Afterword

In the two years since the book was completed, its major themes have been reinforced by the evolution of the American economy. In comparison to the book's "special century" of 1870-1970, or even to the decades of slower growth between 1970 and 2006, the pace of output expansion has slowed to a crawl since 2006. The many "great inventions" of the late 19th and early 20th centuries required several decades to pass before their full impact was felt on the rate of productivity growth. Starting in 1920 that impact began to show up in the statistics, and the five decades between 1920 and 1970 registered productivity growth of 2.8 percent per year, much faster than any sustained period before 1920 or after 1970.

After the transition year of 1970 innovation did not cease but rather, instead of altering all aspects of human activity as had the earlier great inventions, became more narrowly focused on the digital revolution that introduced mainframe computers and subsequently personal computers and the internet. By 2006 most of the digital transformation of business methods and techniques had already occurred, and today we are using desktop and laptop computers hooked up to the internet in much the same way as we did back in 2006.

The Recent Growth Slowdown

The ingredients of the sharp slowdown in GDP growth since 2006 are displayed in the table (see next page). To focus on long-run trends and avoid any influence of the ups and downs of the business cycle, growth rates are calculated between selected calendar quarters of 1970, 2006, and 2016 that shared the same unemployment rate of 4.7 percent. The growth rate of real GDP decelerated sharply from 3.2 during 1970-2006 to only 1.3 percent per year during 2006-2016. By definition real GDP growth equals the sum of the growth rates of output per hour and of hours of work, and these two components slowed respectively from 1.8 to 0.9 percent per year, and from 1.4 to 0.4 percent per year. Growth in output per person almost came to a halt, slowing from 1.8 to 0.3 percent per year.

Despite all the emphasis in the book on the diminished impact of innovation, the demographic headwind of slowing growth in hours of work actually contributed slightly more to the GDP slowdown than did the deceleration of productivity growth. Of the 1.0 percentage point slowdown in hours growth, 0.6 percentage points was contributed by hours per person (which shifted from zero annual growth to negative 0.6 percent). This in turn was due to a shift from a rising labor-force participation rate in the last quarter of the 20th century, as women entered the labor force, to a declining labor-force participation rate since the year 2000, as discussed below. The remaining 0.4 percent slowdown in hours growth was due to slower population growth.

(Table appears on the next page)

Anatomy of the Growth Slowdown in the Total U.S. Economy (percent change at annual rate)			
	1970-2006	2006-2016	Change
Output	3.2	1.3	-1.9
Output per Hour	1.8	0.9	-0.9
Hours	1.4	0.4	-1.0
Hours per Person	0.0	-0.6	-0.6
Population aged 16+	1.4	1.0	-0.4
Addendum: Output per Person	1.8	0.3	-1.5

Source: Based on quarterly data from Bureau of Economic Analysis and Bureau of Labor Statistics. Quarters chosen (1970:Q2, 2006:Q1, and 2016:Q4) are those with an identical unemployment rate of 4.7 percent.

Sources of Slower Growth in Hours of Work

Why is population growth less than before? The speed of population increase reflects the combined influence of fertility, mortality, and immigration. In the last decade the U.S. fertility rate has declined as a reflection of social and economic difficulties afflicting young Americans. The marriage rate has declined, in part because plant closings and wage stagnation have undermined the ability of many young men to hold steady well-paying jobs, and this has made them less attractive as marriage mates. The burden of student loan repayment is also a factor, forcing many college graduates to move back in with their parents, delaying household formation, marriage, and child rearing.

Population growth has also been reduced by a reversal in the historic trend of improved mortality rates for some groups of Americans. As shown in the recent work of Princeton's Anne Case and Angus Deaton, the mortality rate of white adults aged 35 to 54 steadily increased from 2000 to 2015. This trend toward additional mortality reflects what the authors label "deaths of despair" and results from suicide and addition to both opioid drugs and alcohol. Underlying causes of these deaths include in part the same employment problems that play a role in the decline of marriage – plant closings as a result of globalization, layoffs the occur when machines replace workers, and wage reductions as unions fade away in the private sector of the economy.

Immigration makes a direct contribution to population growth. The level of legal U.S. immigration has been roughly constant at about one million per year since 2000, but illegal

immigration has declined to virtually zero as a result of tougher border enforcement and a declining birth rate in Mexico. Improving economic conditions in Mexico have reduced the number of illegals who try to enter the United States, and also have stimulated a return flow of illegals from the U.S. back to Mexico. What matters is net migration, inflows minus outflows, and the return of illegal immigrants to Mexico and Central America has included not only those who decide voluntarily to go back but also those subject to forced deportation.

While fertility and mortality are difficult to influence by government policy, the government has direct control on the net flow of migrants through its policies on deportation and legal immigration quotas. Deportation often involves the cruel separation of parents from their children born in the U. S. who are American citizens; it should be avoided except for those with a record of serious criminal activity. Higher limits of legal immigration would directly contribute to economic growth, not just by increasing the population but by stimulating investment to equip the new immigrants with homes, household equipment, and tools at their jobs.

There is increasing support for a shift in legal immigration criterion from family reunion to a "point system" like that which has been long in place in Canada, where applicants for immigration are scored on points awarded for language skills, education, employment adaptability, and other criteria. In relation to its population Canada admits three times as many legal immigrants as does the U. S., and an adoption by the U. S. of the Canadian system would raise the rate of population growth and stimulate both investment and consumption spending.

As shown in the table, growth in hours of work has slowed not just because of a decline in population growth but also because of a decline in hours worked per member of the population. Most of this reflects a falling labor-force participation rate. About half of this decline is the unavoidable result of the retirement of the baby-boom generation, which began in 2008 when those born in 1946 reached the age of 62 and could qualify for Social Security benefits. Baby-boom retirement will continue until 2034, when the tail end of that generation born in 1964 reaches the age of 70.

The other half of the decline in participation primarily reflects declining employment opportunities for prime-age men, particularly those with a high school education or less. This is the same phenomenon cited earlier in connection with the falling marriage rate and the "deaths of despair" that have pushed up the mortality rate. Lower participation for prime-age men continues a long downward trend that has taken their participation rate from 98 percent in the 1950s to 88 percent today for all prime-age men and to 84 percent for those with a high school education or less. The U. S. male participation rate is the third lowest in the OECD, ahead of only Italy and Israel. This lower participation rate than in other countries could reflect labor market policies, such as the less generous U. S. provision of unemployment benefits, of childcare subsidies, and of support for retraining and moving of workers who experience prolonged spells without employment.

Recent data on prime-age male participation offers some hope that tightening labor markets have begun to draw men back into the labor force. After declining through 2014, the prime-age male participation rate has increased from 88.2 percent in 2014 to 88.8 percent in the first quarter of 2017. This revival suggests the prospect that a continued economic expansion will continue to provide new employment opportunities for those who had previously given up looking for work, as well as boosting long-stagnant wages, particularly for workers in several occupations that are experiencing shortages of skilled workers. The participation revival would extend further into the pool of discouraged labor-force dropouts if the federal government were to develop a more generous and far-reaching set of job retraining programs.

Sources of Slower Growth in Productivity

Productivity growth, which had achieved an average growth rate of 2.8 percent per year in the five decades between 1920 and 1970, fell to 1.8 percent between 1970 and 2006 and then to 0.9 percent per year from 2006 to 2016. That growth rate was an even slower 0.6 percent per year in the seven years between the last calendar quarter of 2009 and the last quarter of 2016. The leading hypothesis to explain this productivity growth slump is that recent innovation has had less impact on methods of production in the business sector than prior to 2006.

The smaller effect of current innovation stands in contrast to the utter change in business methods that took place between 1970 and 2006 and that was reflected in the more rapid productivity growth of that era than in the years since 2006. Repetitive retyping by secretaries and tedious library research was replaced by authors writing their own words directly on personal computers while doing research on the internet. Calculations that were formerly done one at a time on clunk-clunk Marchant calculators could now be performed on personal computer spreadsheet software. Catalogs that consisted of drawers of file cards in libraries or huge books of pages in auto parts departments were replaced by electronic catalogs with their unlimited listing capacity and their ability to display the number of items in stock. Questionnaires, surveys, and ballots for voting all migrated from paper to electronic form. Google, Amazon, Wikipedia, and other marvels of the digital age had already reached their present form by 2006.

The major invention of the last decade, the smart phone, has achieved ubiquity due to the multiple functions it provides in a small package, but its primary use is for consumers in their everyday lives rather than as a tool to boost business productivity. Social networking on Facebook, game playing, trading of digital photos, and direction-finding with GPS functionality on the smart phone do not create business output that allows firms to create jobs or raise wages. The smart phone produces consumer surplus, a type of benefit that is not included in GDP or in the productivity statistics. As pointed out on pp. 320-323 of this book, new inventions have *always* created benefits to consumers that have not been included in GDP, including many of the great inventions of the 1870-1940 era, including such consumer benefits as refrigeration, the

replacement of scrub boards by automatic washing machines, the replacement of horses by motor cars, and the conquest of infant mortality.

Innovation continues in areas besides smart phone apps. 3-D printing greatly eases the task of creating models and prototypes, but it is not mass production capable of producing 17 million motor vehicles per year. Robots are nothing new but rather were first introduced in manufacturing in 1961. By the 1990s robots were welding auto bodies and had taken over the auto paint shop. But thus far robots have made few inroads outside of manufacturing and warehouses. In my daily life I regularly play a game called "find the robot," but there are no robots to be seen so far in retail stores, restaurants, construction sites, hotels, commercial aircraft, hospitals, or the offices I visit of doctors, dentists, and veterinarians, not to mention of fellow professors.

Driverless vehicles are not yet ready to replace the jobs of human taxi and truck drivers, because software and detailed maps have not yet been developed that will allow autonomous vehicles to navigate unmarked rural roads in the dark or make their way without human assistance through parking lots or driveways. Substantial progress is being made in the area of artificial intelligence, known as AI, with computer-assisted applications such as voice recognition and language translation. Indeed, every transaction at the web sites of Amazon, airlines, or hotels represents the application of AI, so in this sense AI has been replacing human jobs for at least two decades. Every time someone calls customer service and is asked by a computer voice to speak an answer, that person is encountering the voice recognition capabilities of AI.

So far, however, AI is on course to replace human jobs in a slow, steady, evolutionary way rather than in a sudden revolution. Many jobs of customer service agents, including such specialities as travel agents, have been replaced by AI, while jobs for young lawyers have become scarcer as computers prove to be adept at carrying out searches for legal precedents. Similarly, computers are developing advanced skills in radiology diagnostics, although so far they are mainly working alongside radiologists rather than replacing them outright.

The slow growth of productivity, only 0.6 percent per year since 2009 compared to 2.8 percent per year between 1920 and 1970, is the strongest evidence available that the impact of 3-D printing, robots, autonomous vehicles, and AI have so far had only a modest effect in eliminating jobs and boosting productivity. The economy has continued to create new jobs, year after year since 2009, at a rate of about 2.5 million jobs per year. This is the good news about the American economy as viewed from mid-2017. The scare-mongering of so-called "techno-optimists" that a fourth industrial revolution is on the verge of destroying millions of jobs *en masse* has so far proved to be a welcome illusion.

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