Some highlights from recent research on economic growth[1]

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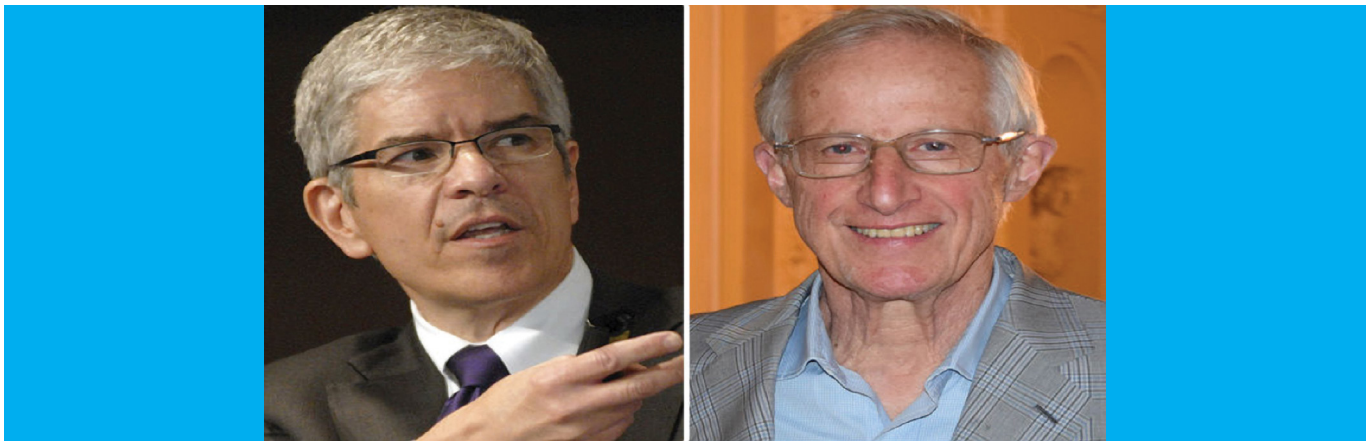
Research in the field of economic growth bloomed following Robert Solow's[2] seminal contributions in the 1950s. This was followed in the 1960s and 70s by a surge of empirical and theoretical discoveries. Scholars such as Edward Denison, Dale Jorgenson, Zvi Griliches and John Kendrick pursued research into the measurement and sources of economic growth. The application of optimal control theory[3] to economic dynamics was at the centre of important contributions from Hirofumi Uzawa, Karl Shell, David Cass and others.

Understanding of the mechanics of economic growth expanded considerably during the 1980s and 90s thanks to the work of Robert Lucas,[4] William Nordhaus, Paul Romer,[5] Philippe Aghion, Peter Howitt, Elhanan Helpman, Gene Grossman and others.

Philippe Aghion and Steven Durlauf assembled an impressive collection of research papers in the *Handbook of Economic Growth*, Volume 1 (published in 2005) and Volume 2 (2014). They provide comprehensive assessments of research into economic growth (and its determinants) and summaries of key theoretical and empirical advances. Since then there have been new developments in the area, and today the literature on economic growth is as vibrant as ever.[6]

This article highlights some of the exciting and important current research in the field of economic growth.

Paul Romer and William Nordhaus, winners of the Nobel Prize in Economic Sciences 2018



Source: www.wsj.com/articles/nobel-in-economics-goes-to-american-pair-1538992672

AI, ROBOTS AND ECONOMIC GROWTH

Developments in the areas of Artificial Intelligence (AI), Big Data, nanotechnology, driverless vehicles, automated factories and other new technologies have already started to transform business models all over the world. Many companies are interested in opportunities resulting from AI.

Are robots coming to steal our jobs? Will AI replace human decision-making? Much of the popular discussion around AI, automation and robots focuses on the labour-market impacts of these new technologies.[7,8]

A robot delivers takeaway food to customers in a trial in London

Source: www.nature.com/news/track-how-technology-is-transforming-work-1.21837

1 This article expands and updates the author's piece he wrote for the newsletter of the New Zealand Centre for Macroeconomics (Üngör 2018).
2 Robert Solow received the 1987 Economics Nobel Prize "for his contributions to the theory of economic growth."
3 Optimal control theory is typically applied in economics for the solution of dynamic problems.
4 Robert Lucas received the 1995 Economics Nobel Prize "for having developed and applied the hypothesis of rational expectations, and thereby having transformed macroeconomic analysis and deepened our understanding of economic policy."
5 The 2018 Economics Nobel Prize was divided between William Nordhaus "for integrating climate change into long-run macroeconomic analysis" and Paul Romer "for integrating technological innovations into long-run macroeconomic analysis."
6 Akcigit (2017) discusses the past, the present, and the future of economic growth. Jones (2016) presents a comprehensive tour of the growth literature from the perspective of basic data.
7 In 2018, the Massachusetts Institute of Technology (MIT) launched its *Task Force on the Work of the Future*, an institute-wide effort to understand how emerging technologies are transforming the nature of human work during an age of innovation in the digital economy (https://workofthefuture.mit.edu).
8 The Centre for Artificial Intelligence and Public Policy (CAIPP) was launched in 2018 to draw together the University of Otago's considerable research expertise on the social effects of AI, providing a hub for collaboration between initiatives at the University (www.otago.ac.nz/caipp).

Automation enables capital to replace labour in doing tasks it was previously engaged in. Recent studies introduce new frameworks for conceptualising automation. Acemoglu and Restrepo (2018a) model automation as the (endogenous) expansion of the set of tasks that can be performed by capital replacing labour.[9]

Aghion et al. (2019) put together these two ideas: (1) economic growth may be constrained not by what we do well but rather by what is essential and yet hard to improve; and (2) AI is a new form of automation that may allow additional tasks to be automated that previously were thought to be out of reach of automation. The authors discuss how such a combination can yield a rich description of the growth process, including the consequences for future growth and income distribution.

DANGER, WILL ROBINSON!

Carefully designed empirical studies have started to use data from the International Federation of Robotics (IFR) to study the implications of automation. Acemoglu and Restrepo (2018c) connect the adoption of industrial robots to lower employment and wages in local labour markets, utilising a model where robots and workers compete in the performance of different tasks. The authors analyse the effect on labour markets of increases in industrial robot usage in 19 industries between 1990 and 2007 in the United States; they estimate that one more robot per thousand workers reduces the employment to population ratio by about 0.18-0.34 percentage points and wages by 0.25-0.5%.

Acemoglu and Restrepo (2019) show that demographic change is associated with greater adoption of robots and other automation technologies across countries. Using US data, they document that industrial robots substitute for middle-aged workers.

On the other hand, a study of German data suggests that the picture isn't quite so bleak. Dauh et al. (2018) estimate the effect of industrial robots on employment, wages and the composition of jobs in German labour markets between 1994 and 2014.[10] Robot exposure has even increased job stability, but many incumbent workers end up performing different tasks than before. The authors find sizable employment reductions in manufacturing industries with industrial robots. But these losses were fully offset by job gains outside manufacturing, most importantly in business services. In other words, robots have strongly changed the composition but not the aggregate level of employment in Germany.

ARE WE RUNNING OUT OF IDEAS?

Can technological progress be sustained in today's most developed countries? Are the best years for US growth and productivity in the past?

Robert Gordon, in his book *The Rise and Fall of American Growth* (Gordon 2016), contends that today's technological innovation cannot drive economic growth as past innovation did. And US productivity growth will be held back by the headwinds of rising inequality, stagnating education, an ageing population, etc.

Similarly, Bloom et al. (2019) argue that new ideas are getting more expensive to find. The authors estimate that research productivity in the US has fallen 5.3% per year on average. This means that the economy has to double its research efforts every 13 years just to maintain the same overall rate of economic growth.

MAYBE NOT

Not everyone is so pessimistic, however. Joel Mokyr, one of the most celebrated economic historians of our time, argues that new technologies such as AI and nanotechnology can be considered as general purpose technologies (GPTs).[11] GPTs take a long time to fully affect the economy, because they require complementary innovations and investments (Mokyr 2018). This view suggests that the recent productivity slowdown may be temporary.

In a related vein, some researchers argue that traditional metrics like GDP and productivity can become more difficult to measure and interpret in today's digital economy.[12] Brynjolfsson et al. (2017) argue that the intangible assets associated with AI can be more than the direct investments in these technologies themselves. In summary, measuring and accounting for innovation have become an active research area.

Daron Acemoglu, Erik Brynjolfsson, Robert Gordon and Joel Mokyr

Source: http://uk.pcmag.com/feature/92091/ais-implications-for-productivity-wages-and-employment

9 Acemoglu and Restrepo (2018b) provide an insightful theoretical discussion of modelling automation.
10 Clement (2018) provides a very insightful review of the findings of Dauh et al. (2018).
11 A drastic innovation qualifies as a GPT "if it has the potential for pervasive use in a wide range of sectors in ways that drastically changes their modes of operation" (Helpman 1998, p. 3). Examples of GPTs are the steam engine, electricity and the computer.
12 http://papers.nber.org/books/corr-2

LARGE-SCALE DIGITISATION OF HISTORICAL RECORDS

Innovation is one of the key determinants of economic growth. Unfortunately, however, there is not much empirical evidence on the long-run patterns of innovation and inventions due to the paucity of historical data.

Assembling new and rich data sets from archival sources has yielded very promising research findings in the fields of international trade, economic development, and economic history.[13] There have also been interesting recent efforts to investigate the determinants of economic growth and innovation using historical records.

Akcigit et al. (2017a,b) utilise a dataset matching millions of investors from patent records to individuals in Federal Censuses and present suggestive evidence that the contributions of foreign-born inventors have provided a long-term boost for American innovation. The authors show that foreign-born people were more prevalent among inventors active in the US than in the non-inventor population and provide suggestive evidence that immigrant inventors were of central importance to American innovation since the 19th century.

IN CLOSING

The list of work covered here is by no means exhaustive, and the area of economic growth is a subject of active research. It is always exciting to see new theoretical frameworks and carefully designed quantitative analyses.

QUESTIONS TO THINK ABOUT

1. What caused American growth in income and productivity to accelerate starting in the mid-1990s?
2. Which technologies are already eliminating, augmenting or transforming which types of jobs?
3. What are the main drivers of technology diffusion? What obstacles prevent the most productive technologies from spreading to less developed economies from more developed nations?
4. If AI increases automation in the production of goods and services, how will it affect economic growth?

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13 Donaldson (2018) is a perfect example of this type of research.