of Figure 5 and Figure 6 shows that there is one industry in which TFP growth was very strong in 2003-2007. Specifically, TFP growth in the computer and electronic products industry exceeded 5 percent per annum between 2003 and 2007, markedly above TFP growth rates in the other industries over that period. Not only is this industry one of the most IT intensive, which makes intuitive sense, but it also experienced the largest percentage swing in profits in the immediate aftermath of the "tech wreck" in 2000. This observation raises the possibility that IT capital intensity and declines in profitability may both be important factors in driving TFP growth in subsequent years. Indeed, a multivariate regression found statistically significant relationships between TFP growth and both independent variables, suggesting that capital intensity and profit difficulties are both important drivers of TFP growth in individual manufacturing industries.[8]

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[6] **See Sandra Black and Lisa Lynch, "What's Driving the New Economy?: The Benefits of Workplace Innovation", The Economic Journal 114 (February 2004), p. 97-116**

[7] **See Oliner et al, 2007that is referenced in footnote #5.**

[8] **The regression shows that capital intensity is an important determinant of TFP growth regardless of the profit decline experienced during 2000-01. Conversely, the degree of profit decline experienced during**

What Does the Future Hold for Productivity Growth?

This analysis above shows that the tremendous productivity growth the manufacturing sector has achieved over the past few decades has been driven largely by strong TFP growth. This finding is consistent with other studies that have found TFP growth has accounted for a large portion of productivity growth in the overall U.S. economy in recent years. Our cross-industry analysis finds that IT capital intensity and the shock of experiencing significant declines in profitability were associated with strong TFP growth during 2003-2007.

TFP growth should remain strong for the foreseeable future.

But will TFP growth continue to be important in the future for individual industries? Making prognostications for the distant future is fraught with peril, but the experience of the past year or so bodes well for TFP growth in the foreseeable future. For starters, the IT capital intensity of the manufacturing sector has increased over the past few years. In 2002, IT represented 5.6 percent of the total capital stock employed in the manufacturing sector. That percentage had risen to 6.4 percent by 2008, with the vast majority of industries within the broad manufacturing sector registering their own increases in IT capital intensity. More recently, orders for computer and electronic products have strengthened, suggesting little diminution in IT capital intensity in the near term.[9] Second, the deleterious effect on profits from the 2008-2009 downturn likely reinforces the perceived necessity among managers to continue to wring inefficiencies out of their companies (i.e., raise TFP further) to survive. Although a significant increase in manufacturing employment in the years ahead does not seem very likely, U.S. manufacturers should continue to be viable competitors if, as we expect, TFP growth remains strong.

2000-01 was an important determinant of TFP growth in 2003-07 regardless of the industry's IT capital intensity. These results are more powerful than the simple univariate regressions shown in Figure 5 and Figure 6. Regression results are available from the authors upon request.

[9] **The value of computer and electronic products orders were about 13 percent in the first five months of this year relative to the same period in 2009.**

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