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# THE DESKILLING vs UPSKILLING DEBATE: THE ROLE OF BLS PROJECTIONS

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# EXECUTIVE SUMMARY

The Bureau of Labor Statistics projections of occupational employment growth have consistently underpredictied the growth of skilled occupations and overpredicted the growth of skilled occupations. In August 1981, for example, the BLS predicted that professional, technical and managerial jobs would account for only 28 percent of employment growth between 1978 and 1990 and that operatives, laborers and service workers would account for 34 percent of growth. In fact, professional, technical and managerial jobs accounted for 52 percent of employment growth during this period and operatives, laborers and service workers accounted for only 9 percent of job growth. Forecasts of 1989 occupational employment shares derived from regressions estimated on 1972 to 1980 data are substantially more accurate then the BLS projections. The primary reason for the bias in BLS projections is the judgmental character of the projections of occupational staffing ratios and the practice of assuming that they will remain fixed if evidence to the contrary is not available. Inevitably, BLS analysts feel that forecasting big changes in staffing ratios involves "going out on a limb" and this naturally results in them being conservative in their forecasts. Workforce 2000's forecasts of occupational skill demands are based on the BLS methodology, so its projections probably also understate the upskilling trend of occupational demand. **This implies that the forecasted shortage of skilled and educated workers is probably even more serious than Workforce 2000 and companion reports project.**

This possibility was investigated by analyzing changes in employment shares during the 1972-1989 period in a regression framework and then using the estimated models to forecast employment shares in the year 2000. For all specifications and scenarios, the regression forecasts predict substantially significantly greater upskilling than the BLS's judgmental forecasts. BLS projects that professional, technical and managerial jobs will account for only 44 percent of employment growth. Our preferred model predicts that these occupations will account for 71 percent of employment growth. In our view, the task that BLS has set for itself--measuring the level and forecasting changes in the absolute number of jobs which "require a college degree"--is impossible. The classification of occupations into a "requires a college degree" category is inherently arbitrary and

idiosyncratic to the analyst; yet the validity of the whole effort to measure "underemployment" depends on this classification being done correctly in every detail.

The paper also evaluated BLS's projections of the supply/demand balance for college graduates. They were found to have been consistently wrong. At the beginning of the 1970s, BLS projected rough balance of supply and demand during the subsequent decade. In fact, however, the supply of college graduates grew more rapidly than demand and, as a result, the college/high school wage ratio for workers with 1 to 5 years of post-school work of experience fell 6.7-7.6 percentage points by 1980. In the later half of the 1970s, BLS projected very large surpluses of college graduates during the subsequent decade. According to their projection, the surplus of college graduates was going to grow at a rate equal to 30 percent of the annual flow of bachelors degrees awarded. If correct, this surplus should have caused the relative wage of college graduates to fall during the subsequent decade. In fact, however, the nation entered a decade in which demand for college graduates substantially outstripped supply and the college/high school wage ratio for those with 1-5 years of experience rose by 23 to 26 percentage points to all time highs.

The problems are much deeper than simple errors in forecasting the future. The description of the present and recent past is wrong as well. It is stated, for example, that 27 percent (6,659,000) of college graduates were "underemployed" in 1988 and that "underemployment" increased by 1,655,000 between 1983 and 1988. Clearly, a measure of "underemployment" for a group that increases simultaneously with the group's relative wages is seriously flawed.

We then do our own examination of the supply/demand balance for college graduates by comparing past and projected percentage rates of change in employment in high skill jobs to actual and projected rates of change in the stock of well educated workers. During the 1980s, employment in professional, technical, managerial and sales representative occupations grew at nearly the same rate as the stock of workers with one or more years of college. Employers wished to increase the proportion of workers in managerial and sales occupations who had a college education but a shortage developed and the wage premium for college graduates rose to unprecedented levels. Our projections for the 1990s predict that the labor market for college graduates will get even tighter. We expect a bidding war to break out for skilled workers and to see further increases in

wage premiums for professional and technical training and for college generally. Early evidence indicates that indeed skill premiums are continuing to grow. Between 1987 and 1989, real weekly earnings rose 2.9 percent for managers, 4.2 percent for professionals and 2.0 percent for technicians. Meanwhile, real wages fell 1 percent for clerical workers, 0.7 percent for service workers other than private household and protective service workers, 3.3 percent for operatives and laborers and 2.5 percent for sales clerks. Real wages of non-supervisory workers continued to decline in 1990--falling 1.2 percent between March 1989 and March 1990.

The growing shortage of professionally trained workers and the rising skill premiums will tend to cause supply to increase more rapidly than we have projected. But the gap between the projected growth of demand and supply is huge. Just to maintain the balance between the growth of supply and the growth of occupational demand that prevailed in the 1980s, itself a period of shortage, it will be necessary to increase in the stock of college graduates in the year 2000 by 3.7 million or, put another way, to raise the number of college graduates entering the labor forces by 462,000 or 42 percent between 1992 and the year 2000.

Policy Implications: The social returns to a college education are extremely high and are likely to go even higher. Supply responses to the strong market do not appear to be sufficient to prevent a continuation of the current escalation of college wage premiums. If wage premiums for college educated workers continue to escalate, inequality will continue to grow, American corporations will be at a competitive disadvantage and multinational corporations will probably transfer offshore functions which intensively employ college graduates such as research, product development, design and marketing.

Education is a public function and a public policy response to the shortage appears to be in order. Probably the most cost effective way of ameliorating the shortage is to change immigration policy. There is a long queue of highly skilled university graduates (many of them with graduate degrees from American universities) seeking permanent residence in the United States and it only requires a change in immigration policy to triple the number of college educated immigrants to 300,000 a year. The number of American born college graduates can be increased by strengthening academic standards in high schools, by reducing the very high dropout rates in American colleges, by encouraging

adults to return to college to complete their degree, by keeping public tuition levels low and by shortening the time required to get a degree by expanding Advanced Placement programs in high schools and encouraging college students to take courses during summers. There needs to be a special focus on increasing the supply of technically and scientifically trained individuals.

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# THE DESKILLING vs UPSKILLING DEBATE: THE ROLE OF BLS PROJECTIONS

by John Bishop and Shani Carter

At the beginning of the 1980s there was a lively debate over the effects of technological change on skill demands. Men and women of affairs were arguing that the computer was transforming the skills needed in the workplace. Speaking at Stanford University in 1983, Steven Jobs, cofounder of Apple Computer, stated that "A massive retraining effort by government and private industry could alleviate the problem of skill obsolescence created by the expanding computer industry."[1] In calling for a major restructuring of education in 1982, the Education Commission of the States said:

> Occupational growth throughout the 1980s is projected to expand most rapidly in the higher-skilled, technical occupations. Tomorrow's workers will likely need improved skills in the selection and communication of information. Many of today's skills considered to be of a "higher" level are the potential basic skills of tomorrow.[2]

Most of the writers on the other side of the debate had PhDs and were based in universities. Barry Bluestone, Bennett Harrison, Henry Levin and Russell Rumberger argued that technological change was deskilling jobs. In February 1983, Levin and Rumberger summarized their position in the following words:

> The expansion of the lowest skilled jobs in the American economy will vastly outstrip the growth of high technology ones; and the proliferation of high technology industries and their products is far more likely to reduce the skill requirements of jobs in the U.S. economy than to upgrade them.[3]

In February 1984, they said, "future job growth will favor service and clerical jobs that require little or no post-secondary schooling and that pay below-average wages."[4] In a 1986 article, Russell Rumberger asks then answers the key question:

> Will workers require more or fewer skills to perform their jobs in the future?...existing studies suggest that technologies often reduce the skills workers require to perform their job....the average skill requirements of jobs in the future job market could actually be lower than they are today.[5]

In 1987, Levin and Rumberger stated:

> In summary, the evidence suggests that new technologies are unlikely to have a profound effect in upgrading the education and skill requirements of jobs, and that most new jobs or job openings will be in occupations that require relatively low skills and education.[6]

The decade is over. It is time to take stock and decide who was right, those who preached that technological progress and greater foreign trade were going to upgrade skill requirements or those who predicted that the 1980s would be a period of deskilling. Let us begin by looking at what happened to the relative share of high skilled and low skilled occupations in the economy. Professional, technical and managerial jobs, which were 24.9 percent of the nation's jobs in 1978, accounted for 52 percent of the job growth between 1978 and 1989. High level sales representative and manager jobs accounted for another 10 or 11 percent of job growth. Operative, laborer, farm laborer and service jobs, which were 37 percent of jobs in 1978, accounted for only 9 percent of the job growth between 1978 and 1989.[7] Even though they are poorly paid, many clerical jobs are not, in our view, low skill jobs. Levin and Rumberger, however, place them in the low skill category and frequently mentioned projected rapid growth of clerical jobs as supporting their deskilling position. Clerical jobs, in fact, grew only 18 percent, 4 percent slower than the growth of all jobs and secretarial and typist jobs failed to grow at all.

Just as one sided in its testimony on the deskilling issue is the recent behavior of real wages. The wage premium that employers must pay for skilled workers tells us a lot about the demand/supply situation for skills. If demand for more skilled workers shifts out more rapidly than the supply, the relative wage of skilled workers will rise. And indeed, skilled workers have been getting higher real wages: the increase in real weekly earnings between 1983 and 1989 was 16.1 percent for technicians, 12 percent for professional workers, 1.5 percent for managers, 6.4 percent for sales representative selling commodities outside of retailing and 1.5 percent for sales representatives in finance and business services. If the demand for unskilled workers shifts out less rapidly than their supply, they will suffer declines in relative wages. During the last six years, a period of recovery from a deep recession, real weekly earnings of operators, fabricators and laborers declined 5.3 percent and the real weekly

earnings of service workers declined 1.3 percent.[8] Real hourly wages of non-supervisory employees fell 8.1 percent in retailing and 4.4 percent in manufacturing.

Schooling is a second way of classifying workers by their skill. What has happened to the relative wages of workers classified by years of schooling? Analyzing CPS data on hourly and weekly wages, Kosters has found that the college-high school wage differential for workers of all experience levels, which was 40-41 percent in 1979 for both men and women, grew rapidly in the 1980s, reaching 82 percent for men and 52 percent for women by 1988.[9] Even more remarkable is the fact that this rapid increase in the relative wage of college graduates was accompanied by a rapid increase in the supply of college graduates. The ratio of college graduate workers to workers with 12 or fewer years of schooling was growing at a rate of 3.24 percent per year during the 1980s.[10]

In the two decades prior to 1980, the relative supply of college graduates grew even more rapidly. The ratio of college educated workers to workers with 12 or fewer years of schooling grew 4.3 percent per year in the 1960s and 5.2 percent per year in the 1970s. College wage premia were stable during the 1960s and declined at a modest 1 percent per year in the 1970s. These data suggest that the demand for skills taught to college graduates was also expanding in the 1960s and 1970s, though probably at somewhat lower rates than prevailed in the 1980s.

Why did Levin and Rumberger so grossly under-predict the growth of skilled occupations? While there are a number of problems in the way they interpret and report BLS occupational projections, the primary cause of their incorrect forecasts is their reliance on the BLS projections. They recently justified this reliance as follows:

> On the basis of their past record they are still likely to provide a better indication of how the overall job market will look in the future than generalizations from a few casual observations, guesswork, or simple extrapolations of past trends. The point is that none of the latter devices has come close to the accuracy of the BLS forecasts in a world where--by their nature--no forecasts will be perfect.[11]

How good is the past record of BLS projections? Is there, as claimed, no way of improving on them? It is to this question we now turn. The first three sections of the paper evaluate the accuracy of the BLS projections for 1990, for 1980-85 and for 1995. We conclude that a regression based forecast does a better job of forecasting future occupational staffing ratios

than the judgmental approach used by BLS. In Section 4 we present a regression analysis of the substantial changes in occupational shares that occurred during the 1972-1989 period and then use these regressions to forecast occupational employment growth to the year 2000. For all specifications and scenarios, the regression forecasts predict substantially greater upskilling than the BLS's judgmental forecasts.

In section 5 we turn our attention to BLS's projections of the supply/demand balance for college graduates. They turn out to have been consistently wrong.

We then do our own examination of the supply/ demand balance for college graduates by comparing past and projected percentage rates of change in employment in high skill jobs to actual and projected rates of change in the stock of well educated workers. During the 1980s, employment in professional, technical, managerial and sales representative occupations grew at nearly the same rate as the stock of workers with one or more years of college. Employers wished to increase the proportion of workers in managerial and sales occupations who had a college education but a shortage developed and the wage premium for college graduates rose to unprecedented levels. Our projections for the 1990s predict that the labor market for college graduates will remain very tight. This suggests that if the supply of college educated workers can not be expanded more rapidly than is projected (either through greater immigration of highly educated skilled workers or by increasing the number of Americans attending and graduating from college), that wage premiums for college are likely to continue to grow. The final section of the paper presents our recommendations for changes in the way the Bureau of Labor Statistics makes and reports occupational forecasts.

## 1. An Evaluation of BLS Occupational Projections for 1990

The occupational projections made by the Bureau of Labor Statistics (BLS) at the beginning of the 1980s significantly underestimated the growth of high skill occupations. In August 1981 the BLS projected that professional, technical and managerial (PT&M) jobs would increase only slightly more rapidly than total employment during the 1980s. It was estimated that PT&M jobs would account for 28 percent of employment growth between 1978 and 1990 and that operatives, laborers, farm laborers, and service workers (OL&S) would account for 34 percent of employment growth.[12] In November 1983 new projections of occupational growth through 1995 were published. The economy had entered a severe

recession and total 1982 employment was at essentially the same level as in 1979. Professional, technical and managerial employment had, however, increased by 4.84 percent and their share of employment had risen by 1.1 percentage points during the three year period. BLS increased its projected rates of growth for PT&M, but not by much. In the projections, PT&M accounted for 30.7 percent of employment growth through 1995 from the 1982 base and for 37 percent of the growth from the 1979 base. BLS projected that OL&S would account for 31.5 percent of growth from the 1982 base and 27.9 percent of growth from the 1979 base.[13]

What were the actual patterns of job growth between 1978 and 1989? Professional, technical and managerial jobs accounted for 52 percent of employment growth between 1978 and 1989 and operatives, laborers, farm laborers and service workers accounted for only 9 percent of job growth. Table 1 presents a detailed comparison of BLS's 1981 projections of occupational employment growth between 1978 and 1990 with actual growth rates between 1978 and 1989. The comparison employs the 1980 Census occupational categories so adjustments were made to the BLS projections to account for the occupations that were switched from one major occupational group to another.[14] The first column of the table presents the actual percentage growth of occupational employment between 1978 and 1989. At the bottom of this column, the 20.9 percent figure is the average absolute size of the deviations of occupational growth from the 22.1 percent growth trend for total employment. The second column of the table presents the low-trend projected percentage growth for 1978 to 1990 that was published by BLS in 1981. The low-trend is used for comparison because actual employment levels in 1989 were very close to BLS's low-trend prediction for 1990. The third column presents the difference between the actual and projected percentage increases for each occupation. At the bottom of the column, the 13.2 percent figure is the average absolute size of these discrepancies. In other words, relative to a baseline in which every occupation is assumed to grow at the same rate, the projections reduced the average error by 37 percent [100(1 - .132/.209)]. The fourth column presents the difference between actual and projected numbers of people in the occupation in 1989. The largest error was in BLS's projection of the growth of managerial occupations. It underestimated the growth of managerial employment by 36.4 percentage points or by 3.4 million jobs. The error in projecting managerial employment was roughly equal to the total number of bachelors and

masters degrees awarded in business, marketing and accounting between 1978 and 1989. The growth of professional employment was underestimated by 1.86 million jobs (17 percent of the 1978 level of professional employment). Operative employment was projected to grow by 14 percent; it fell instead by 10 percent, resulting in an overprediction of 2.2 million jobs. Employment in other services was projected to grow 36 percent; it grew by 24 percent resulting in an overprediction of 1.2 million jobs.

Clearly there is a pattern to the forecast errors: BLS projections made since 1981 have substantially underpredicted the growth of skilled occupations and substantially overpredicted the growth of occupations requiring low or moderate skills. Were these errors unforeseeable consequences of unanticipated events such as the microcomputer revolution and the budget deficit caused trade deficit? Or were the forecasts published in 1981 based on a flawed method of projecting occupational growth?

There are many sources of error in the BLS occupational projections. Projections of final demand shares may be wrong. The input-output matrix is often quite old and this contributes to errors in projecting value added shares. The share of industry output that is imported was particularly difficult to predict in the 1980s. Industry specific productivity growth may also be in error resulting in incorrect predictions of industry employment. Substantial changes have occurred in the occupational composition of specific industries and this has often been a major source of error in occupational projections. BLS derives occupational employment demand by multiplying projected industry employment totals by an assumed industry specific occupational share vector. Adjustments are made to these vectors when BLS studies of the introduction of new technology indicate that changes can be anticipated by the end of the forecast period.[15] Since studies cannot be funded for every industry and for every technological innovation and the effects of these changes are very difficult to foresee 10 years in advance, we hypothesize that many of the changes that will occur in the composition of occupational demand within industry are missed by BLS projections. When the BLS made the projections of 1990 occupational employment in 1981, they had only one wave of Occupational Employment Statistics survey data available to them for most states and industries. The Handbook of Methods describes what is done when data is thought to be of doubtful comparability: "When an occupation is added, deleted or changed in definition from one OES survey to the next, extrapolated trends are not developed: the

current-year ratios for these occupations are held constant in the preliminary projected matrix."[16] Lacking trend data, we suspect that they tended to be conservative in their judgments regarding assumed changes in the industry specific occupation matrix.

We suspect that in 1981 BLS tended to assume that occupational share vectors would be stable when evidence to the contrary was not available. In our view, occupational staffing ratios are seldom stable over periods of ten years or more and it is better to start with an assumption that trends are stable than that the ratios themselves are stable. Let us examine how accurate forecasts would have been if they been based on an assumption that trends in occupational shares are stable. This can be done by simply calculating the rate of change of occupational employment shares for a baseline period and then assuming that these rates of change will continue. To get a preliminary idea about how well extrapolation works, a back-of-the-envelope effort was made to predict 1989 occupational employment levels starting from a 1980 baseline. A 1980 baseline was chosen because that is the information that was available at the time the BLS made its August 1981 occupational projections. First, the growth rate of the logarithm of the employment share for the 12 major occupation groups between 1972 and 1980 was calculated using data employing 1980 Census occupational classifications.[17] Then 1989 occupational share was calculated by simply applying 9 years of this growth rate to the 1980 baseline share for that occupation.[18] The resulting estimates are presented in Table 3. This very simple logarithmic extrapolation does a remarkably good job of predicting occupational employment levels for 1989. The average absolute value of the prediction error is 6.54 percent, a 52 percent reduction from the 13.62 percent prediction error of a naive model in which all twelve occupations grow at the same rate from a 1980 base and the 13.3 percent mean prediction error obtained by the BLS projections published in 1981. If private household workers are treated as a separate occupation, the average absolute prediction error is 7.42 percent, also a 52 percent reduction from the 15.4 percent average prediction error that results from the naive model predicting employment growth for thirteen occupations.

The systematic character of our forecast errors can be explored by comparing the actual and extrapolated shares of employment growth in high and low skill occupations. The MP&T occupations which accounted for 50.9 percent of employment growth between 1980 and 1989 were forecasted to account for 47.8-47.4 percent. The OL&S occupations which accounted

for 12.2 percent of employment growth were forecasted to account for 7.5-8.6 percent of employment growth. The extrapolation method slightly underpredicted the growth of both low and high skill jobs. One reason for these errors is our failure to forecast the slowdown in the growth of clerical jobs caused by the introduction of the microcomputer (an error that was also made by the BLS forecasters in 1981). By 1980, the last year of the baseline period which sets the forecasted growth rate for each occupation, a cumulative total of only 600,000 microcomputers had been sold to business. The IBM PC was not introduced until 1982. When a big change is about to occur but has not yet gotten off the ground, simple extrapolations of past trends in occupational staffing will be wrong.

Another problem with simple extrapolations is that they are likely to be sensitive to which years are selected as the beginning and end of the baseline period. Recessions cause blue collar employment to decline relative to white collar employment, so starting or ending a baseline period during a recession will distort extrapolations into the future. Occupational shares derived from the CPS are measured with error and this can also distort simple extrapolations. A natural way to deal with these two problems is to estimate regression models in which the logarithm of each occupation's share of total employment is predicted by a time trend and a cyclical variable such as the unemployment rate. The model was estimated on CPS data from 1972 through 1980 and forecasts made to 1989 assuming a 1989 unemployment rate of 5.5 percent. The results are presented in Table 4. While the regression equation extrapolation does substantially better than BLS, it surprisingly, does not do better than the straight line extrapolation. The average absolute size of the prediction error is 8.4 percent which is a 38-36 percent reduction from the average prediction errors that result from assuming constant employment shares or using the BLS forecasts published in 1981. While the bias is not as large, the regression forecasts underpredict the growth of high skill occupations and overpredict the growth of low skill occupations as the BLS forecasts did. The MP&T share of job growth is underpredicted by 11.8 percentage points and the OL&S share of job growth was overpredicted by 7.2 percentage points.[19] On a priori grounds, the regression prediction must be preferred over the simple extrapolation. **It would appear that even projections based on an assumption of stable trends in occupational shares underpredict the magnitude of upskilling during the 1980s.** Something happened--probably

the spread of the microcomputer and the large trade deficit in combination--to accelerate upskilling during the 1980s.

## 2. BLS Occupational Projections for the 1970s

Clearly the 1980s were not kind to the occupational forecasters at the Bureau of Labor Statistics. A simple regression based prediction also underpredicts upskilling, though by much less than the 1981 BLS predictions. The BLS did better, however, projecting occupational employment growth during the 1970s. Table 5 compares BLS's employment growth forecasts for 1966 through 1975 to actual growth between 1966 and 1974 for nine major occupation groups.[20] The average absolute forecast error was only 4.41 percent of the 1966 employment levels, a 59 percent reduction from the mean forecast error that results from assuming all major occupations grow at the same rate. Table 6 presents comparable data on the 1971 BLS forecasts of occupational growth for 1970 to 1980.[21] The average absolute discrepancy between actual and projected growth for the 1970s is 6.8 percent, a 45 percent reduction from the mean forecast error produced by a naive model. Overall, projections of the 1970s appear to have been significantly more accurate than the projections of the 1980s made in 1981. We must now ask ourselves, **WHY?**

Let us examine how the earlier projections were made. As we advocated above, industry specific occupational staffing ratios were projected based on trends derived from the 1950 and 1960 Census. The methods employed were described as follows:

> Historical statistics on the changing occupational composition of detailed industries were projected by simple time trend. The trend for each industry-occupational ratio derived from census data was extended to 1975, and the indicated change from the 1960 level was added to the appropriate ratio in the base period (1960) industry-occupational employment table. A variety of other statistics covering varying spans of time between 1950 and 1965 was gathered and arranged to reveal evidence of trends in employment by occupation for particular industries or for the entire economy. Analysis was directed to finding the causes of past changes in occupational structure. An attempt was made to determine whether these factors were likely to continue to affect occupational structure in the period ahead to a similar, greater or lesser extent.[22]

This is essentially the approach advocated above (the complete description of the 1969 methodology is reproduced in Appendix A). It appears that when occupational staffing ratios

are assumed to exhibit a relatively constant trend unless information is available to the contrary, that much better forecasts result.

The resulting forecasts were not perfect, however. While the errors are smaller, their pattern looks familiar. The growth of managerial jobs, which was underpredicted by 36.4 percent during the 1980s, was underpredicted by 17.1 percent during the 1970s. The growth of operative jobs, which was overpredicted by 24 percent in the 1980s, was overpredicted by 11.7 percent in the 1970s. The first two columns of Table 2 present the occupational shares of employment growth projected by BLS in studies completed in 1969 and 1971. These forecasted shares may be compared to the actual shares that are reported in the fifth column of Tables 5 and 6. Managerial, professional and technical jobs, which were projected to account for 33.9-34.7 percent of aggregate employment growth, actually accounted for about 38.1-38.7 percent of employment growth between 1966 and 1980. Operatives, laborers and service jobs, which were projected to account for 27.4-29.6 percent of employment growth, actually accounted for only 19.8 and 13.1 percent of employment growth during these two overlapping periods. It would appear that even when past trends in the occupational composition of industries are extrapolated into the future, there is still a tendency to under predict the upskilling trend that prevailed during the 1960s and 1970s. **It may be that the upskilling demand effects of technological progress and work reorganization are inherently unforeseeable.**

## 3. Assessing BLS Projections for 1995 and 2000.

Silvestri and Lukasiewicz describe the process of projecting occupational staffing patterns for the BLS projections published in 1985 in the following words:

> Staffing patterns of industries in the base-year industry occupation matrix are projected to the target year of the projections to account for changes expected to occur because of technological change, shifts in product mix, and other factors. The changes introduced into the input-output model for expected technological change, as an example, may also change future staffing patterns in industries using the new technology. (For example, one would expect greater employment of computer specialists as computer technology spreads across industries.)[23]

A complete description of the methodology employed in making the occupational projections published in 1985 can be found in Appendix B. It would appear that extrapolation was being

used to generate some of the projected industry specific occupational staffing ratios for 1995 and 2000. It is not clear from this description, however, just how common this practice was.

The OES data becomes available to BLS analysts about 18 months after it is collected. By the time the Bureau of Labor Statistics did its projections in 1983, most industries had responded to at least two OES surveys. Since, however, only 13 states participated in the first wave of OES surveys in the late 1970s, geographic comparability was not maintained between the first and second waves of OES surveys. In addition, the economy went into a deep recession. Thus, the three years of OES trend data that were available to BLS analysts were unreliable indicators of future changes in staffing patterns, and were probably not heavily used to forecast future staffing ratios. Current Population Survey (CPS) data was available and used to some degree but the sample is too small to provide reliable indicators of trends for detailed occupations. Complicating matters further was the change in the occupational classification system for the 1980 Census which was introduced into the CPS and the OES in 1982 and 1983. This meant that observed changes in staffing patterns between the 1970 and 1980 Censuses could not be simply extrapolated into the future. It also meant that much of the data collected in the third and fourth waves of OES surveys was inconsistent with data collected prior to 1983. Comparability over time is also threatened by the periodic changes in the industry specific list of occupations that respondents receive on their questionnaire. BLS staff feel that these changes in the format of the questionnaire have often resulted in data that is not comparable over time. Given these data problems and the BLS's focus on projecting over 500 different occupations, it is easy to see why BLS has not chosen to systematically extrapolate past trends in occupational staffing ratios derived from OES data into the future, but rather to rely on the judgement of analysts who can take data quality problems into account. Sometimes the analysts feel that they are knowledgeable enough about the situation in a particular industry to project substantial changes in staffing patterns. But forecasting big changes in staffing patterns is definitely perceived by them as "going out on a limb."[24] The staff is small and they cannot be expert about all industries and occupations. As one analyst described the situation, "In a lot of cases, if we did not know a lot about the occupation, we just left it alone."[25]

Based on this characterization of the methodology employed for the projections published in 1983 and subsequently, we would expect the forecasts to underpredict upskilling but not by as much as the 1981 projections.

This appears to be what happened. The projections published in 1983 and 1985 appear to have substantially underestimated the growth of skilled jobs. Table 2 presents a history of BLS predictions of occupational shares of employment growth. The projections published in 1983 and 1985 predicted that operative, laborer and service jobs would account for 27.8 percent of employment growth to 1995 and that managerial, professional and technical jobs would account for 35 to 38.7 percent of employment growth. It is now clear that these forecasts are also far off the mark. The low skill OL&S category in fact accounted for none of the employment growth between 1980 and 1984, and only 15 to 21.4 percent of the growth between 1984 and 1990. The high skill MP&T category accounted for 55.4 percent of employment growth between 1980 and 1984, 46.9 percent of growth between 1984 and 1988 and 52.6 percent of growth between March 1988 and March 1990. It would take a massive reversal of recent job growth patterns during the 1990 to 1995 period to make the BLS 1995 forecasts come true.

Workforce 2000's forecasts of occupational skill demands are based on the BLS methodology, so its projections probably also understate the upskilling trend of occupational demand. **This implies that the forecasted shortage of skilled and educated workers is probably even more serious than Workforce 2000 and companion reports project. We can see this unfolding in Table 2. The forecasted growth shares for 1986 to 2000 in column 6 may be compared with the actual growth shares calculated for the first four years of this period located in columns 10 and 11. About 45.8 percent of employment growth is projected to be in managerial, professional, technical and high skill sales jobs (sales managers, proprietors and sales representative jobs outside of retail and personal services) and 36.9 percent of growth is projected to be in operative, service and retail sales clerk jobs.[26] The BLS forecasts published in 1989 predict that the high skill category will account for 48 percent of job growth and the low skill category will account for 33 percent of job growth.[27] Actual employment growth in the latter half of the 1980s has, in fact, been more heavily weighted toward high skill jobs than was projected in 1987 and 1989. The high skill occupations listed above accounted for 56-59 percent of job growth**

**in the period and the low skill category accounted for only 24-26 percent of job growth.**

What about the 1990s? The share of job growth accounted for by managerial, professional and technical jobs was higher in the 1960s than in the 50s, higher in the 70s than the 60s and higher in the 80s than the 1970s. Will the high skill share of job growth be higher in the 1990s than in the 1980s? The BLS answer is no. It forecasts a smaller high skill share of job growth in the 1990s than in the 1980s. What do projections of occupational job growth based on multivariate regression models of the type advocated in section 1 predict? The next section of the paper presents our projections for the 1990s.

## 4. Regression Forecasts of Occupational Employment Growth to the Year 2000

Our forecasts are based on regression analysis of changes in occupational employment shares during the 1972 to 1989 period. The source of the yearly data on occupational employment is the Current Population Survey. Consequently, the dependent variable is the share of workers who describe themselves as being in a given occupation not the share of jobs that are in a particular occupation as described by employers. The advantage of CPS data is that there is no double counting of workers with more than one job and there is no danger of missing jobs being created by new companies as there is with data derived from establishment surveys. The disadvantage of CPS data is the possibility that self reports of occupation are less accurate than data collected from employers and the probable absence of many undocumented workers and homeless individuals (see Appendix C for a description of the differences between CPS and OES data on the occupational composition of the workforce).

In order to assess the sensitivity of forecasts to alternative specifications, a number of different reduced form forecasting models were estimated.[28] In the basic equation the log of the ratio of the "j"th occupation's share of employment in year t relative to its share in 1988, $(S_{jt}/S_{j1988})$, is assumed to depend on the year $(T_t)$, the unemployment rate $(U_t)$ and one or more structural variables, $(X_t)$, intended to capture the influence some of the economic changes that have occurred in the 1980s. The independent variables have been defined relative to their projected value in the year 2000.

$$1)\ \log(S_{jt}/S_{1988}) = a_0 + a_1(T_t-2000) + a_2(U_t-.055) + a_3(X_t-X_{2000}) \qquad t = 1972...1989$$

The advantage of indexing the dependent variable on its value in 1988 and deviating all independent variables from their projected level in the year 2000 is that the intercept term, $a_0$, then provides an estimate of the forecasted proportionate change between 1988 and 2000 for the "j"th occupation's share of employment. The means and standard deviations of the variables are given in Table 7.

The estimation results for the 10 largest occupational categories are presented in Tables 8, 9 and 10. Table 8 reports results for blue collar workers: precision production and craft workers, machine operatives, transportation operatives and non-farm laborers. Table 9 reports results for three high skill major occupational categories: managers, professionals and technicians. Table 10 reports results for sales workers, clerical workers and for service workers excluding private household and protective service workers. Results for the three minor occupations--farm workers, private household and protective service workers--are available from the authors.

Blue Collar Employment Let us begin by examining trends in blue collar employment during the 1970s and 1980s. The simplest model (#1) predicts employment shares with a trend and the unemployment rate. The employment shares of these occupations rise strongly during booms and decline during recessions. A one percentage point rise in unemployment decreases the laborer share of total employment by 1.92 percent, the transportation operative share by 1.23 percent and the machine operative share by 1.57 percent. The employment of craft workers is considerably less sensitive to the cycle. The employment shares of machine and transportation operatives and non-farm laborers were declining quite rapidly at rates of 1.2 to 2.7 percent per year. The employment share of precision production workers fell but only slowly.

Model #2 includes a trend shift variable for the years after 1980 and thus provides a test of the hypothesis that rates of change of employment shares accelerated after 1980. For two blue collar occupations, machine operatives and craft workers, the rate of decline accelerated significantly after 1980. This, of course, raises the question of why the decline accelerated. In model #3 we add the ratio of the merchandise trade deficit to GNP, ($TRADEF_t$), to the equation. The results suggests that the growth of the deficit lowered the employment share of machine operatives but increased the employment of precision production workers.

Model #5 tests for the effects of the microcomputer revolution by adding the ratio of personal computers used in business to civilian employment, ($PCUSE_t$), to model #3.[29] The microcomputer revolution appears to have had a substantial negative effect on the employment share of machine operatives and craft workers. The results imply that the rise in PCUSE from zero in 1978 to 18 percent in 1988 lowered factory operative employment by 14 percent and craft employment by 5.4 percent. The model #5 coefficients on the trade deficit imply that the switch from a merchandise trade surplus of 0.7 percent of GNP in 1976 to a trade deficit of 3.6 percent of GNP in 1987 decreased factory operative employment shares by 10 percent and increased precision production and craft employment shares by 5 percent. The coefficient on the trend is substantially smaller in model #5 suggesting that the recent decline of these two occupations are partly a consequence of these two phenomena.

What do these estimation results tell us about the future? Before we can predict occupational shares using our preferred model #5, we must project unemployment, the trade deficit and PCUSE in the year 2000. Since the foreign debt of the US cannot grow at current rates indefinitely and the growing debt must eventually be serviced by exporting more goods than are imported, it was assumed in our baseline forecast that merchandise trade will be in balance in the year 2000. It was further assumed that unemployment will be 5.5 percent and PCUSE will increase from its current 21 percent level to 45 percent.[30] Since the independent variables are all deviated from their assumed level in the year 2000, the intercept terms of the equations provide an estimate of the forecasted change in the share of employment in each occupation. All four blue collar employment shares are projected to fall by all four of the forecasting models. For transportation operatives, all forecast models predict the share to decline by 13 to 15 percent. [Since total employment is projected to grow 15 percent by 2000, this implies that employment of transportation operatives is projected to be static. For factory operatives and laborers, in contrast, the forecasted decline depends to some degree on the model that is selected. Forecasts based on model #2 which contains a the trend shift beginning in 1980 predict declines of 34 percent (exp -.422) for factory operative share of employment and 24 percent for laborers. Forecasts based on model #5, the trade balance and PCUSE model, imply reductions of 25 percent and 18 percent respectively. The size of the forecasted decline of blue collar jobs is smaller when model #5 is employed to make the

forecast because much of the decline of these occupations during the 1980s is attributed to the growing trade deficit, something which is projected to reverse itself by the year 2000.

Managerial, Professional and Technical Jobs: Clearly employment shares for these three occupations are exhibiting a strong positive trend. For managers and professionals the trend appears to be pretty stable. (In model #2, the coefficients on the trend shift variable are not significant.) Model #5 indicates that the growing use of PCs increased jobs for professionals by a modest 3.6 percent between 1980 and 1988. It also suggests that the growth of the trade deficit reduced managerial jobs by about 5 percent. Recessions increase the employment share of professional and technical occupations, but reduce the share of managerial occupations. Thus, the business press appears to have been correct when, in the face of rising aggregate employment of managers, it pointed to losses of managerial jobs resulting from the recession and the loss of competitiveness. Compared to the cutbacks in factory operative jobs, however, the resulting managerial layoffs were modest indeed. Since the overall upward trend of the managerial employment is so strong (2.1 percent per year), these setbacks turned out to be temporary. Almost all of the growth of managerial jobs has been outside of manufacturing.

The growth of technician jobs decelerated during the 1980s. Electrical and electronic technicians and health technicians both of which grew at a torrid 7.2 percent per year between 1972 and 1982, slowed to yearly rates of only 0.5 and 3.1 percent respectively between 1982 and 1989. The results for model #5 suggest that the 1976-1987 increase of the trade deficit caused a 6 percent decrease and that the growing use of personal computers lowered employment a further 10 percent. These machines have resulted in a drastic decline in the demand for board drafters and have improved labor productivity in a host of other technical occupations.

We forecast strong increases in demand for these occupations. The forecasted growth in the employment share of professionals is about 19 percent (exp. .172) in the preferred model. Specification has little effect on forecasts for professionals. For managers the forecasted increase in their share is 25 percent in model #1 and 36 percent in model #5. Model #5 produces larger forecasted growth because the projected elimination of the trade deficit increases the managerial employment share, reversing a drag that has been operating on managerial jobs in the 1980s. The projected end of the trade deficit also helps technicians

and results in model #5 predicting a slight acceleration of growth in the 90s relative to the growth rates of the 1980s.

Clerical and Service Jobs The growth of clerical employment slowed substantially in the 1980s, apparently because of the growing use of microcomputers. Model #2 suggests that growth of 0.52 percent per year during the 1970s switched to a -0.45 percent per year in the 1980s. The spread of the personal computer appears to have lowered 1988 clerical employment by 7.6 percent. The use of personal computers is projected to double from its 1989 level, so we forecast that the clerical share of employment will continue the slow decline exhibited during the 1980s.

The share of all employment represented by service jobs excluding private household and protective service workers rises during recessions. It grew slowly in the 1970s and 80s (by 0.5 percent per year in model #1) and is projected to continue that growth in the 1990s. Neither the trade balance nor PC use had significant effects on the employment share of other services, so all models generate roughly the same forecasts of job growth.

Sales: Employment in sales grew more rapidly in the 1980s than in the 1970s. The growth of the sales employment share accelerated from 0.57 percent per year in the 1970s to 1.38 percent per year during the 1980s (see model #2). The trade deficit and increased PC use appears to be the cause of this acceleration. The growth of the trade deficit generated jobs in wholesale and retail sales (an 8 percent increase in sales employment) even while it was eliminating production jobs. The growing use of PCs also appears to have increased sales employment. The forecasted elimination of the trade deficit implies a slowdown in the growth of sales occupations. As a result, we project the share of sales to rise by only 7.6 percent.

Some sales occupations require a great deal of education and training--eg. sales representatives in manufacturing, finance, communications and professional services--and others such as sales clerks in retailing and personal services require very little. Which type of sales job is growing most rapidly? When the share of sales workers who are sales clerks in the retail and personal service sector is regressed on time, a significant negative coefficient is obtained, suggesting that low skill sales jobs grew less rapidly than high skill sales jobs in the 1980s (see appendix D). However, the shakeout in the financial sector has slowed the growth of sales workers in that industry and the sales clerk share has been stable since 1987.

Consequently, we project the sales clerk share of sales jobs in 2000 to be the same as it is in 1988.

Aggregate Measures of Upskilling: Our forecasts are collected together in Table 11 and 12 and compared to the BLS's 1989 projections. CPS estimates of occupational employment in 1988 are the baseline for all forecasts and the BLS's projection of the growth of aggregate employment--15.33 percent between 1988 and 2000--is also used in all forecasts.[31] Table 11 presents the forecasts of changes in the numbers of employees in each of the major occupations and the share of job growth that is expected to be in high and low skill occupations. Table 12 presents forecasted percentage rates of growth.

Eleven different forecasts are presented. The BLS forecast can be found in column 1. Forecasts based on the simple model in which occupational shares depend on time and the unemployment rate appear in column 2 and 3. Column 2 presents results for a model in which the share (not its logarithm) is the dependent variable. All other forecasts are based on models where the dependent variable is the logarithm of the share. A model #2 forecast which allows for a trend shift in 1980 is presented in column 4. A model #3 forecast that assumes that the merchandise trade deficit returns to zero can be found in column 5. A forecast based on model #5 which contains both the trade deficit and PCUSE is in column 6. The final five forecasts are based on our preferred set of models but make different assumptions about the economy in the year 2000. Our preferred models are #2 for private household and protective service workers and farmers and #5 for all other occupations. Columns 7 and 8 present the forecasts for our baseline scenario: an unemployment rate of 5.5 percent, a ratio of business PCs to civilian employment of 45 percent and a trade deficit of zero in the year 2000. To test the sensitivity of the projections to the functional form, a linear specification of the preferred model was estimated for managerial, professional, technical and sales occupations.[32] Column 7 presents our most preferred forecast: linear specifications for managers, professionals, technicians and sales personnel and logarithmic specification for all other occupations. Columns 8 to 11 use the logarithmic specification throughout. Column 9 changes that scenario in only one respect: PC use is assumed to climb no higher than 30 percent.[33] Column 10 presents the Good for Blue Collar Workers scenario: an unemployment rate of 4.8 percent, a merchandise trade surplus of 1 percent of GNP and PCUSE equal to 30 percent. Column 11 presents the Bad for Blue Collar Workers scenario: an unemployment

rate of 7.5 percent, a merchandise trade deficit of 1 percent of GNP and PCUSE rising to 45 percent of employment.

Four conclusions emerge from examining these tables. First, for some but not all occupations, the estimation model that is chosen has substantial effects on the forecast. For occupations that are declining, the linear models forecast much larger reductions in employment than the log models. Focusing on the log model specifications, the specification which appears to produce the most discrepant results is #2, the one that allows a simple shift in the trend after 1980, and # 3, the model containing the trade balance. The occupations for which specification makes a difference are managers, technical, sales, clerical, craft and factory operatives.

Second, the scenario matters as well. As expected, the Good Times for Blue Collar Workers scenario increases employment of factory operatives and non-farm laborers but it also increases demand for technical and clerical workers as well. The Bad Times for Blue Collar Workers scenario increases the employment of professionals, sales workers and to a lesser degree service workers. Conservative assumptions regarding the growth of personal computers substantially reduces predicted growth of professionals and sales workers and increases the projected growth of operatives.

Third, all of the regression based forecasts predict a substantial acceleration of upskilling. **The share of job growth that is forecasted to be managers, professionals and technicians ranges from 63 to 78 percent. When sales representatives and sales managers are added to the high skill group, the high skill share of job growth ranges from 75 to 89 percent and is 80.5 percent in the preferred model # 7 baseline scenario. The share of job growth that is forecasted to be in low skill occupations--operatives, laborers, farm laborers, service workers, and retail sales clerks never gets above 10 percent in any specification or scenario.** While forecasts for particular occupations depend on specification and scenario, the conclusion that more than three-quarters of job growth will be in high skill jobs is robust to changes in specification and scenario. This is the forecast even when all three of the much discussed causes of the decline of blue collar employment--high unemployment, the trade deficit and the spread of the microcomputer--are assumed to reverse themselves by the year 2000. Only the BLS forecasts disagree. BLS forecasts that high skill jobs will account for only 54.4 percent of job growth and low skill jobs for 26.4 percent.

The fourth conclusion derives from comparing BLS and regression based forecasts. BLS's judgmental method of forecasting occupational staffing patterns produces very different forecasts of occupational employment levels than regression based models. As in the past, the BLS forecasts significantly understate the upskilling trend that our analysis indicates is underway.

## 5. The Supply/Demand Balance for College Educated Workers

A projection that high skill jobs will grow much more rapidly than low skill jobs does not necessarily imply that a crisis is at hand or that changes in education and training policy are advisable. The ratio of high skill job growth to total job growth is forecasted to be higher in the 1990s than in the 1980s, but this is largely due to the slowdown in total job growth. The gaps between the forecasted percentage rates of growth of high skill and low skill occupations presented in Table 11 are not larger than the growth rate gaps for the 1978-1989 period presented in column 1 of Table 1.

For policy, what matters is (1) the balance between current supply and current demand, (2) the balance between forecasted growth of supply and forecasted growth of demand and (3) the magnitude of the changes in wage premiums necessary to bring ex ante differences in supply and demand into ex post equilibrium. Let us begin by examining the current balance between supply and demand. The wage premiums for obtaining a college degree grew substantially during the 1980s and are now at historic highs. This implies that either the demand for college graduates grew more rapidly than supply or the demand for high school graduates grew much less rapidly than their supply. Either way, social rates of return to a college education have seldom been higher. This implies that public policies which increase college attendance and completion (eg. better academic preparation in high school, low tuition at state colleges and larger grants for needy students) are more cost-effective now than they have ever been before.

Given the clarity of the policy signals being sent by the current wage premiums, it is not clear that forecasts of the balance between ex ante rates of change in supply and demand through the year 2000 are needed for policy formation. It is extremely difficult to make accurate forecasts of rates of change of the supply demand balance for college educated labor; much more difficult than projecting occupational employment alone. Small errors in

forecasting rates of change of demand or supply can translate into big errors in projecting the gap between supply and demand.

BLS projections of Supply/Demand Balance: Despite the difficulties, BLS has been attempting to do it on a biannual basis now for two decades. The starting point of its projections are its forecasts of occupational employment growth. It then projects changes in the proportion of particular occupations that "require a college degree", the number of bachelors degrees to be awarded per year and the annual rates of flow into and out of jobs by workers with a college degree. Comparisons are then made between the projected number of job openings "requiring a college degree" and the projected flow of college graduates seeking work.[34] The record of these projections is presented in column 3 of Table 13.

**Quite clearly the BLS effort to project the supply/demand balance for college graduates has been a failure.** Such a judgement is possible, because changes in the ratio of young college graduate wages to young high school graduate wages over the projection period provide an ex post criterion for evaluating the accuracy of the projections of supply/demand balance. At the beginning of the 1970s, BLS projected rough balance of supply and demand during the subsequent decade. In fact, however, the supply of college graduates grew more rapidly than demand and, as a result, the college/high school wage ratio for workers with 1 to 5 years of post-school work of experience fell 6.7-7.6 percentage points by 1980 (see column 4). In the later half of the 1970s, BLS projected very large surpluses of college graduates during the subsequent decade. According to their projection, the surplus of college graduates was going to grow at a rate equal to 30 percent of the annual flow of bachelors degrees awarded. If correct, this surplus should have caused the relative wage of college graduates to fall during the subsequent decade. In fact, however, the nation entered a decade in which demand for college graduates substantially outstripped supply and the college/high school wage ratio for those with 1-5 years of experience rose by 23 to 26 percentage points to all time highs. Thus, the projections were much worse than uncorrelated with the truth, **they were negatively correlated with the truth.**

The problems are much deeper than simple errors in forecasting the future. The description of the present and recent past is wrong as well. It is stated, for example, that 27 percent (6,659,000) of college graduates were "underemployed" in 1988 and that "underemployment" increased by 1,655,000 between 1983 and 1988. Clearly, a measure of

"underemployment" for a group that increases simultaneously with the group's relative wages is seriously flawed.

In our view, the task that BLS has set for itself--measuring the level and forecasting changes in the absolute number of jobs which "require a college degree"--is impossible. The classification of occupations into a "requires a college degree" category is inherently arbitrary and idiosyncratic to the analyst; yet the validity of the whole effort to measure "underemployment" depends on this classification being done correctly in every detail. This is impossible for three reasons. First, the occupational coding system used by the CPS and the Census is not reliable and comprehensive enough to allow accurate measurement of a concept like underemployment. Many of the apparent mismatches between occupation and education are the result of errors in reporting education or occupation. Census Bureau studies have found that between 18.3 and 27.3 percent of the individuals recorded as professionals, technicians or managers in one interview, are recorded in an entirely different major occupational category in a subsequent interview 4 to 7 months later.[35] The second problem is that for most occupations, the question "Does it require a college degree?" does not have a yes or no answer. Its a matter of degree. Some of the jobs in the occupation are structured in ways that make the skills normally developed in college very helpful, others are not. The correct answer is, "It depends." The third problem is the great heterogeneity of the college graduate category. Seventeen percent of young college graduates read at a level below the typical 11th grader.[36] How can someone with an 11th grade reading level be considered underemployed in a secretarial, a carpentry or retail sales job? We conclude that the BLS method of evaluating the balance between supply and demand of college graduates is a blind alley.

If something useful is to be said about the balance between supply and demand, one must put both price and quantity data to work and give up on the idea of measuring how many people are "underemployed."

A Framework for Interpreting Data on the Supply/Demand Balance: Our approach is simply to compare percentage changes in supply and demand over time and interpret these changes in the light of contemporaneous shifts in the wage premium for college.[37] Changes in the employment of college graduates can be decomposed into two components: (1) shifts that can be explained by changes in the occupational composition of employment and (2)

changes in college graduate share of individual occupations. The growth of the engineering profession from 0.13 percent of the workforce in 1900 to 1.6 percent of the workforce in 1988 is an example of the first source of change. When one projects future occupational employment, one is effectively also projecting this source of change in the demand for college graduates. Historical rates of growth of occupational demand for college graduates are given in the first two rows of Table 14. The second row of the table contains rate of change data for an index of occupational demand for college graduates that was calculated by multiplying employment in each occupation in year t by the 1988 proportion of workers in that occupation who had a college education and then summing across occupations.

The third and fourth rows of table 14 present data on annual rates of change for the supply of college educated workers. Rates of change for the difference between ex post supply and ex post occupational demand are given in the fifth and sixth rows of the table. The normal state of affairs is for college graduate supply to increase more rapidly than an index driven by shifts in occupational employment shares and for the difference to be made up by increases in skill and educational requirements of specific jobs.

Engineers work at a knowledge frontier that has been shifting out at an extraordinary pace during the twentieth century. Consequently, the skills and training required to perform satisfactorily in this occupations have increased. At the beginning of the century most engineers did not have a bachelors degree; now a bachelors degree is required of just about all new entrants and 20 percent of engineers have a masters degree. This demand driven escalation of the educational requirements for being an engineer illustrates the primary reason why college graduate shares of many occupations have increased over time.

This is not, however, the only reason why the share of college graduates in an occupation might increase. During a period when college graduates are in abundant supply, some college graduates may find themselves forced into lower paying occupations which are thought not to make use of the skills developed in college. The signal that this is happening is declining wage premiums for recent college graduates. If, on the other hand, wage premiums for college graduates and professional occupations are stable or growing at the same time as the share of college graduates in specific occupations is rising, it is reasonable to infer that an outward shift of demand within occupations not an increase in supply caused the increase. Rows 7 and 8 of the table provide the data on annual rates of change in the

college/high school wage ratio that is essential for interpreting changes in the supply minus occupational demand index reported in rows 5 and 6.

Interpreting the Past: During the 1960s the relative wage of college graduates rose, even though managerial, professional, technical and sales representative and manager (MPT&SR) jobs grew 1.4 percent per year more slowly than the number of college graduates in the labor force. This means there was an exogenous outward shift in demand for college graduates holding occupation constant of substantially more than 1.4 percent per year during this period. Despite the rise in their relative cost, firms tended to expect new hires to have more schooling than had been expected in previous decades.

During the 1970s the supply of college educated workers grew much more rapidly than the sum of occupational and within occupation demand for college graduates. Supply grew 2.3 percent per year more rapidly than employment in MPT&SR jobs and 2.8 percent more rapidly than the college graduate demand index. Exogenous demand driven increases in the college graduate shares of particular occupations were not sufficient to make up this gap. A surplus of college graduates developed, wage premiums for college and professional occupations fell and some graduates were forced into lower level occupations.

During the 1980s, the number of college graduates in the labor force grew 2 percent per year more slowly than in the 1970s. The slowdown in the growth of MPT&SR jobs and in the demand index was only 0.47 percent per year. This meant that college graduate supply was growing only 0.7 to 1.3 percent faster than the occupational composition demand indexes. Exogenous increases in demand for college graduates within occupations must have been quite strong, for the wage premium for recent college graduates increased 2.8 percent per year between 1979 and 1987 and the premium for all graduates rose 1.5 percent per year. The first seven or eight years of the 1980s were clearly a period of shortage for college graduates.

Projecting the Future: For the twelve year period beginning in 1988, we project that the growth in the supply of college graduates will slow precipitously. Our forecast of the average annual number of BAs awarded is 1,001,000. This is 5 percent greater than the Department of Education's projection for this period. Despite our optimism about supply, our forecasts imply that annual percentage rates of growth in the supply of college graduates will be 1.68 percentage points lower than in the 1980s.[38] The growth of demand is also projected

to slow but only by 0.49-0.88 percent per year (depending on the projection model used and the scenario simulated). In other words, the shortage of college graduates that prevailed in the 1980s will definitely not end and will almost certainly get worse. This forecast of a worsening shortage of college graduates does not depend on selecting a particular forecasting model or a particular scenario regarding the trade deficit or the spread of microcomputers. Even the BLS forecasts of occupational employment growth imply the slowdown in occupational demand for college graduates is substantially ( 0.39 percent per year) smaller than the slowdown in the growth of supply.

During the 1980-88 period employers demonstrated a strong desire to upgrade educational hiring requirements. Despite a 24 percent increase in the wage cost of recent college graduates relative to young high school graduates, employers increased the ratio of college graduates workers to the occupational demand index by 11 percent. During the 1990s, the supply of college graduates is not going to be sufficient to allow further general increases in hiring requirements. For the first time this century, the supply of college graduates is projected to grow at roughly the same rate as demand created by shifts in the occupational composition of employment. During the 1990s a rise in the educational qualifications required by one group of employers will force other employers to lower the educational qualifications that they expect of new hires. We predict a bidding war will break out and there will be further increases in wage premiums for professional and technical training and for college generally. Early evidence indicates that indeed skill premiums are continuing to grow. Between 1987 and 1989, real weekly earnings rose 2.9 percent for managers, 4.2 percent for professionals and 2.0 percent for technicians. Meanwhile, real wages fell 1 percent for clerical workers, 0.7 percent for service workers other than private household and protective service workers, 3.3 percent for operatives and laborers, 2.5 percent for sales clerks and 5.4 percent for sales representatives in finance and business services. Real wages of non-supervisory workers continued to decline in 1990--falling 1.2 percent between March 1989 and March 1990[39]

The growing shortage of professionally trained workers and the rising skill premiums will tend to cause supply to increase more rapidly than we have projected. But the gap between the projected growth of demand and supply is huge. Just to maintain the balance between the growth of supply and the growth of occupational demand that prevailed in the

1980s, itself a period of shortage, it will be necessary to raise the growth rate of college graduates by 0.81 to 1.15 percent per year. To accelerate the rate of growth of college graduates by the low end of our range, .081 percent per year, there would have to be a 3.70 million increase in the stock of college graduates in the year 2000 or, put another way, a 462,000 (42 percent) increase in the annual flow of college graduates into the labor force between 1992 and the year 2000. Even if an increase in the supply of college graduates of this magnitude were to occur, it would probably not be enough to prevent further increases in the college wage premium. All it is likely to do is slow the rate of increase.

College attendance and graduation rates have risen recently in no small measure due to the strong market for college graduates. Our projections take past responses into account and in addition forecast a further 5 to 10 percent increase in the ratio of BAs to 22-24 year olds during the bulk of the 1990s. Even much larger responses to the improved incentives would not change the basic situation; a 20-25 percent increase rather than a 5-10 percent increase in college graduation rates, for example, would only raise the annual flow of college graduates by 150,000. Another possible natural market response to the strong demand for college graduates is further increases in labor force participation rates. The participation rate of male college graduates 25 to 54 years old was 96.7 percent in 1988, so there is not much room for an increase. Participation rates for female college graduates 25 to 54 years old were 81.5 percent so significant increases in labor supply are possible here. A five percent increase in labor force participation rates of women with a college degree would increase the supply of college graduate labor by 850,000 in the year 2000 (an increment of 106,000 per year between 1992 and 2000). Still another way to increase labor supply is to postpone retirement. In 1988 labor force participation rates for 60-64 year old college graduates were 65 percent for males and 46 percent for females. Phasing in a two year increase in the age at which all college graduates retire would have the same impact as a 81,000 increase in the annual number of BAs awarded between 1992 and 2000. Even if all three of these possibilities became reality by the year 2000, there would still be a large and growing gap between the demand and supply of college graduates.

Policy Implications: The social returns to a college education are extremely high and are likely to go even higher. Supply responses to the strong market do not appear to be sufficient to prevent a continuation of the current escalation of college wage premiums. If

wage premiums for college educated workers continue to escalate, inequality will continue to grow, American corporations will be at a competitive disadvantage and multinational corporations will probably transfer offshore functions which intensively employ college graduates such as research, product development, design and marketing. Hewlet-Packard recently announced, for example, the relocation of the headquarters of its personal computer division from the Silicon Valley to Grenoble, France.

Education is a public function and a public policy response to the shortage appears to be in order. Cost effective ways of stimulating a substantial increase in the supply of college graduates are needed. Probably the most cost effective way of ameliorating the shortage is to change immigration policy. There is a long queue of highly skilled university graduates (many of them with graduate degrees from American universities) seeking permanent residence in the United States and it only requires a change in immigration policy to triple the number of college educated immigrants to 300,000 a year.[40] The number of American born college graduates can be increased by strengthening academic standards in high schools, by reducing the very high dropout rates in American colleges,[41] by encouraging adults to return to college to complete their degree, by keeping public tuition levels low and by shortening the time required to get a degree by expanding Advanced Placement programs in high schools and encouraging college students to take courses during summers. There needs to be a special focus on increasing the supply of technically and scientifically trained individuals.

## 6. Recommendations for Changes in BLS Projection Methodology

In our judgement all recent BLS occupational projections have been systematically biased. The occupations that BLS forecasts will grow more rapidly do indeed grow faster than other occupations, but the forecasts systematically underpredict the growth of high skill occupations and overpredict the growth of low skill occupations. All of the BLS forecasts, including those employing an extrapolation methodology and those predicting the more placid 1960s and 1970s, underpredicted upskilling. The biased character of these forecasts appear to have caused some researchers to misjudge the substantial upskilling trend that our economy has been experiencing.

We recommend, therefore, a number of changes in the way BLS makes and reports occupational forecasts:

Making Occupational Forecasts

* BLS should develop data on trends in industry specific occupational staffing ratios for all industries and all occupations by making fuller use of the 1970, 1980 and 1990 Censuses and the OES surveys. It should then use these data to extrapolate changes in staffing patterns into the future. The null hypothesis should be that past trends in occupational staffing ratios will continue in the future unless information is available to the contrary. In other words, we are recommending a return to the occupational projection methodology employed in 1969 and 1971 to forecast 1975 and 1980 occupational employment (see Tomorrow's Manpower Needs: Vol. III, p. 4 for a description). Forecasts should also be developed using regression models similar to those estimated here and comparisons made to forecasts based on the full industry requirements model.

* The process of projecting occupational staffing ratios needs to become less judgmental. A system needs to be developed and documented that makes projecting big changes automatic if powerful trends are visible in time series data. Analysts should not be made to feel that projecting a big change puts them "out on a limb." Documentation is essential because one cannot learn from experience if experience is not documented in a way that one can figure out 5 or 10 years later why the projections were made the way they were. Documentation is also required if scholars outside BLS are to review its procedures.

* Forecasts for five years ahead need to be developed and published along with the longer term forecasts. A shorter forecast horizon means that analysts will learn from their forecast errors more quickly and corrections to the forecasting model can be made in a more timely manner.

* The methodology for projecting the balance between the supply and demand of college graduates needs to be completely overhauled. The effort to measure underemployment of college graduates should be dropped and data on changes in the relative wage of college graduates should be incorporated into the analysis. Basing forecasts of the supply-demand balance on occupational forecasts which do not systematically underpredict the growth of college level jobs will help, but changes in the basic approach to projecting the supply/demand balance are even more important.

Research to Improve Projection Methodology

* A better understanding is needed of why forecasts of occupational growth during the 1980s were so far off the mark. Errors in projecting industry employment (in particular the failure to predict the large decline of manufacturing employment) are one possibility. This can be examined by multiplying actual 1990 industry employment levels by the occupational staffing matrix that was used to make the 1990 forecasts published in 1981. A second way of

examining the issue is to backcast to 1980 by multiplying 1980 industry employment levels by a recent OES staffing matrix. While the unforecasted decline of manufacturing is part of the problem, it is our view that systematic errors in forecasting staffing patterns is also a serious problem.

* A better understanding is needed of the reasons for the explosive growth of managerial jobs in the last two decades, the role of foreign trade, the micro-computer and self employment in that growth and the skill demands of these new jobs.

* Occupational wages are jointly determined along with occupational employment levels. BLS should fund a study which would estimate a structural model of occupational employment demand and supply. It might then be possible to forecast both wages and employment levels.

Presenting Occupational Forecasts

* At the beginning of all future BLS presentations of occupational forecasts and supply/demand projections, it should be pointed out that every single past forecast of occupational growth has understated the growth of skilled occupations relative to unskilled occupations. The reader should be told what changes have been made in projection methodologies to correct the problem and a judgement should be offered as to whether the changes in methods are likely to correct the problem.

* In order to inform users of the sensitivity of predictions to the assumptions used to generate forecasts, alternative scenarios regarding the introduction and effects of new technology and the growth of foreign trade should be developed (either in-house or by contracting with outside organizations) and their impacts on forecasts of occupational demand should be described in the articles reporting new occupational forecasts. The current caveats which warn the reader that forecasts are often wrong is not sufficient. The only way to ensure that users are aware of the uncertainties is to publish the consequences of scenarios which differ greatly in their underlying assumptions.

* The low and high projections offered in current BLS projection reports are not what we mean by alternative scenarios. BLS warns the reader that "the differences in occupational employment from one alternative to another are caused only by differences in projected industry employment levels, because the same set of occupational staffing patterns were used for all alternatives." As a result, occupational growth shares do not differ between the high and low alternatives. What is required is scenarios based on fundamentally different approaches to predicting future occupational staffing patterns. Ron Kutscher's "Changing Skill Requirements" and the work of Wasily Leontief and Faye Duchin, The Future Impact of Automation on Workers is an example of what we mean by a fundamentally different approach to projecting staffing patterns.[42]

* A summary table reporting the forecasted growth of occupations classified by general skill level or average education was introduced for the first time in 1989. This table needs to be better explained and should be given more prominence.

* Future articles should not contain a special table listing the occupations with the largest absolute forecasted growth. Which occupations show up in this table depends on arbitrary decisions regarding the degree of occupational detail that Census and BLS choose to use in their coding scheme. Since the occupational coding schemes used have less detail at the bottom of the skill distribution, these tables give the misleading impression that low skill jobs are growing rapidly even when they are a shrinking share of total employment.

* BLS publications aimed at guidance counselors should provide information on recent rates of growth for wage rates and for employment for each occupation discussed as well as projections of future employment growth. Changes in relative wages are not only important in their own right, they are generally also good signals of demand and supply conditions for an occupation.

## Table 1

### Comparison of Actual and Projected Growth of Major Occupational Groups in the 1980s

| Major Occupation | Actual Growth Rate 1978-89 | BLS Projected Growth Rate 1978-90 | Actual Minus Projected as Percent of Base | Actual Minus Projected ('000s) | Share of Employment Increase |
|---|---|---|---|---|---|
| Total | 22.1% | 22.5% | -.4% | | 21,294 |
| Exec., Admin., Pub. Admin. | 56.7 | 20.3 | 36.4 | 3401 | 25 |
| Professional | 42.3 | 25.3 | 17.0 | 1858 | 22 |
| Technical | 45.8 | 41.8 | 4.0 | 100 | 5 |
| Sales Occupations | 36.7 | 26.3 | 10.4 | 1070 | 18 |
| Administrative Support | 18.4 | 23.6 | -5.2 | -809 | 13 |
| Protective Service | 35.9 | 32.3 | 3.6 | 52 | 2 |
| Private Household | -26.1 | -15.3 | -10.8 | -127 | -1 |
| Other Services | 24.3 | 36.0 | -11.7 | -1198 | 12 |
| Precision Production, Craft | 13.9 | 23.9 | -10.0 | -1214 | 8 |
| Machine Operators | -10.0 | 14.1 | -24.1 | -2209 | -4 |
| Transportation Operatives | 7.9 | 20.4 | -12.5 | -566 | 2 |
| Laborers | -3.9 | 16.9 | -20.8 | -1057 | -1 |
| Farm, Forestry, Fish | -7.9 | -13.1 | 5.2 | 193 | -1 |
| Average Projection Error | 20.9[a] | | 13.2[b] | | |

[a] Average absolute size of the forecast error if all occupations had been assumed to grow at the same rate. It is the mean discrepancy (without regard to sign) between the occupation's percentage growth and the percentage growth of total employment.

[b] Average absolute size of the discrepancy between actual 1978 to 1989 percentage growth and projected 1978 to 1990 percentage growth.

Source: Data on the actual levels of employment is from Employment and Earnings, Jan. 1984, p. 14, and Jan. 1990. Information on the changes in occupational definitions in 1982 is from Gloria Peterson Green, Khoan tan Dinh, John A. Priebe and Ronald R. Tucker, "Revisions in the Current Population Survey Beginning in January 1983," Employment and Earnings, February 1983, pp. 7-15. Projected low trend percentage growth is from Max Carey, "Occupational Employment growth through 1990," Monthly Labor Review, August 1981, pp. 42-55. The comparison employs the 1980 Census occupational categories so adjustments were made to the BLS projections to account for the occupations that were switched from one major occupational group to another.

## Table 2
## Occupational Shares of Employment Growth

| | BLS Projected | | | | | | Actual | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 66-75 | 70-80 | 78-90 LwTr | 79-95 MidTr. | 84-95* MidTr. | 86-00* MidTr. | 50-60 | 60-70 | 72-80* | 80-84* | 84-88* | 88-90* |
| Managers | 11.0 | 7.4 | 7.7 | 11.8 | 15.6 | 14.2 | 4.5 | 4.1 | 17.1 | 23.8 | 26.5 | 20.9 |
| Professional | 20.5 | 26.5 | 14.6 | 18.7 | 17.4 | 17.1 | 22.1 | 28.2 | 17.5 | 25.7 | 16.9 | 22.1 |
| Technical | 4.2 | | 5.7 | 4.5 | 5.7 | 6.7 | 4.6 | 2.9 | 5.3 | 5.9 | 3.5 | 9.6 |
| Sales | 7.5 | 5.6 | 7.1 | 7.7 | 13.9 | 17.4 | 8.9 | 5.0 | 13.3 | 30.3 | 11.7 | 17.4 |
| Clerical | 20.5 | 21.7 | 20.0 | 21.2 | 11.2 | 10.6 | 28.4 | 31.9 | 20.5 | 1.5 | 15.3 | 10.5 |
| Craft & Foreman | 12.3 | 12.7 | 12.1 | 9.3 | 9.0 | 7.8 | 11.8 | 7.7 | 11.2 | 13.7 | 6.1 | 4.6 |
| Operators | 6.2 | 9.3 | 10.0 | 5.3 | 6.3 | 0.8 | 12.5 | 9.1 | 3.4 | -15.4 | 5.0 | -2.9 |
| Non-Farm Laborers | .7 | 0.0 | 4.8 | 3.1 | 1.7 | 1.2 | -2.8 | -1.9 | .3 | -5.0 | 4.5 | 4.0 |
| Service Workers | 20.5 | 20.3 | 20.6 | 19.5 | 19.8 | 25.3 | 18.0 | 13.4 | 13.1 | 18.9 | 11.9 | 13.9 |
| Farm, Fish and Forestry | -3.4 | -3.2 | -2.6 | -1.1 | -0.7 | -0.8 | -31.7 | -14.2 | -1.2 | -0.6 | -1.6 | -0.2 |
| | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Managerial, Professional & Technical | 34.7 | 33.9 | 28.0 | 35.0 | 38.7 | 38.0 | 31.2 | 35.2 | 39.9 | 55.4 | 46.9 | 52.6 |
| M,P&T & Sales Reps & Managers | | | | 39.2 | 46.5 | 45.8 | | | 44.1 | 71.2 | 56.3 | 59.2 |
| Operatives, Labor, & Service | 27.4 | 29.6 | 35.4 | 27.9 | 27.8 | 27.3 | 27.7 | 20.6 | 16.8 | -1.5 | 21.4 | 15.0 |
| O,L&S & Retail Sales Clerk | | | | | 33.9 | 36.9 | | | 25.9 | 12.9 | 23.7 | 25.8 |
| Employment Growth ('000s) | | | | | | | 8,716 | 12,613 | 17,150 | 5,702 | 9,963 | 4,226 |
| Date of Publication | Feb. 1969 | 1971 | Aug. 1981 | Nov. 1983 | Nov. 1985 | Sept. 1987 | | | | | | |

*Based on 1980 Census Occupational Categories and coding procedures.

Sources: Col. 1--Tomorrow's Manpower Needs: Vol. III, 1969, p. 4. Col. 2--Max Carey and Kevin Kasunic, "Evaluating the 1980 Projections of Occupational Employment," Monthly Labor Review (MLR), July 1982, p. 23. Col. 3--Max Carey, "Occupational employment growth through 1990," MLR, August, 1981, pp. 42-55. Col. 4--George Silvestri, John M. Lukasiewicz and Marcus E. Einstein, "Occupational Employment Projections through 1995," MLR, November 1983, pp. 37-49. Col. 5--George Silvestri, John M. Lukasiewicz, "Occupational Employment Projections: The 1984-95 Outlook", MLR, Nov. 1985, p. 42., Col. 6--George Silvestri and John M. Lukasiewicz, "A Look at Occupational Employment Trends to the Year 2000", MLR, Sept. 1987, p. 46. Data on actual employment growth 1950 to 1970 came from Bureau of the Census, Historical Statistics of the United States, D182-D682. Data on the period since 1972 is from Deborah Pisetzner Klein, "Occupational Employment Statistics for 1972-82," Employment & Earnings, Jan. 1984, pp.13-16 and other January issues of Employment and Earnings.

**Table 3**

**Comparison of Actual and Logarithmic Extrapolation of 1980-89 Growth of Major Occupational Groups**

| Major Occupation | Actual Growth 1980-89 | Logarithmic Extrapolation of Growth 1980-89 | Difference Percent Growth | Difference ('000s) |
|---|---|---|---|---|
| Total | 18.2% | 18.2% | | |
| Exec., Admin., Pub. Admin. | 45.4 | 36.9 | 8.5% | 867 |
| Professional | 31.5 | 29.8 | 1.7 | 204 |
| Technical | 28.6 | 44.2 | -15.6 | -441 |
| Sales | 29.6 | 22.0 | 7.6 | 826 |
| Administrative Support | 10.7 | 22.1 | -11.4 | -1892 |
| Protective Services | 31.5 | 19.5 | 11.9 | 178 |
| Other Services incl. PHH | 15.9 | 15.4 | 0.5 | 231 |
| Precision Production, Craft | 12.6 | 13.3 | -.7 | -87 |
| Machine Operatives | -6.7 | -3.6 | -3.1 | -272 |
| Transportation Operatives | 8.8 | 7.0 | 1.8 | 79 |
| Laborers | 4.1 | -5.3 | 9.4 | 439 |
| Farm, Forestry, Fish | -5.9 | -12.2 | 6.3 | 231 |
| | 13.62[a] | | 6.54[b] | |

[a] Average absolute size of the forecast error if all occupations had been assumed to grow at the same rate. It is the mean discrepancy (without regard to sign) between the occupation's percentage growth and the percentage growth of total employment.

[b] Average absolute size of the discrepancy between an occupation's actual 1980-89 percentage growth and extrapolated 1980-89 percentage growth.

Source: Data on occupational employment levels using 1980 Census occupational categories is from Employment and Earnings, January 1990 and Deborah Pisetzner Klein, "Occupational Employment Statistics for 1972-82," Employment and Earnings, Jan. 1984, 13-16.

**Table 4**

**Comparison of Actual and Logarithmic Regression Forecast of 1980-89 Growth of Major Occupational Groups**

| Major Occupation | Actual Growth 1980-89 | Logarithmic Regression Forecast 1980-89 | Difference Percent Growth | Difference ('000s) |
|---|---|---|---|---|
| Total | 18.2% | 18.2% | | |
| Exec., Admin., Pub. Admin. | 45.4 | 31.5 | 13.9% | 1420 |
| Professional | 31.5 | 23.5 | 8.0 | 946 |
| Technical | 28.6 | 36.5 | -7.9 | -232 |
| Sales | 29.6 | 20.9 | 8.7 | 944 |
| Administrative Support | 10.7 | 19.7 | -9.0 | -1497 |
| Protective Services | 31.5 | 14.9 | 16.6 | 248 |
| Other Services incl. PHH | 15.9 | 17.9 | -2.0 | -227 |
| Precision Production, Craft | 12.6 | 20.6 | -8.0 | -982 |
| Machine Operatives | -6.7 | 6.6 | -13.3 | -1175 |
| Transportation Operatives | 8.8 | 7.6 | 1.2 | 54 |
| Laborers | 4.1 | 5.7 | -1.6 | -73 |
| Farm, Forestry, Fish | -5.9 | -16.6 | 10.7 | 389 |
| | 13.62[a] | | 8.41[b] | |

[a] Average absolute size of the forecast error if all occupations had been assumed to grow at the same rate. It is the mean discrepancy (without regard to sign) between the occupation's percentage growth and the percentage growth of total employment.

[b] Average absolute size of the discrepancy between an occupation's actual 1980-89 percentage growth and logarithmic regression predicted 1980-89 percentage growth.

Source: Data on occupational employment levels using 1980 Census occupational categories is from Employment and Earnings, January 1990 and Deborah Pisetzner Klein, "Occupational Employment Statistics for 1972-82," Employment and Earnings, Jan. 1984, 13-16. Regressions predicting the logarithm of the occupation's share of employment with a trend and the unemployment rate were estimated on data from 1972 to 1980 and then forecasts were made for 1989.

## Table 5

### Actual and Projected Growth of Major Occupational Groups 1966 to 1975

| | Actual Growth 1966-74 | BLS Projected Growth 1966-75 | Actual Minus Projected as Percent of 1966 | Actual Minus Projected ('000s) | Share of 1966-74 Employment Increase |
|---|---|---|---|---|---|
| Total | 16.0% | 17.7% | -1.7% | -1265 | 11,835 |
| Managerial | 20.8 | 26.5 | -5.7 | -420 | 13.0 |
| Professional, Technical | 32.7 | 34.0 | -1.3 | -124 | 25.7 |
| Sales Occupations | 12.8 | 16.7 | -3.9 | -183 | 5.2 |
| Clerical Occupations | 27.5 | 23.1 | 4.4 | 523 | 27.4 |
| Service Workers | 17.2 | 28.8 | -11.61 | -1120 | 14.1 |
| Craft and Kindred Workers | 19.6 | 21.6 | -2.0 | -197 | 15.9 |
| Operatives | 0.1 | 0.9 | -0.8 | -106 | 0.0 |
| Non Farm Laborers | 18.4 | 3.5 | 14.9 | 550 | 5.7 |
| Farm Workers | -21.8 | -17.1 | -4.7 | -187 | -16.7 |
| Average Absolute Projection Error | 10.78[a] | | 4.41[b] | | |

[a] Average absolute size of the forecast error if all occupations had been assumed to grow at the same rate. It is the mean discrepancy (without regard to sign) between the occupation's percentage growth and the percentage growth of total employment.

[b] Average absolute size of the discrepancy between actual 1966 to 1974 percentage growth and projected 1966 to 1975 percentage growth minus 1.7 (to adjust for differences between projected 1975 and actual 1974 employment levels).

Source: Projected and actual employment levels for 1974-75 are from Max Carey, "Evaluating the 1975 Projections of Occupational Employment," Monthly Labor Review, June 1980, p. 14. Estimates of occupational employment levels in 1966 are from BLS, Tomorrow's Manpower Needs: Vol. III, 1969, p. 4.

## Table 6

### Actual and Projected Growth of Major Occupational Groups in the 1970s

| Major Occupation | Actual Growth 1970-80 | BLS Projected Growth 1970-80 | Actual Minus Projected as Percent of 1970 | Actual Minus Projected Number ('000s) | Share of 1970-80 Employment Increase |
|---|---|---|---|---|---|
| Total | 23.7% | 20.9% | 2.8% | 2185 | 18,643 |
| Managerial | 31.7 | 14.6 | 17.1 | 1419 | 14% |
| Professional, Technical | 40.2 | 39.1 | 1.1 | 113 | 24 |
| Sales Occupations | 27.2 | 18.7 | 8.5 | 412 | 7 |
| Clerical Occupations | 32.0 | 26.0 | 6.0 | 820 | 24 |
| Service Workers | 33.4 | 34.5 | -1.1 | -102 | 17 |
| Craft and Kindred Workers | 23.3 | 20.5 | 2.8 | 289 | 13 |
| Operatives | -0.7 | 11.0 | -11.7 | -1626 | -1 |
| Non Farm Laborers | 19.7 | -.6 | 20.3 | 756 | 4 |
| Farm Workers | -13.5 | -16.8 | 3.3 | 104 | -2 |
| Average Absolute Projection Error | 16.4[a] | | 6.8[b] | | |

[a] Average absolute size of the forecast error if all occupations had been assumed to grow at the same rate. It is the mean discrepancy (without regard to sign) between the occupation's percentage growth and the percentage growth of total employment.

[b] Average absolute size of the discrepancy between actual 1970 to 1980 percentage growth and projected growth plus 2.8 (to adjust for differences between projected and actual 1980 employment levels).

Source: All data are taken from Max Carey and Kevin Kasunic, "Evaluating the 1980 Projections of Occupational Employment," Monthly Labor Review, July 1982, p. 23.

# Table 7

## Means and Standard Deviations

| Independent Variables | Mean | Standard Deviation | Mean Deviated From Value in 2000 |
|---|---|---|---|
| Year | 1980.5 | 5.30 | -19.51 |
| Unemp. Rt. | .0689 | .0140 | .0139 |
| Year C-T 80 | 4.5 | 3.185 | -17.5 |
| Trade Def. | .01506 | .01263 | .01506 |
| PC Use | .04896 | .06925 | -.40104 |

| Dependent Variables | Arithmetic Mean | SD of Logged Variables | Logarithmic Mean Deviated From 1988 |
|---|---|---|---|
| Managers | .1049 | .1065 | -.1698 |
| Professionals | .1202 | .0696 | -.0821 |
| Technical | .0279 | .10203 | .0988 |
| Sales | .1119 | .0591 | -.0685 |
| Clerical | .1615 | .01911 | .0158 |
| Craft | .1232 | .0242 | .0353 |
| Factory Operative | .0863 | .1483 | .1906 |
| Transportation Operative | .0451 | .0706 | .0680 |
| Laborer | .0476 | .1137 | .1120 |
| Private Household | .0113 | .2395 | .3290 |
| Protective Service | .0157 | .0536 | -.0768 |
| Other Service | .1062 | .0353 | -.0219 |

## Table 8
## Determinants of Blue Collar Employment Shares
## 1972 - 1989

| | Trend | Unemp | Trade Balance | PC Use | Year GT80 | Intercept | MSE | $R^2$ |
|---|---|---|---|---|---|---|---|---|
| **Precision Production** | | | | | | | | |
| 1) | -.0033*** (4.32) | -.479 (1.62) | | | | -.022 (1.33) | .0169 | .606 |
| 2) | .0001 (.05) | -.7984** (2.45) | | | -.0062* (1.83) | -0.059** (2.32) | .0157 | .682 |
| 3) | -.0067*** (5.45) | -0.324 (1.35) | 1.614** (3.14) | | | -.113*** (3.55) | .0134 | .769 |
| 5) | -.0022 (1.211) | -.880** (3.19) | 1.222** (2.78) | -.310** (2.85) | | -0.137*** (5.03) | .0109 | .851 |
| **Machine Operatives** | | | | | | | | |
| 1) | -.0269*** (21.94) | -1.565*** (3.34) | | | | -.312*** (11.89) | .0269 | .972 |
| 2) | -.0166*** (8.31) | -2.520*** (7.80) | | | -0.0185*** (5.51) | -.422*** (16.78) | .0156 | .991 |
| 3) | -.0239*** (10.15) | -1.704*** (3.69) | -1.446 (1.46) | | | -.230*** (3.73) | .0259 | .975 |
| 5) | -.0122*** (5.11) | -3.174*** (8.87) | -2.48*** (4.34) | -.819*** (5.81) | | -.294*** (8.29) | .0142 | .993 |
| **Transport Operatives** | | | | | | | | |
| 1) | -.0125*** (18.43) | -1.227** (4.74) | | | | -.157*** (10.84) | .0148 | .963 |
| 2) | -.0122*** (6.22) | -1.250*** (3.94) | | | -.0004 (.014) | -.160*** (6.47) | .0153 | .963 |
| 3) | -.0120*** (8.64) | -1.248*** (4.59) | -.227 (.390) | | | -.144*** (3.98) | .0152 | .963 |
| 5) | -.0134*** (5.07) | -1.079** (2.74) | -.108 (.17) | .094 (.607) | | -.137*** (3.50) | .0156 | .964 |
| **Laborers** | | | | | | | | |
| 1) | -0.0199*** (16.23) | -1.921*** (4.09) | | | | -.248*** (9.45) | .0268 | .952 |
| 2) | -.0175*** (5.01) | -2.143*** (3.80) | | | -.0043 (0.73) | -.274*** (6.24) | .027 | .954 |
| 3) | -.0180*** (7.31) | -2.009*** (4.17) | -.930 (.90) | | | -.196** (3.05) | .027 | .955 |
| 5) | -.0172*** (3.63) | -2.115** (2.99) | -1.004 (.89) | -.0582 (.21) | | -.200** (2.86) | .028 | .955 |

* Prob. LT .05
** Prob. LT .025
*** Prob. LT .01

## Table 9

### Determinants of Professional, Technical and Managerial Employment Shares 1972 - 1989

| | Trend | Unemp | Trade Balance | PC Use | Year GT80 | Intercept | MSE | $R^2$ |
|---|---|---|---|---|---|---|---|---|
| **Managers** | | | | | | | | |
| 1) | 0.0196*** (33.66) | -0.675** (3.03) | | | | .224*** (17.95) | .0128 | .987 |
| 2) | .0179*** (11.07) | -.517* (1.98) | | | .0030 (1.121) | .242*** (11.89) | .0127 | .988 |
| 3) | .0224*** (26.95) | -.8056*** (4.94) | -1.364*** (3.90) | | | .3011*** (13.66) | .0091 | .994 |
| 4) | .0171*** (12.08) | -.317 (1.15) | | .213* (1.92) | | .2561*** (12.68) | .0117 | .989 |
| 5) | .0207*** (13.83) | -.590** (2.63) | -1.212*** (3.39) | .120 (1.36) | | .310*** (13.99) | .0089 | .995 |
| **Professionals** | | | | | | | | |
| 1) | .0119*** (31.33) | 1.138*** (7.83) | | | | 0.136*** (16.67) | .0083 | .987 |
| 2) | .0099*** (10.53) | 1.327*** (8.78) | | | .0037** (2.33) | .157*** (13.38) | .0073 | .990 |
| 3) | .0127*** (16.98) | 1.102*** (7.53) | -.376 (.96) | | | .157*** (6.73) | .0082 | .988 |
| 4) | .0095*** (12.57) | 1.485*** (9.99) | | .207*** (3.48) | | .167*** (15.36) | .0063 | .993 |
| 5) | .0099*** (9.00) | 1.456*** (8.89) | -.127 (.48) | .197*** (3.06) | | .172*** (10.62) | .0065 | .9930 |
| **Technicians** | | | | | | | | |
| 1) | .0172*** (17.83) | 1.825*** (4.94) | | | | .213*** (10.30) | .0211 | .961 |
| 2) | .0226*** (9.69) | 1.323*** (3.50) | | | -.0097** (2.48) | .155*** (5.28) | .0182 | .973 |
| 3) | .0187*** (9.65) | 1.755*** (4.62) | -.725 (.89) | | | .254*** (5.02) | .021 | .963 |
| 4) | .0223*** (10.25) | 1.104** (2.58) | | -.431** (2.51) | | .148*** (4.75) | .0182 | .973 |
| 5) | .0264*** (9.67) | .7871* (1.93) | -1.407* (2.158) | -.539*** (3.35) | | .212*** (5.24) | .0162 | .980 |

* Prob. LT .05
** Prob. LT .025
*** Prob. LT .01

## Table 10
## Determinants of Sales, Clerical and Service Employment Shares
## 1972 - 1989

| | | Trend | Unemp Rate | Trade Balance | PC Use | Year GT80 | Intercept | MSE | $R^2$ |
|---|---|---|---|---|---|---|---|---|---|
| **Sales** | | | | | | | | | |
| | 1) | 0.0102*** | .298 | | | | .128*** | .0166 | .926 |
| | | (13.43) | (1.02) | | | | (7.85) | | |
| | 2) | .0057*** | .7129** | | | .0081 | .176*** | .0140 | .951 |
| | | (3.19) | (2.46) | | | (2.67) | (7.78) | | |
| | 3) | .0074*** | .430 | 1.378** | | | .050 | .0143 | .949 |
| | | (5.66) | (1.69) | (2.52) | | | (1.47) | | |
| | 4) | .0082*** | .580 | | .169 | | 0.153*** | .0165 | .931 |
| | | (4.16) | (1.49) | | (1.08) | | (5.38) | | |
| | 5) | .0030 | .977*** | 1.763*** | .304** | | .073** | .0121 | .966 |
| | | (1.47) | (3.19) | (3.60) | (2.52) | | (2.42) | | |
| **Clerical** | | | | | | | | | |
| | 1) | -.0002 | .701** | | | | 0.0034 | .0155 | .310 |
| | | (.28) | (2.60) | | | | (.22) | | |
| | 2) | .0052*** | .199 | | | -.0097*** | -.055*** | .0105 | .705 |
| | | (3.89) | (0.92) | | | (4.32) | (3.38) | | |
| | 3) | .0002 | .682* | -.196 | | | .014 | .0159 | .315 |
| | | (.140) | (2.40) | (.32) | | | (.38) | | |
| | 4) | .0043*** | .058 | | -.384*** | | -.054** | .0117 | .628 |
| | | (3.06) | (.211) | | (3.46) | | (.26) | | |
| | 5) | .0065*** | -.111 | -.755 | -.442*** | | -.020 | .0110 | .696 |
| | | (3.51) | (.40) | (1.70) | (4.03) | | (.73) | | |
| **Other Services** | | | | | | | | | |
| | 1) | .0047*** | 1.133*** | | | | .055*** | .0111 | .899 |
| | | (9.290) | (5.86) | | | | (5.11) | | |
| | 2) | .0062*** | .992*** | | | -.0027 | .039** | .0110 | .908 |
| | | (4.43) | (4.38) | | | (1.16) | (2.22) | | |
| | 3) | .0034*** | 1.193*** | .629 | | | .020 | .011 | .914 |
| | | (3.53) | (6.32) | (1.55) | | | (.172) | | |
| | 4) | .0059*** | .959*** | | -.104 | | .040 | .0111 | .905 |
| | | (4.47) | (3.67) | | (.99) | | (2.09) | | |
| | 5) | .0043* | 1.083*** | .551 | -.062 | | .015 | .0109 | .916 |
| | | (2.34) | (3.95) | (1.26) | (.57) | | (.55) | | |

* Prob. LT .05
** Prob. LT .025
*** Prob. LT .01

## Table 11

## Projected Increases in Employment by Occupation 1988-2000

| | BLS | Trend Unemp (linear) | Trend Umemp (log) | Trend YR GT80 Unemp | Trend Unemp. Trade Balance | Trend Unemp. PC Use Trade Balance | Preferred Models | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Linear for High PC Use = 45% | PCUSE =45% | PCUSE =30% | Good for Blue Collar Worker | Bad for Blue Collar Worker |
| **Managerial** | 3128 | 5284 | 5648 | 6150 | 7218 | 7514 | 6507 | 7477 | 6821 | 7124 | 6981 |
| **Professional** | 3594 | 4439 | 4169 | 4725 | 4559 | 4950 | 4791 | 4916 | 4092 | 3883 | 5492 |
| **Technical** | 1113 | 1307 | 1340 | 1098 | 1537 | 1350 | 1247 | 1342 | 1686 | 1719 | 1354 |
| **Sales Reps. & Managers** | 1760 | 2226 | 2051 | 2595 | 1316 | 1571 | 1629 | 1556 | 1035 | 809 | 1910 |
| **Retail Sales Clerks** | 1035 | 1790 | 1649 | 2086 | 1058 | 1263 | 1309 | 1251 | 832 | 650 | 1536 |
| **Clerical** | 2155 | 2880 | 2205 | 1187 | 2408 | 1796 | 2067 | 1762 | 2867 | 2999 | 1582 |
| **Craft & Precision Production** | 1353 | 1744 | 1270 | 828 | - 48 | - 315 | - 135 | - 338 | 120 | 9 | - 400 |
| **Factory Operatives** | - 471 | -2308 | -1480 | -2131 | - 922 | -1338 | -1246 | -1349 | - 562 | - 214 | -1916 |
| **Transportation Operatives** | 570 | - 206 | - 222 | - 202 | - 167 | - 112 | - 49 | - 120 | - 245 | - 215 | - 223 |
| **Non-Farm Laborers** | 102 | - 832 | - 630 | - 709 | - 406 | - 407 | - 346 | - 414 | - 432 | - 329 | - 638 |
| **Private Household Workers** | - 43 | - 673 | - 313 | - 243 | - 403 | - 373 | - 237 | - 247 | - 255 | - 257 | - 246 |
| **Protective Service** | 439 | 443 | 385 | 618 | 394 | 543 | 643 | 604 | 572 | 567 | 606 |
| **Other Service** | 3020 | 2677 | 2243 | 2106 | 1712 | 1706 | 1898 | 1682 | 1631 | 1421 | 2082 |
| **Farm** | - 165 | -1147 | - 692 | - 483 | - 631 | - 524 | - 454 | - 499 | - 536 | - 542 | - 497 |
| **Share Manag, Prof & Tech** | 44.5% | 62.6 | 63.3 | 68.0 | 75.6 | 78.4 | 71.2 | 78.0 | 71.4 | 72.2 | 78.5 |
| **Share Manag, Prof, Tech & Sales Reps and Managers** | 54.4% | 75.3 | 75.1 | 82.7 | 83.1 | 87.4 | 80.5 | 86.8 | 77.4 | 76.9 | 89.4 |
| **Share Operatives, Lab & Services** | 20.5% | - 8.8 | - 2.1 | - 4.4 | - 0.6 | - 1.3 | 2.7 | - 0.4 | 2.6 | 4.1 | - 3.2 |
| **Share Oper, Lab, Serv & SClerk** | 26.4% | 1.3 | 7.2 | 7.4 | 5.3 | 5.8 | 10.0 | 6.6 | 7.2 | 7.7 | 5.5 |

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## Table 12
## Projected Rates of Occupational Growth
## 1988-2000

| | BLS | Trend Unemp. (linear) | Trend Unemp. (log) | Trend GT80 Unemp. (log) | Trend Unemp. Trade Balance (log) | Trend Unemp. PC Use Trend Balance | Preferred Models | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Linear for High Skills PC Use = 45% | PC Use = 45% | PC Use = 30% | Good for Blue Collar Worker | Bad for Blue Collar Worker |
| **Managerial** | 22.0% | 37.1% | 39.6% | 43.2% | 50.7 | 52.8% | 45.7% | 52.5% | 47.9% | 50.0% | 49.0% |
| **Professional** | 24.0 | 29.7 | 27.9 | 31.6 | 30.5 | 33.1 | 32.0 | 32.8 | 27.3 | 25.9 | 36.7 |
| **Technical** | 31.6 | 37.2 | 38.1 | 31.3 | 43.7 | 38.4 | 35.5 | 38.2 | 48.0 | 48.9 | 38.5 |
| **Sales** | 20.3 | 29.2 | 26.8 | 34.0 | 17.2 | 20.6 | 21.3 | 20.4 | 13.5 | 10.6 | 25.0 |
| **Clerical** | 11.8 | 15.7 | 12.0 | 6.4 | 13.1 | 9.8 | +11.3 | 9.6 | 15.6 | 16.4 | 8.6 |
| **Craft** | 9.9 | 12.7 | 9.2 | 6.0 | -0.4 | -2.4 | - 1.1 | -2.5 | 0.8 | 0.0 | -3.0 |
| **Machine Operators** | -5.8 | -28.5 | -18.3 | -26.3 | -11.4 | -16.5 | -15.3 | -16.6 | -6.9 | -2.7 | -23.6 |
| **Transportation Operators** | 11.8 | -4.2 | -4.6 | -4.2 | -3.4 | -2.3 | -1.0 | -2.5 | -5.1 | -4.4 | -4.6 |
| **Non-Farm Laborers** | 02.1 | -17.1 | -12.9 | -14.5 | -8.3 | -8.3 | -7.1 | -8.5 | -8.8 | -6.7 | -13.1 |
| **Private Household Workers** | -4.7 | -74.0 | -34.3 | -26.7 | -44.3 | -41.0 | -26.0 | -27.1 | -28.0 | -28.2 | -27.1 |
| **Protective Service** | 22.6 | 22.8 | 19.8 | 31.8 | 20.3 | 28.0 | +33.1 | 31.1 | 29.5 | 29.2 | 31.2 |
| **Other Service** | 24.2 | 21.5 | 18.0 | 16.9 | 13.7 | 13.7 | 15.2 | 13.5 | 13.1 | 11.4 | 16.7 |
| **Farm** | -4.8 | -33.4 | -20.2 | -14.1 | -18.3 | -15.3 | -13.3 | 14.5 | -15.6 | -15.8 | -14.5 |
| **Management, Professional, Technical & Sales Reps** | 23.0% | 32.9 | 32.8 | 36.2 | 36.4 | 38.2 | 35.2 | 38.0 | 33.9 | 33.6 | 39.1 |
| **Yearly Rate** | .017 | .0237 | .0237 | .0257 | .0258 | .0270 | .0251 | .0268 | .0243 | .0242 | .0275 |
| **College Graduate Index** | 21.1 | 27.9 | 27.3 | 29.8 | 30.0 | 31.5 | 29.6 | 31.3 | 28.2 | 27.8 | 32.5 |
| **Yearly Rate** | .016 | .0205 | .0201 | .0217 | .0218 | .0228 | .0216 | .0227 | .0207 | .0204 | .0235 |
| **College Graduate/High School Demand Index (Yearly Rate)** | .0061 | .0134 | .0126 | .0149 | .0152 | .0166 | .0148 | .0164 | .0135 | .0132 | .0176 |

**Table 13**
**BLS Projections of the Supply/Demand for College Graduates**
**and**
**Subsequent Changes in the College Wage Premium**

| When Published | Projection Period | Average Annual Surplus (in 1,000's) | Change In HS/College Wage Rate |
|---|---|---|---|
| 1970 | 1968-80 | 8 | - 6.7% |
| 1972 | 1970-80 | 20 | - 7.6% |
| 1974 | 1972-85 | 62 | +14.2% |
| 1976 | 1974-85 | 86 | +18.9% |
| 1978 | 1976-85 | 300 | +23.2% |
| 1980 | 1978-90 | 275 | +26.5% |
| 1982 | 1980-90 | 300 | +23.6% |
| 1984 | 1982-95 | 300 | |
| 1986 | 1984-95 | 200 | |
| 1988 | 1986-2000 | 100 | |
| 1990 | 1988-2000 | 150 | |

Source: The record of past BLS forecasts of the supply demand balance is from an unpublished BLS memorandum. The data on subsequent changes in the ratio of college and high school wages for workers with 1 to 5 years of experience is from Lawrence Katz and Kevin Murphy, "Changes in Relative Wages, 1963-1987: Supply and Demand Factors," 1990, which is to published in the Quarterly Journal of Economics next year.

**Table 14**
**Growth Rates of Employment and College Wage Premia**

| | 1950-60 | 1960-70[a] | 1972-80[a] | 1980-88 | Projected 1988-2000 |
|---|---|---|---|---|---|
| **Demand** | | | | | |
| **Prof, Tech, Manager & Sales Rep Emp.** | 2.69 | 3.00 | 3.92 | 3.45 | 2.37/2.75 |
| **Occup. Demand for College Graduates[c]** | 2.29 | 2.93 | 3.43 | 2.89 | 2.01/2.35 |
| **Supply** | | | | | |
| **College Graduate Labor Force** | | 4.34 | 6.22 | 4.18 | 2.50 |
| **College Educated Labor Force** | | 4.62 | 6.11 | 3.63 | ? |
| **Supply minus Demand** | | | | | |
| **College Grad/Prof, Tech, Man & SalesRep Jobs** | | 1.50 | 2.29 | .72 | -.20 |
| **College Grad/Occup. Demand for College Grads** | | --- | 2.78 | 1.30 | 0.15/0.49 |
| **College/HS Wage Ratio** | | | | | |
| **All Exp. Levels** | | 1.1[b] | -1.4[b] | 1.5[b] | ? |
| **1-5 Years Experience** | | 0.1[b] | - .9[b] | 2.8[b] | ? |

[a] Data sources are not comparable before and after 1972 because of changes in occupational coding and because prior to 1972 data on the educational breakdown of the workforce is for individuals above age 18 rather than for those over 16 as in the period after 1972.

[b] For the data on annual rates of change in the college/high school wage ratio the time periods were 1963 to 1971, 1971 to 1979 and 1979 to 1987.

[c] Occupational demand for college graduates index was calculated by multiplying the proportion of the occupation that had a college degree in 1988 by the actual or projected number of employees in each occupation and summing across occupations. In the forecast column, the high end of the range, 2.34% per year, is from the preferred model with a log specification throughout and and Bad for Blue Collar Scenario. The low end of the range, 2.03% per year, is from the logarithmic model that contains only a trend and the unemployment rate.

Source: Occupational employment data is from Historical Statistics of the U.S., D184,D185 & D359-D370 and from Deborah Pisetzner Klein, Employment and Earnings, Jan. 1984 & Jan 1990. Data on the educational breakdown of the Labor force is from Handbook of Labor Statistics, Table 65, 1982. Data on trends in the college high school wage differential is from Katz & Murphy, 1990.

## APPENDIX A. Assumptions and Methodology Used to Develop National Industry and Occupational Projections

From Tomorrow's Manpower Needs Vol. IV, Bulletin #1606 Feb 1969

This volume presents in appendices C and E, the latest national industry and occupation employment requirements projections for 1975 prepared by the BLS. These projections supersede all previous 1975 projections and reflect a comprehensive evaluation of the expected effects of economic and social trends on employment requirements over the 1966-75 period. The methods used by the BLS in developing employment projections are discussed below. These projections represent the collaborative efforts of several research staffs in the Bureau, including those working on occupational outlook, labor force studies, economic growth, technological change, and productivity. For this reason, they reflect the insight derived from the use of a variety of techniques.

### Assumptions

Projections of economic phenomena are based on a series of assumptions about the characteristics of the environment during the projection period.[1] Employment projections based on an assumption of growing defense expenditures for example, would result in different requirements from projections based on an alternative assumption of constant expenditures. Industries dependent upon defense contracts would experience higher output and employment under the former assumption. Moreover, because staffing patterns of defense related industries differ from those of non defense industries, occupational requirements would also differ under the alternative assumptions.

One of the most important assumptions underlying manpower projections describes the labor force in the target year. The BLS projections assume that the size, sex, and age composition of the labor force is expected to change by 1975 as indicated by the latest labor force projections prepared by the Bureau:[2] (1) Total labor force, 94.1 million; (2) Armed Forces, 2.7 million; and, (3) Civilian labor force, 91.4 million.

The assumed size of the Armed Forces in 1975 (2.7 million) is generally consistent with peacetime conditions in the late 1950's and early 1960's. The validity of this assumption depends greatly upon developments in foreign affairs in the 1968-75 period. The Viet Nam buildup has already had a significant influence on a number of industries that are heavily committed to defense production.[3]

Another important assumption underlying the employment projections focuses on the expected unemployment rate in the target year. An unemployment rate of 3 percent was selected for 1975 after considering the unemployment experience of the 1960's and current emphasis on manpower utilization and training programs.[4] Based on a 3-percent unemployment rate, civilian employment in 1975 was computed as follows: (1) Civilian labor force, 91.4 million; (2) Unemployment (3 percent) 2.7 million; and, (3) Civilian employment, 88.7 million.

Other major assumptions underlying the national manpower projections are: (1) No major event will substantially alter the rate and nature of economic growth; (2) economic and social patterns and relationships will continue to change at about the same rate as in the recent past; (3) scientific and technological advances of recent years will continue at about the same rate; and (4) defense expenditures (in constant dollar terms) between 1965 and 1975 will increase at about the same average rate as during the 1955-65 period. This last assumption implies that the Viet Nam conflict will have been over for some time by 1975 and that the level and pattern of defense expenditures in 1975 will reflect a return to the "cold war" situation.

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[1] Users of manpower projections should be fully aware of the nature of the underlying assumptions. The larger the disparity between the assumed and actual conditions through the projection period, the more likely actual employment levels will vary from projected levels, although the implications of these differences may be partially offsetting.

[2] "Labor Force Projections for 1970-80," *Monthly Labor Review*, February 1965, pp. 129-140. (These projections have been adjusted upwards to reflect the larger labor force under a 3-percent level of unemployment.)

[3] The 1975 employment projections for the aircraft and parts industry (SIC 372) are significantly lower than current employment. Similarly, the 1975 employment projection for the electrical machinary industry (SIC 36) was almost reached in 1967. The extent to which Viet Nam will permanently change employment requirements in the years ahead will be reflected in the next revised series of BLS employment projections, available in the fall of 1968 (covering the 1967-80 period).

[4] The national unemployment rate is an average for all industries; rates for some industries are expected to be higher in 1975, and for others, lower. For example, the unemployment rate for the construction industry work force has averaged about twice the national rate during the postwar period. Therefore, an unemployment rate of 6 percent in the construction industry in 1975 may not be inconsistent with an overall unemployment rate of 3 percent.

Other assumptions, such as import-export relationships, are discussed in volume II as they relate to each industry.

## Methodology

Although a variety of techniques were used, two steps generally were followed in projecting the growth c occupations. The first step was to project total manpower requirements in each detailed industry. Secondly, th trends in the use of each occupation in each detailed industry were projected. The projected proportion (ratio) c each occupation in each industry was then multiplied by projected 1975 total manpower requirements in th industry, resulting in an estimate of occupational requirements in each industry in 1975. Requirements in eac occupation were then summed across all industries resulting in projected total employment requirements b occupation. Employment requirements in some occupations were also projected independently of the occupation relationship to particular industries. This technique was particularly useful for occupations that are affected by limited number of variables or are located primarily in one industry or group of industries. When both majc techniques were used, the differences in the results were analyzed and reconciled based on the judgements of th analysts.

*Projections of detailed industry employment*

The first step in developing projections of detailed industry employment was to estimate the level of economi activity (real GNP) in 1975.[6] If a 3-percent unemployment rate is to be achieved in 1975, real GNP must be hig enough to provide employment for 97 percent of the civilian labor force (or 88.7 million workers). In estimating re: GNP in 1975, *preliminary* projections of total employment as well as projections of output per worker were made fc each of the nine major industry divisions.[7] The sum of the product of output per worker (in constant dollars) an total employment in each of the nine major industry divisions was the level of economic activity required to achiev the civilian employment goal for 1975: GNP (1958 dollars) 1975, $950 billion.

In making the preliminary projections of total employment[8] by major industry division, no single source provide historical employment data for all classes of workers for the eight nonagriculture major industry divisions.[9] Howeve historical data for the great bulk of employment–private wage and salary workers–were available from the BL establishment employment statistics series as published in Bulletin 1312-5, *Employment and Earnings Statistics fc the United States, 1909-1967.* In addition, the decennial population censuses and the Current Population Surve (CPS) provided historical data on self-employed workers, unpaid family workers, and domestic workers. Usin projections of wage and salary employment in each of the nonagriculture major industry divisions as a base employment projections for the other classes of workers were developed[10] and distributed among the eigh nonagriculture major industry divisions (and an estimate of the number of dual jobholders subtracted), and the sum c the totals for the major industry divisions were adjusted to agree with the estimate of total civilian employment i 1975.

To the extent that subsequent detailed industry wage and salary employment projections did not add to th preliminary employment projection for a major industry division (after adding in the projection of employment fo the other classes of workers), adjustments were made in employment either at the detailed or major industry divisio

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[5] In practically all industries export and import trends between 1947 and 1965 were assumed to continue between 1966 an 1975.

[6] The growth in real GNP between 1966 and 1975 will be an important determinant of employment growth in individua industries over the period, and was used as an independent variable in the regression analysis approach discussed below.

[7] Major industry divisions are defined as mining; contract construction; manufacturing; communications, transportation, an public utilities; finance, insurance, and real estate; wholesale and retail trade; services; government; and agriculture.

[8] These projections were sometimes modified in the balancing phase of the system.

[9] A total employment series for agriculture, including wage and salary and all other classes of workers, is available from the U.S Department of Agriculture.

[10] The preliminary projections of wage and salary employment for the eight nonagricultural industry divisions and the fina projections of employment for the other classes of workers and total employment in agriculture were made through the use of multipl regression techniques. The independent variables used in the equations were the same as those in the regression equations used tc project detailed industry employment, and are described on page 6.

levels and/or in GNP, so that the system in 1975 was in balance in terms of expected productivity changes, civilian employment, and real GNP.

Three approaches were used in developing projections of detailed industry wage and salary employment requirements. The first approach involved the use of regression analysis to estimate employment in each industry consistent with the assumptions underlying the overall model. Equations were developed which related industry wage and salary employment in the 1947-66 period with different combinations of the following variables: Real GNP, national rate of unemployment, number of personnel in the Armed Forces,[11] civilian noninstitutional population 14 years old and over, and time. These variables were selected because they were considered strategic in determining longrun changes in aggregate employment and because they allowed cyclical and other factors to be separated from secular trends. Detailed industry wage and salary employment projections derived from the combination of variables providing the best statistical tests were tentatively selected as final estimates. (See table 1 for several examples of the model's results.)[12]

A second approach to projecting industry employment requirements involved the use of input–output analysis. Essentially, this technique requires that final demand (GNP divided into its components–investment, consumption, etc.) be specified by producing industry. The demand is then traced back through the chain of production to determine the output required from each industry supplying materials or services to produce the end product. For example, the final demand for automobiles creates an intermediate demand for steel, rubber, etc. The intermediate demand for steel will then create a demand for iron ore, coal, etc. By computing total output requirements for each industry (the sum of final and intermediate demand) in the target year, and relating it to expected output per man–hour in each industry, a projection of industry employment is obtained.[13] A complete set of projections were developed for 1970 and 1980 using this approach; 1975 projections were developed by interpolating the 1970 and 1980 data.

The third approach was to study industries individually and examine the factors expected to influence their future growth. This approach was used for industries in which past trends in employment were not considered indicative of future trends and for those industries for which the model provided unacceptable results (poor statistical tests or unreasonable employment projections). In this approach, a variety of regression equations were developed and tested. For example, in the motor vehicle manufacturing industry the variables which were tested in different combinations included personal disposable income, expenditures for producers' durable equipment, driving–age population, number of households, number of motor vehicle registrations, and number of families with more than $10,000 annual income. Where important, interindustry relationships were taken into account using this technique.[14] The equations for which the combination of variables provided the best statistical results were used to project employment in 1975. (See table 2 for several examples of equations tested to project employment in the apparel industry.) Considering the results obtained from the regression equations, the input–output analysis, the individual industry studies, and qualitative information concerning technology and the structure of the industry, employment projections were made for each detailed industry based on the best judgment of the analysts. Before these projections were considered final, they were reviewed for the following reasons: (1) To reconcile detailed industry employment projections with the preliminary broad industry employment projections previously made, and broad industry employment projections with the civilian labor force estimate, 1975, (2) to insure that productivity expectations, real GNP and civilian labor force estimates for 1975 were in balance, and (3) to make certain that the projections were consistent with the overall assumptions.

[11] Number of personnel in the Armed Forces was used to explain the impact of defense on the economy.

[12] Productivity was handled implicitly in the model. The implicit assumption for each detailed industry projection was that the trend in productivity in the 1947-66 period would continue into the future. (The productivity assumption, and consequently employment, were modified for some industries based on information from the Bureau's Office of Productivity, Technology, and Growth.)

[13] The description of the input-output process has been simplified. It is recommended that readers obtain a copy of *Projections 1970:* Interindustry Relationships, Potential Demand, Employment (BLS Bulletin 1536), for a complete description of the input-output technique.

[14] The total requirements for steel, for example, depend importantly on the output of such industries as automobiles, machinery, and fabricated metals. Therefore, an independent variable in the regression equation for an industry may be employment or production in other industries.

Table 1. Results of Employment Model for Selected Industries

(In thousands)

| Independent variables | Projected employment 1975 | Variables statistically significant (P = .95) | Standard error of estimate | $R^2$ | Durbin-Watson | Years of data |
|---|---|---|---|---|---|---|
| Household furniture (SIC 251) | | | | | | |
| A,B,C,D,E | 409 | B,D,E | 7 | .94 | 1.59 | 20 |
| A,B,C,D | 409 | A,D,E | 6 | .94 | 1.60 | 20 |
| A,B,D | 405 | A,B,E | 8 | .90 | 1.93 | 20 |
| Food and kindred products (SIC 20) | | | | | | |
| A,B,C,D,E | 1,609 | A,C,E | 9 | .91 | 2.15 | 20 |
| A,B,C,D | 1,710 | A,D,C | 12 | .87 | 1.30 | 20 |
| A,B,D | 1,702 | A,B,D | 14 | .80 | 1.13 | 20 |
| Apparel and related products (SIC 23) | | | | | | |
| A,B,C,D,E | 1,767 | A,D | 13 | .97 | 1.67 | 20 |
| A,B,C,D | 1,611 | A,B,D | 17 | .94 | .87 | 20 |
| A,B,D | 1,607 | A,B,D | 17 | .93 | .86 | 20 |

Note: A. Real GNP (constant dollars), B. National unemployment rate, C. Population over 14 years of age, D. Size of Armed Forces, E. Time.

Table 2. Selected Results of Regression Analysis for Employment in the Apparel Industry (SIC 23)

(In thousands)

| Independent variables | Projected employment 1975 | Variables statistically significant (p = .05) | Standard error of estimate | $R^2$ | Durbin-Watson | Years of data |
|---|---|---|---|---|---|---|
| A | 1,529 | A | 27 | .81 | .85 | 20 |
| A,B | 1,579 | A,B | 19 | .91 | .69 | 20 |
| A,B,D | 1,574 | A,B | 19 | .92 | .83 | 20 |
| A,B,D,F | 1,651 | A,B,F | 18 | .93 | 1.05 | 20 |
| A,B,D,E,F | 1,640 | A,B,F | 17 | .94 | 1.09 | 20 |
| A,C | 1,525 | A | 28 | .81 | .87 | 20 |
| B,C,F | 1,560 | B,C | 18 | .93 | .99 | 20 |
| A,B,C | 1,568 | B,C | 17 | .93 | .92 | 20 |
| A,B,C,D | 1,568 | B,C | 18 | .93 | .92 | 20 |
| A,B,C,E | 1,596 | B,C | 17 | .94 | 1.03 | 20 |
| B,C,D,F | 1,561 | B,F | 18 | .93 | .98 | 20 |
| B,C,G | 1,606 | B,C,G | 10 | .97 | 1.57 | 17 |
| C,E,F | 1,600 | C,F | 21 | .90 | 1.94 | 17 |
| B,C,F | 1,597 | B,F | 10 | .98 | 2.17 | 17 |
| A,B,C | 1,557 | B,C | 14 | .96 | 1.23 | 17 |
| A,B,C,E | 1,575 | B,C | 14 | .96 | 1.37 | 17 |
| A,B,C,G | 1,619 | B,C,G | 11 | .98 | 1.51 | 17 |
| B,C,G,F | 1,612 | B,C,F | 9 | .98 | 2.14 | 17 |

1/ Historical relationship between the output of SIC 23 as measured by the FRB index and total wage and salary employment as measured by BLS. The variable takes into account such factors as trends in industry organization, technology, average hours of work, and product mix, as they affect output and employment.

Note: A. Personal disposable income (constant dollars), B. National unemployment rate, C. Families with annual income over $10,000, D. Annual first difference population age 14-44, E. Work/output 1/, F. Time, G. Annual first difference population age 20-44.



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| Durbin-Watson | Years of data |
|---|---|
| .85 | 20 |
| .69 | 20 |
| .83 | 20 |
| 1.05 | 20 |
| 1.09 | 20 |
| .87 | 20 |
| .99 | 20 |
| .92 | 20 |
| .92 | 20 |
| 1.03 | 20 |
| .98 | 20 |
| 1.57 | 17 |
| 1.94 | 17 |
| 2.17 | 17 |
| ..23 | 17 |
| ..37 | 17 |
| 51 | 17 |
| ..14 | 17 |

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yment rate, tion age 14-44,

*Projections of occupational requirements*

Each industry in the economy requires a specific mix of occupations. The relative importance of particul occupations changes over time, however, in response to technological advancement and changes in scale c production, product mix, and organization of industries, among other factors. To reflect these circumstance occupational patterns for each industry in the economy were developed for 1960 and projected to 1975.[15] The patterns were developed on the basis of occupational trends between 1950 and 1966 as interpreted from availab data.[16]

*Data sources for the national industry–occupational matrix 1960*[17]

The main source of detailed and complete information for the national matrix for 1960 was the U.S. Censu Bureau's *Occupation by Industry* report based on the 1960 census.[18] The BLS occupation by industry matri however, differs from the census report in two major ways: (1) The BLS matrix was made consistent with othe sources of data; and (2) the BLS table makes use of occupational data from a number of sources considered preferab to decennial census data. It was desirable to make the matrix consistent with broad industry and occupational grou employment estimates available from the monthly household survey (CPS) so that full advantage could be taken c data available between decennial census years. The following occupational data were used in the BLS matrix i addition to the broad occupational group estimates from the CPS: Employment of scientists and engineers by industr based on BLS surveys of employers; employment of teachers and librarians based on data collected by the Office c Education; employment by occupation data collected by regulatory agencies for interstate industries includir railroads, airlines, telephone and telegraph communications, and pipelines; employment data collected by profession societies, especially for medical and health occupations; selected data from BLS industry and community wag surveys; information from the Post Office Department on employment by occupation in the Post Office; and Feder Civil Service Commission statistics on employment by occupation in other Federal Government agencies.

*Projection of the 1960 national industry–occupational matrix*

The projection of the occupational structure of each industry was based on examination of historical statistics an evaluation of other factors that might influence occupational structure, such as expected new technology, changes i the product mix and general organization of industries.

First, historical statistics on the changing occupational composition of detailed industries were projected by simp time trend. The trend for each industry–occupational ratio derived from census data[19] was extened to 1975, and th indicated change from the 1960 level was added to the appropriate ratio in the base period (196( industry–occupational employment table. A variety of other statistics[20] covering varying spans of time between 195 and 1965 was gathered and arranged to reveal evidence of trends in employment by occupation for particul industries or for the entire economy. Analysis was directed to finding the causes of past changes in occupation structure. An attempt was made to determine whether these factors were likely to continue to affect occupation structure in the period ahead to a similar, greater, or lesser extent. In developing the 1975 matrix, efforts were als made to uncover emerging technological and other factors which may have a significant impact on manpow requirements in the years ahead.

[15] The national industry-occupational matrix 1960 and 1975. (See appendices G and H to this volume.)

[16] For a description of sources and characteristics of occupational statistics, see *Occupational Employment Statistics, Sources a Data*, U.S. Department of Labor, Bureau of Labor Statistics, 1966.

[17] For a more complete description of the industry-occupational matrix and how it was projected to 1975, see *Occupation Employment Patterns for 1960 and 1975* (BLS Bulletin 1599).

[18] U.S. Bureau of the Census. U.S. Census of Population: 1960. *Subject Reports. Occupation by Industry. Final Report PC(2)-7* U.S. Government Printing Office, Washington, D.C. 1963.

[19] Some adjustments to the published census statistics were made for greater comparability between 1950 and 1960 as t industry classification of 1960 differed from that of 1950.

[20] Data for recent years were available on employment by occupation from the noncensus sources of occupational data describ above.

*Projecting occupational requirements directly*

For many occupations an analysis of the factors affecting employment was the basis for direct estimates of future employment requirements. The growth of each occupation is affected by its own complex set of social and economic variables. The number of teachers required, for example, is affected by the number of pupils (which in turn is affected by birth rates and trends in the proportion of children who attend school) and by trends in the ratio of teachers to pupils (which depend upon educational practicies and financing). The number of automobile mechanics required depends on the number of vehicles in use (which in turn reflects population growth, and levels of consumer income and business activity), the frequency with which they need repair, the relative costs of repair and of replacement of defective parts, and a variety of other factors. The requirements for physicians are related to the size of the population, the age distribution of the population, technological developments, and expenditures for health care. Other occupations that were projected directly include engineers and scientists, dentists, registered nurses, TV and radio repairmen, and business machine repairmen. For occupations in which the direct projection technique as well as the industry–occupational matrix approach were used, the differences in the employment projections were analyzed and reconciled.

Unless bases were found for modification, the effects on industry employment and occupational composition of social and technological trends in the post–World War II period were assumed to persist in the period to 1975.[21] Thus for many occupations, particularly those of small size, the initial projections– a continuation of past trends–were accepted. On the other hand, projection of ratios of large size were often modified from past trends on the basis of the analysis of underlying factors. As an increase or decrease in proportionate employment for one occupation in a particular industry requires offsetting changes in other occupations in the industry, few of the final occupational ratios that were as large as 1 percent were exact extensions of past trends.

The industry–occupational ratios for 1975 reflect the skill patterns that will be required by the technology of production in each industry in 1975. In developing these ratios no specific consideration was given to the availability of workers with the required skills. Yet many of the industry–occupational ratios for 1975 (particularly those of small size) are extensions of the changes in ratios reported for the period 1947-65. These ratios, therefore, embody a continuation of unidentified past adjustments to shortages (or increasing relative costs) for some of the occupations. Moreover, the occupational ratios were developed in relation to particular levels of national industry employment–those given in appendix B to this volume. Estimates of industry employment which differ appreciably from these may imply a difference in scale of operations or production methods and therefore a difference in the occupational structure of the industry.

[21] The numerous and fragmented sources of industry-occupational data, the varying time spans of this data, and the prevalence of different occupational concepts highlights the importance of judgment based on familiarity with occupations and industry processes in projecting industry-occupational structures.

Appendix B

# BLS projections procedures November 1985, Silvestre Lukasiewicz

For several decades, the Bureau of Labor Statistics has been preparing 5 to 15 year projections of the U.S. economy. Since the early 1970's, projections have been prepared on a regular 2-year cycle. The projections cover the future size and composition of the labor force, the rate of aggregate economic growth, industrial production, and industrial and occupational employment. The data serve a number of users who need information on future changes in the U.S. economy. The information on future employment opportunities by occupation, for example, is used by counselors, educators, and others helping young persons choose a career, and by officials who plan education and training programs.

Over the years, the procedures used to develop the projections have undergone many changes, as new data series were released and economic and statistical tools improved. Since the late 1970's, the BLS projection methodology has been relatively unchanged and it is that system which is described below.

The BLS projections are developed in a series of five steps each of which is based on a separate model: (1) labor force; (2) aggregate economic performance; (3) industry final demand and total industry production; (4) industry employment; and (5) occupational employment. While each of these five steps is conducted separately, the projection model used in each step depends upon inputs from the earlier step and feeds logically into the next. Although the models used to develop projections for each step in the process are complex, they provide only a framework for detailed analysis of the structure and composition of the economy in the future. As a result of detailed analyses, the models are run and rerun, assumptions are revised, and the results are reviewed until, in the judgment of the BLS staff, projections are achieved for all of the integral parts of the system which are both reasonable and internally consistent.

(1) The labor force projections, the first step in the BLS projections sequence, are determined by the future age, sex, and racial composition of the population and by trends in the labor force participation rates—the percent of a specified group in the population who will be working or seeking work. The population projections, prepared by the U.S. Bureau of the Census, are based on trends in birth rates, death rates, and net migration. With the population projections in hand, BLS analyzes and projects changes in labor force participation rates for 82 age, sex, and race groups.

The labor force participation rate projection for each group is developed by first selecting a trend rate of change based on participation rate behavior during 1962–1984 or for some subperiod which analysis indicates is more appropriate. Second, the rate is modified when the time-series projections for the specific group appears inconsistent with the results of cross-sectional and cohort analyses. This second step, in which many of the selected growth rates are averaged, ensures consistency among the various groups. Finally, the sizes of the anticipated labor force are calculated by applying the labor force participation rates to the population projections. The results are again reviewed for consistency.

(2) Aggregate economic performance–the second model in the BLS projection procedures–is developed by projecting the Gross National Product (GNP), and major categories of demand and income. Because the purpose of the BLS projections is to identify long-term trends, no attempt is made to project cyclical movements. The labor force and population projections are but two of many inputs used in the model. Alternative economic scenarios, usually three, are developed to provide controls for the various categories of demand and employment. The scenarios encompass a range of possible rates of growth. In later stages of the projection process, industry output and employment projections and occupational projections are developed that are consistent with the aggregate economic alternatives.

Wharton Econometrics developed the model used by the Bureau to project aggregate economic trends, in response to a competitive procurement process. The Wharton long-term model is a system of behavioral relationships and identities based on annual data and designed to allow an analyst to explore the determinants of medium- to long-term growth in the U.S. economy. Made up of approximately 2,400 equations, the model is driven by a set of 900 exogenous variables. Under the terms of this agreement, the Bureau uses the Wharton long-term macroeconomic model to develop the BLS projections. BLS analysts determine the assumptions and values for the exogenous variables and equation adjustments in the Wharton model.

The exogenous variables include true policy variables, such as various Federal transfer programs, the response of the monetary authority to growth in the economy, and the level of the armed forces. They also include variables for which other reliable and generally accepted projections are available, such as the population projections developed by the U.S. Bureau of the Census. Finally, the exogenous variables include those items which are too volatile or too politically determined to project. The former group includes such items as economic growth and inflation rates in the economies of the major trading partners of the United States and the long-term behavior of the U.S. dollar's exchange value. The latter group includes items such as energy prices.

It should be noted that the BLS does not rely on the Wharton model alone for projecting possible trends in the future. Rather, the model provides a framework for the preparation of a consistent set of economy-wide projections given a set of exogenous assumptions. BLS analysts then review the aggregate results for reasonableness. The review includes checks on internal consistency, evaluation of continuity with past trends, and comparisons with projections made by others. Although the review tends to focus on such items as GNP, unemployment, and productivity, the model's framework ensures that other important measures of economic performance are not overlooked.

(3) The BLS projection procedure then moves from the aggregate to the industrial level. For the industry output projections, the U.S. economy is disaggregated into 156 producing sectors that cover the U.S. industrial structure, both the public and private. The framework for this procedure is an input-output

model. The initial input-output data used by BLS are prepared by the Bureau of Economic Analysis, U.S. Department of Commerce.

The development of projections of industry output begin with the aggregate demand projections from the Wharton model. In this model, projections are made for 14 categories of consumption, 4 types of investment, 15 end-use categories of foreign trade, and 6 categories of government spending. A further disaggregation of the values from the model is then undertaken: purchases of producers' durable equipment, for example, is estimated for 107 consuming industries.

Furthermore, to develop industry output projections, provision is made to allow for shifts in the industrial makeup of a given demand category. This is accomplished by projecting "bridge tables" relating individual types of demand to producing industries. The bridge table is a percent distribution for each given demand category, such as for a consumption category or for investment, among each of the 156 industries in the BLS input-output model. In projecting changes in these bridge tables, expected changes in technology, consumer tastes or buying patterns, the industrial pattern of exports and imports, the future composition of each industry's business investment, and other structural factors are considered.

The next element in developing industry output projections is the projection of the input-output table which accounts for the changes in the input pattern or the way in which goods or services are produced by each industry. In general, two types of changes in these input patterns are made in developing a future input-output table: (a) those made to the inputs of a specific industry (as, for example, the changes in inputs in the publishing industry); and, (b) those made to the inputs of a specific commodity in all or most industries (as for increased use of business services across a wide spectrum of industries). These changes are based on studies of specific industries conducted internally or by other organizations both within and outside of government. Changing the input patterns in the future input-output table is the procedure used to accommodate the impacts of expected relative price changes, or future changes in technology. The output requirements by industry are developed by multiplying the projected input-output table, by the projected changes in the level, and in the distribution of final demand.

(4) The projected changes in industry employment are computed based on the projected changes in output and other factors. BLS uses a regression model containing an equation for each industry to estimate worker-hours as a function of (a) the industry's output, (b) aggregate capacity utilization, (c) the relative price of labor, and (d) a technology variable as approximated by the output/capital ratio. For each industry, worker-hours are converted into jobs using trends in average annual hours for that industry. In order to balance total employment from the aggregate projections with the sum of employment projections, a number of iterations of the process are necessary.

The projections of employment for the 156 producing sectors in the economic growth model are further disaggregated using a time series regression model into 378 industries that, with few exceptions, correspond to three-digit Standard Industrial Classification codes. The 378 resulting projections are reviewed in light of a broad range of economic information. These projections are then used as inputs into the process of projecting occupational employment.

(5) The model used to develop the occupational employment projections is an industry-occupation matrix showing the distribution of employment for 378 industries and for more than 550 detailed occupations. Occupation staffing patterns for the industries are based on data collected by State Employment Security Agencies and analyzed by BLS.

Staffing patterns of industries in the base-year industry-occupation matrix are projected to the target year of the projections to account for changes expected to occur because of technological change, shifts in product mix, and other factors. The changes introduced into the input-output model for expected technological change, as an example, may also change future staffing patterns in industries using the new technology. (For example, one would expect greater employment of computer specialists as computer technology spreads across industries.) The projected industry employment data are applied to the projected industry occupational staffing patterns, yielding employment by occupation for each industry. This is aggregated across all industries to yield total occupational employment for the projected year.

## Final review

An important element of the projection system is its comprehensive structure. To ensure the internal consistency of this large structure, the BLS projection procedure encompasses detailed review and analysis of the results at each stage for reasonableness and for consistency with the results from other stages of the BLS projections. For example, changes in staffing patterns in the occupational model are closely related to changes in industry productivity and technology projections are reviewed in detail by the BLS Office of Productivity and Technology. In short, the final results reflect innumerable interactions among staff members who focus on particular variables in the model. Because of this review, BLS' projection process converges to an internally consistent set of employment projections across a substantial number of industries and occupations. The continued cross-checking of the assumptions and results makes it difficult to quantify the effects of each change in each variable.

The projection process at the Bureau of Labor Statistics does not end with the development and publication of a set of projections. Once the target year is reached, BLS evaluates the average of the projections to determine what changes in assumptions or models would have made them more accurate. Knowing the sources of errors helps improve the projection process. It also highlights for users the imprecise nature of making statements about future economic, industrial activity, or employment growth.

## Appendix C

Occupational Employment in 1988
From Two Different Surveys

| | OES | CPS | OES-CPS (000's) |
|---|---|---|---|
| Executive & Administrative | 10.25% | 12.37% | -2112 |
| Professional | 12.99 | 13.02 | -346 |
| Technical | 3.27 | 3.06 | 346 |
| High Level Sales | 5.08* | 6.63 | -1614* |
| Retail Sales | 6.19* | 5.33 | 1183* |
| Clerical | 17.84 | 15.89 | 2808 |
| Protective Service | 1.80 | 1.69 | 185 |
| Private Household | .76 | .79 | -7 |
| Other Services | 13.08 | 10.85 | 2969 |
| Precision Production, Craft | 11.99 | 11.89 | 495 |
| Machine Operatives | 6.33 | 7.06 | -604 |
| Transport Operatives | 3.90 | 4.20 | -219 |
| Laborers | 4.14 | 4.23 | 28 |
| Farms, Forestry & Fisheries | | | |
| Owners & Managers | 1.07 | 1.12 | -14 |
| Laborers | 1.89 | 1.87 | +80 |
| Total | 100.00 | 100.00 | 3136 |
| Professional, Technical & Managerial | 25.91 | 28.41 | -2112 |
| Professional, Technical & Managerial and Sales Representatives and Managers | 30.99 | 35.04 | -3726 |
| Operatives, Laborers, Farm Laborers and Service Workers | 31.90 | 30.69 | 2396 |
| Operatives, Laborers, Farm Laborers, Service Workers and Retail Sales Clerks | 38.09 | 36.02 | 3579 |

Appendix D

## Analysis of Trends for Sales Occupations

Growth rates differ across sales occupations. This was determined by regressing the share sales job that were (a) sales clerks in retail and personal services (incl. other sales occupations), (b) sales representatives in finance and business services, (c) sales representatives selling commodities, and (d) supervisors and proprietors on time. The data conformed to the occupational definitions introduced in 1982. The results are given below:

C1) $(SalesClerk_t/SALES_t) = .4117 - .003136*(YEAR_t-2000)$ t=1982-1990
(4.21) R2 = .717

C2) $(SalesFin_t/SALES_t) = .1883 + .001611*(YEAR_t-2000)$ t=1982-1990
(2.38) R2 = .448

C3) $(SaleManag_t/SALES_t) = .3084 + .003303*(YEAR_t-2000)$ t=1982-1990
(14.19) R2 = .966

C4) $(SaleCommod_t/SALES_t) = .09185 - .001761*(YEAR_t-2000)$ t=1982-1990
(5.94) R2 = .834

It appears that the sales jobs which grew most rapidly during the 1980s tend to require the greatest amount of education and training.

Regressions were also estimated to examine the trend in the farm operator and manager share of all farm workers.

C5) $(FarmOper_t/FarmWkr_t) = .3486 - .002662*(YEAR_t-2000)$ t=1982-1990
(2.72) R2 = .514

## ENDNOTES

1. Steven Jobs, Speech at Stanford University, quoted in Henry Levin and Russell Rumberger, "Educational Implications of High Technology," Institute for Research on Education Finance and Governance, February 1983, p. 1.

2. Education Commission of the States, "The Information Society: Are High School Graduates Ready?" Denver, Colorado: Education Commission of the States, 1982, p. 1. quoted in Levin and Rumberger, Feb. 1983, p. 2.

3. Levin and Rumberger, Feb. 1983, p. i.

4. Russell Rumberger and Henry Levin, "Forecasting the Impact of New Technologies on the Future Job Market," Feb. 1984. pp. 1-32.

5. Russell Rumberger, "The Potential Impact of Technology on the Skill Requirements of Future Jobs," The Future Impact of Technology on Work and Education, ed. Gerald Burke and Russell Rumberger, Philadelphia, Pa., Falmer Press.

6. Henry Levin and Russell Rumberger, "Educational Requirements for New Technologies: Visions, Possibilities, and Current Realities" Educational Policy, Vol. 1, No. 3, 1987, p. 344.

7. Calculated from data in Deborah Pisetzner Klein, "Occupational Employment Statistics for 1972-82," Employment and Earnings, Jan. 1984, 13-16 and Employment and Earnings, Jan. 1990.

8. Employment and Earnings, January 1984 and January 1990, Table 56 and Table 60. Nominal weekly earnings figures were deflated by the CPI for all urban consumers which rose 24 percent between 1982-84 and 1989.

9. Marvin Kosters, "Wages and Demographics" presented at Wages in the 1980's, November 3 1989, a conference sponsored by the American Enterprise Institute.

10. John H. Bishop, "Achievement, Test Scores and Relative Wages," paper presented at the Conference on Relative Wages in the 1990s, American Enterprise Institute, November, 1989.

11. Levin and Rumberger, "Educational Requirements for New Technologies: Visions, Possibilities, and Current Realities," 1987, p. 338.

12. Max Carey, "Occupational employment growth through 1990," Monthly Labor Review, August, 1981, pp. 42-55.

13. George Silvestri, John M. Lukasiewicz and Marcus E. Einstein, "Occupational Employment Projections through 1995," Monthly Labor Review, November 1983, pp. 37-49.

14. Gloria Peterson Green, Khoan tan Dinh, John A. Priebe and Ronald R. Tucker, "Revisions in the Current Population Survey Beginning in January 1983," Employment and Earnings, February 1983, pp. 7-15. For managers this involved adding accountants, personnel and labor relations workers and inspectors, n.e.c. to and subtracting ships officers and conductors from both the 1978 base and the 1990 projection. For professional workers it involved adding decorators and window dressers and health trainees and subtracting accountants, personnel and labor relations workers, computer programmers and sales engineers. When separate data was not available for some of the smaller occupations that were reclassified, they were left in the major group they had been prior to 1983. The BLS has published CPS based yearly estimates of employment by major occupation all the way back to 1972 using the 1980 Census classification system in Deborah Pisetzner Klein, "Occupational Employment Statistics for 1972-82." This data series was used to calculate actual percentage rates of growth and actual shares of employment growth. Thus percentage growth calculations are based on definitions of major occupation that are consistent over time but there are slight differences in the detailed occupations included in a major occupation for the two calculations. The data on 1989 employment is from Employment and Earnings, Jan. 1990.

15. This characterization of how occupational staffing patterns were projected is based on Bureau of Labor Statistics, Handbook of Methods, Bulletin 2134-1, 1982, pg. 143, and conversations with Ron Kutscher.

16. Bureau of Labor Statistics, Handbook of Methods, Bulletin 2134-1, 1982, pg. 143.

17. Deborah Pisetzner Klein, "Occupational Employment Statistics for 1972-82," 13-16.

18. The occupation share predictions that result from assuming constant logarithmic rates of change do not sum to one, however. To assure that final predicted shares sum to one, the first stage predicted shares were summed and then new final predicted shares were calculated by dividing the initial prediction for each occupation by this sum. The logarithm of the share not the share itself was extrapolated because declining occupations are eventually predicted to have a negative number of workers when a linear specification is used. If linear extrapolation had been substituted, the average absolute value of the prediction error would have been slightly higher--7.15 percent of the 1980 baseline levels of employment.

19. The regression model predicts a lower high skill share of employment growth than the simple extrapolations because controlling for the unemployment rate lowers the estimated time trends for high skill occupations. The unemployment rate was 7.2 percent in 1980 and this raised the share of professional employment and depressed the share of blue collar employment in that year. The regression models corrected for this effect. Using 1980 as the final year of the base period for calculating the extrapolation growth rates, however, had the effect of raising the rates of growth for professionals and other white collar occupations and making more negative the share decline rates of blue collar occupations. These growth rates happened to be better approximations of what was about to happen than the regression estimated trends.

20. Projected and actual employment levels for 1974-75 are from Max Carey, "Evaluating the 1975 Projections of Occupational Employment," Monthly Labor Review, June 1980, p. 14. Estimates of occupational employment levels in 1966 are from BLS, Tomorrow's Manpower Needs: Vol. III, 1969, p. 4. Comparisons are made with actual levels of employment in 1974 rather than 1975 because 1975 was a period of deep recession. The forecast had assumed that the unemployment rate would be 3 percent in 1975. It was thought that 1974 was a closer approximation to the tight economy that had been assumed in the forecast.

21. Max Carey and K. Kasunic, "Evaluating the 1980 Projections of Occupational Employment," Monthly Labor Review, July 1982, pp. 22-30.

22. Bureau of Labor Statistics, Tomorrow's Manpower Needs: Volume IV. Bulletin 1606, Feb. 1969, US Department of Labor, p. 9.

23. Silvestri and Lukasiewicz, p. 59.

24. This same phrase was also used by Faye Duchin in describing how she and Leontief felt when they projected major declines in the employment of draftsmen and clerical workers as a consequence of the growth of micro-computer technology.

25. Telephone conversation with BLS analyst. May 1990.

26. In 1989 median weekly wages for full time wage and salary workers in sales jobs included in the high skill category were $561 for sales representatives, commodities except retail, $502 for sales representatives in finance and business services and $424 for supervisors and proprietors. Median weekly wages for the other high skill occupations were $583 for managers, $586 for professionals and $475 for technicians. In contrast, median weekly wages for the low skill occupations were $235 for sales workers in retail and personal services, $253 for service occupations, $323 for operatives, fabricators and laborers. Between 1983 and 1989 the ratio of high skill occupation wages to low skill occupation wages rose from 1.68 to 1.88.

27. George Silvestri and John Lukasiewicz, "Projections of Occupational Employment, 1988-2000," Monthly Labor Review, November 1989, pp. 42-65.

28. Sensitivity testing of the forecasts is essential because there are only 18 years of data on which to estimate the forecasting model, some of the regressors are collinear and theory does not yield only one plausible specification. Inevitably the coefficients estimated on variables like the trade deficit and personal computer use will not be estimated with the precision one desires. Under these circumstances, out of sample predictions may be sensitive to small changes in specification and it is important to know just how sensitive the forecasts are to specification of the forecasting model.

29. The estimates of the number of PCs in use in business were made by Future Computing/Datapro Inc and can be found in Table 1340 of The Statistical Abstract, pg. 179. They are derived by cumulating numbers of machines sold. A very low scrap rate of 3.4 to 6 percent depending on the year was assumed. Where possible vendor reports were used to allocate sales of computers between categories of end user--business, education and home. Quite often, however, rules of thumb were used to

make these allocations. Future Computing is no longer in business so more detailed information on how the series was constructed and data for 1989 are not available. Point estimates of PCs in use were made for 1989 and for 1979-80 by extrapolation.

30. According to Future Computing, there were 20,330,000 PCs in use in private business in 1988. An alternative source of data, the COMTEC survey of a stratified random sample business, governmental and non-profit establishments, yields a substantially smaller estimate of the number of PCs in use. The 1989 COMTEC survey estimates there were 9,693,000 microcomputers and 10,462,000 CRT terminals and dedicated word processors in use at workplaces outside of the education sector. Bureau of the Census, "Computers in the Office," Statistical Abstract 1990, pg 943-952. The large discrepancy between these two data sources appears to be due to: (a) the very low scrappage assumed by Future Computing, (b) inflation of sales figures by some of the vendors supplying data to Future Computing (c) delays in the actual installation of the computers, (d) the allocation to business of some PCs that the COMTEC survey appears to place in schools, (e) the exclusion of zero employee firms and home offices from the COMTEC survey and (f) problems with the Dun & Bradstreet list of establishments. The Future Computing data series was used in the analysis because it is available for a longer span of time and because there did not appear to be a good way of extending the series on CRT terminals back into the 1970s. To project this variable ten years into the future, we need an estimate of the possible extent of the eventual workplace market for these machines. Conventionally comparisons are made with white collar employment. The education industry needs to be excluded from both numerator and denominator because students not teachers are the primary users of PCs. Point of sales terminals are not included in the counts of PCs or workstations, so retail sales clerks also need to be excluded from the denominator. The Future Computing estimate of PCs is equal to 37.5 percent of the number of white collar employees minus teachers and sales clerks. In Comtec data, the ratio of PCs to white collar employees who are not teachers or retail clerks was 17.4 percent and the ratio for workstations of all kinds was 35.5 percent. To us, there appears to be considerable room for current levels of PC use to grow, so we assume that it doubles from current levels. THe substitution of Comtec data for Future Computing data does not change our forecasts for the year 2000 as long as one retains the assumption that the year 2000 impact of the PC will be slightly more than double its 1989 impact.

31. The baseline for the forecasts is CPS occupational employment estimates for 1988. Projected total employment in 2000 is 132,594,000 derived by multiplying 1988 employment by 1.1533. The antilogs of the intercept terms for the 13 occupations were multiplied by 1.1533 to produce first stage estimates of occupational employment in 2000. The sum of the first stage forecasts generally exceed 132,594,000, so 1.1533 was replaced by a new multiplier which is calculated so that aggregate employment in 2000 is equal to 132,594,000. To assure comparability with the regression forecasts based on CPS occupational data, the BLS projected rates of increase are applied to the same 1988 CPS occupational employment estimates. No effort was made to adjust our forecasts for the anticipated decline in employment in the defense industries because these industries are only slightly more skill intensive than other industries. The professional, technical and managerial share of employment is 30.4 percent in electrical and electronic machinery, 26.5 percent in transportation equipment and 30.7 in

instruments and related products. For the economy as a whole this share is 28.45 percent in CPS data.

32. Because of compounding, a logarithmic specification produces higher forecasts for rapidly growing occupations than a linear specification. Using a linear specification lowers the forecasted growth of managerial jobs by 970,000 but has little effect on forecasted growth of professionals, technicians and sales workers. Two further tests of sensitivity to functional form were conducted. It was assumed that the growth of an occupation's share of employment followed a logistic function with ceilings at 20 and 25 percent. These logistic specifications were then used to forecast employment shares in the year 2000. These specifications lowered the predicted growth of managerial employment by 1,315,000 and 928,000 respectively but had little effect on the predicted growth of the other high skill occupations.

33. The forecast based on PCUSE reaching 30 percent of civilian employment in 2000 reflects a conservative view that most (70 percent) of the impact of the microcomputer revolution has already been experienced. The Gartner Group, one of the leading marketing consultant firms serving this industry, is a proponent of this view. They argue that the market for workstations--PCs and CRTs--will approach saturation in 1995. They base this forecast on an analysis which compares the number of installed workstations (owned by the firm and in use anywhere in the firm) to desk workers and assumes that the total number of workstations will not exceed the number of desk workers. In 1989 only 64 percent of white collar workers were considered desk workers down from a 69 percent share in 1984. But at many companies PCs and CRTs are currently used by blue collar workers for statistical process control and keeping track of inventory. They are also often used by white collar workers who are not classified as desk workers. This means the ratio figures calculated by the Gartner group exaggerate the proportion of deskworkers who currently have a workstation on their desk and that there is potential for further growth of PC use by workers who do not work at a desk. The power of the machines is increasing and new applications for them are being developed, so their impact on work will continue to grow, even when the total number of workstations eventually stops growing. This is why our baseline forecast took the view that the micro-computer revolution will not have played itself out by the year 2000 and that by 19899 we had experienced only 47 percent of the changes in occupational demand that the technology will generate by the year 2000.

34. Jon Sargent and Janet Pfleeger, "The Job Outlook for College Graduates to the Year 2000: A 1990 Update" Outlook Quarterly, Summer 1990, 1-12 and "1988-2000--Outlook for College Graduates," excerpts from BLS Technical Memorandum, 1990.

35. Census Bureau studies have also found that between 5.5 and 9 percent of respondents who are recorded to have a college degree in one interview are not recorded as having a degree in a later interview. (Bureau of the Census, "Effects of Different Reinterview Techniques on Estimates of Simple Response Variance," Evaluation and Research Program of the U.S. Censuses of Population and Housing 1960, Series ER60 No. 11, Tables 30 and 46).

36. Irwin Kirsch and Ann Jungeblut, Literacy: Profiles of America's Young Adults, National Assessment of Educational Progress, Educational Testing Service, 1986, Table 6, p. 40.

37. Comparisons of percentage rates of change are much less sensitive to arbitrary assumptions regarding which jobs "require a college degree" than comparisons between numbers of openings requiring a degree and the growth in numbers of college graduates. The BLS approach to comparing supply and demand depends critically on analyst judgments regarding which jobs "require a degree" now and which jobs will require a degree 10 years in the future. Ours does not.

38. The no policy change projection of the increase in the stock of workers with 16 or more years of schooling was developed in the following manner. We project that an average of 1,001,000 BAs will be awarded each year during the early 1990s, a 3.7 percent increase from the level that prevailed from 1980 to 1987 (Digest of Education Statistics, Table 200). The number of 17 year olds is now 13 percent below its 1979/80 peak and will fall another 10 percent by 1993/94. If educational policies and the payoff to college do not change, we do not project further increases in BAs awarded because the declining size of the 21-24 year old age cohort is assumed to offset a projected 10 percent rise in the proportion of the age cohort that obtains a BA. Immigration of people with a college degree was about 100,000 per year in the first part of the 1980s and this flow is assumed to continue (data provided by George Borjas). Adkins reports that for every 100 individuals with a BA degree there are about 12.5 individuals reporting 16 or more years of schooling without having a BA or first professional degree. (Douglas L. Adkins, The Great American Degree Machine. The Carnegie Foundation for the Advancement of Teaching, 1975, p. 65) Therefore, our estimate of the flow into the college graduate category is obtained by multiplying 1.1 million by 1.125. The share of the flow of new college graduates assumed to be employed was set equal to the labor force participation rate for this group, .90. The result was a projection of 13,363,000 individuals added to the stock of employed college graduates over the 12 year period. In the March 1988 CPS, there were 3,018,000 college graduates over the age of 65, 3,245,000 between 55 and 64 and 4,982,000 between 45 and 54 years of age. Their labor force participation rates were .906 for 45-54 year olds, .706 for 55-64 year olds and .222 for those 65 and over. (Bureau of Labor Statistics, "Educational Attainment of Workers: March 1988" July 1988). Based on life tables, the estimated 10 year survival rate is .9083 for the 45-54 year old college graduates and .8136 for the 55-64 year old group. (Statistical Abstract, 1990, Table 108). An estimate of the number of college graduates from the 45-64 year old group in 1988 that are still in the labor force 10 years later was obtained by multiplying the population figures by the survival rate and then by the labor force participation rate for the next older group. Exits from the labor force for the 12 year period were estimated to be 1,585,000 of the age 45-54 in 1988 group, 1,729,000 in the 55-64 in 1988 group and 670,000 (all) of those over 65 in 1988. Thus, the projected net growth in the number of college graduates over the 12 year period is 9,379,000 from a 26,812,000 level in 1988. BLS predicts an almost identical--9,105,000--increase in the college graduate labor force (BLS, "1988-2000 Outlook for College Graduates, unpublished technical memorandum, 1990).

39. Bureau of Labor Statistics, Employment and Earnings, Jan. 1988 and Jan. 1990, Table 56, pg. 226-230 and May 1990, Table C4, p. 108.

40. The upsurge of anti-semitism in the Soviet Union has stimulated a massive increase the emigration of Soviet Jews. American immigration policy denies them the opportunity of coming to a country that could use their specialized skills and has plenty of vacant housing and forces them instead to go to a country that needs carpenters and mechanics not violinists and mathematicians and which does not have sufficient housing to absorb the influx.

41. About 21 percent of the freshman in October 1985 did not return the following fall and 27 percent of the sophomores did not return. Nabeel Alsalam, The Condition of Education: 1990, Volume 2, Postsecondary Education, National Center for Education Statistics, 1990, p. 26.

42. see Ronald Kutscher, "Changing Skill Requirements: Evidence from Secondary Sources--Analysis Using the Bureau of Labor Statistics Occupational Projections," Office of Employment Projections, Bureau of Labor Statistics, May 1990, and Wasily Leontief and Faye Duchin, The Future Impact of Automation on Workers.