NORTH CAROLINA'S FUTURE JOB MARKET AND POLICY RESPONSES

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Is Education Enough?

Economists use the term "human capital" as a shorthand for the skills, training, and formal educational levels of the workforce. As the 20th century progressed - and certainly in the 21st century - the development of human capital has become the focus for the economic improvement of nations as well as states.

There are three reasons for the elevated importance of human capital. One is the shift from "brawn power" to "brain power" as the major contribution of a worker. Since the days of the Industrial Revolution and continuing with today's Information/Technology Revolution, tasks requiring physical power and even routine applications have increasingly being accomplished by machines and technology. Workers with talents in management, analysis, problem-solving, and innovation are now in high demand. These are skills that use cognitive abilities and are usually based on higher levels of formal education.

A second reason for concentrating on the development of human capital is the recognition of the rewards provided to human capital are in the marketplace. Therefore, for workers to achieve better wages and salaries, they will need enhanced levels of human capital. This factor becomes increasingly important as technological improvements expand the number of tasks that can be done by machines and electronic devices in place of workers.[1]

Combining the above two observations leads to the third reason – that for an economy to grow – whether it be at the national or state level – workers need to be equipped with sufficient human capital. Amounts of human capital are a main – and perhaps *the* main – factor in determining advances in an economy's aggregate economic growth, and by extension, advances in an economy's standard of living.

North Carolina has made strides in improving its human capital. Figure 4-1 shows the percentage point changes in the early 21st century in adults with various levels of educational attainment in the state and the nation. For each of the three educational attainment levels examined – high school graduate or higher (HS or more), bachelor's degree or higher (Bach or more), and advanced degree or higher (Adv and more) - North Carolina's gains have been better than in the nation.[2] If North Carolina's superior gains continue at the same rate, then the state would catch-up to the nation in high school attainment by 2024, in bachelor's degree attainment by 2042, and in advanced degree attainment by 2056.[3]

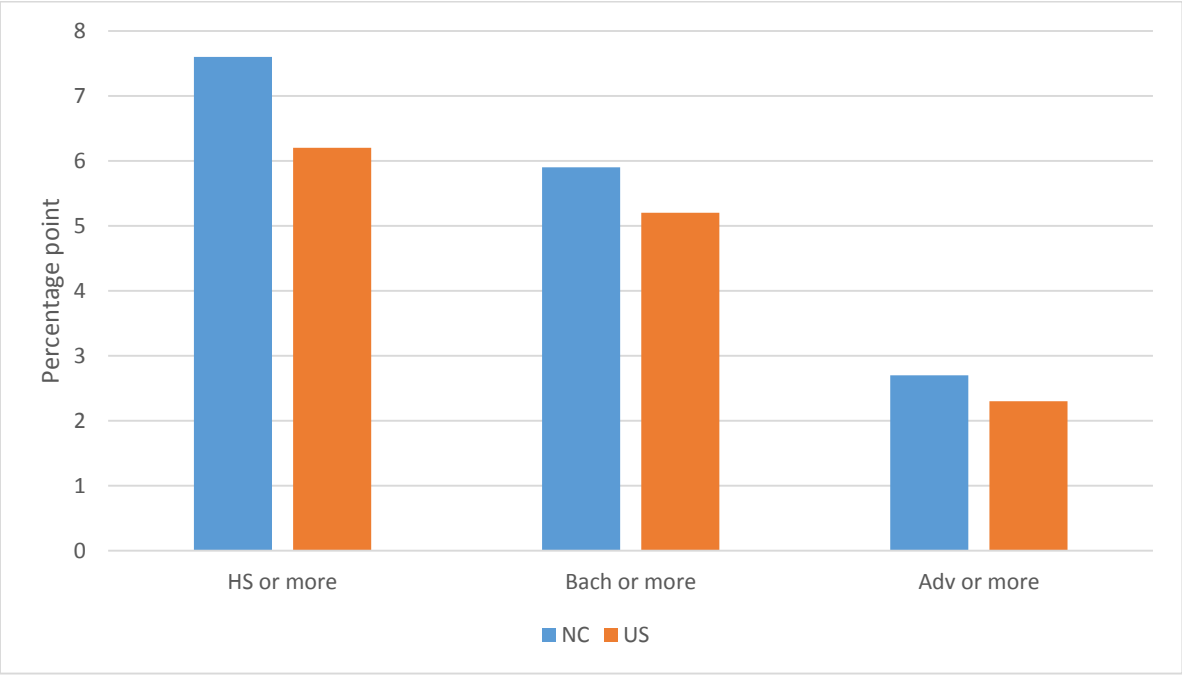
North Carolina looks even better when comparing measures of educational performance. The National Assessment of Educational Progress (NAEP) is considered the "gold standard" for measuring learning achievement at the elementary school level. Beginning in the early 2000s for mathematics, North Carolina 4th graders consistently scored better than their national counterparts, and 8th graders scored either the same or better. For reading, 4th graders scored better or higher than their national counterparts since the mid-1990s. Only 8th graders taking the math test have scored lower than their national counterparts in a few years since the late 1990s.[4]

These comparisons are important because a large body of research suggests training and skill levels of the workforce are key factors in explaining differences in economic growth

between states.[5] Further, some research indicates these skill level differences will become even more important in the future in attracting economic growth.[6]

But will this be enough to raise the productivity and standard of living of North Carolina workers in the 21st century? In the past the answer has been "yes", but is the past no

Figure 4-1. Gains in North Carolina and U.S. Educational Attainment, 2000-2013 (% point change for adults age 25 and over).



Source: U.S. Census Bureau, U.S Statistical Abstract; American Community Survey.

longer a prologue to the future? Will the nature of work, and the quantity of work, be dramatically different in the 21st century than in previous eras?

An End to Work?

In the 21st century, the traditional categories of jobs – white collar, blue collar, manufacturing, service – have increasingly become obsolete. Instead, what a worker can do - that is - the tasks a worker can perform, is now the preferred measure for worker classification.

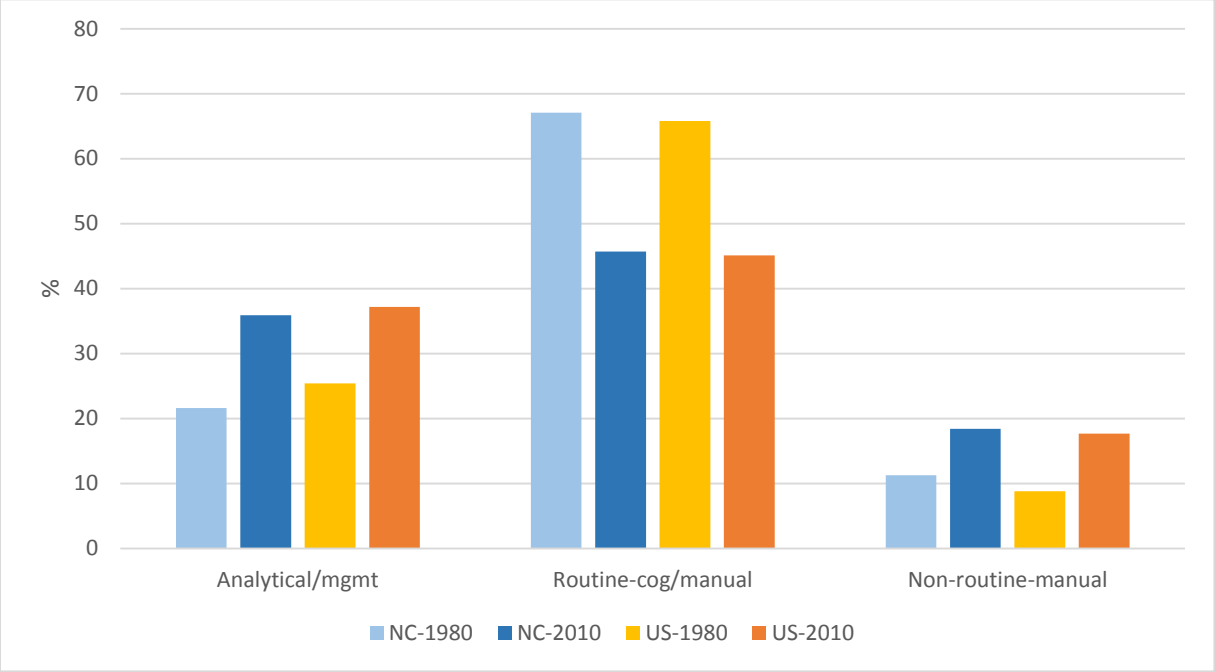
Researchers today think of jobs categorized into three broad groupings of tasks.[7] *Abstract analytical and managerial tasks* require creativity, hypothesis formation and testing, and problem-solving skills. *Routine cognitive and manual tasks* are performed in a logical, repetitive process requiring little variation or thought. *Non-routine manual tasks* require flexibility and adaptation to observed situations that vary enough as to not be applicable to routine and repetition.

Abstract analytical and managerial tasks are those requiring the highest levels of educational training. They have benefited most from the technological and digital revolution and the increase in societal demand for individuals working in scientific fields and complex organizations. Routine cognitive and manual tasks have been those most susceptible to performance by technology and machinery, and thus individuals performing these tasks have been significantly adversely impacted from "technological unemployment". Non-routine manual tasks have grown with the expansion of the personal service economy, but their formal training requirements – and thus their compensation – have tended to be low.

Recent changes in the distribution of employment among the three "task" categories are shown for both North Carolina and the nation in Figure 4-2.[8] Several trends are clear. Analytical and managerial task positions rose substantially in both the state and the nation in the late 20th and early 21st centuries, increasing their share of all jobs by 50% to over one-third of the total in 2010. Non-routine manual task jobs almost doubled their share to near 20% in 2010 for North Carolina and the nation. The relative gains in these two task categories were at the

expense of routine cognitive and manual task jobs, whose share declined by approximately 20 percentage points for the state and the nation during the three decade period.[9]

Figure 4-2. Distribution of U.S. and North Carolina Workforce Between "Task" Job Categories, 1980 and 2010 (workers 16 years and older).



Source: U.S. Census Bureau.

Certainly the relative decline of routine task jobs, whether cognitive or manual, has been a result of advances in labor-replacing technology and machinery, whereas these substitutions have been more difficult to make in the analytical/management and non-routine-manual task jobs. This point is reinforced by noting that measures of labor productivity gains have been far greater for routine cognitive and manual task jobs than for the other task categories.[10]

The questions are whether these trends will continue for routine task jobs and if they could even be extended to the two other task categories, especially with significant advances in

artificial intelligence.[11] Frey and Osborne recently performed a detailed analysis of the U.S. labor market which assigned a probability of an occupation's replacement by computerization (their term for technological unemployment).[12] Their probability rates were based on detailed analysis of over 700 occupations and an assessment of the likelihood of each occupation's tasks eventually being accomplished by either programming or machine technology. The researchers' conclusion was that 47% of U.S. employment in 2010 could eventually be replaced by technology in upcoming decades. Of course, the U.S. labor market has always been dynamic, continually creating new occupations while downsizing others. Yet Frey and Osborne's conclusion suggests an acceleration of the occupational reorganization that has recently occurred.[13]

The Frey/Osborne methodology was applied to North Carolina's occupational structure in 2013, and the results are given in Table 4-1. Using the same categorizations as Frey/Osborne, just under half of the occupations (44%) and employees (48%) face a high probability (over 70%) of replacement by technology. Another approximately 20% of occupations and employees have a moderate (31% to 70%) chance of technology replacement, and close to a third of occupations and employees have a low (0% to 30%) likelihood of replacement by technology.

There is a trend in the salaries of the three groups with an inverse relationship between the probability of technology replacement and median salary. The median salary of the lowest probability group is almost double that of the highest probability group. The same inverse relationship can also be seen between the probability of replacement and the highest occupational salary of the group. Again, the highest salary of the lowest probability group is close to double the highest salary of the highest probability group.

Tables 4-2, 4-3, and 4-4 list the North Carolina occupations with 10,000 or more

Table 4-1. Projected Occupational Changes in North Carolina from Technology Replacement.

Probability of Replacement by Technology	*Number of Occupations (% of total)*	*Number of Employees (% of total)*	*Median Salary*	*Low Salary/ High Salary*	*For 10,000 or more Employees, Percent of Occupations Paying over $55,000*	*For 10,000 or more Employees, Percent of Occupations Paying under $30,000*
0-30%	262 (37%)	1,245,150 (32%)	$57,370	$19,910/ $215,780	48%	14%
31-70%	133 (19%)	775,700 (20%)	$39,940	$19,410/ $107,580	11%	44%
71-100%	307 (44%)	1,882,190 (48%)	$33,110	$17,830/ $122,020	8%	63%

Source: Author's calculations using Frey/Osborne methodology applied to North Carolina 2013 occupational data from the North Carolina Office of Employment Security.

employees in each of the three technology-replacement categories, arrayed in each table from lowest to highest probability of technology replacement. There is, of course, a variety of occupations in each group, but there definitely are patterns in both the tasks and earnings of the occupations. Most of the occupations with a low probability for technology replacement (Table 4-2) involve non-routine cognitive tasks in the supervisory, health care, technology, legal, and protective and personal services industries. Almost half of the occupations have earnings over $55,000, while only 14% pay under $30,000 (Table 4-1). The occupations with a moderate likelihood of replacement by technology (Table 4-3) include several manual occupations in construction, food production, delivery, and personal services – occupations which could be replaced by technology if sufficient advances were made in artificial intelligence to allow performance of non-routine tasks. Four times as many of the occupations have earnings under $30,000 as have earnings over $55,000. Occupations with the highest chance of technological replacement (Table 4-4) are overwhelmingly composed of routine cognitive and manual jobs

Table 4-2. North Carolina Occupations with Greater than 10,000 Employees and a 0% to 30% Probability of Replacement by Technology (ranked from lower to higher probability of replacement).

Occupation	*Number of Employees*	*Annual Earnings*
Supervisors of mechanics, installer, repairers	15,340	$59,610
Physicians and surgeons	17,880	$200,000
Elementary school teachers	40,430	$42,870
Computer systems analysts	16,210	$84,760
Pre-school teachers	11,300	$25,530
High school teachers	24,190	$43,510
Registered nurses	88,350	$59,290
Supervisors of offices	38,070	$49,910
Supervisors of production facilities	21,370	$55,430
Nursing assistants	50,990	$22,860
College teachers	50,800	$75,000
Lawyers	11,820	$114,840
Computer systems managers	11,440	$129,280
Software developers	20,190	$92,410
Emergency medical technicians	10,430	$31,980
Licensed practical nurses	15,550	$41,570
Financial managers	15,210	$127,320
Supervisors of non-retail sales workers	10,370	$90,870
Childcare workers	22,500	$19,910
Law enforcement officers	19,630	$40,940
Management analysts	11,230	$84,330
Electricians	12,960	$39,890
General and operation managers	52,080	$125,240
Firefighters	12,800	$32,720
Supervisors of construction	18,200	$54,410
Middle school teachers	17,470	$42,160
Web and network developers	31,720	$60,000
Business operations specialists	28,240	$69,170
Supervisors of retail sales workers	42,890	$40,930
Medical assistants	13,890	$29,390

Source: Author's calculations using Frey/Osborne methodology applied to North Carolina 2013 occupational data from the North Carolina Office of Employment Security.

Table 4-3. North Carolina Occupations with Greater than 10,000 Employees and a 31% to 70% Probability of Replacement by Technology (ranked from lower to higher probability of replacement).

Occupation	*Number of Employees*	*Annual Earnings*
Human resource specialists	12,430	$58,580
Packers	27,460	$21,360
Home health aides	47,860	$19,410
Customer service representatives	83,650	$31,550
Teacher assistants	33,070	$22,640
Auto service technicians	20,980	$39,130
Correctional officers	17,150	$31,890
Meat packers	10,180	$24,250
Market research analysts	12,130	$67,050
Supervisors of food preparation	33,160	$31,840
Maintenance and repair workers	39,810	$37,240
Stock clerks	47,310	$23,700
Machinists	11,530	$37,550
Heating and air conditioning installers	10,800	$39,690
Production worker helpers	17,280	$23,850
Janitors and cleaners	53,940	$21,730
Delivery service drivers	22,410	$32,550
Maids	28,820	$19,530

Source: Author's calculations using Frey/Osborne methodology applied to North Carolina 2013 occupational data from the North Carolina Office of Employment Security.

prominently in the food service, retail, hospitality, sales, and financial sectors.[14] Almost two-thirds of the occupations have earnings under $30,000, while less than 10% have earnings over $50,000.

A conclusion of this analysis is that a large number of lower and middle-paying occupations face significant downsizing, while many higher-paying occupations are much safer from technological encroachment.[15] The question then becomes, where will those workers in the lower and middle-paying occupations go? Will new similar paying occupations be developed? Or will these workers need to substantially upgrade their human capital in order to move in to non-routine cognitive occupations?

Table 4-4. North Carolina Occupations with Greater than 10,000 Employees and a 71% to 100% Probability of Replacement by Technology (ranked from lower to higher probability of replacement).

Occupation	*Number of Employees*	*Annual Earnings*
Amusement and recreation attendants	10,520	$18,520
Personal care aides	13,740	$19,430
Bartenders	10,170	$20,810
Dishwashers	12,550	$17,980
Heavy truck drivers	48,370	$38,480
Medical secretaries	10,780	$30,200
Security guards	26,380	$24,880
Moving laborers	73,580	$25,280
Sales personnel in wholesaling and manufacturing	43,270	$60,070
Executive secretaries	25,060	$46,530
Food preparation workers	20,430	$20,290
Construction laborers	16,470	$25,920
School bus drivers	16,890	$24,850
Pharmacy technicians	11,680	$28,090
Retail salespersons	139,330	$24,430
Fast food restaurant workers	134,960	$17,830
Industrial truck drivers	19,250	$29,880
Accountants	29,000	$68,970
Waiters and waitresses	76,860	$18,890
Bill collectors	11,840	$32,490
Landscaping workers	27,360	$23,740
Receptionists	28,340	$26,220
Office clerks	68,750	$27,220
Cafeteria and coffee shop attendants	11,880	$18,160
Secretaries, except medical, legal, and executive	63,020	$32,790
Restaurant cooks	32,640	$21,340
Bill clerks	15,740	$33,610
Team assemblers	38,530	$28,040
Cashiers	106,010	$18,950
Counter and rental clerks	11,570	$24,860
Restaurant hosts and hostesses	12,430	$17,950
Inspectors and testers	18,870	$34,030
Bookkeeping clerks	43,900	$35,150
Driver/sales workers	14,390	$27,770
Shipping and receiving clerks	20,980	$30,280
Packaging machine operators	14,070	$30,320
Tellers	12,480	$27,690
Loan officers	10,400	$71,870
Other sales representatives	18,980	$63,170

Source: Author's calculations using Frey/Osborne methodology applied to North Carolina 2013 occupational data from the North Carolina Office of Employment Security.

Dueling Forecasts

A first step to answering these questions is to attempt to forecast the number and kinds of jobs in a future North Carolina. Projecting occupational and employment trends decades in advance is obviously a heroic undertaking. Therefore, it is wise to use alternative approaches in order to see the degree of consistency and range in the estimates. Two different methods are used. The first applies the detailed occupational forecasts of the U.S. Department of Labor to North Carolina's occupational structure in 2013 to develop forecasts for 2022 (the last year in the U.S. Labor Department's forecast). The forecasts are then extended to 2050 using the implied trend between 2013 and 2022.[16] The second method applies the technology replacement rates from Frey/Osborne to occupations and then augments the results by the forecasted growth rates in the occupation's industry from the U.S. Department of Labor's forecasts and by the rate at which employment changes with changes in economic output.[17] So, for example, if Frey/Osborne indicated fast food workers faced a 92% probability of replacement by technology, yet the fast food industry was expected to expand by 50% with a 1% growth in employment for every 2% growth in output, then the forecasted number of fast food workers would be found by reducing today's number by 92% and then increasing the result by 25% (50% x ½).

The results are presented in two ways – first using the three-part task classifications and second using the major industry sectors within each task category. In both cases the percent of the total workforce as well as the employment numbers are presented.

Table 4-5 shows the U.S. Department of Labor (DOL) forecasts are fairly optimistic. The 42% increase in the number of jobs is well above the estimated 36% increase in total population and 30% increase in working age (25 – 64 years of age) population.[18] DOL also sees

Table 4-5. Alternative North Carolina Employment Forecasts from 2013 to 2050.

	U.S. Dept. of Labor	Frey/Osborne
Total jobs, percentage change, 2013-2050	*42%*	*-32%*
Analytical/management share % pt. change	+8 % points	+26 % points
Routine cognitive/manual share % pt. change	-9 % points	-17 % points
Non-routine manual share % pt. change	+1 % point	-9 % points
Change in analytical/mgmt. task jobs	+1,044,810	+288,439
Change in routine cognitive/manual task jobs	+327,532	-1,125,263
Change in non-routine manual task jobs	+366,880	-460,723

Source: U.S. Bureau of Labor Statistics, U.S. Department of Labor, "Industry Employment and Output Projections to Projections to 2022"; Frey and Osborne; calculations by the author.

a continued expansion in the proportion of analytical/management jobs, a contraction in the share of routine jobs, and little change in the proportion of non-routine manual jobs.

Yet the forecasts are not nearly as optimistic using the Frey/Osborne expectations for technology replacement. Rather than increasing, total jobs decline by almost one-third. The shifts between the three task-based job classifications are similar to the DOL forecasts, but much more pronounced. The share of analytical/management task jobs increase by 26 percentage points, to almost 60% of all jobs, while routine task jobs drop by 17 percentage points. Rather than rising modestly as in the DOL projections, non-routine manual task job lose 9 percentage points in their total job share.

The two forecasts agree that the total number of analytical/management jobs will increase – but DOL forecasts the increase as three times more than Frey/Osborne. But the forecasts disagree in both the direction and size of change in the other two task categories. Routine task jobs increase modestly in the DOL projections but decline by over 1 million using the Frey/Osborne methodology. Likewise, non-routine manual task jobs increase by approximately 360,000 using DOL but decrease by over 460,000 by Frey/Osborne.

These forecasts are both interesting and troubling. The interest comes from the continuing dynamism of the economy and the relative speed at which job options can shift. If accurate, both forecasts suggest the North Carolina labor market would have moved from an economy based primarily on manual skills to one based on cognitive skills within the span of a century. And, if recent trends continue, the faster growth in cognitive analytical/management task jobs will also mean higher-paying jobs will the most rapidly expanding.

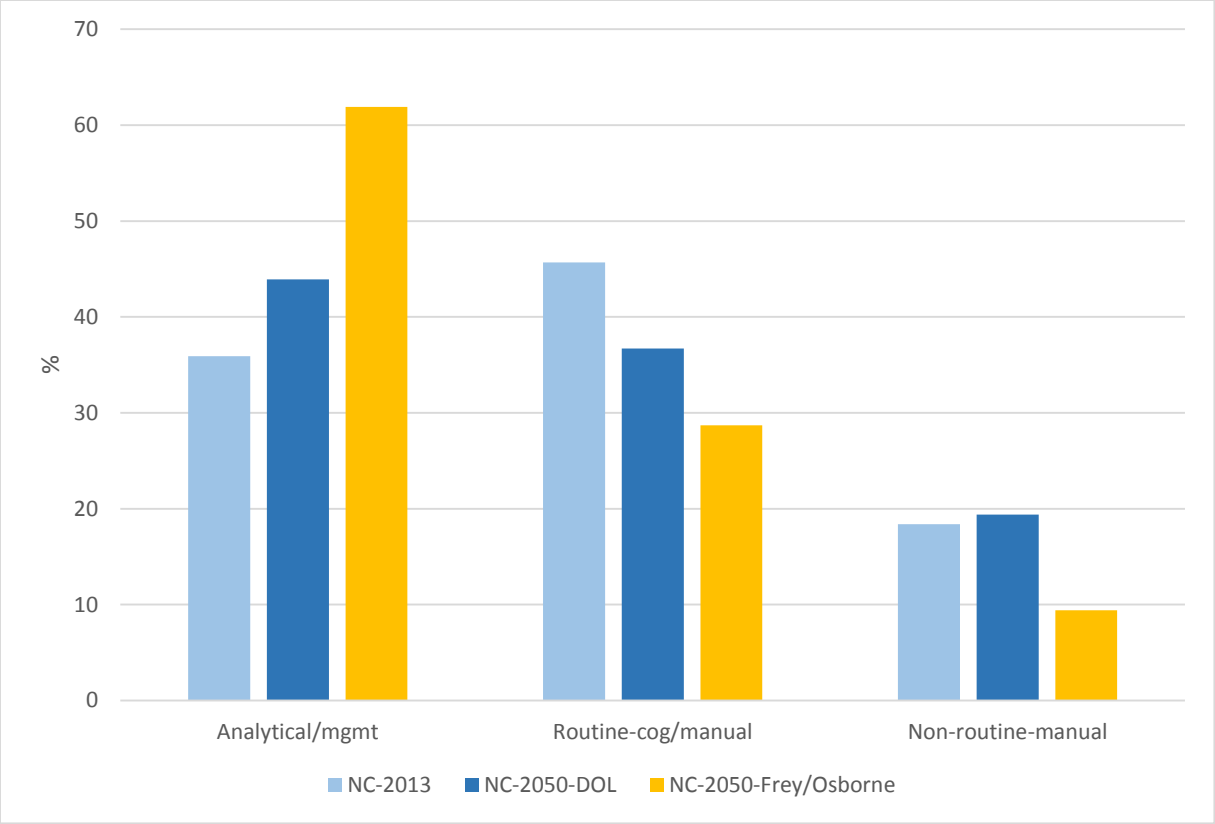
But the forecasts clearly raise worries. Both forecasts indicate a shift from non-routine manual task and routine analytical/manual task occupations to analytical/management task occupations, but to different degrees. Figure 4-3 shows how the trends in the three "task" classifications of occupations following the two forecasts and the implications for the education system. Substantially more skill upgrading would be required for the Frey/Osbourne forecasts than for the DOL forecasts. Then questions arise about the resources and abilities to accomplish this change.

Yet the biggest concern is the 1.3 million total job loss predicted by the Frey/Osborne methodology. What will these workers do? Will there be new industries and occupations absorbing them? What change in public policy might be needed to address this employment dislocation?

Underclass or New Class?

The answers to these questions follow along the lines staked out by the pessimists and optimists of the economic future. Pessimists see a future world requiring fewer workers as machines, technology, and productivity increasingly control the marketplace. They see a new

Figure 4-3. Alternative North Carolina Workforce Forecasts.



Source: Table 4-5.

and expanded underclass developing – termed "precariats" – who lack job security and who are dependent upon crime, charity, or governmental assistance to survive.[19] Government "make-work" jobs, financed by public revenues paid from the increased concentration of income among those performing cognitive analytical/management tasks, will be needed to give the precariats purpose and to divert them from engaging in unproductive actions.[20] The future labor market is therefore composed of the well-paid, highly trained cognitive workers engaged in analytical and management tasks, a much smaller and likely decreasing number of cognitive manual and non-routine support workers, and a large and growing number of precariats who perform token tasks and who are primarily supported by the public sector.

The optimists see a brighter ahead for the labor market future, based mainly on history. Citing two major transformations of North Carolina's labor market in just the 20th century – from farm to factory, and from factory to services – the optimists say another transformation will certainly happen. Even if income is increasingly concentrated in an educated elite, the optimists argue the income will be spent, and spending will create economic opportunities and labor demand.[21]

I see six contenders for significant creation of new occupations, all developing from trends in the economy of the next four decades: household management, repair/maintenance of new technology, global interaction, logistics/data management/analysis, aged assistance, education/re-training, and artisanship.

- Household management: As the income earning opportunities of the cognitive elite expand, their time becomes more valuable. The cognitive elite will increasingly look for ways to reduce their time use in non-earning time use by purchasing assistance for everyday tasks. Shopping, meal preparation, cleaning, childcare, personal care, home maintenance, and household organization are all tasks open for paid performance. While some of these tasks can be – or will be able to be - accomplished by technology, the cognitive and "on the spot" decision-making requirement for many of them may be high enough to be best accomplished by human direction. While a "Downton Abby" style situation of live-in servants is unlikely for many of the cognitive elite, paid assistants visiting residences on a regular basis to perform work is certainly possible. Some call this the "concierge economy" where workers will be summoned via phone apps.[22] The workers will be highly trained, screened for

security and reliability, and professional in all aspects of their work. Hence, decent salaries in the mid to high five figures (2015 dollars) could be expected.

- Repair/maintenance of new technology: As technology becomes more pervasive in the economy, the need for their upkeep increases. While some of the repair and maintenance of technology can be done by other technology, much of the "trouble-shooting" and analysis will – at least initially – be done by humans who can react to specific and unusual situations. This set of occupations will be fast-changing and will require continual re-training of personnel as technology evolves. New occupations will focus on emerging technologies in virtual reality, robots, advanced telecommunications, and 3-D manufacturing.
- Global interaction: As world trade and interactions increase, there will be developing occupations facilitating these interactions. While certainly technology will continue to increase the ability of individuals to communicate across the world, there are some personal interactions for which cyber communications are not good substitutes. Occupations specializing in understanding foreign markets, dealing with foreign customs, recognizing foreign laws, navigating political obstacles for trade, and attracting and servicing foreign tourists are good examples. Language requirements for these occupations will be moderated with advances in translation technologies.
- Logistics and data management and analysis: The plethora of data that will be collected in the emerging economy will be used for analysis to improve the efficiency and logistical operations of businesses – and even of households and of government. There will be a set of occupations developed around these components that will become increasingly essential and high-profile for almost every industry and

economic sector to successfully achieve and compete.[23] While in the early 21st century financial occupations were the stars, in the mid-21st century it will be "logo (logistics) people"!

- Aged assistance: The most dominant demographic trend of the next several decades is the relative growth of the elderly population – generally measured by the proportion of the population over age 65. Clearly this trend has implications for the health care industry. But a large number of the elderly will continue to be healthy and relatively active. They will not need hospitalization or institutionalized living, but they will need modest assistance to continue independent living. This will create occupations similar to those in household management occupations, but with the focus on the special characteristics and needs of the elderly.
- Education/re-training: The next economy will be marked by fast changes in businesses and rapid turnover of occupations. Not only will individuals work for several employers over their career, but they will also work at several different occupations. Educational, training, and re-training opportunities will have to be focused on current trends, be rapid, and be affordable. New educational institutions will be required, which will also create new educational and training occupations.
- Artisanship: Some see a revival of artisans and artisanship almost as a rebellion against the low-cost, mass-made products that will likely dominate the 21st century.[24] The increased demand for specialty, hand-crafted products – particularly by the upper-income elite – could spark a boom for traditional artisans, from carpenters to stone layers to seamstresses to jewelry makers.

Despair and Hope in the Labor Market

North Carolina's labor market will be the most challenging aspect of the state's economy in the 21st century. For some it will be an exciting time, as new products and services, industries, and occupations are developed. In 2050 we will look back in amazement at what had changed. But for others it will be a challenging time. Occupations and livelihoods will be destroyed, leaving many workers adrift with no obvious means of support. Re-training, re-skilling, and re-purposing workers will be the crucial element in addressing this reality. The educational system will need to respond to these challenges in a timely and pro-active manner that facilitates an efficient and rapid transition from outdated skills to new skills. This will require substantial restructuring of the system from K-12 to advanced college studies. Still, many individuals will likely find they are not needed in the new labor market. The question then becomes how to make their lives meaningful and productive.

Endnotes

[1] See Goldin, Claudia and Lawrence Katz, *The Race between Education and Technology*, Cambridge, MA: Harvard University Press, 2008, for an excellent discussion of the changing workplace roles of workers and technology and implications for educational training.

[2] One reason for North Carolina's better educational gains than the nation may be the state's greater support of higher education, which has been found to be positively related to greater higher education enrollments and better improvements in workforce educational attainment (Kennan, John, "Spatial Variation in Higher Education Financing and the Supply of College Graduates, Working Paper 21065, National Bureau of Economic Research, April 2015).

[3] The annual gains in the three levels of educational attainment varied somewhat for the last decade of the 20th century and the first thirteen years of the 21st century. For North Carolina, the average annual percentage point gain for high school or greater attainment was 0.81 points between 1990 and 2000 compared to 0.58 points between 2000 and 2013; for a bachelor's degree or greater attainment, the average annual percentage point gain was 0.51 points between 1990 and 2000 compared to 0.45 points between 2000 and 2013. For the nation, the greatest difference was for high school or greater attainment, where the average annual percentage point gain was 0.52 points between 1990 and 2000 compared to 0.48 points between 2000 and 2013.

[4] U.S. Dept. of Education, *National Assessment of Educational Progress*, State Profiles: North Carolina, 2013.

[5] See, for example, Romer, David and Justin Wolfers, eds, *The Casual Impact of Education on Economic Growth; Evidence from the United States*, Brookings Papers on Economic Activity, Washington, DC; The Brookings Institution, Spring 2009.
[6] Jorek, Norbert, Johan Gott, and Michelle Battat, *The Shifting Geography of Offshoring*. A.T. Kearney, Chicago, 2014.
[7] See Acemoglu, Daron and David Autor, "Skills, Tasks, and Technologies: Implications for Employment and Earnings", MIT and National Bureau of Economic Research, June 2010; and Levy, Frank and Richard Murnane, *The New Division of Labor*, Princeton, NJ: Princeton University Press, 2004.
[8] There are no official statistical counts of jobs using the task definitions. Following Acemoglu and Autor, analytical and management task jobs are defined as managerial, professional, technical, and public administration occupations; routine cognitive and manual task jobs are defined as clerical, administrative, and sales occupations (routine cognitive) and transportation, production, and operative occupations (routine manual); and non-routine manual task jobs are defined as remaining service occupations, mainly in the personal and business services.
[9] The absolute number of routine cognitive and manual task jobs declined for the nation by 1.5 million positions between 1980 and 2010 but still rose for North Carolina due to the state's much faster population and labor force growth.
[10] Comparing labor productivity rates (real-dollar GDP/employment) for sectors categorized by the three tasks for the nation and North Carolina for the years 1997 (earliest available) and 2010 show gains of near 25% for routine cognitive and manual tasks and no gains for the two other task categories (data from the U.S. Bureau of Economic Analysis).
[11] Ford, *op. cit.*
[12] Frey, Carl and Michael Osborne, "The Future of Employment: How Susceptible are Jobs to Computerization?" Oxford University, Oxford UK, September 2013.
[13] Wyatt, Ian and David Hecker, "Occupational Changes during the 20th Century", *Monthly Labor Review*, March 2006: 35-57. The McKinsey Institute found that one-third of U.S. jobs that existed in the early 21st century did not exist twenty-five years earlier (McKinsey Institute, *Global Growth: Can Productivity Save the Day in an Aging World?"* January 2015. Ford (*Rise of the Robots*) sees some potential for a return of some jobs to the U.S. from foreign countries ("re-shoring") if technological unemployment reaches all countries, but he estimates the gain would be small.
[14] There is even a new wave of technology-driven mechanization coming to agriculture, with robot-controlled fruit pickers being an example (Brat, Ilan, "Goodbye Field Hand, Hello Fruit-Picking Robot", *The Wall Street Journal*, April 24, 2015, pp. B1, B6.
[15] Jaimovich and Siu documented an acceleration of technological unemployment after the Great Recession and argued their finding was a reason for the relatively slow post-recession job recovery (Jaimovich, Nir and Henry Siu, "The Trend is the Cycle: Job Polarization and Jobless Recoveries", Working Paper 18334, National Bureau of Economic Research, August 2012.
[16] U.S. Bureau of Labor Statistics, U.S. Department of Labor, "Occupational Employment Projections to 2022", *Monthly Labor Review*, December 2013. One issue is whether the national growth rates should be adjusted upward for North Carolina, since the state has grown more rapidly than the nation in the post-World War II era. However, the positive difference between the North Carolina growth rate (in gross domestic product) and the national growth rate has been narrowing, from 28% during the 1980-1990 decade to 23% during the 1990-2000 decade to 11% during the 2000-2010 decade (U.S. Bureau of Economic Analysis, *GDP by State and Metropolitan Area*). This trend is in line with the theory of growth convergence between states and regions (Higgins, Matthew, Daniel Levy, and Andrew Young, "Growth and Convergence across the U.S.: Evidence from County-Level Data", *Review of Economics and Statistics*, November, 2006, 88(4): 671-681). The national growth rates for occupations were therefore directly applied to North Carolina.
[17] U.S. Bureau of Labor Statistics, U.S. Department of Labor, "Industry Employment and Output Projections to 2022", *Monthly Labor Review*, December 2013. Following the logic of the above footnote, the same national industry growth rates were applied to North Carolina. The rate at which employment changes when economic output changes is from Seyfried, William, "Examining the Relationship Between Employment and Economic Growth in the Ten Largest States", *Southwestern Economic Review,*Vo. 32, No. 1, Spring 2005, pp. 13-24.
[18] Total population and working age population growth rates are from the U.S. Dept. of Labor and Table 1-2.

[19] See Standing, Guy, *The Precariat: The New Dangerous Class*, London: Bloomsbury, 2014; and Beck, Ulrich, *The Brave New World of Work*, Cambridge, MA: Polity, 2000. The word "precariat" is derived by merging precarious with proletariat and connotes a permanent situation of job insecurity and underemployment.
[20] Cowen, *op. cit.*; Thompson, Derek, "A World Without Work", *The Atlantic*, 316, 1: 50-61, July/August 2015.
[21] Optimists also think the two forces of technology and economic liberalization will make it easier for business start-ups to develop and new industries to take hold (Hagel, John. "The Disruption Debate – What's Missing?" *Edge Perspectives*, February 5, 2015, www.edgeperspectives.tyepad.com). Others see a rise of self-employment in the future workforce, which – they argue – could increase worker happiness (Frey, Carl and Michael Osborne, *Technology at Work: The Future of Innovation and Employment*, University of Oxford, UK, February 2015. There is also the theoretical argument over whether labor and capital (technology) are substitutes or complements. If the latter, then technological improvements would increase the value of labor and lead to greater labor usage (Lawrence, Robert, "Recent Declines in Labor's Share in U.S. Income: A Preliminary Neoclassical Account", Working Paper 21296, Boston: National Bureau of Economic Research, June 2015).
[22] Fowler, Geoffrey, "The Uber of Everything: Build a Staff with Apps," *The Wall Street Journal*, May 6, 2015, pp. D1, D3.
[23] See Lohr, Steve, *Dat-ism: The Revolution Transforming Decision-Making, Consumer Behavior, and Almost Everything Else*, New York; HarperCollins, 2015, for a detailed look at this future industry.
[24] Risk and Well-Being, "Hiding from Computers Part 4: Time to get Skeptical or Lump of Labor Skeptics", June 11, 2014, www.therationalpessimist.com.