U.S. Productivity Growth: An Optimistic Perspective

Martin Neil Baily
Brookings Institution and McKinsey Global Institute
James Manyika
McKinsey Global Institute and Brookings Institution
Shalabh Gupta[1]
McKinsey & Company

ABSTRACT

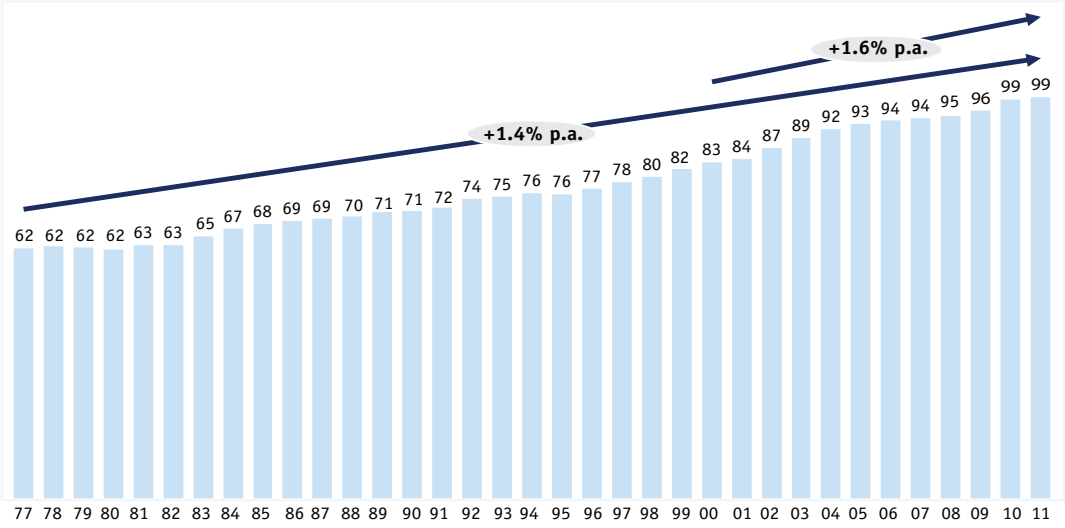
Recent literature has expressed considerable pessimism about the prospects for both productivity and overall economic growth in the U.S. economy, based either on the idea that the pace of innovation has slowed or on concern that innovation today is hurting job creation. While recognizing the problems facing the economy, this paper offers a more optimistic view of both innovation and future growth, a potential return to the innovation and employment-led growth of the 1990s. Technological opportunities remain strong in advanced manufacturing and the energy revolution will spur new investment, not only in energy extraction, but also in the transportation sector and in energy-intensive manufacturing. Education, health care, infrastructure (construction) and government are large sectors of the economy that have lagged behind in productivity growth historically. This is not because of a lack of opportunities for innovation and change but because of a lack of incentives for change and institutional rigidity.

RÉSUMÉ

Récemment, la littérature a exprimé un pessimisme considérable en ce qui concerne les perspectives de croissance économique et de croissance de la productivité aux Etats-Unis, soit en soutenant l'idée que le rythme d'innovation a ralenti, soit en soutenant la crainte que, de nos jours, l'innovation nuit à la création d'emplois. Cet article offre une perspective plus optimiste de l'innovation et de la croissance future, en affirmant le retour potentiel de l'innovation et de la croissance tirée par l'emploi des années 1990. Les opportunités au niveau technologique restent fortes dans la fabrication de pointe et la révolution énergétique entrainera de nouveaux investissements, non seulement dans l'extraction des ressources énergétiques, mais également dans le secteur du transport et dans la fabrication à intensité énergétique élevée. L'éducation, les soins de santé, l'infrastructure (construction) et le secteur gouvernemental sont des secteurs vastes de l'économie qui ont historiquement affiché un retard en terme de croissance de la productivité. Ceci n'est pas la conséquence d'un manque d'opportunités pour l'innovation et le changement, mais plutôt la conséquence d'un manque d'incitatifs au changement et de rigidités institutionnelles.

1 Martin Neil Baily is a Senior Fellow at the Brookings Institution and a Senior Advisor of the McKinsey Global Institute. James Manyika is the Director of the McKinsey Global Institute and a Non-Resident Senior Fellow at the Brookings Institution. Shalabh Gupta is an Associate at McKinsey & Company. The authors would like to thank Jaana Remes and the many other McKinsey staff that have worked on a series of reports on productivity, which can be found online at http://www.mckinsey.com/Insights/MGI/Research/Productivity_Competitiveness_and_Growth; Email: mbaily@brookings.edu.

Chart 1
GDP per Worker in the United States, Total Economy, 1977-2011
(thousands of 2005 U.S. dollars)



Sources: U.S. Bureau of Economic Analysis, Moody's Analytics.

THE IMPACT OF THE GREAT RECESSION that swept through the advanced economies in 2008 has lingered, with unemployment remaining high and economic growth slow. Forecasters predict that the U.S. economy will not return to full employment until 2017, marking a decade of moderate growth and employment weakness. Parts of Europe face even tougher conditions and little prospect of restoring prosperity for up to ten years into the future.

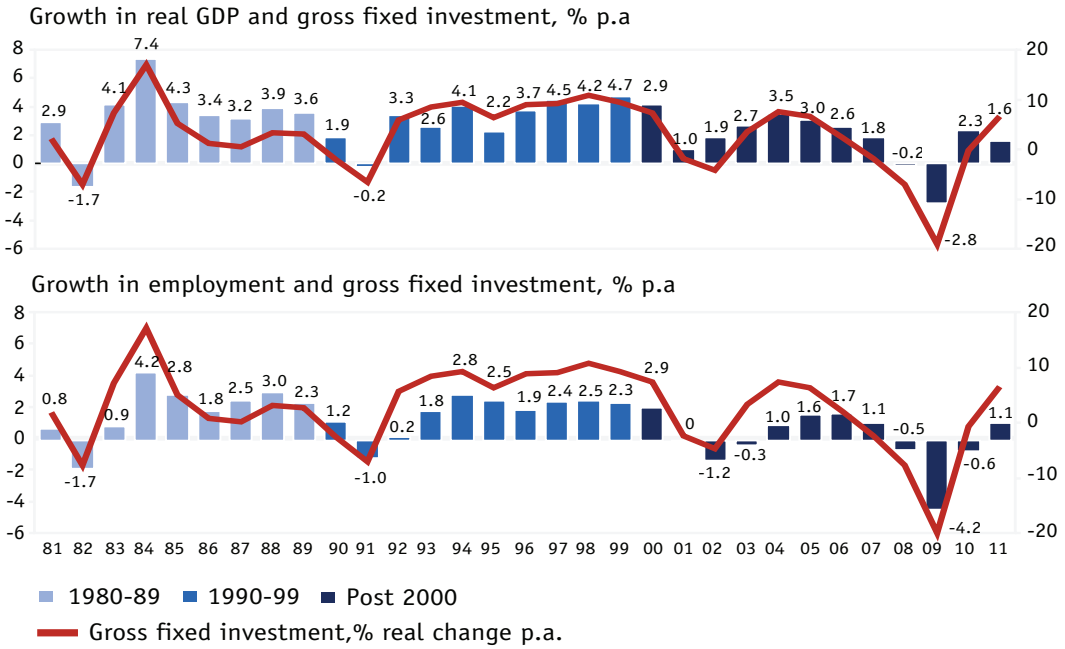
In such a difficult short-run environment, it is not surprising to find pessimistic assessments of the long-run growth path of the economy. Both Robert J. Gordon in his discussion of this article (Gordon, 2013) and in his forthcoming book on U.S. economic growth, and Tyler Cowen (2011) in his recent book, *The Great Stagnation* argue that the golden age of innovation is over. Even technology optimists such as Erik Brynjolfsson and Andrew McAfee (2011), while optimistic about growth and innovation, are pessimistic about future employment prospects, finding that while the digital revolution is accelerating innovation, it is also automating away increasing numbers of jobs. We are, to use their term, in *A Race Against the Machine*.

We do not wish to be Pollyanna, assuring readers that everything will turn out for the best and that rising living standards are guaranteed; indeed, the challenges or headwinds facing the economy are real and important. Even before the onset of the recession in 2008, there was concern over sluggish employment growth, an overvalued housing market and widening income inequality. Global competition has become much more intense and the United States has run trade deficits since the early 1980s.

Where we differ with other authors is that we see tremendous opportunities along with the challenges. We strongly agree with Brynjolfsson and McAfee that digital technology and the digital revolution are proceeding apace, and we also agree that this will eliminate many traditional jobs in manufacturing and elsewhere. But the offset is that innovation-led growth can create new jobs, new lines of business and new profit

Chart 2

Real GDP, Gross Fixed Investment and Employment in the United States, 1987-2011



Sources: U.S. Bureau of Economic Analysis, Moody's Analytics; The Economist Intelligence Unit.

opportunities. Indeed, we saw this in the 1990s when innovation-led growth created new products and services and expanded output and new technologies made productivity gains possible, even though many of these were concentrated in certain sectors (Lewis, 2004). Perhaps even more important, today there are large sectors of the economy that have continued to lag behind in productivity growth, notably health care, education, and construction. Adopting best practices and taking advantage of existing technologies can yield substantial productivity gains for the economy. Another important opportunity lies in energy. New technologies have unlocked reserves of natural gas and oil buried deep below the surface and made it possible to extract these reserves at favorable prices. While we do not ignore the environmental challenges inherent in accessing these reserves, we judge that these can be overcome and that natural gas at low prices and a more stable and secure source of oil are becoming available, a revolution that will have a large impact on U.S. productivity and GDP growth.

In addition to being productivity optimists, we also observe that at the level of the national economy, the history of the last 80 years has shown that productivity growth has largely occurred hand in hand with employment growth. In its February 2011 report *Growth and Renewal in the United States*, the McKinsey Global Institute looked at the past 80 years and found that, while over one-year periods there was some tradeoff between productivity and employment growth, this tradeoff was reduced as the time period was extended and had essentially disappeared over 10-year time spans (Manyika *et al.*, 2011a:6). While demand weakness currently remains a serious issue, in the long-run productivity growth is still the most important way to improve living standards and does not come at the expense of

employment (Brynjolfsson and McAfee, 2011).

This article will first review highlights of the performance of U.S. productivity over the past two or three decades. It will then turn to examine a sample of the productivity opportunities available and some of the challenges in seizing these opportunities and generating innovation-led growth in the years ahead.

The Pattern of Recent Economic Growth

A broad measure of overall labour productivity is GDP per person employed. It captures the extent to which technological change, as measured by multifactor productivity growth (MFP) (also known as total factor productivity), increased capital per worker, and changes in human capital have allowed an increase in the amount produced on average by each worker.[2] As Chart 1 shows, the rate of growth of GDP per worker has maintained a fairly steady overall trend since 1977, albeit with periods of faster and slower growth over shorter periods within this time span.

Chart 2 shows the numerator and denominator of the ratio of GDP per worker on an annual basis for the 1981-2011 period, matched to investment data. One finds a significant variability in pattern by business cycle. The expansion of the 1990s was characterized by strong innovation— both technological innovation and innovation in providing new services and devising improved business processes. That expansion incented businesses to invest, create new capacity and increase employment, visible in the high level of investment over this period. Investment was rather weak in the 1980s. From 2000 to 2007 investment was strong in housing but much weaker overall. Investment was hard hit in the Great Recession and since then has not recovered even to its 2007 level. Weak business investment is a problem not only for the cyclical recovery but also for longer term growth.

The pattern of growth just described also shows up in the industry data illustrated in Charts 3 and 4. In the 1990s, the industries that contributed to productivity growth also contributed to both output growth and employment growth.[3] Manufacturing employment held steady. Since 2000, the industries making the biggest contributors to labour productivity growth experienced slow output growth and declining employment. The period since 2000 has been one of extensive restructuring as companies responded both to the dot.com crash and the Great Recession by eliminating employees and lines of business that were not expected to be profitable. Many multinationals saw better investment opportunities in fast-growing emerging markets and labour-intensive manufacturing activities were shutdown in favour of imports.

Opportunities for Productivity Growth

Despite the economic problems encountered in the past decade, we see a range of opportunities for productive economic growth for the U.S. economy going forward. Innovation is still proceeding rapidly and there is tremendous scope to improve productivity in industries such

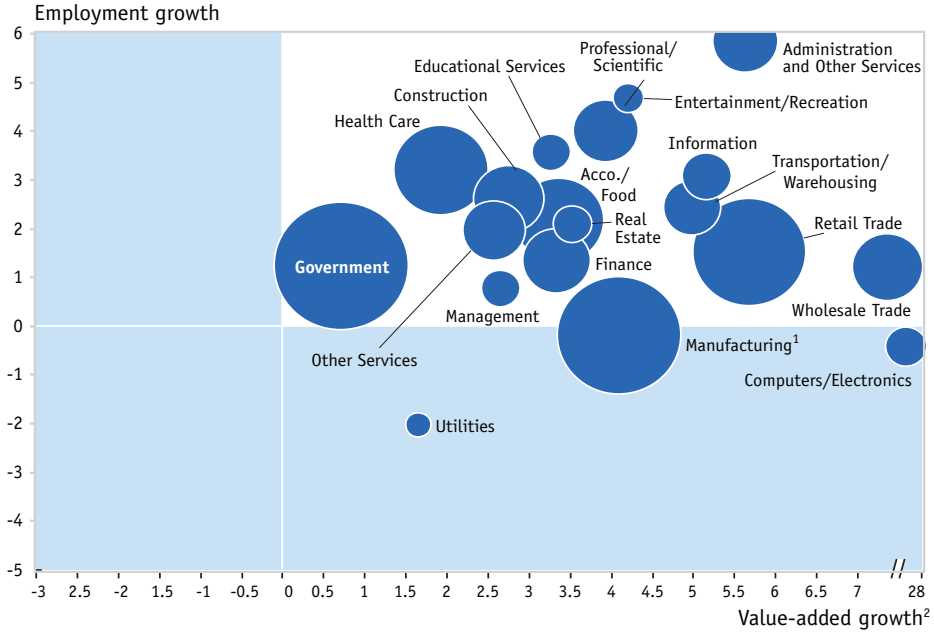
2 Productivity studies often focus on multifactor productivity in the business sector of the economy, or in a specific industry, which is the best way of capturing shifts in the production possibility frontier. GDP per worker is useful as a guide to the amount of economic resources produced by each participant in the economy, whether it comes from multifactor productivity, capital per worker, human capital or the mix of industries.

3 De Avillez (2012) shows that assigning the contribution of labour productivity by industry depends on the approach and formula used. The charts shown here rely on a simplified approach developed by the McKinsey Global Institute, the details of which are available on request. The conclusions of this article are not sensitive to precise estimates of industry contributions shown.

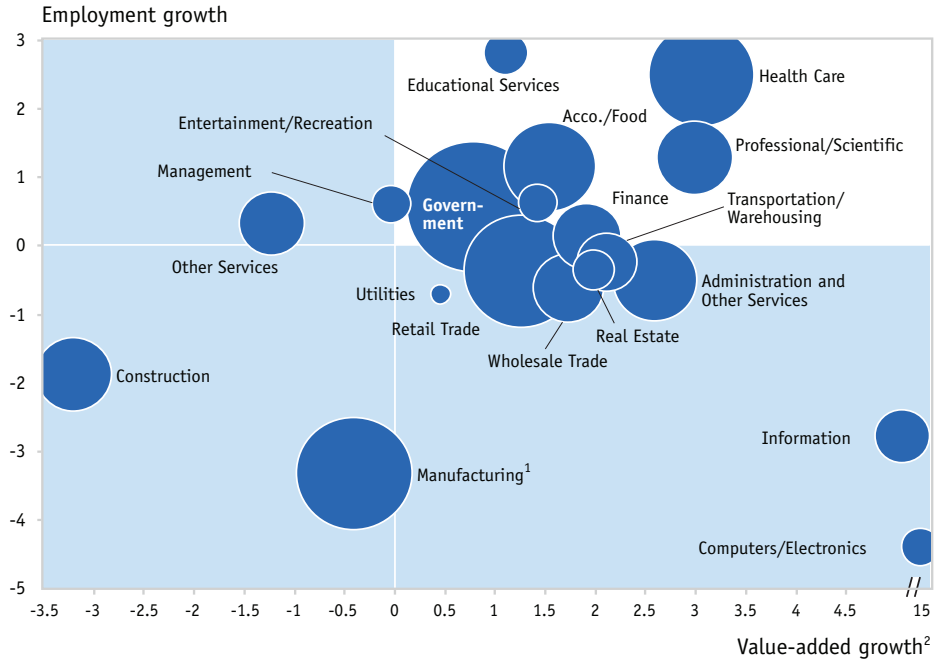
Chart 3

Relationship between Employment and Value-Added Growth by Industry in the United States, average annual rate of change, 1990-2000 and 2000-2011

A) 1990–2000



B) 2000-2011



Notes: 1) Size of bubble represents the share of employment in 1990 in Panel A and in 2000 in Panel B;
2) GDP per worker grew by 1.6 per cent per year in both the 1990–2000 period and the 2000-2011 period;
3) Manufacturing excludes Computers/Electronics.

Sources: U.S. Bureau of Economic Analysis, Moody's Analytics; McKinsey Global Institute Sunrise Productivity Model.

as health care, education and government that have lagged behind historically. In the remainder of this article we will outline some of the opportunities that we see, specifically in manufacturing, energy, health care, and infrastructure. These will be spelled out in more detail in an ongoing McKinsey study of "game changers," opportunities that could move the economy forward substantially.

Manufacturing

Technological innovation is transforming multiple aspects of manufacturing. It is no more a stretch to imagine manufacturing a decade from now barely resembling current processes. We briefly discuss several reasons to be optimistic about productivity growth in manufacturing.

Industrial robotics and automation

The beginning of this decade has seen rapid strides towards adoption of industrial robots for a wide set of tasks that can today only be performed by humans. Many of these tasks require dexterity that robots do not yet possess, while others require minor adjustments and variances which are difficult to program a machine to effectively respond to. While industrial robotics has been a reality and a necessity in industries requiring heavy lifting and repetitive, precise movements – automotive is a classic example – it has been priced well out of range for more regular 'human' tasks. While robotic arms can lift and place heavy car frames on a car manufacturer's assembly line, the robot assembly of mobile phones is not yet viable.

That could soon change with low-cost robots like 'Baxter', which have the potential to fundamentally change manufacturing by increasing precision and productivity without incurring high costs. Baxter is a robot developed by Boston's Rethink Robotics with the capability to work safely alongside humans. Baxter's arms can sense a human in their path and stop movement. It can be 'reprogrammed' for new tasks by a human operator who physically manipulates its arms to move, bend, lift or drop in the desired way. At a sticker price of $20,000, the company claims its costs are equivalent to a human worker earning $4 per hour.

3D printing and additive manufacturing

New technology has provided the ability to create complex objects using a computer-controlled "printer" that deposits successive layers of material to form a metal, plastic or even organic object. The implications for manufacturing are immense. Thus far 3D printing has mostly been used to create prototypes or objects that would be impossible to machine, but in the future the technology could usher in a new ecosystem of smaller value chains and new companies providing printable designs on the web, instead of products on the shelf. With increasing adoption, everyday products will be endlessly customizable – in form, material and dimensions. Small businesses will be able to compete with traditional manufacturers, products will never go out of stock, size of batches will become meaningless, and manufacturing will become truly just-in-time.

Big data

For a number of reasons, the application of big data and advanced analytics is particularly relevant to the manufacturing sector. It is a sector that has already experienced rapid productivity growth in the past decades through IT and automation and therefore owns large, fully digital data sets in several functions along the value chain. Truly global supply chains add significant complexity regarding data security/rights and global real-time data sharing and collaboration. The "extended enterprise" model of most manufacturing companies brings about growing data pools, which span business units and require

vertical data integration and coordination across organizational boundaries. As a result, stored data in manufacturing is the biggest among industry sectors globally and is projected to grow further and become more integrated along the supply chain, e.g. through radio-frequency identification (RFID) technologies.

In a report on the economic impact of Big Data (Manyika *et al.*, 2011b), the McKinsey Global Institute identified value levers along the whole manufacturing value chain with the ability to lead the sector to higher productivity levels, indicating huge potential. As an example, application of big data and advanced analytics to R&D and product development was estimated to reduce costs by 20-50 per cent, and a big data-enabled supply chain optimization was estimated as yielding a 2-3 percentage point profit margin improvement.

The '*Internet of Things*'

This refers to the massive connectedness of all manner of inanimate things to networks and to each other, enabled through the proliferation of low-cost sensors. The possibility to connect machines and equipment to each other and to common networks promises to push productivity in several interesting ways.

Connecting machines allows for their remote monitoring. Instructions can be provided to a set of equipment based on the activity of other equipment. We foresee a future where manufacturing facilities can be fully shut down and started up by the owner sitting at home with the help of an internet connection. Extending the applications of connected devices, we could set up closed-loop systems which would automatically make decisions based on optimization algorithms and stimuli from various equipment in the network..

The 'Internet of Things' could also enable greater energy efficiency in manufacturing. A recent report by the International Energy Agency (Waide and Brunner, 2011) investigated energy consumption of electric motor-driven systems (EMDS) and found them to be responsible for over 40 per cent of global energy consumption, leading to over 6,000 megatons of CO2 emissions. Traditionally, motors operate at peak capacity irrespective of load. Smart motors are able to adjust power usage with output, usually through variable speed drives controlled by an intelligent motor controller (IMC). With low-cost sensors allowing improved inter-machine and system communication over wireless networks, it will be possible to make manufacturing systems with thousands of motors smarter, enabling substantial improvements in energy efficiencies.

Taken together, new technologies are transforming manufacturing processes across the value chain. Developments in new materials through breakthroughs in nanotechnology or biologics promise to fundamentally change manufacturing. Product design is witnessing a change with human-centered design driving new research with the help of Big Data on customer preferences collected through social media and the Internet of Things. Production processes are progressing rapidly with advances in modeling and simulation, advanced robotics and additive manufacturing. Traditional business models are being challenged by new ideas like frugal innovation[4] and the circular economy.[5] Entirely new service models are likely to evolve as technologies

4 Frugal innovation is a term coined by the McKinsey Global Institute. It refers to companies in emerging economies that are finding ways to innovate even though they lack the R&D resources of developed country economies. In the fastest-growing markets for manufactured goods — developing economies — company R&D budgets and government research spending tend to be far lower than in advanced economies. For example, India's national R&D budget was around $14 billion in 2010 — a year when Microsoft, Pfizer, and Intel each spent $8 billion to $10 billion on R&D. In this environment, frugal innovation changes the business model by emphasizing shorter launch cycles, innovation through commercialization, and reverse-engineered innovation.

like 3D printing become more widely available, e.g. distributed manufacturing.

Energy

The most important development in the U.S. energy sector is undoubtedly the extraction of natural gas from shale deposits and, increasingly, light tight oil (LTO) – crude oil trapped in shale. Natural gas resources in the United States have nearly doubled since 2003, driven by the development of shale deposits nationwide. The United States has the second largest recoverable shale gas reserves in the world at 24 trillion cubic meters (tcm), after China's reserves of 36 tcm. However, the United States is substantially ahead of the rest of the world in developing these reserves. By 2020, shale gas is expected to add 10-15 billion cubic feet per day over current levels and grow to over 25 per cent of total gas production. This will also lead to a 60 per cent drop in natural gas imports. Substituting energy imports and increasing energy exports could reduce U.S. net energy imports to zero, and cut the goods trade deficit by more than half (ceteris paribus). Along with shale gas, light tight oil production has also developed rapidly. Current LTO production estimates for 2020 are between 5 and 10 million incremental barrels per day, although some see even higher numbers as possible.

The impact of increased domestic energy output is greatest for large energy purchasers, such as manufacturing and transport industries. Within manufacturing, the greatest impact will be on sectors that are highly energy intensive, such as chemicals, metals, paper and pulp, and food manufacturing. Cheaper natural gas is expected to generate an additional investment of $50-$65 billion in domestic petrochemical products and around $15 billion in natural gas-based petrochemical products. While downstream sectors will be advantaged due to cheaper fuel and feedstock, other sectors (e.g. services, construction) could see increased activity to support oil-gas production and manufacturing output.

The new technology of drilling has opened up an opportunity for profitable investment and employment that will increase both GDP and productivity. This will help move the economy back to full employment and generate economic activity that has higher productivity levels than the alternative use of resources.

Health care and life sciences

Productivity growth in health care has traditionally been stymied by poor regulation, institutional inertia and perverse incentives. Cost of treatment, the high cost and risk of malpractice litigation on care-givers and the cost-plus nature of Medicare payments work together to make health care costly and slow to innovate.

In recent years, however, there has been widespread recognition of misaligned incentives, and progress has been made on aligning them through ACOs (accountable care organizations) and other risk-sharing models. Many of these new models have been proposed by the Centers for Medicare and Medicaid Services through the Affordable Care Act, as well as private insurers.

Given regulatory progress and alignment of incentives, several new innovations in life sciences as well as delivery models promise exciting opportunities in health care:

- Data driven decision-making: Technology that allows collection and analysis of massive

5 Circular economy is another term coined by the McKinsey Global Institute. It refers to an alternative to the "take-make-dispose" business model for use of materials in manufacturing. The circular economy maximizes the productivity of materials and energy and minimizes the impact of their extraction and processing. The circular economy is built on four principles: designing products with their entire life cycles in mind; maximizing product life cycles; recycling materials from end-of-life products; and reusing materials across diverse industries and value chains.

datasets is already changing R&D, clinical care, forecasting and marketing. McKinsey Global Institute's 2011 report on Big Data estimated the long term potential of applications across health care to be over $300 billion per year, with more than $200 billion savings on national health care spending. In all, the report estimated Big Data levers could save up to 12 per cent of national health care expenditures in the long term and add nearly 0.7 per cent to average labour productivity growth in the U.S. health care system. Health care providers who have harnessed the power of data driven analysis have often reaped rich dividends.[6]

- Transparency in delivery systems: Ease of connectivity and an expectation of openness between patients and providers is driving pricing transparency. Increased usage of self-diagnosis through online resources and social media is shifting some power towards patients.
- Low-cost channels and solutions: The growth of new low-cost channels and solutions, e.g. "minute clinics", remote care tools and self-service at clinics, promises better care for patients with little or incomplete insurance coverage.

Personalization and the "quantified self": a major trend in health care is the use of big data and advances in obtaining granular information on individuals (e.g. through genome sequencing) to enable the development of highly personalized treatments and medicines. New personal fitness devices like the Fitbit offer the option to track the wearer's activity and sleep cycles. Increasingly, these devices will allow the monitoring of more indicators, like body temperature or pulse rate. These will permit individuals not only to better understand their own unique physiology, but also to be alerted in a timely manner to the need for treatment or exercise.

Infrastructure

This sector has been a laggard in improving productivity – there has been no measured gain in the labour productivity of the construction sector in the last 20 years! The implications of improving productivity are huge. To keep pace with growth, infrastructure investment in the United States will have to rise to 3.6 per cent of GDP, up from the current 2.6 per cent.

McKinsey Global Institute research has shown opportunities in three areas to reduce the need for new investment by obtaining more from the current infrastructure (Dobbs *et al.*, 2011):

- Making better decisions about project selection, e.g. Department of Transportation in Washington state publishes detailed information on plans and progress in a comprehensive performance report to legislators and the public each quarter.
- Streamlining project delivery – More efficient delivery can generate savings of as much as 25 per cent on new projects, or 15 per cent savings on total infrastructure investment. The state of Virginia moved ahead with a controversial plan to widen the I-495 interstate after a private design company came up with a route that eliminated the need to remove hundreds of homes. The plan also reduced the project cost from about $3 billion to around $1 billion.
- Making the most of existing infrastructure –
  a) Intelligent transportation systems (ITS) for roads, rail, airports, and ports can double or triple asset utilization.
  b) Smart grids could help the United States avoid $2 billion to $6 billion a year in

6 In a study conducted in a 20-bed multi-disciplinary PCCU in a major metropolitan area, McKesson's WizOrder system was installed for allergy alerts, drug interaction and dosage and was integrated with EHR data. It was found that the new system helped reduce Adverse Drug Events by 41 per cent through near-elimination of prescription errors, previously responsible for three-fourths of the events.

power infrastructure costs and also help reduce the likelihood of outages that cost the economy tens of billions of dollars per event.

c) Efficient demand management, e.g. California employs a range of demand-management measures to lower per-capita energy use to 40 per cent of the U.S. average.

Conclusion

The growth of GDP per worker has remained fairly solid during the past 30 years and even over the past 10 years, but there are some warning signs. Labour productivity growth was slow from 1973 through 1995 and may now be slowing again. The long period of economic weakness triggered by the financial crisis has been compounded by political gridlock and an unwillingness to resolve policy differences and deal with the long-run deficit problem. The rapid increases in the labour force that occurred with the baby boom generation and the increased entry of women into the workforce are now over.

However, we reject the idea that growth opportunities have vanished. The signs of ongoing innovation abound in Silicon Valley and far beyond. And necessity can be the mother of invention if pressure on budgets forces businesses and government to find ways to cut costs and raise efficiency in health care and infrastructure. Moreover, the energy revolution is a tribute to the innovative power of small and medium-sized businesses in the oil and gas sector that kept looking for ways to drill productively in the United States. Technology support from the Department of Energy also helped. If the environmental challenges are met and overcome, this revolution will open up a wide range of investments, job opportunities and productivity improvements.

References

Brynjolfsson, Erik and Andrew McAfee (2011) *Race Against The Machine: How the Digital Revolution is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment and the Economy* (Digital Frontier Press).

Cowen, Tyler (2011) *The Great Stagnation: How America Ate All The Low-Hanging Fruit of Modern History, Got Sick, and Will (Eventually) Feel Better* (Dutton).

De Avillez, Ricardo (2012) "Sectoral Contributions to Labour Productivity Growth in Canada: Does the Choice of Decomposition Formula Matter?" *International Productivity Monitor*, No. 24, Fall, pp. 97-117.

Dobbs, Richard, Herbert Pohl, Diaan-Yi Lin, Jan Mischke, Nicklas Garemo, Jimmy Hexter, Stefan Matzinger, Robert Palter, and Rushad Nanavatty (2013) "Infrastructure Productivity: How to Save $1 Trillion a Year," McKinsey Global Institute report. http://www.mckinsey.com/insights/engineering_construction/infrastructure_productivity.

Gordon, Robert J. (2013) "U.S. Productivity Growth: A Not So Optmistic Perspective, Comments on 'U.S. Productivity Growth: An Optimistic Perspective'," *International Productivity Monitor*, No. 25, Spring, pp. 13-19.

Lewis, William W. (2004) *The Power of Productivity - Wealth, Poverty and the Threat to Global Stability* (University of Chicago Press: Chicago).

Manyika, James David Hunt, Scott Nyquist, Jaana Remes, Vikram Malhotra, Lenny Mendonca, Byron Auguste, and Samantha Test (2011a) "Growth and Renewal in the United States, February," McKinsey Global Institute report, February. http://www.mckinsey.com/insights/americas/growth_and_renewal_in_the_us.

Manyika, James, Michael Chui, Brad Brown, Jacques Bughin, Richard Doobs, Charles Roxburgh, and Angela Hung Byers (2011b) "Big Data: The Next Frontier for Innovation, Competition, and Productivity," McKinsey Global Institute report, May. http://www.mckinsey.com/insights/business_technology/big_data_the_next_frontier_for_innovation.

Waide, Paul and Conrad U. Brunner (2011) "Energy-Efficiency Policy Opportunities for Electric Motor-Driven Systems," International Energy Agency, Working Paper. http://www.energiestiftung.ch/files/downloads/energiethemen-energieeffizienz-industriegewerbe/ee_for_electricsystems-2-.pdf.