

# **THE STRUCTURE OF PRODUCTION**

**MARK SKOUSEN**



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*To the memory of Carl Menger,  
who paved the way*

**I**t appears to me of preeminent importance to our science that we should become clear about the causal connections between goods.—Carl Menger, *Principles of Economics*

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## PREFACE

In the summer of 1988, I had the opportunity to meet 84-year-old Sir John Hicks, the Nobel laureate who transformed Keynesian economics into the grand neoclassical synthesis with his 1937 article in *Econometrica*, "Mr Keynes and the 'Classics.'" Despite his age and physical ailments, his mind was alert and, during our meeting, he recounted how he had gradually become disenchanted with many aspects of the modern economic theory he helped to develop. In particular, he seemed greatly displeased by the failure of orthodox economists to teach the importance of time and the stages-of-production concept in macroeconomics, a subject he emphasized in his own textbook, *The Social Framework*, and more recently in his treatise, *Capital and Time*. He called it a great mistake that most economists had abandoned this essential doctrine.

Several years earlier, I had met with another Nobel-prize-winning economist, Friedrich von Hayek, at his summer home in the Austrian Alps. Like Hicks, Hayek reflected on his long career, and expressed dismay and disappointment that so few economists had attempted to extend his work on the time theory of capital, which he regarded as a critical link to understanding macroeconomic phenomena.

It is my intention to fulfill this ambitious role. My efforts to bring together the essentials of capital, production, and time into a coherent macroeconomic theory have not been easy. But the thesis is starting to show tangible results. This work culminates ten years of research, writing, and theorizing; efforts aimed toward a practical alternative to the standard neoclassical model of macroeconomics. Like Hicks and Hayek, I have serious misgivings about the way economics is taught. As a young econom-

ics student, I concluded that the two main forces in economics today, Keynesianism and monetarism, were both technical and ethically flawed. I sensed that there was something inherently wrong with the Keynesian *paradox of thrift* as well as with the monetarist's rigid quantity theory of money. But like the mathematician Karl Friedrich Gauss, "I have been sure of my results for some time; what I don't know is how I shall arrive at them."

I was led to the intertemporal structural approach developed in this treatise upon reading Ludwig von Mises's *Theory of Money and Credit* many years ago. In the development of my thesis, I have relied most heavily on Mises's followers, F. A. Hayek, Murray Rothbard, and Roger Garrison, who have developed the most rigorous theoretical foundation for a macroeconomic model based on time and capital. In this treatise, I have attempted to broaden the Austrian concepts of time and production into a full-scale macroeconomic model that, as the reader will see, is especially useful in analyzing the aggregate effects of a wide variety of market and government actions, including such variables as an increase in savings, the adoption of technological improvements, an expansion of the money supply under a gold standard as well as a fiat-money standard, an increase or reduction of taxes, and the adoption of anti-recession policies.

During my research, I have come across several books that I found particularly insightful, many of which are now out of print, but which deserve a wider audience, including but not limited to: *Common Sense Economics*, by German economist L. Albert Hahn; *The Economics of Knut Wicksell*, by Carl G. Uhr; *Market Theory and the Price System*, by Israel M. Kirzner; *Prices in Recession and Recovery*, by Frederick C. Mills, a professor of statistics at Columbia University who pioneered the relative price studies at the National Bureau of Economic Research; and *Business Cycles*, by James Estey. There were also several noteworthy textbooks published prior to 1960, which preserved the Böhm-Bawerkian vision: *Economics: Principles and Problems*, by Paul F. Gemmill and Ralph H. Blodgett; *The Economic Process*, by Raymond T. Bye and William H. Hewett; and *Introduction to Economics*, by John V. Van Sickle and Benjamin A. Rogge.

## **THIS WORK AS A "ROUNDAABOUT" PROCESS**

The writing and publishing of this book is itself, in many ways, an example of my central thesis: *a time-oriented process of production* aimed at achiev-



ing an economic end. My book went through a myriad of stages before the final work was completed and ready for use by the reader. My method was very roundabout, to use Böhm-Bawerk's favorite expression. At first it was merely an idea. The early, raw-production stage included researching and reading literally hundreds of books and journal articles on the structure of production and related macroeconomic topics. The research time was lengthened (or delayed) by the necessity of going through card catalogs and book stacks at over twenty university libraries in the United States and England, since no single university, no matter how large, possesses everything needed. The works of former economists served as the "fixed" capital necessary to help me transform my "working" capital into a finished good.

After researching, reading, and making notes on a wide variety of books and journals, I formulated an outline and summary of my thesis, the next stage of production. I spent many hours thinking through a maze of often contradictory theories, trying to make sense out of a complex subject. Sometimes it was necessary to create a whole new apparatus or original technique as a tool to explain an economic phenomenon. For example, my diagrams on time preference and technology in chapter 7, my use of the Hayekian triangles to explain inflationary recession in chapter 9, and contrasting supply-credit inflation with demand-credit inflation in chapter 10 were all created to illustrate certain economic conditions. Most significantly, I have been able to demonstrate in chapter 7 the fallacy of the paradox of thrift by recasting the Keynesian mold onto the Hayekian framework. I have also created a new economic statistic, Gross National Output, as a more accurate and complete description of economic activity than GNP.

Just as a manufacturer will experiment with his product to refine and perfect it, several drafts were made of this manuscript as new material came to light and mistakes were corrected. Copies of the completed draft were sent to several economists of varying backgrounds and schools of thought, not necessarily in agreement with my own theories or policy recommendations. They suggested many additions and changes. In particular, I would like to thank the following for their assistance: Israel Kirzner at New York University, G. C. Harcourt at Cambridge University, Michio Morishima at the London School of Economics, Mark Blaug at the University of London, Larry Wimmer at Brigham Young University, Murray N. Rothbard at the University of Nevada at Las Vegas, Roger Garrison at Auburn University, Gary North of the American Bureau of Economic Research, Richard Band of *Personal Finance*, Kenna Taylor at Rollins College, Malte Faber at University of Heidelberg, Richard Ebeling at Hillsdale College, and Joe

Salerno at Pace University. I would also like to thank my editor, Colin Jones, at New York University Press, for his support and efforts in publishing this work, and to Charts & Graphs Unlimited for doing an excellent job on the graphs.

A great deal of crucial work was provided by Royal Skousen at Brigham Young University, who helped immensely in developing the mathematics, diagrams, and statistical studies herein.

I would also like to thank my wife, Jo Ann, for reading the manuscript carefully for stylistic improvement. I was lucky enough to marry an English major with an uncanny eye for accuracy and a felicity of literary expression. She has been a tremendous support in this seemingly never-ending project, and without her steady encouragement and farsightedness, I suspect the whole production process would never have ripened into a fruitful work.

Once the manuscript is edited, printed, and marketed by the publisher—an intricate process in and of itself—the book reaches the point of final consumer use, to be bought, read, and referred to by teachers, students, businessmen, and readers in general. Is a book a final consumer good or an intermediate capital good? I suppose it depends on the audience. A paperback novel read by consumers at home or on vacation may only be read once, and then discarded, never to be opened again. As such, it is consumed as soon as the last page is read. But a classic novel or philosophical book may be read over and over again, especially if it is available at a library, thus making it a durable consumer good. Books of a technical nature used in college classes or on-the-job training must be regarded as intermediate capital goods, in furtherance of a degree or a job.

Needless to say, I am hopeful that this work will serve well as a durable capital good that will not depreciate too rapidly in the minds of its readers.

## **THE PHILOSOPHICAL DEBATE OVER MACROECONOMICS**

My time-oriented approach to macroeconomics is far more significant than a simple entry in the debate over which model best describes the inner workings of the economy. It is a continuation of the great philosophical debate that began in earnest in the 1930s. During that decade, John Maynard Keynes turned the world on its head by developing a “general theory” aimed at overturning classical economics. Over the centuries, the classical economists had created a body of economic theory which supported the traditional virtues of thrift, the gold standard, and balanced budgets. The

Great Depression of the 1930s provided fertile ground for Keynes's attack on these old-fashioned values. By developing a theory which justified unconventional policies whenever there were unemployed resources, he was able gradually to convince the economics profession that savings may be counterproductive and deficit financing beneficial whenever the economy was at "less than full employment."

Keynes's principal theoretical opponent in the 1930s was the Austrian economist, Friedrich A. Hayek, who argued strenuously that Keynes's new theories were defective because, among other criticisms, they failed to take into account the critical role of time. According to Hayek, Keynesianism was purely a short-term theory, and its policy recommendations would be disastrous in the long run.

Keynes won the battle of men's minds in the depression years. But his anti-savings, anti-gold, and pro-inflationary theories endured beyond the 1930s. We are now living in the Keynesian long run that Hayek warned about. Despite the development of monetarism, rational expectations, and other new theories, many Keynesian concepts are still being taught today, including the paradox of thrift and the necessity of running a government deficit during an economic downturn.

It is not enough to dismiss a theory simply because it may be morally bankrupt or financially ruinous. An unsound theory must be shown to be defective on purely theoretical grounds as well. The goal of this work is to create a model which answers the excesses of Keynesianism and other forms of macroeconomic interventionism on their own theoretical grounds. I believe that the time structural approach, as developed by Hayek and other economists over the years, forms the basis for this counterattack.

I am hopeful that economists and students of all persuasions will give an impartial and fair hearing to this reconstructed theme in macroeconomics. Far too often, academicians too quickly label this or that theory as representing one particular school of thought, and reject it out of hand without much analysis. The fact that many neoclassical economists, including Michio Morishima, Kenneth Boulding, G. L. S. Shackle, and John Hicks, have been attracted to this method should be grounds for a dispassionate review.

When Keynes introduced his revolutionary new approach to economic theory in the 1930s, he warned about the "struggle of escape from habitual modes of thought and expression."<sup>1</sup> After having been indoctrinated by Keynesian themes for many decades, economists face this same challenge today to give a fair hearing to alternative ideas. In the early 1930s, Lionel Robbins introduced a new translation of Hayek's work with a caution that

applies just as much today as when he wrote it: "The criteria of scientific validity take no account of origins, and the economist who refuses to avail himself of a particular set of propositions because they were foreign would be acting no less unscientifically than the chemist or physician who acted on similar principles. It has been well said that there are only two kinds of economics—good economics and bad economics. All other classifications are misleading."<sup>2</sup>

It is in this spirit that I make a case for a new macroeconomics.

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## NOTES

1. Keynes, *The General Theory*, xxiii.
2. Robbins, Foreword to Hayek, *Monetary Theory and the Trade Cycle*, 5–6.

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## ONE

# INTRODUCTION: THE CASE FOR A NEW MACROECONOMICS

If we are witnessing the dissolution of an intellectual establishment, and its fragmentation into conflicting schools, what this eventually leads to—if one reads the history of any intellectual discipline—is the development of a new, comprehensive framework.—Daniel Bell and Irving Kristol, *The Crisis in Economic Theory*

**M**acroeconomics needs a new approach. The corpus of contemporary macroeconomic modeling is excessively aggregative, too abstract, and ultimately deficient as a way of analyzing the inner workings of a constantly changing economic landscape. The conventional “neoclassical” models seem almost helpless in rescuing the economy from fundamental *structural* defects (defects that their macro models are unable to uncover) which have built up over the past fifty years, created by ruinous and vacillating fiscal and monetary policies.<sup>1</sup>

Orthodox economists have been chipping away at the foundation of these macro models for decades, but have been unable to salvage them. A growing number of economists, recognizing this dilemma, are searching for a workable alternative. With this in mind, I propose an entirely different edifice with which to describe and analyze the production process for the whole economy, a new *tableau économique*. My method could be called a Mengerian “vertical” framework, which is strictly the opposite of the conventional Clark-Walrasian “horizontal” method, the basis of standard macroeconomics today. I am not suggesting that my task of reconstruction is entirely new or original—it is not—but I have attempted to extend my

analysis of the whole economy beyond what has been done in the past in an effort to show how this alternative method is a better and more useful macroeconomic tool for economists than the currently orthodox perspective.

## A SHORT CRITIQUE OF CONVENTIONAL MACRO THEORY

Let me be more specific in my criticism of conventional macro theory, and why I think it should be replaced with a new model. Essentially, neoclassical macroeconomics, which forms the foundation of Keynesian, monetarist, and other modern theories, envisions the economy as a collection of large aggregates in a timeless dimension of simultaneous production and consumption. Although its roots can be traced back as far as Adam Smith and the “classical” economists, the modern formula goes back primarily to John Bates Clark, who envisioned the economy as a large reservoir, where the production of goods and services are seen as a permanent, malleable, flowing fund, and to Leon Walras, who saw the economy in a horizontal, timeless fashion where the factors of production were converted instantly into final consumer products.

This Clark-Walras confluence is apparent throughout modern macroeconomic models—in the *circular flow* diagram, the neoclassical production function, capital theory, the Keynesian consumption function, the monetary “cash balance” effect, and aggregate supply and demand curves.

The standard circular flow diagram, which is used in introductory economics textbooks to describe the interdependence of production, consumption, and exchange, is an abstraction that completely ignores the time element. “It assumes everything is happening *at the same time*, a false and misleading assumption,” says L. Albert Hahn.<sup>2</sup> Moreover, there are no savings, no financial institutions, and no intermediate capital goods of any kind. The circular flow diagram offers no explanation for dynamic changes in the economy—shifts in employment, prices, production, the business cycle, and economic growth, for example.

The neoclassical production function, commonly used in intermediate economics textbooks to analyze changes in output and economic growth, is just as obtuse and barren as the circular flow diagram. The conventional production function envisions the volume of output as a function of inputs, expressed in the form of isoquants, where labor and capital are substituted at varying levels of production.

Michio Morishima is one of many economists who are highly critical of the neoclassical production function, which assumes "that all capital goods are made of putty" that can be combined in any fashion "instantly" and "costlessly." The concept "is like trying to build a tower on a large ant-hill."<sup>3</sup> Because the "immobility of capital goods" makes "aggregation" virtually impossible, Morishima rejects the neoclassical model and opts for a "de-centralized" *microeconomic* approach involving a "vertical genealogy" of product transformation, similar to mine.

Neoclassical capital theory follows the same lines as the production function and the circular-flow diagram. Capital, as characterized by J. B. Clark and Frank Knight, is represented as a permanent homogeneous fund or stock, rather than as distinct commodities of varying age distributions. As such, notes B. S. Keirstead, their theory "not only does not answer the question of what determines the structure of real capital at any time, it does not even permit the question to be asked."<sup>4</sup>

Robert M. Solow refers to the permanent fund concept as a "homogeneous jelly," where capital goods are nonspecific and "instantaneously substitutable" for labor and other inputs. Solow, a principal proponent of the neoclassical position, admits that such an oversimplified view is wrong, especially in the short run.<sup>5</sup> Solow is also critical of an attempt by Clark-Knight followers to represent capital models in terms of a single number instead of a variety of heterogeneous goods. "For there is no reason to suppose that any single object called 'capital' can be defined to sum up in one number a whole range of facts about time lags, gestation periods, inventories of materials, goods in process, and finished commodities, old and new machines and buildings of varying durability, and more or less permanent improvements to land."<sup>6</sup>

According to F. H. Hahn, the neoclassical models of capital involve numerous unrealistic assumptions, such as: capital lasts forever, there are no intermediate goods, nor is there a time factor, workers do not save, and capitalists do not consume.<sup>7</sup>

## **EXCESSIVE AGGREGATION IN MAINSTREAM ECONOMICS**

Mainstream economists, still under the influence of Keynes, think in terms of gross national product, the inflation rate, the interest rate, total investment, the unemployment rate, and other singular figures.

For Keynesians, national income is expressed in terms of broad aggre-

gates, as indicated in the well-known consumption function. As Benjamin M. Anderson states, "Throughout Keynes's analysis he is working with aggregate, block concepts. He has an aggregate supply function and an aggregate demand function. But nowhere is there any discussion of the interrelationships of the elements of these vast aggregates, or of elements in one aggregate with elements in another."<sup>8</sup>

Monetarists, with their attention to the real balance effect and the quantity theory of money, are not so distinct from Keynesians in terms of their methodological approach. They also analyze the economy in terms of such broad aggregates as the money supply, the price level, and national output.<sup>9</sup> Indeed, the quantity theory of money is expressed mathematically in aggregate form, with single numbers for the money stock, velocity, output, and the price level. According to proponents of the quantity theory of money, velocity is relatively stable, and under full employment the national product is held constant. Hence, the consumer price index is directly correlated to the change in the quantity of money.

Aggregate supply and aggregate demand curves, now a standard method of introducing macroeconomics to students, are only two-dimensional in nature. The economy is neatly fit into an apparatus that links the *price level* on the vertical axis and *real output* on the horizontal axis.

Each of these quantities represents large aggregates or averages which completely obscure changes in relative prices, the allocation of resources among various sectors of the economy, and the progressive nature of the production process.<sup>10</sup>

Kenneth E. Boulding is highly skeptical of macroeconomic models, which he calls an "unworkable fallacy." According to Boulding, it is essential to realize the "composition" or "structure" of the economy or national income. "It is clearly not merely the aggregate total of production, consumption, and accumulation that matters; it matters *what* is produced, consumed, and accumulated, i.e., of what goods these aggregates are composed."<sup>11</sup>

## **INPUT-OUTPUT ANALYSIS: A STEP IN THE RIGHT DIRECTION?**

In response to these criticisms, economists have been in search of new directions in macroeconomics. One alternative for describing and analyzing the economy has been input-output analysis.

Wassily Leontief suggests the use of input-output analysis as a valuable



way of looking at the whole economy, and has written extensively on the subject. According to Leontief, economists should not rely solely on GNP, the interest rate, and price levels, but on the “intervening steps” between inputs and outputs, steps which involve “a complex series of transactions . . . among real people.”<sup>12</sup>

Input-output analysis appears to be the only major alternative presented by mainstream economists to describe the *micro* foundations of the economy. Don Lavoie comments, “What is compelling about this approach is that it is, in principle, microscopic rather than macroscopic. That is, it directs attention to the complex details of interdependence of the structure of production rather than to some single-dimensional measure of the size of the nation’s wealth or capital stock.”<sup>13</sup>

In an input-output table, the horizontal rows show how the output of each sector or industry (agriculture, apparel, vehicles, and so on) is used by the other sectors, while the vertical columns show how each sector obtains from the other sectors its needed inputs of goods and services. For example, the vertical column for the automobile industry shows such inputs as ferrous metals, rubber, electrical equipment, and textiles. These are the basic materials which go into the making of vehicles. The horizontal rows indicate who are the final users of automobiles, trucks, and other vehicles: construction, manufacturing, other industries, and individual consumers.

However, while input-output analysis is a move in the right direction—i.e., as a microfoundation for macroeconomics—it has limitations. The input-output table is essentially only two-dimensional in nature. It links various industrial sectors with their direct factors of production and direct users, but not the indirect, more distant factors. It may demonstrate how shoes come primarily from leather products, but obscures the whole series of processes shoe production goes through, from cowhides to footwear. In short, the input-output (I-O) table does not delineate the entire genealogy of a particular product or industrial sector. It only lists the sector’s close relatives.<sup>14</sup>

Input-output analysis becomes hardly useful as a macroeconomic tool if one concludes from the I-O table that “everything depends on everything else,” a common interpretation in economics textbooks. In the end, such a holistic notion amounts to nothing more than a homogeneous Clark-Walrasian version of neoclassical macroeconomics.

There has been an effort to rearrange the input-output table according to the natural stages of economic production, “the hierarchy of interindustrial dependence,” as Leontief calls it. This method is termed “triangula-

tion.”<sup>15</sup> Sectors are arranged in the upper rows of the table which deliver most of their output to final demand and little to other industrial sectors more distant from consumption. At the same time, the outputs of the sectors toward the bottom of the table are distributed primarily as inputs to the other sectors. In general, sectors above any row are *customers* of that industrial sector, and industries below any row are their *suppliers*. At best, however, triangulation amounts to a two-dimensional division of the industrial sector, the consumer-goods industry and the capital-goods industry. While this technique provides greater detail and reflects a more natural relationship between goods, it does not provide the whole picture that we seek in order to analyze the full effects of changing economic events. Our objective is to develop an economic model that represents an *array* of capital and consumer goods, not just a two-sector economy.

## **THE STAGES OF PRODUCTION: AN ALTERNATIVE APPROACH TO MACROECONOMICS**

Morishima suggests that neoclassical economists turn to a vertical approach to production economics instead of the more popular horizontal method. He says that looking at the economy from the point of view of what he terms a “vertical genealogy of production” is very recent and generally ignored by mainstream economists.<sup>16</sup>

What is this vertical method of analyzing macroeconomics? Basically, it is a conceptual framework which visualizes the whole economy in terms of stages of production passing through time. Economics, in fact, may be defined as a process of transforming raw materials into intermediate goods and eventually into final consumer goods. Initially, every product starts with the crudest of raw materials and then, through a long string of intermediate steps, is gradually changed into a finished product ready for use by consumers or business. In a modern economy, this process involves a long and complex chain of economic stages running over varying periods of time.

## **AN INTERDISCIPLINARY APPROACH**

In researching this subject, I have found that a number of associated disciplines use this natural concept of economic hierarchy, including the

theories of industrial organization, marketing and retailing, statistical data gathering, and investment analysis. These disciplines are what economists have generally referred to as *applied economics*.

In the field of industrial organization, a common subject is *vertical integration*. Oliver E. Williamson notes that vertical integration involves three elements: "backward into materials, laterally into components, and forward into distribution."<sup>17</sup> F. M. Scherer discusses the stream or flow of production in relation to vertical integration, and a firm's decision to incorporate either "downstream" or "upstream" to minimize costs. He points out that such decisions are made frequently in the steel, auto, and other major industries. Scherer notes that "Most goods pass through numerous intermediate transactions before reaching the consumers' hands. Consumers buy from retailers, who may obtain their supplies from wholesalers, who buy from consumer goods manufacturers, who secure raw materials, equipment, and parts from other manufacturing and mining firms, who in turn purchase from still other companies, etc."<sup>18</sup>

In the area of marketing and retailing, distribution channels have become a subject of intense interest since the late 1960s. Marketing analysts have developed extensive techniques to improve the distribution of goods and services through these *marketing channels*, whether it is between manufacturers and dealers or between wholesalers and retailers. Marketing specialists are not particularly interested in the production or construction of the product itself, but in its distribution to the final user once it's manufactured. Lusch and Lusch define a *marketing channel* as "the set of institutions or people that participate in moving goods and services from point of initial source or production to point of final consumption or use."<sup>19</sup> According to Lusch and Lusch, the study of marketing channels serves in part to improve customer services, reduce costs of distribution, control inventories, and reduce negotiation time.

In statistical research and data gathering, government and private research organizations extend their resources far beyond the preparation of national income, the consumer price index, consumer expenditures, and other macroeconomic figures. Detailed microeconomic data are also a main area of research. Standard classifications include price, employment, and output figures for specific industrial groups classified according to their distance from final use. Price, inventory, and output indices are put together for raw commodities, agricultural products, producers' goods, manufactured products, wholesale goods, and final consumers' goods, among others. Frederick C. Mills, who pioneered this method at the National Bureau

of Economic Research, refers to these price and output relationships as “of central importance in the working of the economic system.”<sup>20</sup> As I will demonstrate, such micro data will prove extremely valuable in analyzing the economy and the financial markets according to the time structure of production and the associated theoretical framework.

## THE CHALLENGE OF A NEW CONCEPT

My use of the stages-of-production viewpoint may seem somewhat unfamiliar to students of conventional economic analysis. Today most introductory college textbooks ignore this basic process inherent in all economies, except as it may apply to a discussion of the *value added* tax, or *cost push* inflation. The value added tax is imposed on businesses at each stage of production. In the case of cost push inflation, researchers try to determine to what extent changes in wholesale costs affect retail prices. For example, during an energy crisis, if the price of crude oil doubles, how much will gasoline prices go up? Or, if the price of agricultural commodities declines, how will this affect food prices in the grocery store?

But other than these two examples, the time structural view is not discussed. Nor is it a familiar subject in intermediate macro or micro textbooks. Anne P. Carter notes that this alternative theory that “converts inputs into final output” is very much an “economic black box.”<sup>21</sup> The only place the structure-of-production concept may be introduced is in conjunction with input-output analysis, business cycle theory, and the history of economic thought.

The vertical production methodology has a long history in economics and was a major theme of conventional economists in the late nineteenth and early twentieth centuries, and can even be found in a number of economics textbooks through the 1950s. I have devoted the next three chapters to an extensive review of this approach in the history of economic thought in order to put it into proper perspective.

While the Clark-Walras system of macroeconomics became the pervasive orthodoxy by the 1930s, it is appropriate that we resurrect the notion of a “natural” market process and structure of production. The structure-of-production concept can be an extremely valuable tool for economists in analyzing aggregate supply and demand and the effect of government policy on the economy. I would even venture to suggest that viewing the economy in this manner can serve as an essential link between micro and

macro theory. Moreover, such an approach is a more realistic method of analyzing aggregate economics than the Keynesian consumption function, the monetarist cash balance effect, or aggregate supply and demand.

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## NOTES

1. The crisis in conventional macroeconomic orthodoxy is discussed intelligibly in D. Bell and I. Kristol, eds., *The Crisis in Economic Theory*, as well as in Wiles and Routh, eds., *Economics in Disarray*.
2. L. A. Hahn, *Common Sense Economics*, 116.
3. Morishima, *The Economic Theory of Modern Society*, 50.
4. Keirstead, *Capital, Interest and Profits*, 47.
5. Solow, *Capital Theory and the Rate of Return*, 26–27.
6. *Ibid.*, 13–14. See also Solow, Review of J. Hicks's *Capital and Time*, 191. Paul Samuelson adds, "Repeatedly in writings and lectures I have insisted that capital theory can be rigorously developed without using any Clark-like concepts of aggregate 'capital,' instead relying on a complete analysis of a great variety of heterogeneous physical capital goods and processes through time." Samuelson, "Parable and Realism in Capital Theory," 193. Unfortunately, in this same article, Samuelson develops a homogeneous capital concept based on a single "surrogate" production function!
7. Hahn, "Equilibrium Dynamics," 634.
8. B. Anderson, *Economics and the Public Welfare*, 393. Roger Garrison adds, "Keynes's propensity to aggregate conceals critical market processes." "The Austrian-Neoclassical Relation," 155.
9. Milton Friedman rejects many of the Keynesian policy recommendations and economic theories, but uses many of the methodological aggregates such as consumption, investment, and income. "We all use the Keynesian language and apparatus; none of us any longer accepts the initial Keynesian conclusions." Friedman, *Dollars and Deficits*, 15. The emphasis on aggregate analyses is apparent in all Friedman's works. For example, see Friedman and Schwartz, *Monetary Trends*, 16–72.
10. Don Patinkin's monetary theory is a prime example of the high degree of aggregation in neoclassical macroeconomics. See D. Patinkin, *Money, Interest and Prices*. On Patinkin's methodology, Roger Garrison comments, "Patinkin equals, actually outdoes, Keynes in his willingness to use broad economy-wide aggregates and hence to suppress capital-theoretical considerations . . . and, like Wicksell, he elevates the real-cash-balance effect to the status of the sole equilibrating force in the economy. . . . Real cash balances are one-dimensional and homogeneous. Disequilibrium in the Patinkin model is reduced to a comparison of the actual quantity of money in existence to the quantity demanded." See Garrison, "The Austrian-Neoclassical Relation," 117, 128.

11. Boulding, *A Reconstruction of Economics*, 202. See also 175, 187–188.
12. Leontief, *Input-Output Economics*, 14–15.
13. D. Lavoie, *National Economic Planning: What Is Left?*, 105.
14. G. L. S. Shackle comments, “Leontief was concerned with the technical structure, but within this technical structure there is latent a *temporal* structure, residing in the fact that what exists today as yarn, and what exists today as cloth, and what exists today as finished garments, do not and never will belong in the same physical object, yet today’s finished garment was at an earlier time cloth, and that cloth at any earlier time still was yarn. Leontief was not immediately concerned with the temporal structure, but if changes are made in the ‘bill of goods for final use’ these changes will require time spans in order to have their full effects, and those time spans will reflect the technical capital structure of production. They are the reality of the time-structure of production.” Shackle, “New Tracts for Economic Theory, 1926–1939,” 34.
15. Leontief, *Input-Output Economics*, 162.
16. Morishima, *The Economic Theory of Modern Society*, 35–36. Carl G. Uhr agrees that a “revitalized analysis” of a time-structure of production concept “may be of great service.” Uhr, *Economic Doctrines of Knut Wicksell*, 146.
17. Williamson, *The Economic Institutions of Capitalism*, 86.
18. Scherer, *Industrial Market Structure*, 239. See also 69–71, 85–86.
19. R. F. Lusch and V. N. Lusch, *Principles of Marketing*, 302. Also, see B. Rosenbloom, *Marketing Channels: A Management View*, and Stern and El-Ansary, *Marketing Channels*.
20. Mills, *Prices in Recession and Recovery*, 26. Referring to price and production indices of individual sectors, Carl Uhr adds, “The ‘standard’ classifications still in use were developed several decades ago, long before analyses of national income, employment, and economic growth came to demand so much attention of economists, leaders of the business community, and elected and appointed public officials in charge of developing economic policy.” Uhr, *Economics in Brief*, 120.
21. Carter, *Structural Change in the American Economy*, 3–4. Referring to her alternative approach to production theory—which generally resembles mine—she writes in the preface, “This book is a mere drop in an enormous—and barely damp—intellectual bucket.” (vii).

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## **PART I**

# **THE STRUCTURE OF PRODUCTION: A HISTORICAL SURVEY**

A study of the history of opinion is a necessary preliminary to the emancipation of the mind.—Lord Keynes

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## **TWO**

# **THE THEORY OF PRODUCTION IN CLASSICAL ECONOMICS**

The whole of the organon of pure economics thus finds itself unified in the light of a single principle—in a sense in which it never had been before.—Schumpeter on Carl Menger, *History of Economic Analysis*.

**T**he idea that production takes time and passes through a series of stages before reaching consumption was not seriously developed as an important economic principle until the Austrian economist, Carl Menger, wrote about it in the 1870s. Earlier economic thinkers referred to the manufacturing process through time, but did not dwell on it or develop it into a complete macroeconomic concept.

### **EARLY FRENCH VIEWS OF THE ECONOMY**

In the early eighteenth century, the French physiocrat François Quesnay (1694–1774) attempted to describe the production process in his famous work *Tableau Economique*. His complex diagrams tried to show, in a zigzag fashion, the successive rounds of annual expenditures by the major sectors of the economy. Although Quesnay incorporated capital (*avances*) in his model, he focused primarily on the relationship between the “productive” agricultural sector and the “unproductive” manufacturing and landlord sectors rather than on the time-consuming transformation process of individual goods.<sup>1</sup>



The French financial magistrate, A. R. J. Turgot (1727–81), worked out a proto-“Austrian” theory of production in his short work, “Reflections on the Formation and Distribution of Wealth,” published in 1766. “The products of the earth require long and difficult preparations in order to make them suitable for the wants of man,” he wrote.<sup>2</sup> Using the examples of shoes and leather, Turgot discussed how labor, combined with land and “capitals,” is used to transform goods through intermediate “operations.” He stated: “A vast number of Crafts, and even those Crafts engaged in by the poorest members of Society, require that the same materials should pass through a multitude of different hands, and undergo, for a very long time, exceedingly difficult and varied operations.”<sup>3</sup>

## ADAM SMITH AND THE CLASSICAL VIEW

Ten years later, in his monumental work, *The Wealth of Nations*, Adam Smith (1723–90) examined the industrial process using his well-known example of pins. Smith referred to eighteen distinct operations, some occurring simultaneously, in the pinmaking trade. Although he used the manufacturing of the pin to demonstrate the principle of division of labor, it also demonstrated the sequential “assembly line” nature of the pin factory. “One man draws out the wire, another straightens it, a third cuts it, a fourth points it, a fifth grinds it at the top for receiving the head; to make the head requires two or three distinct operations.”<sup>4</sup>

Beyond this brief outline, however, Smith moved on to an extended discussion of “productive” and “unproductive” labor, which could be loosely defined as a distinction between *capital goods* and *consumer goods*.<sup>5</sup> Smith favored the accumulation of capital over consumption, but did not develop a general theory based on the causal nexus between capital goods and consumer goods. His theory of production was more *cross-sectional* in nature, analyzing the economy in terms of the factors of production—land, labor, and capital—in contrast to Turgot’s *longitudinal* approach of analyzing the intertemporal transformation of raw materials and intermediate goods into final consumer products. He used the terms, *fixed capital*, referring to machinery and durable producer goods, and *circulating capital*, referring to unfinished products that are transformed by manufacturing firms, but did not extend his analysis any further.<sup>6</sup>

Smith’s theory of production became known as the “classical” position. His emphasis on the factors of production (land, labor, and capital) and

their costs, irrespective of their place in the industrial hierarchy, became the traditional framework for Ricardo, Malthus, Mill and other classical economists. In this sense, they were the forerunners of the Clark-Walrasian formula of the neoclassical production function and macroeconomic analysis (hence, the appropriate term, *neoclassical*). Like the classical economists, the neoclassical economists see the economy in a “cross-sectional” or “horizontal” fashion, in a timeless, homogeneous realm, as opposed to the “longitudinal” or “vertical” view of a time-oriented structure of economic processes.

Schumpeter argued that David Ricardo (1771–1823), despite his emphasis on the costs of production and the labor theory of value, was a forerunner of Jevons and Böhm-Bawerk because he analyzed capital and machinery from the point of view of the time it took to bring commodities to market. Thus, Ricardo wrote,

On account then of the different degrees of durability of their capitals, or, which is the same thing, on account of the time which must elapse before one set of commodities can be brought to market, they will be valuable, not exactly in proportion to the quantity of labour bestowed on them, . . . but something more, to compensate for the greater length of time which must elapse before the most valuable can be brought to market.<sup>7</sup>

By the same token, classical economists J. B. Say (1767–1832) and J. S. Mill (1806–73) developed embryonic notions of Menger’s forthcoming theory of imputation. Mill, for instance, dealt with the value of indirect factors of labor in lengthy processes of production, as in the case of breadmaking: “All these persons ultimately derive the remuneration of their labour from the bread, or its price: the ploughmaker as much as the rest.”<sup>8</sup> However, Mill was more concerned with the distinction between the production of “necessities” and “luxuries” and how such luxuries constituted a “fund” available for “pleasures and for all higher uses.”<sup>9</sup>

Fortunately, a more complete picture was developed by a few lesser known nineteenth-century writers, such as Mountifort Longfield (1802–84) and John Rae (1796–1872). Longfield used the example of a cotton gown, referring to the labor and materials that went into it—raw materials, freight, nails in building the freight ship, and so on. “Carry on this analysis in your mind, as far as your imagination dares to wonder, and you will find in the most distant ages, certain employments of labour, and accumulation of capital, indirectly contributing to the production of this cotton gown.”<sup>10</sup>

John Rae’s theory of production was much more elaborate than Longfield’s. He used the example of bread and discussed its gradual transforma-

tion, from the farmer's wheat seed to the consumer's loaf of bread. Rae proposed that "the steps of these various processes depends on a knowledge of the course of natural events" and referred to capital instruments as the "supply of future wants." In his description of capital, he noted that (1) instruments are made by labor and other instruments; (2) capital is consumed, slowly or quickly (thus forming the important distinction between durable and nondurable goods); and (3) there is a time element in production and consumption. "Between the formation and exhaustion of instruments a space of time intervenes." Sometimes it could be months, sometimes years.<sup>11</sup>

Despite these occasional forays into a time-oriented, capital-using description of the economy, the idea that capital goods were unfinished products which ripened into consumption goods over a period of time was an uncommon approach in the early nineteenth century. It was only briefly and occasionally referred to by the principal classical economists. The most one can generally expect to find in that era was a highly simplified distinction between capital goods and consumer goods, or more generally, between production and consumption.<sup>12</sup>

## THE MARXIAN NATURE OF CAPITALISTIC PRODUCTION

Karl Marx (1818–83), the most influential theorist in socialist economic thought, was heavily affected by Ricardian economics and adopted a labor factor-of-production approach to explain his peculiar theory of capitalist exploitation. Accordingly, Marx viewed capital and labor as essentially homogeneous in value, with no concept of a time structure of production in the Mengerian sense. Capital was heterogeneous in physical things and in exchange, but homogeneous in terms of labor value, when converted to monetary terms. Marx, like Adam Smith, also divided his economic model into two departments only: commodity capital and commodity consumption.<sup>13</sup>

Granted, Marx made frequent reference to what he called the "process of capitalist production," but his formulation is quite distinct from the one presented here. When he analyzed the transformation of commodities over time, he stressed almost exclusively the monetary or exchange aspect of the industrial process. Marx used the term *metamorphosis of capital*, as if to liken the production process to the successive stages of larva, chrysalis, and moth; but not at all in the sense of the physical transformation of raw

commodities into final consumer goods. Rather, he meant the production of goods for the marketplace, for money instead of self-consumption, and the separation of money from labor.

Marx's three stages of "circuit capital," mathematically represented as  $M-C-M$ , meant (1) the capitalist as buyer of commodities and labor, called *money capital*; (2) the transformation of capital into commodities of greater value, known as *productive capital*; and (3) the capitalist as seller to another capitalist or the consumer, termed *commodity capital*.<sup>14</sup> Only the second stage approaches the concept of a vertical production schedule, but even here Marx's emphasis is on the rate of profit for individual firms, irrespective of the position of the capitalist and his employees in the production process. Time and the durability of capital are also crucially important in Marx's methodology, but only insofar as they affect the "turnover of capital," and the necessity for capitalists to expand their market to avoid the "inevitable" decline in the rate of profit.<sup>15</sup>

Friedrich Engels (1820–95), in his preface to volume 3 of Karl Marx's *Capital*, made a short reference to the technical stages of production in an effort to expose the injustice of the capitalistic system. But while capitalists are categorized according to their distance from final consumption, Marxists see no reason why workers should be.

The capitalistic sellers, i.e., the raw material producer, the manufacturer, the wholesale trader and the retailer, make a profit in their businesses by each selling dearer than he buys, i.e., by increasing the price that his commodities cost him by a certain percentage. Only the worker is unable to obtain an additional value of this kind, for his unfortunate position vis-à-vis the capitalist compels him to sell his labour for the same price that it costs him himself, i.e., for the means of subsistence that he needs.<sup>16</sup>

## MENGER: THE CAUSAL CONNECTION BETWEEN GOODS

The publication of Carl Menger's *Grundsätze der Volkswirtschaftslehre* (later translated into English as *Principles of Economics*) in 1871 was a landmark in the history of economic theory for two reasons. First, Carl Menger (1840–1921) established himself as one of the principal architects of microeconomics by formulating the principle of marginal utility, along with William Stanley Jevons (1835–82) and Léon Walras (1834–1910). (In contrast to Jevons and Walras, Menger's approach to marginal utility was strictly individualistic and subjective.) Second, he was the first economist to develop more fully a time structure of production and thus formulate the

basis for a theory of macroeconomics. These two monumental contributions to the science of economics places the founder of the Austrian school among the great economic thinkers of our age.

Schumpeter recognized the universal applicability of Menger's marginal utility principle, which "covers the cost phenomenon and in consequence also the logic of the allocation of resources." Moreover, Menger's insights meant that the theory of distribution "really ceases to be a distinct topic," wrote Schumpeter, concluding, "The whole of the organon of pure economics thus finds itself unified in the light of a single principle—in a sense in which it never had been before."<sup>17</sup> Thus, there is little dispute over who was the primary mentor of the Austrian school: "Its fundamental ideas belong fully and wholly to Carl Menger," Hayek stated unequivocally.<sup>18</sup>

Menger's first chapter, "The General Theory of the Good," developed the principle of the "causal connection between goods." Menger rejected the simple two-good model (production goods and consumption goods) of the classical school. Instead of focusing on goods as if they were homogeneous, he envisioned consumer and capital goods as an *array* of goods—of the first order, the second order, the third order, and so forth.

Consumer goods are defined as "goods of first order," because they "serve our needs directly."<sup>19</sup> Goods of a second order are used in the production of goods of a first order. Goods of a third order are used in the production of second-order goods. And so forth. There is a vertical hierarchy in Menger's ordering of goods—from lower-order goods (close to consumption) to higher-order goods (furthest from consumption).

Production is defined as the process of transforming higher-order goods into successively lower-order goods. Menger viewed economic production as "[t]he process by which goods of higher order are progressively transformed into goods of lower order and by which these are directed finally to the satisfaction of human needs."<sup>20</sup> Like so many others, he used the simple example of making bread, a consumer good. Starting at the beginning of production, seed grain is planted in the ground by machines and labor. This stage represents "goods of a fourth order." The "goods of a third order" consist of grain mills, wheat, rye, and labor services, all used to produce flour. "Goods of a second order" include flour, baking utensils, and the journeyman baker and other workers to produce bread. The bread is a "good of first order," consumed by individuals.

Menger also emphasized the critical factors of time and uncertainty in the production process: "Time is an essential feature of our observations." The period of time it takes for higher-order goods to be transformed into

lower-order goods may be long or short. An oak tree may take one hundred years before it can be cut, while the serving of food or beverages may take only a few moments, Menger commented.<sup>21</sup>

Menger stressed the subjective nature of goods and the mutual interdependence of value between goods. Specifically, he developed the principle of imputation of value, how the value of higher-order capital goods depends on the value of lower-order consumer goods. As Menger put it, "The goods-character of goods of higher order is derived from that of the corresponding goods of lower order."<sup>22</sup>

Moreover, if the demand falls for a particular lower-order consumer good, the higher-order capital good used to produce the consumer good would not necessarily lose its value, but would fall to its next best *marginal* use. Menger used as his example tobacco consumption. If people stopped smoking, the price of all final tobacco products would fall to zero. But what about the value of higher-order goods used in the production of tobacco, such as raw tobacco leaves, tools used in making tobacco, tobacco seeds, tobacco farms, and accompanying labor services? Menger points out that those of *exclusive* or specialized use, such as tobacco seeds, would lose their entire value. But because farms and machinery have other uses, they do not lose their value completely. Their value falls to the next best *marginal* use. "Goods of higher order thus do not lose their goods-character," said Menger, "if but one, or if, in general, but a part of these needs ceases to be present."<sup>23</sup> In this manner Menger developed the principle of marginal utility.

Roger Garrison makes the critical point that Menger's value theory (as well as Turgot's) was a "sharp break from the Ricardian cost-of-production theories. . . . [T]he direction of causation was reversed by Menger. A consumption good is not valued *because* of the labor and other means of production that were used to produce it. Rather, the means of production are valued because of the prospective value of the consumption goods."<sup>24</sup>

## JEVONS'S INVESTMENT FIGURES

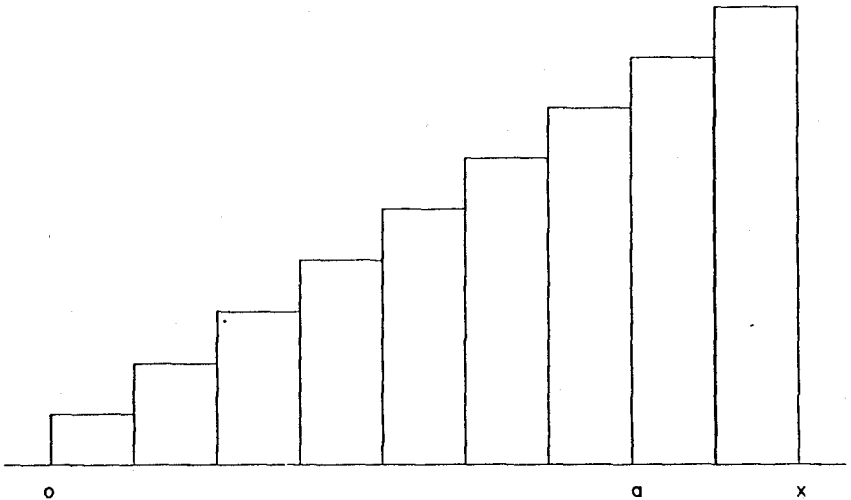
William Stanley Jevons (1835–1882) pursued the same line as Menger, in both the principle of marginal utility and the theory of production. This was evidenced in his seminal work, *The Theory of Political Economy*, published in 1871. Jevons emphasized the importance of time and the period of production. He stated, "The single and all-important function of

capital is to allow the laborer to await the result of any long-lasting work—to put an interval between the beginning and the end of enterprise.”<sup>25</sup> Jevons also used his triangular “investment” figures to show the marginal increase in values as production moved from higher stages to lower stages toward consumption (see figure 2.1).

Later in his *Principles of Economics*, he developed the concept of a period of production. He wrote extensively about “the orders of industry” and “the classification of trades,” according to the stages of industrial production. He divided various occupations and trades into six general levels of industry, according to their distance from consumption: (1) sources of raw materials (e.g., landowners), (2) producers of raw materials (farmers), (3) dealers in raw materials (cotton traders), (4) manufacturers (bakers), (5) wholesalers (shippers), and (6) retailers (shopkeepers).<sup>26</sup>

However, Jevons ultimately rejected the concept of goods in varying lengths from consumption because the manufacture of products is often complex, involving many other intermediate goods of varying stages. “But, though the principal material of a trade, such as wheat, cotton, or wool, often pursues a simple linear course from the field to the household, there is often a very complicated pedigree when we take into account the series

**Figure 2.1. Jevons’s Investment Figures**



“The length along the line  $ox$  indicates the duration of investment, and the height attained at any point,  $a$ , is the amount of capital invested.” Jevons, *The Theory of Political Economy*, 250.

of minor materials and implements required at the several stages of production."<sup>27</sup> He reached the conclusion that "it is hopeless to attempt to draw out any written or printed scheme of classification which could in the least degree cope with the complexities of industrial relations."<sup>28</sup>

Fellow British economist Alfred Marshall (1842–1924) concurred with Jevons's conclusions. "Of course a good may belong to several orders at the same time," Marshall stated in the third edition of his popular textbook.<sup>29</sup> In a later edition, he stated that Carl Menger "says bread belongs to the first order, flour to the second, a flour mill to the third order and so on. It appears that if a railway train carries people on a pleasure excursion, also some tins of biscuits, and milling machinery and some machinery that is used for making milling machinery; then the train is at one and the same time a good of the first, second, third and fourth orders." The Mengerian distinction between consumers' goods and producers' goods seemed "vague and perhaps not of much practical value."<sup>30</sup>

## **MENGER'S STUDENTS: WIESER AND BÖHM-BAWERK**

Menger's followers continued to amplify and refine his theory of sequential processes. Friedrich von Wieser (1851–1926) defined Menger's structure of production as a "stratification" and "complete genealogy" of the economy, elucidating the "vertical and horizontal relationship of all productive goods and all products."<sup>31</sup> Wieser developed a theory of economic growth based on this framework. "As production becomes more highly developed, it extends through a greater number of stages. It operates with the aid of many more capital goods and much more labor."<sup>32</sup> In essence, the length of the capital process increases, and "capital in its simultaneous increase and improvement is applied to more and more remote stages of production."<sup>33</sup>

Eugen von Böhm-Bawerk (1851–1914), who was one of Austria's foremost economists and statesmen at the turn of the century, made a systematic critique of the theories of capital and interest, and engaged in a broadside attack on Marx. His principal theoretical work, *The Positive Theory of Capital*, was first published in 1889, and was based on Menger's premises, although at critical junctures he departed from Menger. The work received considerable acclaim and criticism, especially after it was translated into English in 1890. Böhm-Bawerk's period of production model is still a principal point of debate in capital theory, and in the words of one

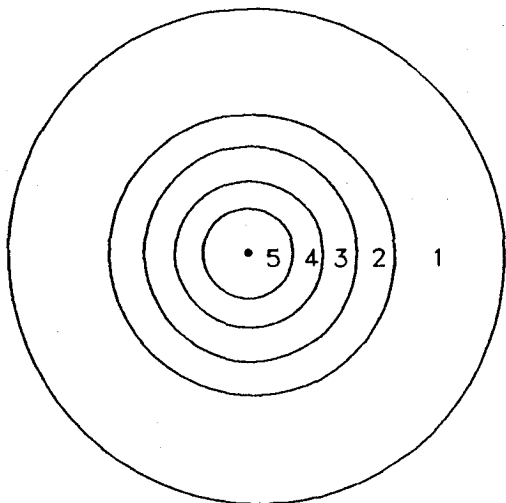


sympathetic critic, his concept is “a ghost that haunts the structure of economic theory.”<sup>34</sup>

Böhm-Bawerk was also the principal architect and defender of the time preference theory of interest. It is based on the “cardinal principle . . . that present goods have a higher value than future goods of like kind and quantity.”<sup>35</sup> He defended this approach against Clark’s productivity theory of interest and other competing theories, although he adopted some elements of the productivity arguments in his concept of “roundaboutness.”

Böhm-Bawerk began by defining capital: “Capital is nothing but the complex of intermediate products which appear on the several stages of the roundabout journey.”<sup>36</sup> His definition of capital excluded lands, durable consumer goods, and “all goods that serve for immediate satisfaction of wants.”<sup>37</sup> Following Menger’s path, he stated that capital goods lie at varying distances from consumption, which he illustrated with “concentric annual circles,” similar to tree rings (see figure 2.2). As Böhm-Bawerk stated:

**Figure 2.2. Böhm-Bawerk’s “Concentric Annual Circles”**



“The outmost circle embraces those goods which will be transformed into goods ready for consumption within the coming year; the second circle represents those goods which will ripen into consumption goods in the year after; the third circle, those which will be ready in the year after that, and so on.” Eugen von Böhm-Bawerk, *Capital and Interest*, trans. George D. Huncke, Hans F. Sennholz, 3 vols. (Spring Mills, Penn.: Libertarian Press, 1959) vol. 2, *The Positive Theory of Capital*, 106–7.

Many an intermediate product has just entered on a very lengthy roundabout road, as, for instance, a boring machine, whose life-work it will be to drive a gallery in a mine. Some are midway. Others, again, like clothing stuffs ready for making into coats and mantles, are near the end of the journey their particular production process has to take.<sup>38</sup>

Thus, Böhm-Bawerk's "Austrian" approach envisioned capital "longitudinally through time rather than cross-sectionally, as a succession of intermediate products moving through the production process, changing at every stage as they absorbed primary factor services, and ultimately destroying themselves in a harvest of consumption goods."<sup>39</sup> According to Kuenne, Böhm-Bawerk's view of capital is "organic," like a seed that is planted, absorbs primary services, and over a period of time, is harvested as a consumption good.<sup>40</sup> This sets the stage for two contrasting views of capital theory—the Austrian view of circulating capital moving through stages versus the neoclassical view of fixed capital yielding a return. Frank H. Knight made the comparison succinctly: "What Jevons and Böhm-Bawerk do to the Ricardo-Mill theory of distribution and of capital is essentially to drop the assumption of a natural annual cycle in production and the corresponding fixity of proportions between labour and capital, and to make the quantity of capital (for a given quantity of labour and land) a linear function of a variable production period."<sup>41</sup>

## **ROUNABOUT METHODS AND THE "AVERAGE" PERIOD OF PRODUCTION**

Böhm-Bawerk made extensive use of the term *roundabout* in describing the capitalistic process as the basis for his theory of economic expansion. By roundabout, he meant the indirect use of capital goods in order to make consumption goods. Roundabout methods are used, according to Böhm-Bawerk, to increase output. He used several examples, one of which is as follows:

I require stone for building a house. There is a rich vein of excellent sandstone in a neighbouring hill. How is it to get out? First, I may work the loose stones back and forward with my bare fingers, and break off what can be broken off. This is the most direct, but also the least productive way. Second, I may take a piece of iron, make a hammer and chisel out of it, and use them on the hard stone—a roundabout way, which, of course, leads to a very much better result than the former. Third method—having a hammer and chisel I use them to drill a hole in the rock; next I turn my attention to procuring charcoal, sulphur, and nitre, and mixing them in a powder, then I pour the powder into the hole, and the explosion