
AIKO IKEO  
*Waseda University, Japan*

Jeff E. Biddle has produced a remarkable book on the history of regression studies on the Cobb-Douglas production function covering the period from the 1920s through the 1960s. He used published literature rather than archival or audio (e.g., recordings of interviews) materials to depict the rich research context surrounding the Cobb-Douglas production function. He begins with Paul Douglas’s (1892–1976) initial attempt to produce a tool for analysing the statistical relationship between production, labour, and capital, and discusses various appraisals, criticisms, replies, and new applications of this analytical tool. Biddle then describes how through these developments the production function eventually gained acceptance as a general-purpose tool in the community of economists.

The Cobb-Douglas function relates output ($P$) to the product of a coefficient ($b$), labour ($L$) to the power of $k$, and capital ($C$) to the power of $j$, namely $P = bL^kC$. It was first used by the economist Douglas and mathematician Charles W. Cobb as the basis of their statistical research estimating the parameters of the equation in the manufacturing sector. According to Biddle, it was a bold statistical attempt to find the shape of the production function, which was studied abstractly in economic theory, but that few had attempted to specify (45). Nonetheless, the two made their parameters a ‘good-fit’ start in regression estimations which could relate to neoclassical theory.

The book has two main parts: Part I, “Paul Douglas and His Regression, 1927–1948” and Part II, “The Diffusion of the Cobb-Douglas Regression”. Chapter 1 is titled “The Origins of Douglas’s Production Function Research Program and his Initial Time Series Studies”. From the late 1910s, Douglas was interested in labour legislation and the living standards of the working-class. While lecturing at Amherst, Douglas came up with the idea of using the function to relate production to the total fixed capital
and total number of wage earners employed in manufacturing. Douglas presented the research results at the 1927 meetings of the American Economic Association (AEA) and Cobb and Douglas (1928) was published in the *American Economic Review*. Douglas (1934) linked the function with marginal productivity theory and firmly connected his estimations with abstract theory.

Chapter 2 is titled “The Douglas-Mendershausen Debate and the Cross Section Studies”. Horst Mendershausen, who was trained by Ragnar Frisch, rightly argued that production function estimation should be based on the measures of capital and labour *actually used*, whereas Douglas used *available capital* as a representation. Douglas admitted that available capital was a lesser approximation of the capital actually used especially for 1908 and 1921, which were years of depression. Against Douglas’s claim that labour-saving technology might increase capital, Mendershausen also attacked Douglas’s assumptions that neither technical progress nor improvements in the efficiency of labour had occurred over the sample period. Mendershausen was also concerned about multicollinearity in the time series data and the choice of the regression direction. Douglas and his associates moved on to use cross-sectional data and corresponded the estimated production function to plant-level production theory to bridge economic theory and their regression estimations.

Chapter 3 is titled “Theoretical and Econometric Challenges of the Early 1940s, and Douglas’s Final Word”. First, Biddle explained why Jan Tinbergen was concerned about the importance of technical change and the collinearity between time and the capital-labour ratio. In fact, Spurgeon Bell showed that the data indicated output in 1937 was slightly greater than output in 1929 despite smaller quantities of both capital and labour being employed in 1937 (110). Jacob Marschak and William Andrews (of the Cowles Commission) made the most comprehensive and critical assessment and considered the limitations in the available published data. They appreciated Douglas’s method as a way avoiding the criticism of “Measurement without Theory” (Koopmans 1947) and put Douglas’s production function in a system of stochastic simultaneous equations by considering Trygve M. Haavelmo’s probability approach to econometrics. Victor Smith was interested in the value of $k + j$, which he called the ‘degree’ of the production function (for the automobile industry). According to Biddle, Smith demonstrated that the numerical results were sensitive to the “peculiarities of statistical techniques” (126).
After being seriously injured while serving in the U.S. Marine Corps in Okinawa, Japan in May 1945 and spending one year of recuperation in the United States, Douglas was elected as AEA president and gave his final word on his production function estimates as a presidential address to member economists in 1947. He successfully campaigned to be elected a United States senator in 1948 and switched his career as an economist to the political arena. However, the Cobb-Douglas regression research programme continued, and the production function (regression) became a widely accepted tool for empirical research in economics. This is the theme of the second part “The Diffusion of the Cobb-Douglas Regression”.

Chapter 4 is titled “Three Important Developments in the Life of the Cobb-Douglas Regression, 1952–1961”. First, Biddle refers to two econometrics textbooks for graduate students, Gerhard Tintner (1952) and Lawrence Klein (1953), which covered both production function regressions and the probabilistic approach promoted by the Cowles Commission. Biddle states:

Through these books, several cohorts of economics graduate students were exposed through concrete examples to the nuts and bolts of estimating both cross-section and time series Cobb-Douglas regressions. (148)

Notably, the two authors mentioned little about the criticism of empirical production function studies that had been raised before.

Second, tracing E. H. Phelps Brown's “The Meaning of the Fitted Cobb-Douglas Function” (1957), Biddle states:

Phelps Brown was rejecting a priori Douglas's implicit assumption that the production of value product from capital and labour in all of the heterogeneous industries represented in his cross-section data sets was governed by the same Cobb-Douglas function. (152)

Biddle argues that Phelps Brown’s criticism was less jargon-laden and was probably more clearly understood by readers than Mendershausen's of the 1930s.

Third, a constant elasticity of substitution, or CES, production function was introduced by the collaboration of Kenneth Arrow, Hollis
Chenery, Bagicha Minhas, and Robert Solow (1961), which was immediately adopted as the first generalization of the Cobb-Douglas production function used by many empirical researchers. Biddle underscores the importance of the ‘elasticity of substitution’ between labour and capital and its generalization in economic theory. Biddle trails their collaboration and the massive reactions until the early 1970s.

Chapter 5 is titled “The Cobb-Douglas Regression in Agricultural Economics, 1944–1965”. During the interwar period, the U.S. Department of Agriculture and the federal government supported land grant colleges to employ economists that could conduct research useful for farmers and agricultural policymakers. Relatively rich agricultural data collected by the government and funding for the collection and analysis of experimental and survey data on the activities of individual farmers were made available. Gerhard Tintner (1944) was the first to apply the Cobb-Douglas regression using data from (Iowa) farms.

Chapter 6, entitled “The Cobb-Douglas Regression as a Tool for Measuring and Explaining Economic Growth”, conveys a broader story of the economists’ efforts to provide a proper understanding of how and why the Cobb-Douglas regression became a common tool in the 1950s. Interestingly, the U.S. government was considering public policy measures to increase the economic growth rate and that many economists became involved in the measurement of economic growth and the quantification of its causes. Biddle’s story begins in the 1920s and covers Simon Kuznets, his direction of the National Bureau of Economic Research, and other economists’ contributions to the measurement of national income and its components, including physical capital. Morris Copeland and E. M. Martin managed to produce new time series for the real value of the capital stock for sectors and for the entire economy, which were the first such capital measures developed since 1928. Thanks to the creation and refinement of capital stock measures during the 1940s and 1950s, it became possible to implement the Copeland-Martin procedure to construct what would become called indexes of ‘total factor productivity’.

The next part pivots to Robert Solow’s “Technical Change and the Aggregate Production Function” (1957). Solow first used an Aggregate Production Function that related output to the two inputs of capital and labour measured in physical units and time. He defined technical change as ‘any kind of shift’ in the production function. Then, he decomposed it and inserted a coefficient (dependent on time) and multiplied it to another production function. This coefficient measured the cumulative shifts in
the production function over time and was regarded as the technological change factor. Citing the neoclassical assumption that factors are paid their marginal products, Biddle stated:

This assumption along with some calculus and algebra allowed Solow to conclude that the percentage change in output would be equal to the percentage growth in the technological change factor plus the percentage growth in capital time capital’s share in output, plus the percentage growth in the labour input times labour’s share in output.

(248)

Constructing empirical analogues for the variables covering the period between 1909 and 1949, Solow estimated that seven-eighths of the economic growth per capita were due to technical progress and demonstrated that capital accumulation did not account for economic growth. Solow and other economists' research led to the statement that 'the measure of ignorance' in economic growth was large. Evsey Domar (1961) named it 'the Residual'. The high level of interest in economic growth led researchers to work on technical changes being embodied and not embodied in capital, the vintage of capital, education, research, public health, expertise, and know-how, and they opened up a new field called 'growth accounting'.

The Cobb-Douglas production function was born out of the regression studies and polished through friendly criticisms. It is not just related with neoclassical theory, whose image is static. Interestingly, based on the neoclassical assumption of distribution, it has contributed to measuring most of dynamic technical progress under the name of total factor productivity, and has become a general-purpose tool to make economists continually work with both theory and statistical estimation. Yet, Biddle's book is written mainly for an American readership.

On a final note, Biddle suggests that Martin Bronfenbrenner made a graduate study of statistical techniques (114). However, Bronfenbrenner completed his dissertation thesis, "Monetary Theory and General Equilibrium", in 1938 under the strong influence of his supervisor Henry Schultz (1893–1938) and received his doctorate from the University of Chicago in 1939. After the sudden death of Schultz, Bronfenbrenner was fortunately hired by Douglas as one of his assistants in statistical studies and gained necessary skills through on-the-job-training rather than through graduate studies. In September 1945, he was sent to Japan as a Japanese language
officer for the U.S. Occupation Force. His mission included communication with Japanese economists and he was pleased to find Yukichi Kurimura (1899–1983) writing something like a Cobb-Douglas production function on the blackboard in a class at Kyushu University. Kurimura was authoring books on economic theory and statistical estimations while he was reading related articles carried in economics journals (Ikeo 2014).

REFERENCES

Aiko Ikeo is a professor in the Faculty of Commerce at Waseda University, Tokyo. She was a research fellow at Duke University’s Center for the History of Political Economy. She has been working on the history of Japanese economic thought from around 1600 to the present, and the biography of Tameyuki Amano (1861–1938) for several years. She published A History of Economic Science in Japan (Routledge, 2014). She edited Economic Development in Twentieth Century East Asia (Routledge, 1997) and Japanese Economics and Economists since 1945 (Routledge, 2000).
Contact e-mail: <aikoikeo@waseda.jp>