

This Week's Citation Classic

NUMBER 17
APRIL 23, 1979

Arrow K J, Chenery H B, Minhas B S & Solow R M. Capital-labor substitution and economic efficiency. *Rev. Econ. Statist.* 43:225-50, 1961. [Stanford University, Stanford, CA]

The way in which capital and labor cooperate in production is of basic importance for economic development. Previous analysis had been largely based on a linear logarithmic relation. The empirical data has disconfirmed this simple view and more flexible forms have been found, in which the elasticity of substitution between capital and labor was no longer restricted to one, but could be any constant. These new production functions have proved to allow for simple and yet flexible research, confirmed on several different bodies of data. [The *Science Citation Index*® (SCI®) and the *Social Sciences Citation Index*™ (SSCI™) indicate that this paper has been cited over 260 times since 1961.]

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December 27, 1977

"Output can be thought of as a function of capital labor and technological knowledge. For a single country the latter variable could be approximated by time; we can also consider different countries representing varying technical levels. Decomposition about the changes into these factors had been begun by Tinbergen and Solow. However, they have been constrained, in order to achieve manageable formulas, to use a Cobb-Douglas production function, in which output is linear-logarithmic in capital and labor. This implied that the value shares of the two factors were in constant proportion over time.

"I had speculated that the decomposition

might be faulty if the wrong production function were used, but I had done little about it. Chenery had been collecting a great deal of data about different countries. In particular, a then graduate student at Stanford, Bagicha Minhas, now a professor at the Indian Statistical Institute in Delhi, had been doing careful cross-country comparisons and held that the share of labor in value added for a given industry was not constant across countries. Specifically they found that value added per worker had a good linear logarithmic fit to the wage rate, but the coefficient for many industries was less than one, where the Cobb-Douglas assumption would imply a coefficient of one. They discussed this problem with me, and after a couple of wasted weeks I realized that their findings could be rationalized by the assumption of a production function with an elasticity of substitution different from one but constant. It turned out that Solow had in fact suggested just such a production function in a theoretical paper.¹

"It turned out that constant elasticity-of-substitution-in-production-function had implications which were relatively easy to fit, being linear in form. As a result, we were able to test our hypothesis on a wide variety of data and attained some interesting results.

"Subsequent work has gone still further, but the impulse to find useable new production functions was released by our paper and resulted in a flood of subsequent work. Our original incentive to confine ourselves to functions giving relatively simple derived forms has probably been made obsolete by the improvements in computer technology, which make fitting complex nonlinear forms much easier. Our paper now is probably of historical significance in pointing to a more general methodological approach."

1. Solow R M. A contribution to the theory of economic growth. *Quart. J. Econ.* 65:65-94, 1956.