

RESEARCH BRIEF

Technology and Skill: Twin Engines of Growth

Based on BFI Working Paper No. 2018-26, "[Technology and Skill: Twin Engines of Growth](#)," by Nancy Stokey, UChicago professor of economics

KEY TAKEAWAYS

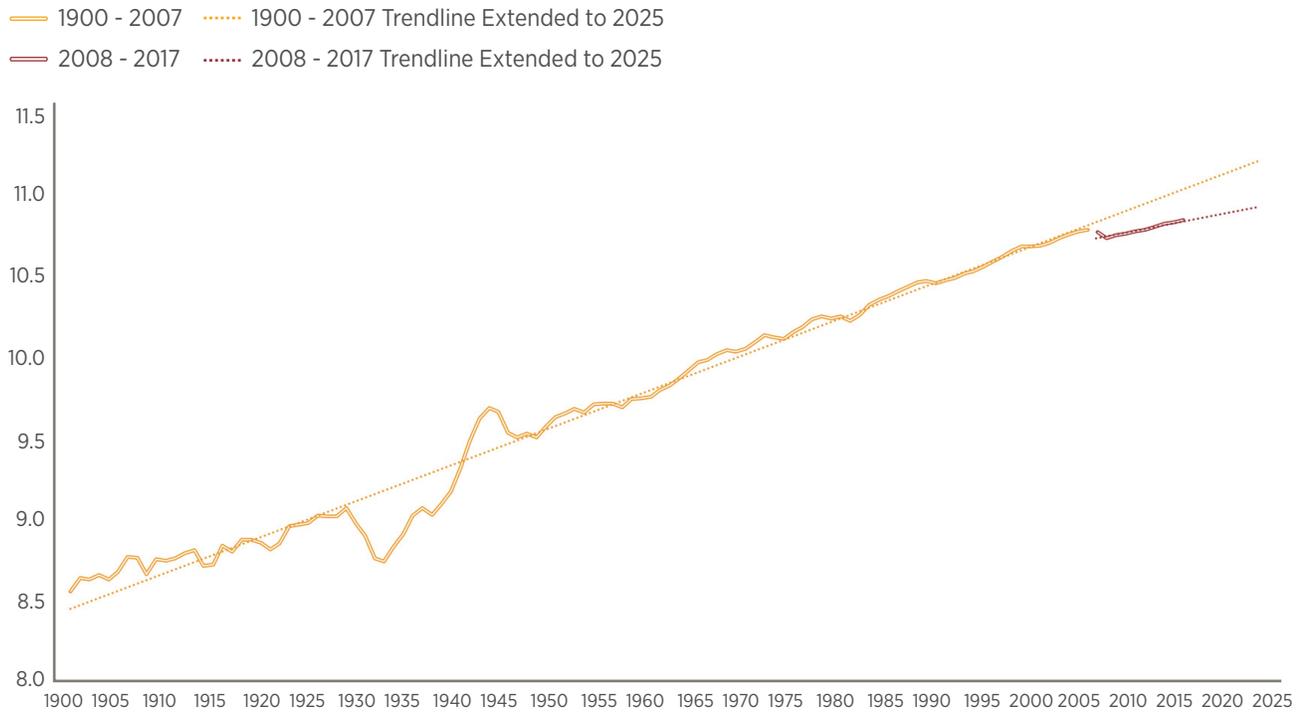
- ✓ US per capita GDP is below its historic trend line since the Great Recession of 2008-09, although the growth rate has recovered
- ✓ Technology advancement and skills enhancement are two key contributors to an economy's growth rate
- ✓ New theoretical models offer insights into how technology and skills impact an economy's growth, and how they interact with each other to drive that growth
- ✓ This paper suggests that policymakers should pay particular attention to skills enhancement

The Great Recession of 2008-09 officially lasted 18 months, but the lingering effects of the downturn still hang heavily on the economy. After a century during which average per capita GDP growth was about 1.5 percent per year, income fell sharply in 2009 (see Figure 1).

Today the growth rate is back at its trend value, but the economy has not regained, in terms of levels, the "lost years" of growth after the 2008 crash. Instead, per capita GDP seems to be on a new trend line, parallel to the old one instead of catching up, prompting some observers to dub this the "new normal." Of course, the growth rate could suddenly surge, raising income to the old trend line, but after nearly nine years of subdued growth, that prospect seems dim, at least in the near term. Why didn't US GDP bounce back following the Great Recession? What are the factors that determine economic growth, and how can economic theory help us understand how these factors influence each other?

These are the types of questions that motivate the latest working paper from UChicago economist Nancy Stokey. In "[Technology and Skill: Twin Engines of Growth](#)," Stokey develops a model in which two factors contribute to growth: investments in technology by firms, and investments in human capital by workers, where both firms and workers are acting in their own best interests.

Figure 1: U.S. Real GDP Per Capita (1900 - 2017)



Source: Data from 1929 to 2017 is from the U.S. Bureau of Economic Analysis (BEA). Data from 1900 to 1928 is adapted from the 2018 Maddison Project Database.

Income growth in turn takes two forms: growth in the quantity produced of each good, and growth in the number of goods available. Stokey's model provides a deeper understanding of the relationship between these two instruments of growth—technology and human capital—and how the incentives to invest in the two sides interact with each other.

Modeling growth

It's not difficult to imagine a city that has lost a legacy manufacturing plant or an entire industry, and that consequently suffers from high unemployment, declining property values, and other ills associated with a such a negative economic shock. At a time when most growth industries are related to high-tech (whether medical, social media, biosciences, and even manufacturing) and the skilled workers that such industries demand, it is also easy to imagine that such a city would have a difficult time luring high-tech companies to its metro area, in large part because that city's labor force would not supply the in-demand skills.

For a city, such economic events are often devastating and can have long-lasting effects. For workers, the same

can also be said, except that people have the ability to move and/or acquire new skills. When we consider the country as a whole, the issue isn't necessarily whether some cities are doing well and others poorly, but rather whether the country itself is growing in the aggregate and its citizens have the opportunity for gainful employment. For those charged with shaping policy, then, there are broad questions about how much investment should be made in technology and how much in human capital such as education and training.

Stokey's contribution to this question is to bring human capital and technology together in a model where interactions between factors affecting growth can be examined: for example, what happens if firms add more technological capital and workers do not respond in kind with more education and training? What about factors outside a firm's or a worker's control, like input prices and interest rates?

There is a balance among all these factors that leads to the optimal amount of technology and skill. On the other hand, large increases in the amount of education and training would not be efficient if there weren't opportunities to put those skills to use. On

the other hand, without a skilled workforce it would not be worthwhile—or even possible—to develop new technologies. Improvements need to happen on both sides of the equation, according to Stokey, otherwise incentives to improve diminish.

In Stokey’s model, growth takes two forms: total factor productivity growth (TFP) and growth in product variety. (TFP is the portion of output not explained by the amount of inputs used in production and is likewise determined by how efficiently those inputs are used. Product variety growth is exactly as it seems: growth in the range of products that firms produce.) The main result of Stokey’s model is to provide conditions for the existence of a balanced growth path (BGP), to show how the rates of TFP and variety growth depend on the parameters governing technology and skill acquisition, and to show that the incentive to invest in either factor depends on the availability of its complement.

Economists use the term balanced growth path (BGP) to describe when skill and technology grow at a common rate, which is also the rate of TFP growth. However, which is more important to the rate of TFP growth: skill accumulation or technical change? According to Stokey’s model, the parameters governing skill accumulation are more important than those governing technological change. Stokey employs a roughly calibrated numerical example to reveal a surprising finding about the relationship between existing and new workers. She shows that a retooling subsidy has a large effect on TFP growth, and hence on growth in per capita output and consumption. But the reason isn’t obvious. A subsidy to retooling is powerful not just because of the direct effect on the workers receiving the training, but also because it changes how new workers learn their skills. Role models are important here: they are the templates that new workers imitate.

For an economy experiencing balanced growth, continued investment in either skills or technology remains worthwhile only because the other grows: the technology and skill distributions must shift together.

Removing the lowest-skill role models means that young workers who would have imitated them instead draw lessons from higher-skilled workers.

For an economy experiencing balanced growth, continued investment in either skills or technology remains worthwhile only because the other grows: the technology and skill distributions must shift together. The incentive for either factor to invest depends on the relative level of development of its complement. In particular, if one factor has a distribution that gets “ahead” of the other, the incentive to invest in the leading factor declines while the incentive to invest in the lagging factor gets stronger.

Conclusion

Stokey’s theoretical model about the dynamic inter-relationship between skill enhancement and technology advancement, and their contributions to growth, addresses key questions about how economies grow and, ultimately, what policies will bring the best results. However, such theoretical models are rarely directly employed by policymakers. But that isn’t necessarily the point of such work. In an essay supplementing his paper, “The Price of Macroeconomic Uncertainty with Tenuous Beliefs,” co-written with Thomas Sargent, UChicago economist Lars Peter Hansen describes the nature of theoretical modeling and the value it brings to real-world applications. “... The models that we as economists build and analyze are highly stylized. These include ‘shocks,’ random impulses such as technology shocks or monetary policy shocks that are transmitted over time. They are at best approximations because they ignore some forces and oversimplify others. (Put impolitely, our models are ‘wrong.’)” Wrong by design, in other words, but with an eye toward getting things right. As Hansen explains, theoretical research “aims to convert abstract insights into operational tools of analysis.”¹

¹ http://larspeterhansen.org/wp-content/uploads/2018/05/tenuousblurb_new.pdf

Stokey's model achieves this end by offering a more sophisticated tool for economists to consider the complex role and relationship of skills and technology in advancing an economy's growth. She shows that to increase the rate of TFP growth, possible policy interventions could include subsidizing research and development and the entry of more firms or products, and/or to subsidizing worker training to advance obsolete skills. Of the two—subsidizing R&D vs. skill training—the latter is more effective. Temporarily removing lesser-trained (and often older) workers from the workforce and upgrading their skill set not only improves their productivity but also has a positive effect on new workers, who experience better role models. Further, the workers that are retrained are often at the bottom of the wage distribution, so advancing their skills also has a positive income effect.

Stokey's model also offers challenges for policymakers who may have a preconceived notion about the role of government policy in driving economic growth. For example, it is not always obvious that the market, left alone, will produce the right amount and variety of goods and also deliver the optimal level of education and skills training. Firms may invest in R&D to increase profits, but what if their research reveals other benefits to society that do not improve that firm's bottom line? In such a case, the firm might discontinue the research program because most of the benefits accrue to society and not the firm: TFP is lower than it otherwise would be.

CLOSING TAKEAWAY

Temporarily removing lesser-trained (and often older) workers from the workforce and upgrading their skill set not only improves their productivity and also has a positive effect for new workers, who experience better role models.

READ THE WORKING PAPER

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