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Decomposition of total factor productivity growth in U.S. states

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Abstract

This paper applies the stochastic frontier production model to the lower 48 U.S. states over the period 1977–2000 to decompose the sources of total factor productivity (TFP) growth into technological progress, changes in technical efficiency, and changes in economies of scale. We find that technological progress comprises the majority of TFP growth but that differences in efficiency change explain cross-state differences in TFP growth. TFP growth was greater towards the end of the time period.

JEL classification: D24; O47

Keywords: TFP growth; Technical efficiency

1. Introduction

For decades, economists have been interested in measuring and identifying sources of productivity change. Fisher (1922) and Törnqvist (1936) provide early examples of constructing superlative productivity indices using price and quantity data. Researchers also measured productivity change by computing a Malmquist (1953) productivity index. Solow (1957) measured productivity growth for the U.S. economy using an aggregate production function. He computed total factor productivity (TFP) growth as the residual after subtracting labor and capital growth (i.e. growth in inputs) from output growth. His procedure, often denoted as "growth accounting" has been replicated for many other countries, time periods, and sets of inputs which Barro and Sala-I-Martin (1995, Chapter 10) summarizes.

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Such exercises are not merely academic but offer implications as to what extent output growth is sustainable in the future. Neoclassical growth models argue that economic growth (in terms of output per person) is not sustainable without continuous increases in TFP since factor accumulation exhibits diminishing returns that is eventually self defeating. Detailed decompositions along the lines of Solow (1957) have also changed perspectives regarding different growth episodes. Krugman (1994) argues that the East Asian Growth Miracle is not so miraculous once one accounts for increasing input levels. Young (1995) presents a more detailed account and reaches similar conclusions in that the East Asian Growth Miracle is better explained by rapid factor accumulation and not by increases in TFP. Therefore, measuring productivity growth and understanding why it does or does not occur becomes important for how we interpret various growth episodes.

However, a disadvantage of using the approach in Solow (1957) is that it does not identify sources of TFP growth. For example, it does not indicate whether TFP growth stems from technological progress or from efficiency gains. An inefficiency in production exists when production takes place inside the technological (or production) frontier since output can be increased given the same technology and input levels. The farther one is below the frontier, the larger is the inefficiency and so measuring inefficiency is equivalent to measuring the distance from the production frontier. Efficiency gains occur as this distance decreases. Technological progress occurs when the frontier itself shifts. Distinctions between the two can be important. Efficiency gains are not sustainable without technological progress since they cannot recur once the frontier is reached.

The issue then becomes how to decompose TFP growth into its components or, in other words, to find the sources of productivity change. Domazlicky and Weber (1997) use nonparametric techniques to create a Malmquist productivity index for the lower 48 U.S. states from 1977 to 1986.[1] A disadvantage of their approach is that it is deterministic and so it labels any deviation from the frontier as an inefficiency. It does not allow for the possibility of random events or for other factors to affect output. Given the presence of random shocks affecting production, the use of a deterministic methodology is unwarranted.[2] Only stochastic frontier models, which we use in our methodology, can account for the sources of TFP growth while also allowing for a stochastic environment. Stochastic frontier models consider both inefficiency and random disturbances as reasons why production is not at the technological frontier and distinguish between the two. Deterministic models do not consider random deviations and so attribute all of the discrepancy from the frontier to inefficiencies of production although this would not be appropriate in cases where random measurement errors are present, for example. Many applications of stochastic frontier estimation have examined the efficiency of firms or individual farmers. For example, Battese and Coelli (1992, 1995) examine efficiency levels of paddy farmers in India. Piesse and Thirtle (2000) estimate efficiency gains in Hungarian agricultural and manufacturing firms during the transition away from communism. Other references are provided in Coelli, Rao, and Battese (1998) and Kumbhakar and Lovell (2000).

Recent studies have also applied stochastic frontier estimation to compare efficiency differences across countries or across regions within a country. Wu (2000) examines Chinese regions

[1] Färe, Grosskopf, Norris, and Zhang (1994) and Ray and Desli (1997) construct Malmquist productivity indexes for OECD countries using nonparametric programming techniques.

[2] One can also compute a Malmquist productivity index with a stochastic frontier model but only if one assumes constant returns to scale. We do not opt to make such a restrictive assumption here.