

Example of simulation study:

Andreas Hornstein, “Growth Accounting with Technological Revolutions”
Federal Reserve Bank of Richmond Economic Quarterly Summer 1999, 1-24

This paper's empirical work uses “calibration:” parameter values are plugged into the equations of a model, and a computer program is used to simulate or solve the model.

1. Topic

Measurement of technological progress during a period of “technological revolution”

Related literature:

- a. Some authors believe that the introduction of information technology is revolutionary, in the sense that previous experience gives us little guidance about how to use the technology effectively
- b. There is a puzzle in that some measures of total factor productivity growth show persistent declines in the 1970s and 1980s (dashed line in Figure 1)
- c. There is evidence from case studies of “learning by doing:” with experience, it takes less time to produce a given amount (Figure 2)

2. Specification of theoretical framework and initial empirical results

A. Reminder about Solow framework

(Notation matches Hornstein)

$$y(t) = z(t)k(t)^\alpha n(t)^{1-\alpha}$$

$y(t)$ =output

$z(t)$ =total factor productivity

$k(t)$ =capital stock

$n(t)$ =labor

[Solow notation was: $Y(t) = A(t)K(t)^\alpha N(t)^{1-\alpha}$]

“Solow residual” constructed as:

(7) growth rate of Solow residual =

$$\begin{aligned} & \text{growth rate of output} - \alpha * (\text{growth rate of } k(t)) \\ & - (1-\alpha) * (\text{growth rate of } n(t)) \end{aligned}$$

Like Solow, Hornstein constructs the Solow residual using share of capital income in total income rather than α , share of labor income in total income rather than $(1-\alpha)$.

Hornstein's model:

1. He distinguishes between “vintages” of capital manufactured in different years.
2. Technology is embodied in new capital goods. For example, \$1000 of personal computers produced in 2009 is more powerful than \$1000 of personal computers produced in 2001. One can only exploit this new technology by buying new capital goods.
3. The more experience we have with capital produced in a given year, the more productive we are. Consider, for example, personal computers produced in 2001. We are more productive with those computers in 2009 than we were in 2001.

4. According to point 2, businesses have an incentive to buy new capital goods, to exploit recent technological improvements. According to point 3, however, it will take a while before they can use the new capital goods productively.

5. Hornstein specifies equations for the advancement of technology and for how rapidly experience leads to productive use of new technology. He acknowledges that we don't have a good feel for how experience relates to productive use, and so he tries various specifications for the link between the two. He assumes certain parameter values (for example, $\alpha=0.3$), and simulates his model on a computer, for each of his specifications.

3. Simulation results

Initially, the Solow residual (total factor productivity) falls. We spend money on capital embodying the new technology. But even though the capital stock grows, output does not grow very much, because we don't have much experience using the technology.

Eventually, we get experience, output growth rises (Figure 5d). Ultimately, so does total factor productivity. Over time, as we get more and more experience with the new technology, we get more and more productive (Figure 5c).

Unlike Solow, Hornstein also does a certain adjustment that is appropriate if some forms of technological progress affect only new capital. This yields a total factor productivity series that is depicted in Figure 1.

Figure 1 indicates negative technological growth in the 1970s and 1980s. Perhaps people were learning how to use information technology.

4. Discussion of results

Unfortunately, a change in the specification of how experience accumulates (equation 8(c) in the paper instead of (8a)) causes dramatic changes in the simulation (Figure 6 vs. Figure 5). Hornstein is unaware of any empirical work that would guide specification of accumulation of experience. He acknowledges that his analysis is “somewhat speculative in nature.”

