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John Fernald started the discussion by thanking Samuel Kortum, Unni Pillai, and John Haltiwanger for their prepared comments, highlighting the depth of both discussions. He recognized that if half of the evolution of productivity can be explained by semiconductors, as Kortum argued, then this suggested that his arguments are about the other half. Additionally replying to one of Kortum’s comments, he explained that the increase in offshoring has an effect on the Domar weight of semiconductors, but it has been partly offset by terms of trade gains. In terms of interpreting aggregate numbers it matters, but it does not matter for an information technology (IT) user. Answering Haltiwanger’s question regarding whether IT-producing or IT-using industries experienced larger declines in productivity, the author explained that the data is not sufficient to provide an answer. Finally, the author mentioned his paper (Fernald and Jones 2014) to explain the causes of the decline in productivity growth. That paper has an endogenous growth model and technological progress is represented by a shift in the shape of the idea production function, which depends on the amount and type of ideas at any point in time. The difference in growth can be explained because the mid-1990s was a time of high marginal product of research and during the current period, even though there are a lot of start-ups, the new ideas being generated may be not as big or as important. He also mentioned that other factors may influence the process, such as regulation and dynamism.

Valerie Ramey continued the discussion by making three comments. The first was about cautioning the author about extrapolating trends from the late 1990s, because of the Year-2000 (Y2K) problem. She explained that in the second half of the 1990s, many firms were worried...
that their software would malfunction on the arrival of January 1, 2000, because so many programmers had used two-digit year dates rather than four-digit ones. Because of this fear, many companies decided to move up their IT investment earlier in time, before 2000 started. This temporary higher demand for IT investment also gave IT-producing companies an incentive to speed up their innovations. This can explain the boom years for IT investment at the end of the 1990s and the bust afterward if there is endogeneity in total factor productivity (TFP) among IT-producing firms. The second comment was about demographics. She explained that innovation may have decreased because the population is older and innovation is generally done by young people. Finally, she proposed an alternative calculation of potential gross domestic product (GDP) that should be closer to the author’s calculation than to the measure by the Congressional Budget Office. The calculation is done by projecting current and future GDP assuming no change in the speed of adjustment from an estimated error correction model of the Keynesian gap, meaning the gap generated by wages and prices not fully adjusting in the short term.

Robert Gordon then continued by relating Fernald’s findings to two of his papers (Gordon 2000, 2014). First, Gordon (2000) and Fernald’s paper gave the same negative answer to the question of whether inventions happening around the first decade of the twenty-first century were as big as the ones made in the past. Second, Gordon (2014) argues that there is a big difference between the second and third industrial revolutions. The second, which started in 1870 was so big that it took 100 years, and the post-1970 productivity slowdown can be interpreted as the depletion of ideas and diminishing returns. This idea was originated by William Nordhaus and is the subject of Gordon (1972). In contrast, the third industrial revolution that started 50 years ago had all its visible effect reviving productivity growth concentrated in the years identified by Fernald, 1996–2004. He cautioned the author about the end of that period, because when using gross domestic income over household hours as an alternative measure of productivity growth, the decline in productivity started earlier. Then he highlighted three pieces of evidence in Gordon (2014) supporting the temporariness of the information and communication technology (ICT) revolution. The first is the growth of manufacturing capacity per capita that went from 2% in the 1970s and 1980s to 6% in the late 1990s, peaked in 1998, and has been slightly negative for the last six years. The second is the value added of ICT as a percentage of total US manufactured value added that started
at 3% in 1972, peaked at 8% in 1998, and is now back at 3%. The third is the Bureau of Economic Activity ICT Deflator that started decreasing at 3% in the late 1980s, peaked at an annual decreasing rate of 15, and is now decreasing at 1%. Continuing with his comment, Gordon pointed out that in table 5 of Fernald’s conference draft that shows the projections for labor productivity, the author highlighted the average of projections, that is 1.91, but Gordon argued that an alternative equally valid number is 1.6, which is close to the projections made with data since 1973:Q1 and also since 2003:Q4. Additionally, he pointed out that he and Dale Jorgenson separately got to the same labor productivity projection for the whole economy of 1.3 implied by Fernald’s estimates. To get to the estimate for the whole economy, the 1.6 mentioned previously needs to be lowered by 0.3, since Fernald’s number refers to the business sector and productivity grows slower outside the business sector. Finally he asked about the trajectory for hours and productivity when the cyclical recovery is over and hours go back to normal.

Michael Kiley continued by making the observation that the slowdown in productivity in the middle of the first decade of the twenty-first century is consistent with the timing of housing boom and bust, contrary to what was argued by the author. He explained that in the 1990s, there was an increase in innovation and IT because there was overexuberance about long-run prospects of IT as argued in Kiley (2000). Then, when that bubble burst at the beginning of the twenty-first century, the irrational exuberance went toward an unproductive asset, housing, which is consistent with the timing because housing should be dragging down productivity at the time the sector is booming and not when the bust occurs. Then, Kiley continued by questioning the slack measured by the author’s approach that uses utilization adjustment that relies on hours per worker, since other measures of labor underutilization are at historically extreme values.

Mark Gertler then highlighted that the paper was very convincing about the break in trend productivity in 2003–2004. He also noted that the recent recession, even though it is different from other US recessions, shares similarities with recessions in emerging economies since there is no return to trend, it is preceded by a financial crisis, and there is a persistent decline in productivity. This is why, he proposed to complement the analysis, using emerging market recessions and other countries currently experiencing a great recession to isolate a component of the decline in TFP due to the recession. Robert Hall mentioned that he does not think that there is saturation in the potential productivity con-
tributions of IT. He gave the example of UBER, that brought important productivity changes by raising the utilization of urban transport, and he thinks that is only the beginning. He recognized that it takes a long time and new organizations for such innovations, but IT evolves as a random walk, and so it is not forecastable.

Martin Eichenbaum said that he thinks future big productivity improvements are going to be in biotechnology and not in IT, which is what young people are excited about.

Responding to a comment about the lack of important new technology firms of recent vintage, Jonathan Parker pointed to a change in the IT industry from firms having initial public offerings (IPOs) to being bought by large firms. He highlighted that the same innovative dynamism can be occurring, but observed differently due to a different way of growing profitably.

Unni Pillai then pointed out that the technological progress in semiconductors happened because of miniaturization, and he thinks that in other areas, such as biotechnology and renewable energy, miniaturization is still possible and will drive future progress.

Robert Gordon continued by reminding everybody that neither he nor Fernald are saying that productivity growth will be zero. Instead, output per hour will grow around 1.3, which allows for a lot of innovations. Regarding the utilization adjustment made by the author, he thinks that there could be a problem if the workweek of labor is the proxy for the utilization of capital. He explained that in the case of a change in the number of shifts per day, but not in the hours per shift, this measure implies wrongly constant capital utilization. Finally he questioned how the quality of workers fits into the story, since he thinks it had a sizable contribution to Fernald’s productivity growth in the last 6–7 years as the low-quality workers were laid off and a mix of workers got hired.

Frederic Mishkin then raised the issue of the mismeasurement of technological improvements in medicine. He explained that the increase in productivity of emerging economies is substantial when taking into account increases in life expectancy. Hall explained that even though it is imperfect, improvements in medicine are measured since they are scored as a price decrease by the Bureau of Economic Analysis (BEA), which maps into productivity increases.

Robert Gordon added to the comment about life expectancy, noting that Nordhaus (2002) showed that the value of improving life expectancy is as great as all improvements in consumption over the whole
post-war period, but it is also a fact that the improvement in life expectancy was twice as fast in the first half of the twentieth century than in the second half because of the reduction of infant mortality.

Jonathan Parker expressed his concerns about the future, since productivity growth declined despite being in a period of extremely cheap capital and very low interest rates.

John Fernald finished the discussion by giving answers to some of the comments. He replied to Gordon by saying that his reading of the data is more agnostic and concurred that there is a lot of uncertainty over future productivity growth. Some of the previously mentioned specific examples of technological progresses could end up being quantitatively important. He agreed with Gertler, that there are many stories that could imply big recessions associated with decreases in TFP, but he pointed out that according to historians, the Great Depression happened during a period of very high innovation. The evidence in Oulton and Sebastia-Barriel (2013) on the effect of financial crises on TFP concluded that there is no permanent effect for developed countries, but for those developing it is negative and large. In response to the measurement of capital utilization, the author highlighted that hours per job are currently in line with historical levels, while hours per person are unusually low because the number of jobs per worker/person are low. This suggests that firms are increasing labor on the extensive margin rather than the intensive margin. Fernald agreed that the link between measured hours per job and capital utilization is weak, but he thinks his paper’s measure of utilization is a good approximation, since the correlation between his measure and Shapiro-Gorodnichenko direct measure of the capital workweek is high.

Finally in response to Ramey, Fernald mentioned that the measure of output gap from the FRB/US model of the Board of Governors, which uses the Fleishman and Roberts state space supply model is close to his.

Endnote

1. In the final version this remark refers to table 4, and the updated projection for labor productivity is 1.85.