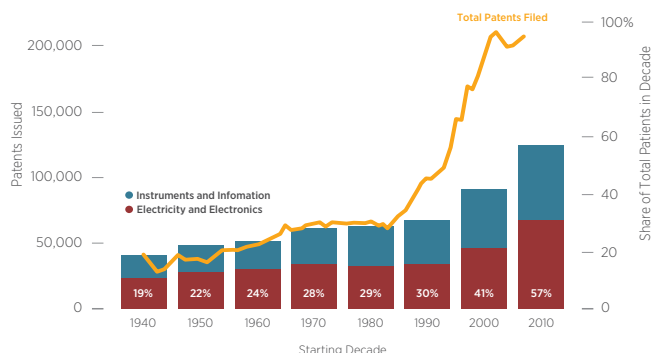


Bottlenecks: Sectoral Imbalances and the US Productivity Slowdown

Based on BFI Working Paper 2023-90, [*"Bottlenecks: Sectoral Imbalances and the US Productivity Slowdown,"*](#) by Daron Acemoglu, MIT; David Autor, MIT; and Christina Patterson, University of Chicago

Lagging US productivity growth since the 1970s, despite the rapid pace of innovation in information and communications technologies (ICT) and electronics, is explained in part from an unbalanced sectoral distribution of innovation; that is, technological advances over the last several decades have been unbalanced across sectors and have created endogenous bottlenecks, holding back aggregate productivity.

Figure 1 • Counts of US Patents Issued, 1940–2010, and Shares in Electricity and Electronics and Instruments and Information

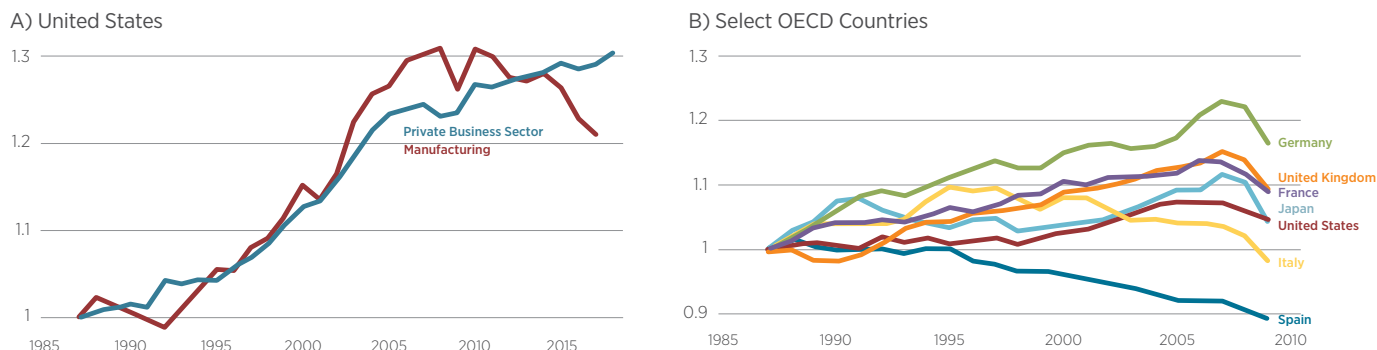


Note: This figure plots the evolution of the counts and share (among all US utility patents) of electricity and electronics, instruments and information patents, thus illustrating how the breakthrough technology of transistors fueled the patenting surge in electronics and information and communication technologies. Specifically, the left-hand y-axis (green line) gives the count of US utility patents issued in each year (yellow line), while the right-hand y-axis corresponds to the share of patents granted in each decade that are in Electricity and Electronics (red bar) and Instruments and Information (blue bar). Instruments and Information is synonymous with information and communications technologies (ICT).

Do a quick internet search and you will find that the electronic device on which you are likely reading this Research Brief has many thousands of times more computing power than Apollo 11 back in 1969. Of course, Apollo 11's relatively modest computing power was designed to fly a rocket, and your device is not. Even so, you might assume that such technological advances—evident across many electronic and communication devices—suggest large increases in aggregate productivity over that time. If so, you would be wrong.

Let's observe the evidence from the accompanying two Figures. Figure 1 illustrates breakthroughs in information and communication technology (ICT) and electronics by plotting the distribution of patents granted over the last several decades, and reveals two key patterns: A rapid takeoff in the total number of patents, and a surge in the share of ICT and electronics patents, both beginning in the 1980s. So far, so good. However, Figure 2 reveals that the minimal growth rate of Total Factor Productivity

Figure 2 • Time Series for Aggregate Total Factor Productivity



Note: This figure depicts the growth rate of Total Factor Productivity (TFP) in the US economy and in the leading OECD economies in recent decades. Productivity growth in the United States has been minimal since the mid-2000s, and it has been slower still in many OECD countries, with the possible exception of Germany.

(TFP)¹ in the US economy has been minimal since the mid-2000s, and even slower in many OECD countries, with the possible exception of Germany.

How can these facts be reconciled? On the one hand, some believe that we stand on the verge of a new technical revolution driven, in part, by increasingly intelligent machines. On the other hand, some argue that the most-impactful technologies already exist and that any improvements will be marginal, at best, leading to a prolonged period of slow productivity growth. (The leap to the first handheld phone was huge, for example, but the step from model no. 12 to 13 is marginal, at best.)

This paper offers a novel reconciliation of these competing hypotheses: Technological advances over the last several decades have been unbalanced across sectors and have thus created unexpected bottlenecks, holding back aggregate productivity. Put simply, imagine a product with three inputs, A, B, and C, where A and C make technological leaps but B lags behind. Without B, the final product cannot incorporate the advances of A and C. Innovation is bottlenecked and the final product does not benefit. Aggregate productivity remains the same, despite the relative gains of two inputs. Now imagine that these bottlenecks occur across sectors and over time, and you will get a theoretical sense of how these logjams restrict aggregate productivity.

The authors offer three real-world examples of such innovation bottlenecks—high energy-density rechargeable batteries, the transistor, and the global positioning system (GPS)—and for the purposes of this brief, we will review the history of the transistor, a foundational technology of recent economic growth. Through the 1950s, the productive development of such electronic devices as radios, transmitters, audio amplifiers, and early computers were hampered by electromechanical switches and vacuum tubes, which were bulky, fragile and slow. The arrival of the transistor

supplied a tiny, fast, and (ultimately) very cheap, mass-produced alternative to vacuum tubes, thus breaking the bottleneck that had impeded progress in scores of ICTs, as well as giving birth to digital communications. Today, the internet, artificial intelligence, and autonomous vehicles owe their existence to the transistor's blazing switching speed.

To investigate the role of endogenous industrial bottlenecks in restricting aggregate productivity growth, the authors develop a model where technological advances (modeled as quality improvements) in a given sector depend upon simultaneous improvements in the sector's supplier industries. Although advances in each upstream sector are potentially beneficial, these advances are complements, so that, while more of any one of them is good, an imbalance among them hold back further innovation. A balanced distribution of technological improvements, in other words, determines the viability of further innovations.

The authors use data from 462 manufacturing industries between 1977 and 2007, and also data for the entire US economy between 1987 and 2007, to develop an equation linking growth in sectoral TFP to both the average TFP and the dispersion (variance) of TFP among that sector's inputs, to find the following:

- Greater dispersion of TFP growth among an industry's suppliers exerts a powerful negative influence on its own growth opportunities; a doubling of the variance of input-supplier TFP growth for a sector is associated with about 0.9 percentage points slower TFP growth for that sector.
- A substantial share of the productivity slowdown in the United States (and several other industrialized economies) can be accounted for by the marked increase in cross-industry variance of TFP growth and innovation in recent decades. For example, if TFP growth variance had remained at the 1977-1987 level, the authors' estimates imply that US manufacturing productivity would have grown twice as rapidly in 1997-2007 as it did—yielding a

¹ Total Factor Productivity measures the growth in total output by not only including labor and/or capital as inputs, but also others like energy, materials, and services; in other words, it is usually measured as the ratio of aggregate output to aggregate inputs.

counterfactual growth rate that would approximate that of the previous two decades.

- Leading “bottleneck industries” include pharmaceutical preparation, basic inorganic chemicals, electronic connectors, and surface-active agents (molecules with the capacity to adsorb to solid surfaces and/or fluid interfaces, used in a wide range of consumer products in various industrial sectors, like cosmetics, personal care, detergents, food, etc.).
- A 20% decrease in the TFP growth of the 10 fastest-growing industries and a simultaneous increase in the TFP growth of each of the bottom 50% of industries would have led to 0.6 percentage points higher aggregate TFP growth in manufacturing.
- Finally, surgical and medical instruments, gas engines, and industrial valves are among the most consequentially bottlenecked sectors, which means that they are large contributors to GDP but are inhibited by high TFP growth dispersion among their suppliers.

While these findings lend strong credence to the authors’ hypothesis, they are not yet conclusive. The work is a first step in the theoretical and empirical investigation of the interlinked nature of innovation across sectors, and it raises critical questions for our understanding of productivity: Will the forces shaping technological progress tend to clear productivity bottlenecks, or might the market mechanism exacerbate imbalances? What can we learn about the relationships between sectoral innovators and their buyers? What is the role of global supply chain networks in productivity bottlenecks? What can the authors’ bottleneck hypothesis tell us about technological breakthroughs throughout history? And finally, what happens if and when bottlenecks are broken, so that lagging industries ultimately increase their innovation and productivity growth rates: Will aggregate productivity experience a rapid takeoff as this research predicts? These and related questions await further research.

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