

U.S. CONSTRUCTION LABOR PRODUCTIVITY TRENDS, 1970–1998

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ABSTRACT: Construction productivity trends carry immense consequences for the economy as a whole. However, there is little scholarly consensus concerning even the direction of such trends. The main objectives of this paper are to (1) present an approach to studying long-term productivity trends in the U.S. construction industry; and (2) provide a preliminary indication of such trends over the past 25–30 years. Subsequent, extended statistical studies are suggested that may be based on the approach of the selected work presented here. Labor cost and output productivity trends are tracked for tasks that represent different trades and differing levels of technological intensity within the building construction sector. Specific tasks dealt with a range from a zero technology impact task, such as hand trenching, to compaction with a sheepsfoot roller. Means's cost manuals were used to trace the benchmark values for these tasks. These values reflect productivity trends. Unit labor costs in constant dollars and daily output factors were compared over decades for each task. Direct work rate data from 72 projects in Austin, Tex., over the last 25 years were also examined. Increasing the direct work rate usually increases construction productivity. The combined data indicate that productivity has increased in the 1980s and 1990s. Depressed real wages and technological advances appear to be the two biggest reasons for this increase. The data also indicate that management practices were not a leading contributor to construction productivity changes over time. Subsequent studies are required to add weight to these observations and can be based on the approach presented here.

INTRODUCTION

Labor productivity is of central importance to the economic health of the United States' economy. Due to the size of the construction industry, productivity changes within it have significant direct effects on the national productivity and economic well being of the United States. In 1997, new-construction-put-in-place accounted for roughly 7% of the gross domestic product (GDP), and if one includes remodeling and repair work the total rises to over 10% of the GDP (Barry 1998). In addition, over 10,000,000 people are employed in the U.S. construction industry including design, new construction, renovation construction, equipment and materials manufacturing, and supply, thus making the design and construction industry the largest manufacturing industry in the United States (Bernstein and Lemer 1996).

This influence explains why many have expressed concern over productivity in the construction industry. Perceptions of productivity trends vary widely within engineering academia, industry, and economic academia. One seminal industry document has influenced the belief that construction labor productivity has been decreasing for decades (Business Roundtable 1988). Current perceptions of those in industry have not been well quantified, however two industry leaders have stated that productivity has increased in the last 20 years (T. Kennedy and D. McCarron, personal communications, Oct. 30, 1998). Economists are split, with many questioning the existence of any construction productivity decline (Griliches 1988; Eisner 1994), as others speculate the causes. Clearly there is a lack of agreement and understanding concerning this critical issue. Construction labor productivity remains one of the least understood factors in the American economy. As a reflection of

this, the Bureau of Labor Statistics (BLS) maintains productivity indices for all significant sectors of the economy except for the construction sector. The BLS states this is due to a lack of "suitable data" (M. Jablonski, electronic correspondence, Mar. 16, 1998).

There has been much work identifying the factors that affect productivity. Ineffective management has been cited as the primary cause of poor productivity rather than an unmotivated and unskilled workforce (Sanvido 1988). Consequently, there has been significant research on how to make management more effective in supporting craftworkers in the field. There is no doubt that management effectiveness ultimately determines profitability in most cases. Four primary ways of increasing productivity through management include (1) planning; (2) resource supply and control; (3) supply of information and feedback; and (4) selection of the right people to control certain functions (Sanvido 1983).

OBJECTIVES

This paper has two main objectives. First, a method is proposed to study long term productivity trends in the U.S. construction industry. Using this method, an analysis of the productivity trends over the past 25–30 years is then presented. Additional statistical analysis based on the approach of the selected study presented here is underway.

SCOPE

The American Association of Cost Engineers defines productivity as a "relative measure of labor efficiency, either good or bad, when compared to an established base or norm." Whereas this relative nature of productivity creates great difficulties in tracing it as an absolute value over time, it is possible to gather information on movements of the established base, or benchmark, values; this paper focuses on such benchmark values. Occasionally, productivity changes over a period of time necessitate adjustment of the benchmark so that it continues to provide a realistic and useful point of reference. As such, changes in the benchmark values reflect broader trends in the nature of productivity itself.

METHODOLOGY

The benchmark values considered for the purposes of this study were the unit labor cost and unit output figures given in

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Means's *Building construction cost data*, published by R.S. Means Co. Inc. (Kingston, Mass.) from 1960–1997. Contractors lacking complete internal data use these numbers as reference values for purposes of cost estimation. These two measures reflect two different types of productivity. Unit labor cost figures provide an indication of productivity as it relates to capital resources. Unit output figures measure efficiency of labor application on the job site. Problems with using these two measures are discussed later in this paper.

From a national perspective, output growth in the economy as a whole has varied in rate over the past several decades (U.S. Bureau 1998). During the expansion of the early post-WWII period, output per labor hour grew at an average rate of 2.8%. It slowed considerably during the 1970s, however. Following this slowdown, output has only grown at an average of 1.1% yearly. In the late 1990s, output has grown more swiftly again, but it is difficult to determine if this will be a long-term trend.

To develop an approach to study long-term construction labor productivity trends, an initial decision was made to (1) choose a limited number of representative tasks; and (2) use a long series of work sampling studies to track direct work rate. Selection of tasks to be studied was focused on achieving a range of technological intensity while maintaining variety in terms of trade and sector. Technological intensity of a task is roughly defined as the ratio of equipment to labor cost per unit output. A more thorough definition might account for other factors as well, such as complexity, skill level required, planning required, and interaction with other tasks. For subsequent studies, technology should be precisely defined and its measurement specified.

In covering heavy construction, soil compaction by sheepsfoot roller was chosen. This provided an example of a task in which technology has played a remarkable role in productivity change. At the other extreme, hand trenching was included due to its inherent lack of technological change. This task also reveals real monetary compensation trends for the very lowest paid construction labor. Data for steel pipe installation and acoustic ceiling tile installation were collected to examine areas with differing levels of technological intensity. To include residential construction, 2 × 4 stud wall framing was chosen. Open web joist assembly, performed by a number of trades, represented commercial construction.

Generalized data on output for construction tasks and their costs have been available for several decades through cost-estimation manuals. Such manuals are not intended for productivity studies, but they provide one of the best sources for time-series data on productivity that is publicly available. Means's *Building construction cost data*, the particular manual selected, is a standard industry reference used in cost-estimation. Using this type of data source provided consistency in data collection and simplified output comparisons across tasks.

The consumer price index (CPI) was then used as the deflator in converting cost figures into real terms, with 1990 dollars used as the reference. Some feel the CPI overstates inflation, and some also feel that wages reflect a more procyclical pattern if the CPI is used as opposed to other inflation deflators (Abraham and Haltiwanger 1995). Often in adjusting construction prices, the cost indices published by the *Engineering News Record* are used. However, the CPI provides the more universal constant value figure desired, as opposed to a narrow, industry specific, conversion factor.

To compare the productivity trends examined in Means's estimation manual, data relating to direct work rates from 72 projects in Austin, Tex., over the last 25 years of work sampling studies were also examined. The direct work rate is a percentage of time on such productive actions as erecting formwork, tying reinforcing steel, and placing concrete. Other

work activities such as transporting materials and tools or getting instructions are considered support time. Finally, when the workforce may be waiting or taking a break, this is considered idle time. Direct work rates are a measure of efficiency in terms of time, therefore increasing the direct work rate usually increases construction productivity.

PRODUCTIVITY CONSIDERED

Defining productivity is not a simple task. Marketable output was essentially the main measure used for analysis within this paper. Focusing on such a simple indicator given the complexity of the modern economy can be dangerous. Under normal economic circumstances, an expansion of the economy must be accompanied by a proportional rise in productivity or inflation will inevitably set in. However, over the past 7 years, the U.S. economy has grown at a robust rate of approximately 2.5% whereas inflation has remained in check. Many economists, including Federal Reserve Board chairman Alan Greenspan, reject the accuracy of such a productivity index claiming that the math leaves no other choice (Uchitelle 1997).

The remainder of this article is focused on the compilation and analysis of the productivity data related to the construction activities described earlier. First, however, factors affecting productivity are reviewed.

REVIEW OF FACTORS AFFECTING CONSTRUCTION LABOR PRODUCTIVITY

The difficult nature of construction productivity can be attributed to the myriad of factors exercising influence over it.

Project Uniqueness

Projects in construction are never designed or built exactly in the same manner as previous projects. Environmental factors such as the landscape, weather, and physical location force every project to be unique from its predecessors. There are also aesthetic factors that create uniqueness from project to project. Such factors have a significant impact upon major project characteristics. Whereas most construction personnel find this uniqueness to be an attractive element for a career in construction, it can have an adverse effect upon construction productivity. Project uniqueness requires modifications in the construction processes. These modifications require workers to go through a learning curve at the beginning stages of each project activity.

Technology

Technology has had a tremendous effect on overall productivity. All but the most basic of tasks on a site have seen changes due to advances in technology over recent years. Tools and machinery have increased both in power and complexity. These advances in technology can significantly modify skill requirements. This can create difficulties in separating the contributions of technology, management, and labor to productivity.

Introducing new technology can be more difficult in the construction industry than in other industries. Innovation barriers such as diverse standards, industry fragmentation, business cycles, risk aversion, and other factors can create an inhospitable climate for innovations. In many regions of the country, labor costs for many skills are relatively low. There is less motivation to automate a task when the labor associated with it is not expensive.

Due to such impediments, firms are naturally reluctant to try a new technology, particularly if it amounts to putting the entire company on the line. Should the new technology prove effective, the firm gains only a temporary strategic advantage.

Once it is proven, other bidders can quickly begin to adopt the technology. Gestation periods can vary widely depending on the market force behind the innovation and other factors. This cycle is typical and is one reason for the step change nature of construction productivity changes for individual activities or tasks when technology is the main factor.

Management

Management complicates progress in productivity within the construction industry. Past studies found that poor management was responsible for over half of the time wasted on a job site (Business Roundtable 1983). Good management is required for profitability and success.

Labor Organization

Cross training and multitasking can reduce unit labor costs (Burlinson 1997). Contracts that create flexible work rules on the jobsite promise productivity benefits as well. Barriers between trades have historically been a source of problems in construction. Reduction in the percent of the workforce composed of organized labor and improved project agreements with remaining construction labor organizations have reduced this problem.

Real Wage Trends

Real wages have fallen in the construction industry at a more rapid pace over the past 30 years than have wages for most American workers. An increasing percentage of open and merit shop work partially drove this downward trend. It is estimated that union labor declined from approximately 70% of the construction work force in the 1970s to 20% in the 1990s. Wages in real terms were driven down as shown in Fig. 1 (Slater 1997). Additionally, total compensation rates may compare with other industries even less favorably than wage rates suggest, as construction industry work is often sporadic, whereas transportation and moving costs are higher. Older craftsmen have retired and younger entrants to the labor pool increasingly choose career paths other than construction, creating a skilled labor shortage that is plaguing the industry (Business Roundtable 1997). This trend has been compounded by the tendency of workers in the construction industry to retire at an earlier age than those in other industries (*The construction* 1997). Not only is construction drawing a lower proportion of potential workers, but the total size of the potential worker pool also shrunk during the early 1990s due to a decreasing number of 18–24-year-olds entering the job market (Emerick 1989).

Construction Training

There is currently a lack of formal training in construction—the lowest of any major sector of the economy (*The con-*

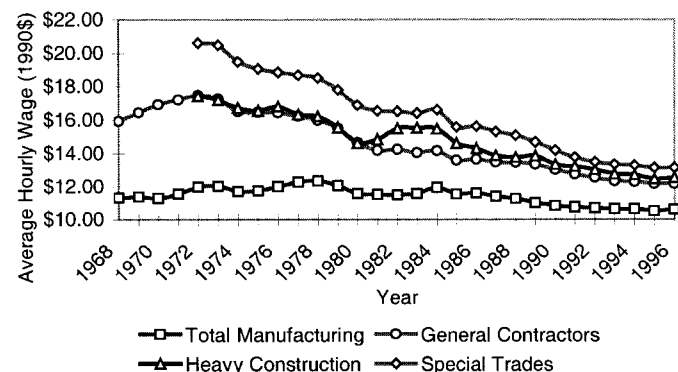


FIG. 1. Trends in Real Wages

struction 1997). This lack of training is due to practical concerns such as employers completing the increased percentage of nonunion work. In general, the work force of contractors is highly mobile. For this reason, contractors are often reticent to invest capital to train those who may soon be someone else's employees. The result may be a decrease in the construction workforce average capability level. It is unclear how this affects productivity. More effective utilization of large narrow skilled and core multiskilled workforces may even result in higher productivity on some projects.

CASE STUDIES

As noted, Means's cost manuals were used to provide the data to analyze productivity trends in the U.S. construction industry over the past 25–30 years. Labor and output productivity were tracked for residential framing, commercial web joist construction, compaction, hand trenching, welded steel pipe, and ceiling tile installation. These activities were chosen to sample a wide array of technology intensities. The wages are adjusted for inflation using the CPI.

Framing Productivity in Housing Construction

Housing construction comprises a significant portion of overall construction activity. In 1994, 63% of all private sector construction by value consisted of residential construction (Anderson 1994). Productivity in this area has profound effects on not only the industry, but on society at large. Increased productivity could lead to more affordable housing.

Different subcontractors must perform the carpentry, masonry, electrical, mechanical, and earthwork processes to name only a few. The market share of prefabricated joists, roof trusses, and other subsystems, as well as manufactured housing is growing. This likely has a positive impact on housing productivity, however small independent contractors still largely dominate the industry. Such fragmentation is partly due to the regulatory situation. For housing construction, differing codes exist throughout the United States creating additional roadblocks to standardization that could potentially increase productivity (Anderson 1994).

Framing costs were examined over the past 30 years as an indicator of productivity within residential construction. Framing is considered to have medium to low technological intensity. While it is only one of many operations carried out in the construction of a residence, framing constitutes an important task similar to several others performed by carpenters—a trade in which productivity affects many different stages of the construction process. The average house requires only 1,500 to 2,500 linear feet of lumber for outside framing walls (Siddens 1995). This is roughly equivalent to between 1 and 1.6 MFBM [1 MFBM equals 1,000 foot board measures (FBM), and 1 FBM is equivalent to the volume of 1 sq ft of lumber 1 in. thick, or 1/12 of 1 cu ft of lumber], meaning that such an operation could be completed within the span of only a few days for the average house at the productivity rates contained in Means.

It is important initially to note the interaction between the cost of framing labor and the business cycle, as can be seen in Fig. 2 (Darnay 1994). Even though housing starts may decrease during recessions, the real cost of framing labor has a general tendency to increase during these periods. During recessions, the companies can no longer afford to keep all their employees and the most skilled laborers are those they keep. These most skilled members of the workforce also generally constitute the most highly paid.

If it is true that the workforce is more efficient during such recessions, then this points to a typical discrepancy in the Means data (Fig. 3), because efficiency appears to be constant

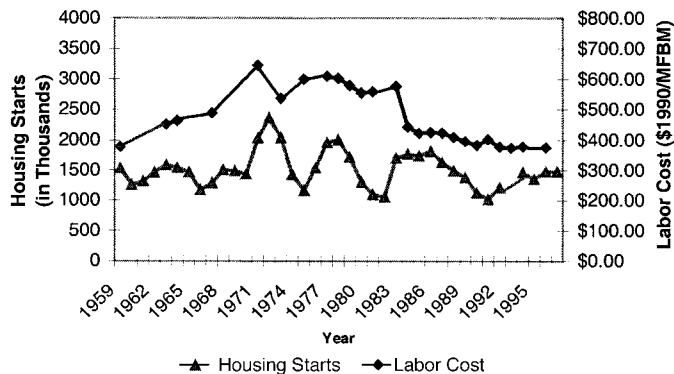


FIG. 2. Housing Starts and Framing Labor Costs

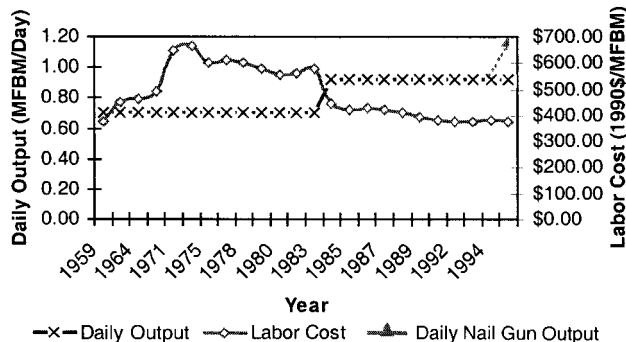


FIG. 3. Framing Output and Labor Costs

throughout. This chart demonstrates graphically both the accuracy of Means as a real-time indicator of labor costs and one of the ways in which it is inadequate as a real-time indicator of output. The workforce consists of only the most productive workers during recessions and absorbs less productive workers during expansions, yet the output appears to have remained constant across these cycles. As the composition of the workforce changes, estimators alter how they interpret the benchmark values. This indicates how subjective, and unpredictable, construction estimation can be.

Examination of framing labor output, as shown in Fig. 3, reveals an interesting trend as well. The assumed output remained constant from 1960 to 1983, at the same time the labor productivity numbers reflected an increase of 0.22 MFBM/day. This constituted a 31% productivity increase. Clearly this is an adjustment and it may reflect an underlying trend. The overall economy in 1985 had exhibited a 32% output gain since 1966.

Technology may have played a partial role in this particular increase. As tracked, the task had always used power tools but at no point explicitly included the use of pneumatic nail guns. The use of such tools was introduced into practice in the 1980s. Only in 1996 was the use of pneumatic nail guns separated out as a distinct method with significantly higher productivity associated with it. This is an example of a productivity jump to 1.1 MFBM/day that is more likely due to technological advances in equipment.

No major equipment cost increase preceded the output jump, as might be expected if the equipment were the causal factor in the productivity change. Equipment costs given are per day, not per unit output. Had output been increased by the use of more expensive equipment, the expense would be reflected even if equipment costs per unit decreased.

Web Joist Productivity in Commercial Construction

Commercial construction makes up a large share of total construction as well, although this share varies. At one time

in the 1980s, commercial construction accounted for over 19% of all construction spending in the United States (Anderson 1994). Since then, and partially due to the high amount of spending in this area during the 1980s, the proportion of construction money spent in this area has fallen considerably. Web joist cost data was chosen to examine this area due to the use of structural steel in much of commercial construction. Web joist installation is considered to have medium technological intensity.

The labor cost trends of web joist installation, as they appear in Fig. 4, follow generally the same trend as those for framing, reflecting the overall decrease in construction industry wages. The increase during the mid-1970s reveals a generally accepted period of decreasing construction productivity. The high inflation of the late 1970s may have contributed to the drop in real wages during the latter part of the decade.

Output data for web joist assembly does not reflect the positive trend that framing cost data revealed. Output remained assessed at a constant 17 t/day throughout the 30 years that data was available. Reasons for this could be many.

Besides cost trends and output trends, the web joist task also demonstrated a personnel trend. Means's crew E-7 performed this particular task. In 1975 the crew included two light equipment operators in addition to the crane operator. By 1980 one of these light equipment operators had been removed, leaving only one light equipment operator for crane maintenance. However, the number of crewmembers remained constant due to the addition of a welder foreman to the crew during the same time period. In 1975 two welders had been included on the crew with no supervision included. Yet, as was shown in Fig. 4, the wage rates for the overall crew continued to decline steadily over this time period.

Compaction Productivity in Heavy Construction

Regardless of the type of construction performed, the site will require alteration as preparation for the construction. One part of this preparation is compaction of the soil. Compaction is considered to be a high technological intensity task. Means's crew B-10G, composed of one heavy equipment operator, performed this task. Compaction using a sheepsfoot roller with 8 in. lifts was therefore traced over the past 22 years.

Compaction exhibited a 260% increase in productivity during the mid-1980s, as shown in Fig. 5. The addition of vibration to the rolling action of the compactors occurred during this time period (Caterpillar 1990). This change in technology greatly increased the productivity of the task in relation to labor and equipment costs. Unit labor costs decreased 75% as a result of this productivity improvement. As the daily carpentry wages declined 18% from 1974 to 1996, the daily wages for equipment operators in the compaction task fell 9%. Whereas this decrease is by no means good news for the workers, it does indicate their wages have been less affected by recent negative trends.

Although the equipment change led to a 40% increase in daily equipment costs, as shown in Fig. 6, it also led to a 60%

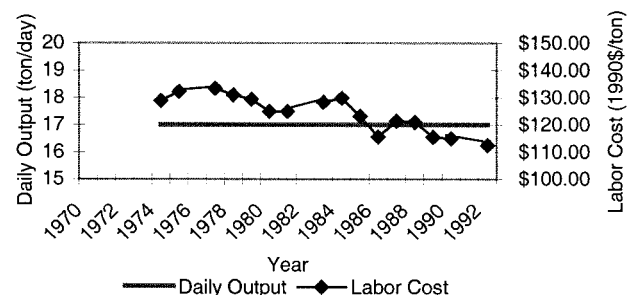


FIG. 4. Open Web Joist Output and Unit Labor Costs

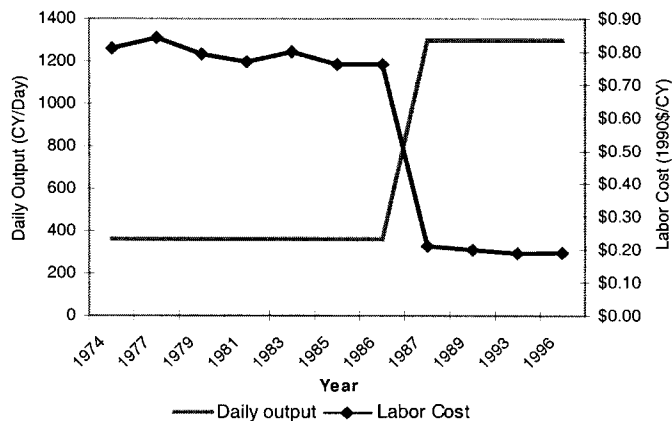


FIG. 5. Compaction Output and Labor Costs

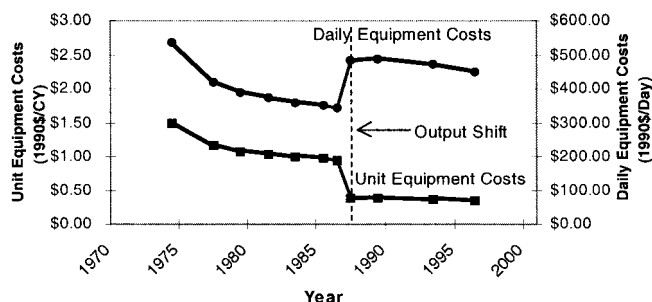


FIG. 6. Unit and Daily Equipment Costs for Compaction

decrease in unit equipment costs. This demonstrates both the dramatic increase in capital costs when employing new equipment and the high potential such equipment has to improve production and decrease unit costs in the long run. Such capital investment increases can prohibit the entry of new equipment into the industry as it remains unproven, but the tremendous decrease in costs explains the willingness of some to take risks on new equipment.

Hand Trenching

In contrast to the effect of technology reflected in sheep-foot-roller compaction, the hand trenching performed during the site-preparation phase involves minimal technology (the last technological progress in this area seems to have been the invention of the metal spade). No change in output was expected for such a task, and none was observed. However, the trends in wages of the common laborer—the entry-level position for much of construction—were revealed, as reflected in Fig. 7.

In 1996, common laborers in the construction industry had seen a 40% reduction in their real wages since 1970. In contrast, over the same period total manufacturing wages in real terms fell only 6%. This fall in wages at common laborer and entry-level positions has hurt construction in attracting new entrants.

Welded Steel Pipe

Examining productivity and wage trends for the installation of welded steel pipe broadened the focus to include the plumbing trade. Means's crew Q-16, composed of two plumbers, performed this task. One 400A welding machine was also used for this task throughout the period under consideration. This particular welding task is considered to have medium technological intensity.

As shown in Fig. 8, unit labor costs fell steadily for this task just as they had for other tasks. From 1974 to 1996, daily

wages for plumbers fell 9%, roughly equal to that of equipment operators such as those involved in the compaction task, but considerably less than the fall in wages of the common laborer. The data reflected a 16% increase in output during the early 1980s, from 31 to 36 LF/day.

Measurement of this task is somewhat problematic from at least one perspective. In the last decade, there has been a marked increase in prefabricated spools, welded in the shop, using automated orbital welding machines. It might be more accurate to aggregate the productivity and output measures for the pipe that is eventually put in place for a particular facility. This may be particularly true for industrial construction, however for the purposes of this study, it is adequate and appropriate to limit the scope to field welding.

No change in daily equipment costs coincided with the output change in the welded steel pipe task as shown in Fig. 9. This would seem to indicate that no change in equipment type used occurred to bring about this change in output. Conversely, an increase in daily equipment costs occurred in the late 1980s without resulting in any type of output increase. Either equipment costs and output are not related in this case,

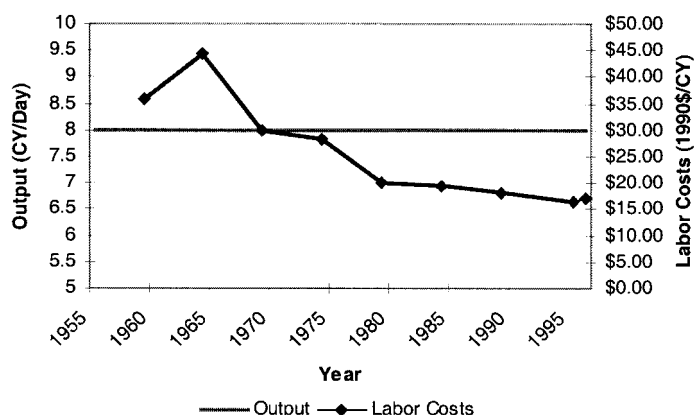


FIG. 7. Hand Trenching Output and Labor Costs

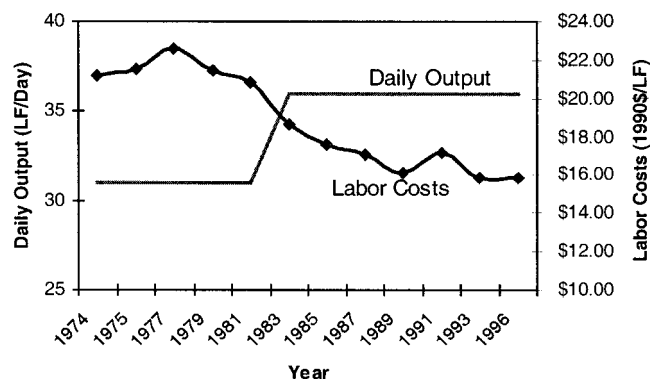


FIG. 8. Welded Steel Pipe Daily Output and Labor Costs

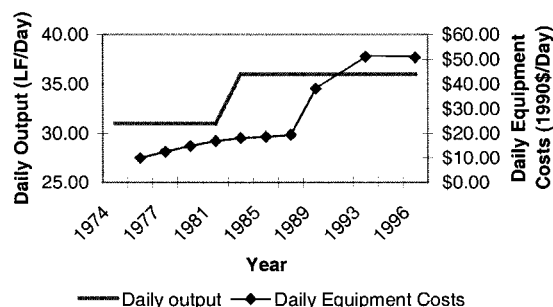


FIG. 9. Historical Trends in Welded Steel Output and Daily Equipment Costs

or Means delayed adjustment of its equipment costs for six years.

Acoustic Ceiling Tiles

Acoustic ceiling tile data was gathered due to the role of technology change in this task (the introduction of rotating laser levels) and to gain a different perspective on the carpentry trade already examined in framing. Because the carpentry trade also performs this task, it shows wage trends similar to those seen in framing. The only difference is that very slight economies of scale may have been gained in the two member framing crew when compared to the one carpenter ceiling tile crew.

The data on acoustic ceiling tiles reflected a task where output exhibited a trend very different from the static nature of construction productivity. Since 1971, the output benchmark for this task has been adjusted three times, as can be seen in Fig. 10. Of the tasks considered, this is the only one to exhibit a drop in output at any point in time. In the early 1980s, output was adjusted down approximately 50% from 410 to 200 SF/day. Toward the end of the decade, output was adjusted upward on the order of 500%. It is possible that the introduction of the use of lasers as an aid in performing this task ultimately improved productivity over time. It would be interesting to investigate whether the radical adjustments were due to errors and corrections, or if they reflect other factors such as learning and training delays.

Results from these case studies are analyzed later, along with work sampling data presented in the next section.

Work Sampling Study

Work sampling is a system for indirectly measuring productivity on construction sites, which has been used for more than thirty years. Work sampling measures how time is utilized by the labor force (Thomas et al. 1984). The analysis of work sampling data is the same as measuring how the time is utilized by the workers on a jobsite and thus gives insight into their productivity rates. Analyzing work sampling data collected over a period of time can suggest trends in productivity rates during that period. A study conducted at the University of Texas at Austin examined work sampling data collected from 72 typical construction projects in the Austin, Tex., area over a 25-year period.

In the work sampling technique, observations of what each worker is doing at a particular instant are made and recorded. The activities of workers are typically divided into three categories: direct work, supportive work, and delay. Although the definition of each category can be dependent upon the craftsman performing the work, the type of work, and view point of the observers, it is very important to set a clear definition of the categories for reliable data collection to take place (Business Roundtable 1982). Typical definitions of the three

categories are the following: (1) Direct work includes productive actions, picking up tools at the area where the work is taking place, measurement on the area where the work is taking place, holding materials in place, inspecting for proper fit, putting on safety equipment, and all cleanup; (2) supportive work includes supervision, planning or instruction, all travel, carrying or handling materials or tools, and walking empty-handed to get materials or tools; and (3) delay includes waiting for another trade to finish work, standing, sitting or any non-action, personal time, and late starts or early quits.

Work sampling gives information about time spent on activities and therefore gives indirect information about productivity. However, direct work time does not necessarily correlate with unit rate productivity. In other words, a higher percentage of direct work time would not always indicate an equally high level of unit rate productivity because of variation in skill levels of the workers sampled, work methods, and types of tools and equipment used. For example, a skilled worker may produce more than an unskilled worker performing the same task even though both have the same direct work rate. A carpenter utilizing a power saw will out-produce a carpenter with a handsaw even though the direct work percentage may be the same. Even considering these constraints, work sampling can be useful as a diagnostic tool for productivity improvement programs (Business Roundtable 1982).

The direct work rate is a percentage of the time spent on direct work in all working hours. In other words, direct work rate determines the efficiency of workers in terms of time. Therefore, it is clear that increasing the direct work rate usually increases construction productivity.

Fig. 11 represents the chronological development of the direct work values for the previously mentioned 72 projects. The annual direct work mean values of the projects varies from 41 to 61%. This result is in line with a previous prediction that states that direct work values fall within 40–60% in most construction projects (Oglesby et al. 1989). Note that data were not collected every year after 1985.

Fig. 11 indicates that direct work values have not been affected over the last two decades in the Austin area. Austin is typical of other building markets in the United States. Reasons to explain the stagnation may be that the characteristics of the labor force have not changed significantly over the last two decades, and management and supervisory effectiveness has not improved over the same time period. This coincides with the findings in the previous case studies. In the activities where there had been substantial technological improvement, such as compaction, it is clear that there has been an obvious increase in output. However, in activities that have not been affected by technology improvement, such as hand trenching, the output has remained constant. This reflects a broad historical trend in advanced countries. Whereas opportunities exist on every project to improve management, historically, technology has been the main driver behind productivity increases.

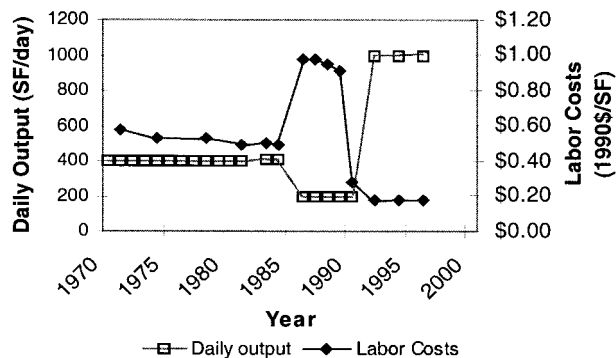


FIG. 10. Ceiling Tile Output and Unit Labor Costs

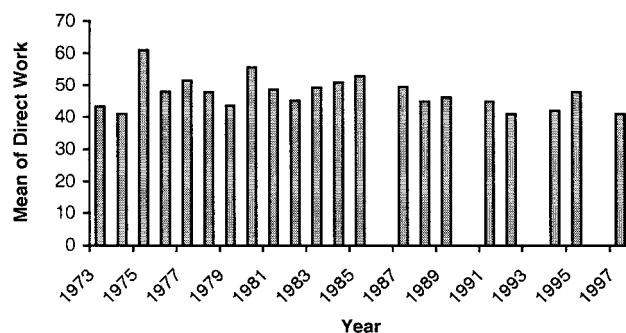


FIG. 11. Annual Sample Mean of Direct Work

SUMMARY AND ANALYSIS OF RESULTS

The method presented for studying broad productivity trends included measuring unit labor costs, output, and direct work rates. It also involves the investigation of underlying technological shifts and socioeconomic trends. Although such a combination of case studies can set the groundwork for more thorough subsequent statistical analysis, it does not comprehensively deal with productivity within the construction industry. It may be that productivity for other tasks or within different trades has exhibited different trends. However, some preliminary results may be observed.

Summary of Data

The data show that productivity has increased for all tasks studied in this paper. Not all tasks increased output, though the majority did so, but all tasks reflected a decreasing unit labor cost in real terms, as shown in Fig. 12. Both of these trends reflect an increase in productivity. Tasks such as trenching and joist installation where the output has remained constant demonstrate the extent of the fall in wages of unskilled labor. Data were also collected for 14 arbitrarily selected, additional tasks as shown in Fig. 12. Once again, these additional tasks were selected based on diversity in technical intensity and diversity in trade and sector. All of the tasks showed an increase in productivity as well, except for electric poles (installation) and cork tiles, which showed a decrease in output although they showed a decrease in unit cost as well. The reasons for these and other peculiarities could be studied with further research. Alternatively by examining direct work data, it is evident that there is still room for improvement through field management practices such as detailed preplanning even in cases that have no option for technology improvement.

Productivity Case Studies Indicate an Overall Upward Trend

Over the entire span of the past 25 years, no overall decrease in productivity was noted. If productivity has decreased,

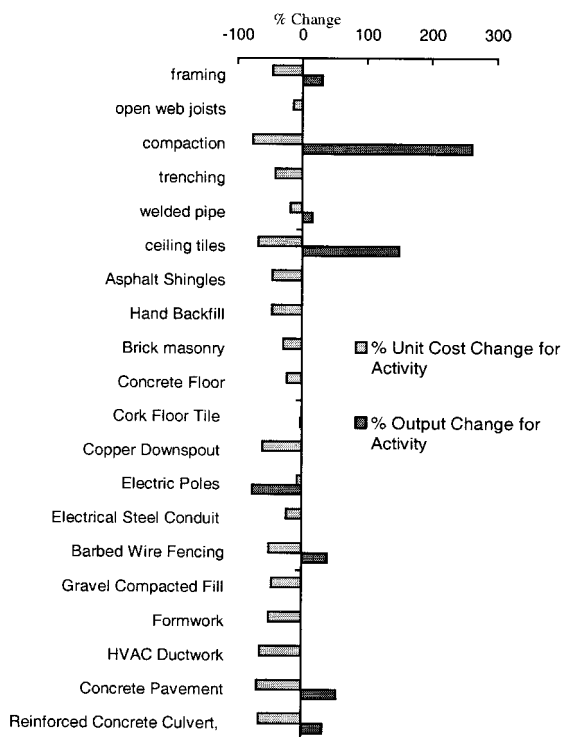


FIG. 12. Change in Output and Unit Labor Costs 1974–1996

no evidence for it exists in these tasks. In fact, some tasks demonstrated dramatic productivity increases, such as the 500% increase for ceiling tile installation during the early 1990s and the 250% increase in compaction. However, all productivity increases noted occurred following 1980. It appears that overall productivity may have decreased during the 1970s but recovered in the 1980s. Many of these productivity increases appear to be due to technology, although the increases in welded pipe installation and framing possibly involved labor skill productivity increases.

Study Agreement with Broader Indicators

Although limited, some other data exist describing the overall productivity in the construction industry. Fig. 13 (Bernard and Jones 1996) shows total factor productivity (TFP) and a weighted average of the contributions of labor and capital to productivity within the construction industry for the time period 1970–1987 based on unpublished BLS data. Following 1981, TFP ceased its downward trend and resumed the climb it had exhibited in the early post-WWII period. A change at this time agrees with the data gathered from Means. None of the output improvements noted occurred prior to 1981 but were spread out after this time. If the correspondence between contractor wages and log (TFP) holds, productivity would seem to have increased since 1981.

Measuring productivity by using TFP is problematic however. Based on this measure, not only did construction productivity fall at an average annual rate of 5.1% from 1967 to 1973—compared to an average rate of 1.1% decline from 1974 to 1985 in the economy as a whole—but productivity within the financial and service sectors of the economy showed no growth during the postwar period. None of these indications of productivity change seem to coincide with reality (Griliches 1988). It seems much of the problem in explaining trends in productivity is the lack of an adequate productivity measure.

Wage Adjustment Issues and Problems Using Economic Time Series Data

The CPI was used as a wage deflator due to its adherence to industry standards. Many question the validity of this particular measure as an inflation deflator. Some economists assert that constant productivity is an underlying assumption for use of any cost index, which complicates matters even more for studies such as this one (Pieper 1989). One alternative is to use national annual GDP as a deflator. A comparison of results yielded by using this indicator when compared to using the CPI for the hand trenching task—which exhibited the greatest change in wages of all the tasks examined—appears in Fig. 14. Although the fall in real wages was great using the CPI, it is even more pronounced when using the GDP. Which deflator is chosen makes a 30% difference in the apparent real

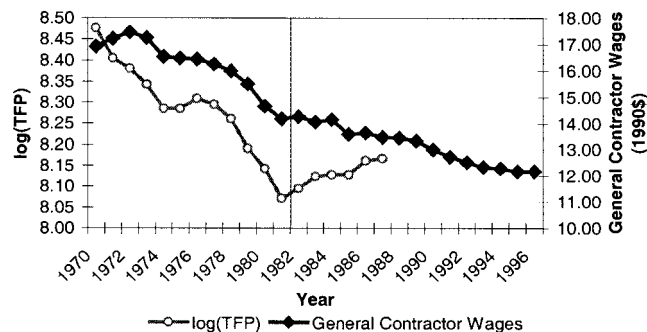


FIG. 13. Construction log(TFP) 1970–1998, General Contractor Wages 1970–1996

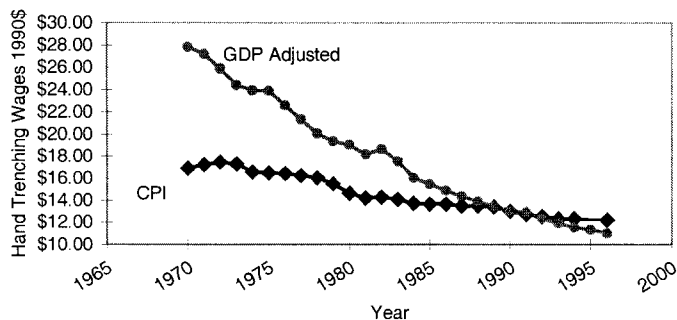


FIG. 14. Hand Trenching Wages, Using CPI and GDP as Inflation Deflators

wage change. This difference emphasizes the great difficulty in comparing economic series across time.

Some economists would argue that filtering out real wage changes is necessary for any study of true productivity changes. The preceding discussion points out the difficulty of this task, however it may be necessary for further research in this area.

RECOMMENDED FURTHER RESEARCH

This analysis of productivity trends should serve as a predecessor for extensive statistical studies. This study collected 50–60 data points from Means's catalogs for each case study. The results of these analyses produced significant results for the examined tasks. A good follow-up to this study would be to use the same methodology but expand it to a wide array of construction activities (i.e., 300 activities distributed over construction sectors and degrees of technological intensity). By collecting a reduced number of data points, approximately 10–15 for each activity, a broader and more statistically significant picture of the overall productivity trends for the U.S. construction industry could be obtained. The larger sample size would also allow a greater statistically significant correlation to be investigated between technology change depressed real wages and productivity improvement. Additional data sources should also be obtained to cross validate the results.

CONCLUSIONS AND RECOMMENDATIONS

The method of examining construction productivity presented here provides a starting point for more focused and statistically robust future studies. It suggests many avenues of future investigations such as the impact of technology on construction productivity. A few preliminary observations may also be made. Productivity, as defined here, appears to have increased substantially in construction in the last two decades. Whereas technological advances may have been a factor and management practices were likely not a leading contributor, the majority of the increase appears to have resulted from depressed real wages. More thorough statistical analyses are required to confirm the preceding preliminary observations.

The industry needs to expand benchmarking efforts such as those being pursued by the Construction Industry Institute (Austin, Tex.) and Associated Building Contractors. More thorough additional measures of productivity should be ex-

plored. More thorough research is needed to conclusively determine productivity trends. Part of the problem at this time is the availability of data. The reluctance of the BLS to publish information on productivity due to a lack of reliability demonstrates this difficulty. The Means manuals provide an indication of productivity trends, but any detailed analysis is difficult due to the crude nature of the source. Proprietary sources and other manuals such as Richardson's Process Plant Estimation Guidelines should be cross-checked to validate each source of data. Additional detailed data and analyses would provide opportunities for more research to understand the relative contribution of the controlling factors.

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