
THE PURE THEORY OF CAPITAL



F. A. HAYEK

THE COLLECTED WORKS OF
F. A. Hayek

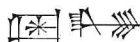
THE PURE THEORY
OF CAPITAL

F. A. HAYEK
Edited by Lawrence H. White



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EDITORIAL FOREWORD

Bruce Caldwell

The Pure Theory of Capital occupied a great deal of Hayek's time during the 1930s. As noted in the editor's introduction by Lawrence H. White, there were some false starts as well as some full stops. Though he was more or less done with it by the end of 1939, the exigencies of the war delayed its publication until 1941.

It is a great pleasure to present here, as volume number 12 in the series, the *Collected Works* version of the book. As with all the other volumes, this one contains an editor's introduction as well as numerous explanatory footnotes to help the reader follow Hayek's argument. More so than is usually the case, both the introduction and the explanatory notes are invaluable aids in this volume, for capital theory is one of the most opaque areas of economics, and Hayek's book is accordingly one of the most difficult of his technical contributions. We are in Professor White's debt for the light he sheds on the arguments in the text, as well as for placing the book within an historical and theoretical context.

The text is faithful to the original, and includes Hayek's preface, both the standard and the analytical table of contents, as well as the three appendices that Hayek had originally included. Two more appendices that were not in the original have been added. The first is a one-page comment by Hayek on an article by Professor Friedrich Lutz titled "Professor Hayek's Theory of Interest". Both the Lutz paper and Hayek's comment appeared in the November 1943 issue of the journal *Economica*. Appendix 5 contains a longer piece by Hayek, "Time-Preference and Productivity: A Reconsideration", that appeared in the February 1945 issue of *Economica*. Following the appendices is an index listing pages where terms are defined, as well as Hayek's bibliography, both of which were included in the original. Though all of Hayek's citations in the text have been standardized to reflect modern form, the bibliography is not: it is just as it was in the original.

I thank Larry White for doing a superb job of editing this volume, and also for doing the initial creation of a master text from which to work. Kevin Welding produced master copies of the appendices, and Brandon Beck of the index of definitions and the bibliography. Brandon also assisted me in doing a line-by-line check of the text against the original. I finally thank the Earhart Foundation, the Pierre F. and Enid Goodrich Foundation, and the Morris Foundation for their financial support of this volume and of the *Collected Works* series as a whole.

EDITOR'S ACKNOWLEDGEMENTS

Lawrence H. White

I wish to thank Bruce Caldwell for his judicious guidance as series editor, and additionally for sharing his findings from the Hayek-Machlup correspondence in the Hayek Collection at the Hoover Institution. I thank Jack Birner for incisive comments, and for providing a copy of Hayek's unpublished notes to *The Pure Theory of Capital*. Roger Garrison, Israel Kirzner, and George Selgin provided helpful comments on early drafts of the introduction. None of the aforementioned is responsible for the shortcomings that remain in this volume. John L. Chapman provided able research assistance in the early stages of the project.

EDITOR'S INTRODUCTION

Lawrence H. White

[William Bartley]: Wouldn't you say in retrospect that capital theory in the Austrian sense ended with *Pure Theory of Capital*?

Hayek: I'd say very largely. No one has done what I hoped would be done by others.¹

[Interviewer]: You had participated in the capital controversies of the 1930s along with Professor Hayek and Professor Knight. How do you evaluate that debate and your rôle in it?

[Fritz] Machlup: I think it's very valuable and I think we should go back to it. It's too bad that Hayek's *Pure Theory of Capital* is no longer being read and that nobody tries now to work on it, after all, it is not the end. The relation of money capital to pure capital has still to be worked in. It's terribly important, but there is still not sufficient interest in it.²

In sharp contrast to his vibrant and much-debated lectures published as *Prices and Production* ten years earlier, F. A. Hayek's 1941 book *The Pure Theory of Capital* attracted little attention. Years of painstaking intellectual effort had produced a dry treatise that became, not coincidentally, Hayek's last book in economic theory. *The Pure Theory of Capital* offers a detailed account of the equilibrium relationships between inputs and outputs in an economy where production takes time and where some capital goods are not completely versatile. It moves from the relatively simple type of input-output mapping assumed in *Prices and Production* to increasingly complex types of relationships between dated inputs and outputs. Hayek's stated objective was to make capital theory—which had previously been devoted almost entirely to explanation of the interest rate—"useful for the analysis of the monetary phenomena of the real world."³ His ambitious goal, then, was nothing less than to develop a capital theory that could be

¹F. A. Hayek, *Hayek on Hayek: An Autobiographical Dialogue*, Stephen Kresge and Leif Wenar, eds (Chicago: University of Chicago Press, and London: Routledge, 1994), p. 96.

²Fritz Machlup, "An Interview with Fritz Machlup", *The Austrian Economics Newsletter*, vol. 3, Summer 1980. http://www.mises.org/journals/aen/aen3_1_1.asp

³F. A. Hayek, chapter 1 below, p. 32.

EDITOR'S INTRODUCTION

fully integrated into business cycle theory. That no subsequent writers have actually applied *The Pure Theory of Capital* to business cycle analysis suggests that what he ultimately produced was overly elaborate for the purpose.

The Book's Place in Hayek's Research Programme

The Pure Theory of Capital began as attempt to re-state the business cycle theory of *Prices and Production* with a more rigorous capital-theoretic foundation. As Don Bellante and Roger Garrison note, *Prices and Production* "was intended only as an outline".⁴ In the preface to the second edition of *Prices and Production*, Hayek explained that it was a sketchy outline at best. The invitation to give the lectures that were published as *Prices and Production*

came at a time when I had arrived at a clear view of the outlines of a theory of industrial fluctuations but before I had elaborated it in full detail or even realised all the difficulties which such an elaboration presented. The exposition, moreover, was limited to what I could say in four lectures, which inevitably led to even greater oversimplification than I would probably have been guilty of in any other case.⁵

Later in the same paragraph Hayek added:

Contact with scientific circles which were less inclined than I was to take for granted the main propositions of the 'Austrian' theory of capital on which I have drawn so freely in this book has shown—not that these propositions were wrong or that they were less important than I had thought for the task for which I had used them—but that they would have to be developed in far greater detail and have to be adapted much more closely to the complicated conditions of real life before they could provide a completely satisfactory instrument for the explanation of the particularly complicated phenomena to which I have applied them.⁶

This was the agenda Hayek would pursue in *The Pure Theory of Capital*.

Among the key simplifications of *Prices and Production* was Hayek's well-known graphical device in Lecture II representing an economy's aggregate 'structure

⁴Don Bellante and Roger W. Garrison, "Phillips Curves and Hayekian Triangles: Two Perspectives on Monetary Dynamics", *History of Political Economy*, vol. 20, Summer 1988, pp. 213–15, notes 10, 13.

⁵F. A. Hayek, *Prices and Production*, 2nd ed. (London: Routledge and Kegan Paul, 1935; reprinted, New York: Kelley, 1967), p. vii.

⁶*Ibid.*, p. viii.

of production' as a series of 'stages' leading to the output of consumers' goods. At each stage, an application of 'original means of production' (labour and land inputs) adds value to goods-in-process. In the case of continuous and even application of inputs over time, the rising value of the goods-in-process describes the hypotenuse of a right triangle (one leg is value, the other is time).

The Hayekian triangle thus drawn corresponded to the simple case of 'continuous-input point-output' production that had earlier been analysed by economists William Stanley Jevons and Eugen von Böhm-Bawerk.⁷ Such a case can be illustrated by considering a growing tree, supposing that the tree must be continuously tended. (If no tending is needed between planting and harvesting, the production process would be 'point-input point-output'.) The tree (a capital good) 'matures' into firewood (a consumer good) with the application of land and labour inputs over time. Or consider a grazing steer that matures into steaks. With a perfectly even application of inputs over the production process, an 'average period of production' (APP), summarising the duration or time-consumption or 'roundaboutness' of the process in 'technical' terms (independent of the interest rate), can readily be identified: it is one-half the length of the process from start to finish. For each unit of land or labour that the process 'bottles up' for longer than the APP, there is another unit that it bottles up for correspondingly less time.

Under the classical assumption that workers are paid during the duration of the process by drawing down a previously accumulated 'wages fund', greater saving (accumulating a larger fund) allows a longer APP and hence the use of more-productive-but-more-roundabout techniques that yield a greater (undiscounted or steady-state) consumption per worker. A reduction in saving does the reverse. The equilibrium interest rate balances the marginal gain from lengthening the APP against savers' preference for consuming sooner rather than later.⁸

Hayek soon came to recognise that the case of even-continuous-input followed by point-output is a very special case.⁹ An APP is no longer technically

⁷Ibid., p. 38, n. 1, noted that "similar triangular figures" had earlier been used by Jevons and Knut Wicksell. He cited William Stanley Jevons, *The Theory of Political Economy*, 4th ed. (London: Macmillan, 1911), and Knut Wicksell, *Lectures on Political Economy*, vol. 1, translated by E. Classen (London: George Routledge & Sons, 1934; reprinted, Fairfield, N.J.: Kelly, 1977). In his footnote Hayek also endorsed Jacob Marschak's suggestion that such triangles be called "Jevonian investment figures".

⁸Optimisation and stationary equilibrium conditions in Böhm-Bawerkian models have been analysed by Robert Dorfman, "A Graphical Exposition of Böhm-Bawerk's Interest Theory", *Review of Economic Studies*, vol. 26, February 1959, pp. 153–58; and by Jack Hirshleifer, "A Note on the Böhm-Bawerk/Wicksell Theory of Interest", *Review of Economic Studies*, vol. 34, April 1967, pp. 191–99.

⁹Hayek noted already in a 1934 article that the use of *two* dimensions to represent the range of input investment periods "cannot usefully be replaced—except by way of a provisional simplifi-

definable (independent of the interest rate) in more complicated cases. One complication, made famous decades later by the 'reswitching' examples of the 'Cambridge controversies' over capital, is an uneven time-distribution of inputs. A second complication is introduced by durable capital goods that help produce streams (rather than single points) of outputs. With durable capital goods like a lumberjack's axe in mind, Robert Solow remarked that "Böhm-Bawerk, who seemed to be thinking mainly about the age at which trees should be cut down, seemed to worry too little about the implement to be used in felling them".¹⁰ Hayek's aim in *The Pure Theory of Capital* was to analyse such complications, relaxing the Böhm-Bawerkian simplifying assumptions about production technology (in particular, no durable inputs or outputs) that Hayek had adopted in *Prices and Production*.

Also for simplicity, *Prices and Production* had made its equilibrium benchmark a stationary economy. Under stationarity, the 'time' axis of the Hayekian triangle can do double duty. The diagram can be interpreted either as (a) showing the growth in value through time of the particular batch of goods-in-process that will reach consumption on a particular date, or (b) showing the values held at a moment in time (today) by all the goods-in-process across the various stages of completion. Stationarity implies that the through-time profile looks the same as the across-stages profile. In *The Pure Theory of Capital*, Hayek disentangled these two aspects of time by giving each its own axis (in addition to the value axis). Readers of the book have often had a difficult time making intuitive sense of the resulting 'three-dimensional' diagrams.¹¹

In tandem with his work in business cycle theory, Hayek by 1941 had done important work on the meaning of economic equilibrium through time. He had addressed the question in a 1928 essay, "Intertemporal Price Equilibrium and Movements in the Value of Money".¹² In the 1937 essay "Economics and

cation in an early stage of the analysis—by any one-dimensional magnitude such as the 'average period of production'. F. A. Hayek, "On the Relationship between Investment and Output", *Economic Journal*, vol. 44, June 1934, p. 211.

¹⁰Robert M. Solow, *Capital Theory and the Rate of Return* (Amsterdam: North-Holland, 1964), p. 12.

¹¹Jack Birner argues that the proposition Hayek called 'The Ricardo Effect' provided an important bridge in the development of Hayek's capital theory between *Prices and Production* and *The Pure Theory of Capital*. Birner finds the Ricardo Effect expressed, though not always by name, in various diagrams Hayek used in *Prices and Production*, in the 1934 article "On the Relationship between Investment and Output", and finally in *The Pure Theory of Capital*. See Jack Birner, "The Place of the Ricardo Effect in Hayek's Research Programme in Economics", *Revue d'Economie Politique*, vol. 109, November-December 1999, pp. 804–16.

¹²F. A. Hayek, "Intertemporal Price Equilibrium and Movements in the Value of Money", reprinted as chapter 5 of *Good Money Part I: The New World*, ed. Stephen Kresge, which constitutes vol. 5 (1999) of *The Collected Works of F. A. Hayek* (Chicago: University of Chicago Press, and London: Routledge), pp. 186–227. For a critical discussion of this essay see Lawrence H. White, "Hayek's Monetary Theory and Policy: A Critical Reconstruction", *Journal of Money, Credit, and Banking*, vol. 31, February 1999, pp. 109–20.

Knowledge” he argued that an economic equilibrium through time is best conceived as the ongoing compatibility of various agents’ plans.¹³ *The Pure Theory of Capital* puts the compatibility-of-plans concept to work. Though the book begins with the simple case of a stationary economy, Hayek notes that to grapple with many important problems of capital theory—such as the use of inherited capital ‘relics’ that it does not pay to reproduce in the same form, or the transition to a more or less capitalistic structure of production—analysis must go beyond examining stationary states.¹⁴ The broader plan-coordination notion of equilibrium then serves as the relevant benchmark.

Hayek’s Long Struggle with the Book

Hayek admitted in the preface to *The Pure Theory of Capital* that the book had been a struggle to write, and had not reached the complete form he had planned.¹⁵ In unpublished notes to *The Pure Theory of Capital* he wrote: “The period of gestation of this book has been unduly long and protracted. . . . I fear that even in this last form in which I have finally decided to publish it bears far too much the marks of long toil and labour and has not achieved anything like the comprehensive analysis of the whole problem which I should like to give it”.¹⁶ As published, it laid out the capital-theoretic foundations, but did not fully complete the originally intended superstructure: a full-dress re-statement of Hayek’s business cycle theory. As Kenneth Boulding wryly suggested in a review, this development was ironic given that Hayek’s own cycle theory emphasised the economy’s inability to complete projects with overly elaborate foundations:

One has the impression that many of Dr. Hayek’s abstractions are foundations without a superstructure. The theory of capital teaches an important lesson—that foundations may be too elaborate. The lesson of Luke 14:28—

¹³F. A. Hayek, “Economics and Knowledge”, *Economica, N.S.*, vol. 4, February 1937, pp. 33–54; reprinted in *Individualism and Economic Order* (Chicago: University of Chicago Press, 1948), pp. 33–56. For an account of Hayek’s evolving views on equilibrium constructs see Bruce Caldwell, *Hayek’s Challenge: An Intellectual Biography of F. A. Hayek* (Chicago: University of Chicago Press, 2004), pp. 224–30. Hayek was already in the midst of writing *The Pure Theory of Capital* when he wrote “Economics and Knowledge,” so the essay was undoubtedly influenced by the book project as much as the reverse.

¹⁴G. L. S. Shackle, “F. A. Hayek, 1899–”, in *Austrian Economics*, ed. Stephen Littlechild (Aldershot, UK: Edward Elgar, 1990), p. 167, discussed the integration of these themes into *The Pure Theory of Capital*. Uniquely among surveyors of Hayek’s thought, Shackle spent more than a third of his essay on *The Pure Theory*.

¹⁵F. A. Hayek, Preface below, p. 5.

¹⁶Friedrich A. Hayek, unpublished appendices and notes to *The Pure Theory of Capital* (undated), ms., p. 1. I am indebted to Jack Birner for providing a copy of this document.

31—perhaps the first example of capital theory—may also apply to the construction of intellectual structures.¹⁷

The difficult progress of the book is documented by Hayek's correspondence in the 1930s with his friend and former Viennese classmate, economist Fritz Machlup.¹⁸ Machlup had gone to the United States on a Rockefeller Fellowship in 1933, and accepted a teaching position at the University of Buffalo in New York in 1935. Machlup provided Hayek with encouragement and advice on numerous occasions during the writing of *The Pure Theory of Capital*, including extensive line-by-line recommendations for wording changes.

In a letter dated February 15, 1934, Machlup told Hayek that he was awaiting a draft copy of the first part of the book with keen anticipation, which indicates that Hayek probably began the book sometime in 1933. The draft copy arrived a few months later, and Machlup provided Hayek with his first set of extensive comments in September. In addition to three pages of recommendations for revision of specific passages, Machlup repeatedly emphasised the need for clarity in Hayek's presentation. He suggested that Hayek reorganise his presentation so that diagrams would accompany the relevant part of the text, that the diagrams should only be supplemental to his written formulations, and that formulas used in each chapter should stand on their own rather than requiring the reader to go back to earlier chapters to decipher them. Machlup praised Hayek's efforts with such difficult material, but clearly thought that much more needed to be done. The next month Hayek replied, saying that he was going to set aside the first part of the book to begin work on the second. In the winter he sent a copy of the first chapter of the second part (in their correspondence this is referred to as chapter 7; in the published version Part II begins with chapter 8), and in April 1935 Machlup sent him some more detailed comments.

Hayek apparently put the book on hold in the summer of 1935, reporting that he was enjoying the summer and working very little, but returned to working on it in the fall. In May of 1936, Hayek wrote to Machlup that he had finished a first draft of the book before the Easter vacation and was now bringing it to completion. In his next letter, dated June 21, 1936, Hayek informed Machlup that he had completely rewritten the introductory section of the book: "from that which you have already seen nothing remains". By summer's

¹⁷Kenneth E. Boulding, "Review of *The Pure Theory of Capital*", *Journal of Political Economy*, vol. 50, February 1942, p. 131. In the Bible passage that Boulding cites, Luke 14:28–30 (New International Version), Jesus says: "Suppose one of you wants to build a tower. Will he not first sit down and estimate the cost to see if he has enough money to complete it? For if he lays the foundation and is not able to finish it, everyone who sees it will ridicule him, saying, 'This fellow began to build and was not able to finish'".

¹⁸The correspondence may be found in the Fritz Machlup collection, Box 43, folders 15 and 16, The Hoover Institution Archives, Stanford, California. I am indebted to Bruce Caldwell for the information drawn from the correspondence.

end Machlup had received eleven chapters. In the fall of 1936 he provided Hayek with eight pages of line-by-line comments.

In December Machlup, who must have believed that the manuscript was nearly complete, asked Hayek when he expected it to be published. Progress on the manuscript was, however, going sideways. Hayek replied that he was still working on it, and had totally redone the second chapter.¹⁹ In 1937 Hayek reported that he had gotten so frustrated that he had to put the book aside. In the unpublished notes Hayek refers to “having tried even the experiment of putting the practically finished manuscript aside for a considerable period”.²⁰ Their correspondence languished, and the book was not mentioned again until Feb 14, 1938, when Hayek asked Machlup to send him a few pages from one of the chapters, apparently because he had lost his own copies.

Hayek must have resumed serious work on the book in 1938, judging from a letter to Hayek in November from Vera Lutz, a former student then living in Princeton, who was reporting her progress in typing chapters 20 through 26.²¹ In April 1939 Hayek told Machlup that he was working on a chapter on the business cycle (presumably chapter 27), and by August 1939 he could finally report that the book was almost completed. All but the final revision would be done in the next month or so.

The evidence from the correspondence is consistent with the recollections of G. L. S. Shackle, who was a graduate student at the London School of Economics at the time, describing the difficulties Hayek encountered in trying to write the book:

The Pure Theory of Capital emerged in its published form from several manuscript versions which I had the privilege of reading during its composition. The sustained intensity of thought which it cost its author . . . [required] high moral courage and implacable resolve. . . . As this work progressed through several drafts during the middle and later 1930s, he responded to its ever-freshly multiplying difficulties with an intense and sustained effort nothing short of heroic.²²

¹⁹In the second chapter, “Equilibrium Analysis and the Problem of Capital”, Hayek offers his conception of equilibrium as a relationship of mutual compatibility among agents’ plans such that expectations are not disappointed. That conception, as Hayek notes, was one he had proposed in his paper “Economics and Knowledge”, which was a presidential address delivered before the London Economic Club on November 10, 1936. The timing is right for Hayek’s writing of the address to have overlapped with his rewriting of the chapter.

²⁰F. A. Hayek, unpublished appendices, ms. p. 1.

²¹Letter, Vera Lutz to F. A. Hayek, November 11, 1938, in the Hayek Collection, Box 36, folder 11, The Hoover Institution Archives, Stanford, California.

²²G. L. S. Shackle, “F. A. Hayek, 1899–”, op. cit., pp. 163, 157. Incidentally, the false starts and periods of inactivity revealed in the correspondence may help to explain why Hayek would sometimes say in reminiscences that the book took seven years to write, and at other times report that it took four. See, e.g., Hayek, *Hayek on Hayek*, pp. 90–91, p. 101.

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The correspondence also corroborates one of Hayek's later explanations for why *The Pure Theory of Capital* never completed its planned re-statement of Hayek's business cycle theory, but instead concluded with comparatively brief remarks on the relationship between capital theory and the theory of the cycle. As Hayek told one interviewer,

. . . I never really started on the intended monetary or dynamic continuation. Though I tried hard to concentrate further on this subject, my interest began to wander to other topics.²³

Hayek's August 1939 letter to Machlup specified his new interest: research on the scientific foundations of economics that would trace the conceptual errors of the last one hundred years, from Saint-Simon to Hitler. Hayek would later call this line of research the 'Abuse of Reason' project. It would occupy him through the war years and generate such essays as "Scientism and the Study of Society" and "The Counter-revolution of Science," as well as his most famous book, *The Road to Serfdom*.²⁴ Hayek made it plain in the letter that he was eager to begin his new project.

Complementary to these rising opportunity costs, Hayek in another interview cited declining benefits: to continue to work on the planned re-statement of his cycle theory "would have meant working for a result which I already knew, but had to prove it, which was very dull".²⁵

In a third interview Hayek offered a third (but less persuasive) rationale, besides distraction by other topics and fatigue with pure theory, for why he didn't continue with the intended monetary extension:

It may surprise you, but during the war I was fighting on Keynes's side against his critics, because Keynes was very much afraid of inflation. I actually had published one or two essays, one reviewing his wartime pamphlet and another one on the problem of combating inflation, which he already approved. During the war years, the great danger had become inflation, no longer deflation; so we were up against inflation. And in these circumstances, where I wanted to strengthen his influence against the inflationists, I did not want to continue the book.²⁶

²³Hayek, *Hayek on Hayek*, pp. 78–79.

²⁴F. A. Hayek, "Scientism and the Study of Society" [1942–44] and "The Counter-Revolution of Science" [1941], both reprinted in F. A. Hayek, *The Counter-Revolution of Science: Studies on the Abuse of Reason* (Glencoe, I.L.: The Free Press, 1952; reprinted, Indianapolis: Liberty Press, 1979), pp. 19–182, 185–363; F. A. Hayek, *The Road to Serfdom* (Chicago: University of Chicago Press, 1944; reprinted, 1956, 1976, 1994).

²⁵Hayek, *Hayek on Hayek*, p. 96.

²⁶*Ibid.*, p. 91. Hayek's review of J. M. Keynes' pamphlet, *How To Pay for the War*, as well as other writings relating to the topic of war financing, are reproduced in part 2 of *Socialism and War*:

Given the sharp criticism of Keynes that appears in the published book in chapter 27, we are perhaps entitled to discount the importance of this last rationale.

The Relationship of Hayek's Theory to Its Predecessors

Hayek described his aim in *The Pure Theory* as “in some respects no more than an attempt towards a systematic development and elaboration of the fundamental ideas underlying the theory of interest of W. S. Jevons, E. v. Böhm-Bawerk, and Knut Wicksell”, though he noted that “parts of their theory” might be “changed beyond recognition”.²⁷ Among these authors, Hayek gave higher marks for originality and fruitfulness to Jevons than to Böhm-Bawerk:

Böhm-Bawerk in many respects simply developed the ideas propounded by Jevons and made them intelligible to wider circles by elaborating them: but at the same time he gave the impetus to a movement away from what seems to me to be the more fruitful approach on Jevonian lines.²⁸

The ideas about capitalistic production that these authors propounded had come to be known as ‘Austrian’ capital theory after Böhm-Bawerk’s nationality, despite the distinct nationalities of Jevons (English) and Wicksell (Swedish), and despite the fact that Böhm-Bawerk’s theory of interest was not endorsed by his fellow native Austrian economists Carl Menger, Friedrich von Wieser, or Joseph Schumpeter.

Austrian capital theory began with a chapter of Menger’s 1871 *Principles of Economics*.²⁹ Menger emphasised that the market prices of ‘higher-order’ goods (land, labour, and capital goods) derive from their prospective contributions to the production of valued consumer goods (goods of ‘lower order’). Menger thus inverted the classical ‘real cost’ doctrine according to which the prices of consumer goods derive from the amount of labour or land that goes into them.

Böhm-Bawerk elaborated on Menger’s distinction between higher- and lower-order goods with a fairly straightforward model of aggregate production through time.³⁰ In that model semi-finished goods proceed from the highest (raw

Essays, Documents, and Reviews, ed. Bruce Caldwell, which constitutes vol. 10 (1997) of *The Collected Works of F. A. Hayek*.

²⁷F. A. Hayek, chapter 4 below, p. 62.

²⁸*Ibid.*, p. 63.

²⁹Carl Menger, *Principles of Economics*, translated by James Dingwall and Bert Hoselitz (New York: New York University Press, 1981), pp. 149–74.

³⁰Eugen von Böhm-Bawerk, *Positive Theory of Capital*, translated by George D. Hunke, which constitutes vol. 2 of *Capital and Interest* (South Holland, I.L.: Libertarian Press, 1959). For discus-

material) stage downward through successively lower stages, with the application of land and labour services at each stage, until they finally become consumable products. Böhm-Bawerk's (in)famous summary measure of the time spent in production was the aforementioned 'average period of production'.

Hayek used the APP concept in *Prices and Production* to describe cyclical changes in the 'length' of the capital structure. By 1936 Hayek would admit that in general it "is in fact inadmissible, to reduce the description of the range of periods for which the different factors are invested to an expression of the type of a single time dimension such as the average period of production".³¹ Hayek accordingly acknowledged that while Austrian capital theory was "essentially right and even . . . indispensable for a more detailed analysis, I can see that in the simplified form in which I had to use it in my former book it may be more misleading than helpful".³²

The APP could be misleading because it cannot generally be measured purely in technical terms. An 'investment period' (IP) can be technically identified for a particular marginal input such as an hour of labour, measuring the time (or array of times) between its application and the maturing of the final product(s) due to its application. In principle, identifying an input's contributions to *dated* output(s) merely generalises the standard concept of identifying the physical product of a marginal unit of input in timeless production. Beyond the very simplest cases, many inputs go jointly into producing a given final product, and many final outputs (at many dates) result jointly from inputs that go into producing a durable tool. Finding the average or aggregate IP for the entire series of inputs that produces a given final product, *a fortiori* for the aggregate of final products produced by an entire economy, would require weighting and summing the IPs associated with all the various inputs. The proper relative weights on inputs at different dates (the relative amounts 'tied up' in present value terms) vary with the rate of interest. Only in special cases can an average be formed of various IPs in purely technical terms, independent of the interest rate, as would be required for the APP to serve as a datum in a theory determining the interest rate. *The Pure Theory of Capital* aimed to show that the analysis of time-consuming production can proceed in a modified fashion, and can still reach the key conclusions associated with Austrian capital

sion of Hayek's departure from Böhm-Bawerk in interest theory see Jack Birner, "Money, Utility, Intertemporal General Equilibrium, and Cyclical Fluctuations: On the Origins of F. A. Hayek's Research Programme in Economics", working paper 17/97, ICER (Turin, Italy).

³¹F. A. Hayek, "The Mythology of Capital", *Quarterly Journal of Economics*, vol. 50, February 1936, p. 206.

³²F. A. Hayek, *Profits, Interest, and Investment: And Other Essays on the Theory of Industrial Fluctuations* (London: Routledge and Kegan Paul, 1939; reprinted, Clifton, N.J.: Kelley, 1975), p. 7. I thank Greg Ransom for bringing these passages to my attention.

theory, without relying on an interest-rate-independent 'average period of production'.³³

In the place of the APP measure, which is a simple scalar, Hayek (in chapters 8 and 9 below) offered the more complex notion of "the time distribution of the output due to a moment's input", a function that maps from a date-zero marginal input dose to the array of dates at which its physical products will mature. This mapping can be represented either by an 'input curve' that shows the share of the total *date-zero input* to which each later date's output is due, or by an 'output curve' that shows the share of the total *all-dates output* (attributable to date-zero input) that each date's output represents. The difference between the two curves reflects compound interest, corresponding in equilibrium to the greater physical productivity of the more time-consuming production processes chosen.

The greater physical productivity of more time-consuming techniques, Hayek explained, is not an empirical generalisation but a necessary feature of the frontier of potentially well-chosen techniques in the face of any positive discount rate.³⁴ If a more time-consuming technique is *not* physically more productive, it is dominated and never chosen.

In an interview with Jack High in the late 1970s, Hayek identified the book's aim as the rehabilitation of Böhm-Bawerk's theory. The book's notorious complexity was due to replacing the APP with more sophisticated concepts:

[High]: You have written an extraordinarily difficult book on capital theory—in my opinion, it's difficult. What message did you want to convey in that book?

Hayek: To put it briefly, I think that while Böhm-Bawerk was fundamentally right, his exposition in terms of an average period of production was so oversimplified as to mislead in the application. And that if we want to think the Böhm-Bawerk idea through, we have to introduce much more complex assumptions. Once you do this, the things become so damned complicated it's almost impossible to follow it.

Q₂: Did you have any idea the work was going to be that complicated when you undertook it?

³³Malte Faber has noted that Wicksell in 1913 had already "given up the average production period concept" because the measured length of such an average period is not generally independent of the rate of interest. Malte Faber, *Introduction to Modern Austrian Capital Theory* [Lecture Notes in Economics and Mathematical Systems, vol. 167] (Berlin: Springer-Verlag, 1979), pp. 20, 29. In Faber's view (*ibid.*, p. 29 n. 1) the "most convincing critique of the average production period concept" was provided by Oscar Morgenstern, "Zur Theorie der Produktionsperiode", *Zeitschrift für Nationalökonomie*, vol. 6, 1935, pp. 196–208.

³⁴F. A. Hayek, chapter 6 below, p. 90.

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Hayek: No, no. I certainly didn't. It very gradually dawned upon me that the whole thing seemed to change its aspect once you could not put it in the simple form that you could substitute a simple average period of production for the range of investment periods. The average period of production is the first model showing a principle, but it is almost inapplicable to the real situation.³⁵

Hayek considered Wicksell's work on capital and interest to have been the most immediate predecessor to *The Pure Theory of Capital*. In the area of interest theory, Wicksell and his students "have systematically developed the productivity approach. It is in the shape into which this type of theory has been fashioned by Wicksell that it provides the most useful basis for the present study".³⁶ Wicksell in turn had seen his own analysis as a re-statement and extension of Böhm-Bawerk's theory.³⁷

In Wicksell we find versions of four of the key concepts that Hayek emphasises in *The Pure Theory of Capital*:

1. The essential rôle of capital arises from the time-consuming nature of production.³⁸
2. Two key features distinguish capital goods from other inputs: capital goods (a) are non-permanent (get used up) and (b) can be used up faster or slower. Pure land and labour, by contrast, are permanent and yield an invariable flow of services.³⁹
3. The economy's capital structure can be sliced cross-sectionally at a moment in time (thus viewing capital goods as factors of production cooperating with land and labour) or sliced lengthwise through time (thus viewing capital goods as semi-finished goods in the process of reaching final consumption with the successive application of land and labour services).⁴⁰
4. Net capital formation requires a diversion of input services that could otherwise go to the immediate production of consumer goods.⁴¹

Hayek departed from Wicksell by offering a consistently forward-looking conception of capital, in contrast to Wicksell's backward-looking suggestion

³⁵Hayek, *Hayek on Hayek*, pp. 141–42.

³⁶F. A. Hayek, chapter 4 below, p. 65.

³⁷Wicksell, *Lectures on Political Economy*, vol. 1, p. 147. Wicksell expounded his capital theory most fully in *Value, Capital, and Rent*, translated by S. H. Frowein (London: George Allen & Unwin, 1954; reprinted, New York: Kelley, 1970), and *Lectures on Political Economy*, vol. 1. Both works cite Böhm-Bawerk extensively. For a helpful exposition of Wicksell's capital theory see Carl G. Uhr, *Economic Doctrines of Knut Wicksell* (Berkeley: University of California Press, 1962), chapter 5.

³⁸Knut Wicksell, *Lectures on Political Economy*, vol. 2, translated by E. Classen (London: George Routledge & Sons, 1935; reprinted, Fairfield, N.J.: Kelly, 1978), pp. 150, 171–72, 236.

³⁹Wicksell, *Value, Capital, and Rent*, p. 99.

⁴⁰Wicksell, *Lectures*, vol. 2, pp. 236–37.

⁴¹*Ibid.*, pp. 217–18.