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The role of factor substitution in the theory of economic growth and income distribution: Two examples ☆

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Abstract

While much empirical evidence suggests that the Cobb–Douglas production function may be a reasonable benchmark for aggregate analysis, we argue that the practice, particularly prevalent in contemporary growth theory, of adopting the Cobb–Douglas technology, may lead to misleading implications. Using two examples, we show that key implications of the models are highly sensitive to small deviations of the elasticity of substitution from unity. The first employs the standard neoclassical model and emphasizes the sensitivity of the speed of convergence to small changes in the elasticity of substitution. This in turn has profound consequences for wealth and income distribution. The second deals with foreign aid and highlights how the relative merits of "tied" versus "untied" aid are also very sensitive to the elasticity of substitution.
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1. Introduction

The practice of factor substitution in response to relative price changes is fundamental for productive efficiency. The notion of the elasticity of substitution is central to describing this process and the constant elasticity of substitution (CES) production function, pioneered by Pitchford (1960), Arrow et al. (1961) provides an elegant formulation for parameterizing different (constant) degrees of production flexibility. For nearly 50 years now, the CES production function has played a key role in production theory, growth theory, and income distribution.[1]

But despite the importance of the CES formulation, the bulk of the recent literature on growth theory employs the Cobb–Douglas production function; see e.g. Lucas (1988), Barro (1990), Jones (1995), among the most influential. Part of the reason for this is that for many countries, the Cobb–Douglas production function in fact characterizes the aggregate economy rather well. Many of the empirical estimates of the elasticity of substitution are insignificantly different from unity, suggesting that the Cobb–Douglas serves as a reasonable working hypothesis.[2]

In this paper, we suggest that, even if one accepts the empirical estimates supporting a unitary elasticity of substitution, one should nevertheless be careful in restricting oneself to the Cobb–Douglas function, as contemporary growth theory frequently does. Even small deviations from this specification, well within typical statistical sampling errors, can lead to very different implications for economic growth, income distribution, and welfare.[3] We illustrate this using two examples from the growth literature of the last 50 years.

The first example is a neoclassical growth model in which agents have heterogeneous initial endowments of physical capital. Assuming agents' utility functions are homogeneous with respect to consumption and leisure, the macroeconomic equilibrium has a simple recursive structure. First, the dynamics of the aggregate stock of capital and leisure are jointly determined, independently of distribution across agents. The individual allocations are then obtained as individuals respond to factor returns, determined by the aggregate behavior of the economy, in light of their own specific endowments. Thus we are able to characterize the transitional dynamics of the distribution of wealth, and ultimately, income.

Within this framework, we investigate the effect of the elasticity of substitution on the speed of convergence, which in turn is shown to have important consequences for wealth and income distribution. With the heterogeneity of the initial endowments being the source of income inequality, the faster the speed of convergence, the more rapidly the return to capital converges to its long-run equilibrium following a shock, and the less

[1] As a historical point, Solow (1956) briefly introduced the CES production function as an example of a constant returns to scale production function.

[2] As justification for this, Berndt's (1976) early comprehensive study is often cited. For the preferred methods of estimation, using superior data, he finds estimates of the elasticity of substitution to range from around 0.8 to 1.2. However, recent authors have argued that the treatment of technological change has biased the estimates toward unity, and that modifying the econometric specification leads to significantly lower estimates of the elasticity, in the range 0.5–0.7, thus rejecting the Cobb–Douglas specification; see e.g. Antràs (2004), Klump et al. (2007), Duffy and Papageorgiou (2000) estimate the elasticity of substitution using cross-sectional data and find that the Cobb–Douglas production function is an inadequate representation of technology across countries. Their evidence suggests that the elasticity of substitution exceeds unity for rich countries, but is less than unity for developing countries.

[3] These differences are exacerbated as the elasticity of substitution deviates further from unity.

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