Endogenous depreciation, mismeasurement of aggregate capital, and the productivity slowdown

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Abstract

When we allow capital depreciation to be endogenous, the acceleration of investment-specific technological progress can distort the measurement of the aggregate capital stock. Our quantitative exercise shows that this effect may cause a substantial bias in the measurement of total factor productivity and can account for a large portion of the observed productivity slowdown since the 1970s. © 2006 Elsevier Inc. All rights reserved.

1. Introduction

This paper demonstrates that, when we allow capital depreciation to be endogenous, the acceleration of investment-specific technological progress can distort the measurement of the aggregate capital stock. The mechanism is that faster investment-specific technological progress makes the replacement of capital more frequent,[1] and this faster depreciation

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[1] Howitt (1998) made a similar point by analyzing an endogenous innovation model. In his model, the replacement of capital is linked to the rate of innovation in a mechanical fashion. In this paper, the decision of replacement is explicitly analyzed. An independent recent work by Musso (2004) also makes a similar point.

leads to a bias in the measurement of the capital stock. Rapid replacement of capital leads to an overestimation of the existing amount of capital since the capital depreciation rate is assumed to be constant in the conventional measurement.[2] This mismeasurement is potentially very important. Caballero (1999) writes:

> Scrapping is an important aspect of the process of capital accumulation. Understanding it is essential for constructing informative measures of the quantity and quality of capital at each point in time. Nonetheless, the scrapping margin is seldom emphasized, I suspect, mostly because of the difficulties associated with obtaining reliable data. As a result, many time series comparisons of capital accumulation and productivity growth (especially across countries) are polluted by inadequate accounting of scrapping. Effective capital depreciation must surely be higher in countries undergoing rapid modernization process. (p. 847).

Here, we formally evaluate this "scrapping margin". Our approach is to use a formal model of the replacement decision to overcome the lack of economy-wide data on scrapping. Although Caballero's emphasis is on cross-country comparison, we believe that this concern is warranted even when we analyze one country over time, especially when the economic environment is changing rapidly.

Many economists reported an acceleration of investment-specific technological progress in the late 1970s. In a recent paper, Cummins and Violante (2002) argued that during this period, investment-specific technological progress accelerated from an annual rate of 3% to 5%. Our analysis shows that this acceleration can cause a large change in the rate of replacement. As a result, with the conventional measurement of capital (the perpetual inventory method with constant depreciation), the aggregate capital stock is overestimated. This bias has an important consequence in measuring total factor productivity (TFP). In the usual growth accounting exercise, the growth rate of TFP is measured as output growth minus the contribution of the growth in capital and labor. When the existing amount of capital stock is overestimated, the contribution of capital accumulation is overstated. Therefore, the growth rate of TFP is underestimated.

The productivity slowdown in US economy since the 1970s has been the subject of many recent studies. In their paper analyzing recent US economic growth, Greenwood et al. (1997) observed that when investment-specific technological progress is taken into account, the *level* of the TFP in the US economy has been *declining* secularly since the late 1970s.[3] From their Fig. 3 (p. 351), it can be seen that the TFP level (z) in 1990 is about 13% lower than in the late 1970s. This amounts to a 1% annual rate of decline. This large decline during the span of more than one decade is puzzling, since it is difficult to believe that the US economy has suffered from technological regress for so long. We show that the underestimation of TFP due to the mismeasurement of capital can resolve a substantial part of this puzzle.

This paper is organized as follows. The next section reviews the empirical literature on investment-specific technological progress. Section 3 describes our model. In Section 4, we

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[2] An early study by Feldstein and Rothschild (1974) points out the importance of economic forces (including embodied technical change) in the replacement decision. Hulten (1990, p. 126) also acknowledges this problem of conventional measurement.

[3] Cummins and Violante (2002) provide a similar observation. Their Table 4 shows that the contribution of TFP to GDP growth declined dramatically after 1970s—it became very small or even negative.