ELSEVIER

Economic Modelling

Economic Modelling 17 (2000) 13–34 www.elsevier.nl/locate/econbase

Endogenous technological advance in an econometric model: implications for productivity and potential output in the United States

Gordon R. Richards[1]

National Association of Manufacturers, P.O. Box 9238, Arlington, VA 22219, USA

Accepted 20 May 1999

Abstract

This paper estimates a production function with endogenous technological advance, and incorporates it in a small econometric model to analyze its implications for long-term growth. The production function has constant returns to scale in labor and capital, and increasing returns to scale in all factors. Disembodied technological advance is measured primarily using the stock of research and development (R & D). Technology embodied in computers, or capital-augmenting technical advance, is implicitly taken into account through the hedonic price index. The efficiency of R & D improves over time, so that the elasticity for R & D in the production function is time-varying and increasing. The rate of increase is associated with computer quality, which is measured as a function of capacity and processing speed. In essence, there is a synergistic, multiplicative relationship between computer-based technology and R & D. Residual technical advance is a stochastic process, showing substantial variation over time. In the model, the stocks of both physical capital and R & D are determined by a neoclassical adjustment equation. The equilibrium stocks are a negative function of the user cost and a positive function of growth in demand. The projected rate of productivity growth is much higher than in calculations using deterministic technology. While extrapolations based on deterministic technology estimated the sustainable rate of productivity in the United States at roughly 1.1% per year in the late 1990s, this model

[1]Tel.: +1-202-637-3078; fax: +1-202-637-3182.
E-mail address: economist@nam.org; econ1955@msn.com (G.R. Richards)

PII: S0264-9993(99)00018-8

yields a sustainable growth rate of over 1.9% per year. Potential output in the early 21st century is significantly higher than widely predicted.

Keywords: Potential output; Technological advance; R & D; Productivity

1. Introduction

In the neo-classical model of Solow (1957), technological advances are treated as exogenous. Econometric models based on this paradigm have often approximated technology as a deterministic trend in total factor productivity. Over the last 10 years, a series of new endogenous growth models have been proposed [notably Romer (1986, 1990)]. This article estimates a production function with endogenous technological advance, and incorporates it into a small econometric model to analyze its implications for long-term growth. Models with endogenous technology can include either labor-augmenting or capital-augmenting technical advance, as in Jorgenson (1990), or direct investments in the creation of knowledge. In this study, the latter approach is used. Technological advance is modeled primarily using the stock of research and development (R & D). The efficiency of R & D improves over time, so that the elasticity of output with respect to R & D is time-varying and increasing. Technology embodied in computers is implicitly taken into account through the hedonic price index. Finally, residual technical advance is not a deterministic trend, but is a stochastic process that shows evidence of substantial variation over time.

This investigation was motivated primarily by a policy debate that emerged in the United States during the early 1990s. On one side, the more pessimistic camp argued that the trend in productivity during the late 1990s would be in the range of 1.1% per year. This low rate of productivity growth was often cited as justifying a more restrictive monetary stance. One of the reasons for this rather pessimistic assessment of economic potential was the finding in several studies that computer-based technologies were having only a minimal impact on productivity growth (Oliner and Sichel, 1994). The opposing viewpoint was that the trend in productivity was accelerating as a result of faster technical advance. In 1996, the evidence initially seemed to favor the pessimistic case, since preliminary estimates of the rate of productivity growth in non-farm business were in the range of only 1.3%. Subsequently, however, the Bureau of Labor Statistics (BLS) revised this figure up to 2.4%. Moreover, over the next 2 years, a significant acceleration in measured productivity took place, with the BLS reporting an average growth rate of 1.93% in 1996–1998 (BLS, *Productivity and Costs*, 9 March 1999).

The model used in this study was originally constructed in 1996 at the behest of the National Association of Manufacturers, an industrial federation, in order to analyze the causes of the acceleration and determine whether it would be sustainable. Since this time, the model has been rebuilt, and re-estimated on the most