

THE CURRENT STATE OF CAPITAL THEORY: A TALE
OF TWO PARADIGMS*

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... when a theoretical question remains debatable after 80 years there is a presumption that the question is badly posed—or very deep indeed [21, 10].

... we really want a theory of interest rates, not a theory of capital [21, 16].

I have long since abandoned the illusion that participants in this debate actually communicate with each other [20, 207].

I. HISTORICAL INTRODUCTION

To most economists, with the exception of Mrs. Robinson,¹ "capital theory" is almost synonymous with "controversy." I am not an historian of economic thought; those who are more knowledgeable in this field could probably push the capital controversy back into antiquity. However, one may certainly take 1818 as a seminal date, when Torrens published his scathing attack on Ricardo's theory of value in the *Edinburgh Magazine* and, three years later, elaborated upon his criticism in a book.

* The background work underlying this synopsis was accomplished by means of financial assistance from the National Science Foundation, G.S. 2430, and the TAMU Research Foundation. My colleague, Alfred Chalk, provided many helpful hints into the history of economic doctrine, especially as it pertains to Ricardo and Wicksell. I acknowledge with appreciation helpful comments from Robert Solow and Martin Bronfenbrenner, who are representative of one paradigm, and from Geoffrey C. Harcourt and Edward J. Nell, who are representative of the other. Finally, several of my Texas A&M colleagues have read this essay as economists but not as capital theorists. This has resulted in many simplifying and clarifying changes. The usual *caveat* applies.

¹ Mrs. Robinson calls neoclassical capital theorists "mumpsimus," a delightful word that everyone should add to his vocabulary (letter from Mrs. Robinson to author).

... the basic fallacy on which the "production function" is erected is the idea that the marginal product of labour determines the wage rate [16, 414].

No sense can be given to the "contribution" to production of a *fund* of capital. The theory of distribution must do without marginal products [14, 10].

... which demonstrates the intellectual sterility engendered by the methods of Neo-classical Economics [9, 309].

But this was at most a beginning. Subsequently there followed the polemical debates between Böhm-Bawerk and J. B. Clark in the 1890's and early 1900's, which centered around the nature of capital, the origin of interest, and the validity and relevance of the period of production concept. The last-mentioned issue gave rise, directly or indirectly, to the arguments between Knight and the "Austrians," not all of whom were Austrian. This controversy centered chiefly around the distinction between permanent and non-permanent resources, the distinction between "maintaining" and "replacing" resources, and the correlation between the period of production (i.e., the "roundaboutness" of production) and the quantity of capital.² Yet another issue always lurked in the background: is capital theory relevant only to

² Knight argued that an increase in the quantity of capital did not imply more time-consuming productive processes or more durable capital equipment. Kaldor took him to task on this point; and it is interesting to note that Kaldor has gone full-cycle and now supports Knight's original position. Kaldor [8] acknowledges this reversal of position; and Solow [21, 9] remarked, "Between his famous *Econometrica* article of 1937 and his latest work, Nicholas Kaldor appears to have switched sides; I am afraid I prefer early Kaldor to late."

the stationary state or should trade cycles and the effect of changes in relative prices on investment enter the analysis?

Finally, from the mid-1950's on, the chief controversies have concerned the "price" and "real" Wicksell effects, or the valuation of capital and the "reswitching of techniques" respectively. The central issue in this regard is whether there is a one-to-one correspondence between factor and commodity markets and the sphere of production or between neoclassical inferences concerning the relation between the wage-rate of return ratio and the "aggregate" capital-labor ratio, if the latter in fact exists.

A. Some Totally Irrelevant Controversies

As previously indicated, the various debates have centered around many aspects of capital theory. Among the first of these, and certainly the most idle, concerns "What is Capital?" Is it a subsistence fund to advance to workers, an indestructible reservoir of productive power, a mixture of "fixed" and "circulating" funds, or an heterogeneous collection of "non-labor things"? These are the types of questions that were debated by Böhm-Bawerk and Wicksell, on the one hand, and J. B. Clark, Åkerman, and Hayek on the other. Even more recently the last question has tangentially occupied the attention of Mrs. Robinson, Champernowne, Solow, and F. Fisher.

Another idle question: "Is capital productive, and if so, why so?" Everyone knows that workers work, but what does capital do? This question is so trivial, I take it, that no answer is required. Nonetheless, suggested answers to this question have figured importantly in the theoretical works of, *inter alia*, Böhm-Bawerk, Irving Fisher, and Cassel.

A final controversy that is now entirely irrelevant, although it was the subject of heated debate over many years, concerns the "period of production." Suppose that

all capital is "circulating capital" or subsistence advances to labor. This is the world of Böhm-Bawerk, of maturing wine or growing forests. Böhm-Bawerk seemed satisfied with the concept although his disciple, Wicksell, expressed more and more skepticism about it, especially in regard to the ambiguities that are introduced when it is recognized that compound interest must be used in calculating the average period of production. Indeed, Wicksell finally abandoned the concept in favor of the closely related "average period of investment."

Despite the efforts of Gaitskell and a few others to resurrect the concept, it was laid to rest, permanently if not peacefully, by Morgenstern, Åkerman, and Hayek. The main thrust of their attack concerned the fact that "fixed" as well as "circulating" capital exists; and when it does one must go back to the dawn of time to calculate the various "average periods" of outputs that become inputs in an ever-increasing succession until the SST of some future time is completed.

By the turn of the century, most economists were ready to reject the period of production concept and the production model that followed from it. Few, however, were ready to accept Knight's charge that there is *of necessity* no positive correlation between the quantity of capital, however defined, and the "roundaboutness" or "capital intensiveness" of production.

B. Some Recently Relevant Controversies

Other issues debated have not been totally irrelevant, at least in the development of the two paradigms discussed below. If "capital" in fact consists of heterogeneous outfits of capital equipment, can these be aggregated into a meaningful magnitude that represents the aggregate capital stock of the entire economy? If so, can we say that the rate of interest is the marginal product of "it," however "it" may be defined? Next, suppose "capital" can be

treated as an homogeneous input (Meade's "steel" or Mrs. Robinson's "leets"). Can a unique value be ascribed to it? If not, is its value particularly sensitive to variations in relative factor prices? The answer to this question is "yes," an answer that is no longer disputed by either side in the current debate.³

In concluding this section, two side issues that have never caused acrimonious debate should be mentioned. They are side issues because they represent alternative approaches to the problems of capital theory. First, should capital theory be approached technologically from a production function or productive technique point of view, or should one begin with the trade-off between present and future consumption and between present consumption and present leisure. Actually these two approaches are mutually reinforcing and can easily be unified. The choice of approach in this case depends upon the questions to which answers are sought.

The second issue concerns "real" as against "monetary" theories of the rate of interest (or Wicksell's *Lectures* Volume I as against Volume II). I shall deal with neither utility maximization nor monetary theories in this essay. In any event, these "issues" are fictitious. An integrated theory can be developed when it is realized that the existence of a monetary economy permits individuals to hold cash balances and reduce their transactions time; this, in turn, affects the utility maximizing choice between income and leisure and, through the given technological conditions and profit maximization, the quantity and composition of current output.

C. *The Real Controversy: What is Capital Theory All About?*

Most of the issues, controversies, and debates have either been settled or dropped. Yet the two chief contending groups of capital theorists are an ocean apart, the

Atlantic Ocean to be more precise. Indeed, it has become fashionable to speak of Cambridge, Massachusetts *versus* Cambridge, England.⁴ The fundamental differences between these two groups, so it seems, lies not in the nature of capital or capitalistic production but in the *object of capital theory*, i.e., what are the chief concerns and methodology of this particular branch of economic theory?

The expression "capital theory" has so far been frequently employed. In self defense, and in partial expiation of past and current sins, let me say that "capital theory" should be expunged from the lexicon of economic jargon because it is in no way descriptive of the issues currently debated under this title. In the same breath, let me add that I shall continue to use this expression until a more inventive mind devises a succinct phrase that is descriptive of the issues at hand.

What is capital theory all about? At the outset this question simply leads to a succession of further questions. Is it a micro-economic theory that relates commodity markets to the sphere of production and commodity prices to factor prices, both via the maximization principle for consumers, resource suppliers, and producers? Is it a theory of wages and the rate of return that incidentally leads to a theory of distribution and relative factor shares?⁵ Is it a theory of perfect competition in a stationary state or a "golden age" growth model,⁶ or is it a

⁴ This dichotomy is an exaggeration. Meade in England and Swan in Australia are certainly neo-classical theorists, while the Cambridge, England, group is liberally endowed with Italian (e.g. Pasinetti, Garegnani) and Indian (e.g. Bhaduri, Naqvi) economists. Just where Hicks should be placed is as much a puzzle as some of the unsettled issues in capital theory.

⁵ This question carefully avoids the *aggregate* theory of distribution and relative shares.

⁶ The "stationary state" model is simply a special case of the "golden age" model in which all variables grow at the constant rate of zero. A "golden age" model is one in which all variables grow at a constant rate (which may or may not be zero).

³ For example, see Solow [21] and Robinson [17].

theory that must account for all sorts of imperfections in commodity and factor markets and for disequilibrium situations? Is it a theory that is chiefly built upon behavioral relations, or is it a theory that begins with conventionally defined aggregates such as consumption, saving, investment, and income and, chiefly by means of accounting identities, yields a theory of aggregate distribution and relative shares that is independent of factor prices? Finally, and perhaps most important of all, is it a theory whose simplified versions may give some useful hints to those engaged in empirical or econometric research?

II. THE TWO PARADIGMS⁷

A paradigm is not a theory; it is a vision, a *weltanschauung* of the organization and operation of an economic system. The paradigm to which a person subscribes naturally conditions not only the theoretical models he builds but also his choice of the area in which to concentrate his research efforts.

A theory follows from a paradigm. This may be a simplistic theory, which we shall often call a "parable," or a very sophisticated theory. Depending upon one's own paradigm, either simplistic or sophisticated theory *may or may not* be used as the basis for constructing empirical or econometric models whose statistical inferences allow one tentatively to accept or reject the fundamental postulates upon which the theory rests.

Figure 1 provides a schematic representation of the notions expressed in the preceding two paragraphs. The chief point to be noticed is that a paradigm may lead either to simplistic or sophisticated theory, and a simplistic theory may be elaborated into a sophisticated theory or the latter distilled into a parable. Further, the diagram indicates that econometric research, if one

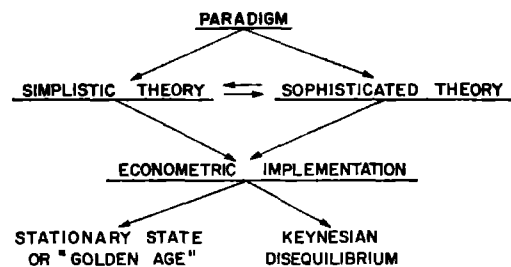


FIGURE 1.

believes such to be possible, may be based either on simplistic or sophisticated theory.

A. Digression on Terminology

I have previously alluded to two paradigms concerning capital theory, going to the extent of dichotomizing them into the Cambridge, Massachusetts, and the Cambridge, England, *weltanschauungen*. We need more precise terminology; unfortunately, any convention adopted has its shortcomings. One group, now largely represented by American economists, has long been called neoclassical theorists. This term may mean many things; but it has the advantage of being commonly understood to denote the intellectual successors of Clark, Wicksteed, Walras, and Marshall.

The English side is more difficult to describe. Kaldor [7] originally called it neo-Keynesian theory. There are good grounds for this designation in that it emphasized both the widow's cruse model of Keynes' *Treatise on Money* and the aggregate underemployment equilibrium of *The General Theory*. Others, especially Nell and Bhaduri, prefer to call it a neo-Marxian paradigm, while Ferguson and Harcourt have simply called it the Cambridge Criticism and the Cambridge Controversy respectively. Throughout the remainder of this essay, I shall refer to the representatives of the Cambridge, England, paradigm as neo-Keynesian theorists.⁸

⁷ The emphasis on "paradigms" obviously springs from Nell [14].

⁸ With equal reasonableness, one might refer to the neoclassical paradigm as CHSS (Clark, Hicks, Samuelson, and Solow) and the neo-Keynesian

B. The Neoclassical Paradigm

The questions posed in Subsection I.C may now be given tentative answers.⁹ The neoclassical paradigm envisages a world in which Walrasian general equilibrium prevails. Technology, commodity and factor prices, and commodity and factor markets are linked together through the independent maximizing behavior of individual economic agents. Marshall's theory of marginal productivity factor pricing emerges; and if one wishes to aggregate as in Hicks [5], a theory of aggregate distribution and relative factor shares emerges as well. To be sure, these are by-products of the general equilibrium system; and it should be emphasized that neoclassical economic theory does not stand or fall on the basis of marginal productivity theory.¹⁰

Further, the neoclassical paradigm envisages a perfectly competitive economic world that is in a stationary state or is moving along a "golden age" growth path. Finally, neoclassical theorists generally do not hesitate to construct simple parables (simplistic theory), and they generally believe that useful econometric studies can be based upon either simplistic or sophisticated theory.

The neoclassical paradigm can perhaps best be summarized by a quotation from Samuelson [19, 444-5]:

Until the laws of thermodynamics are repealed, I shall continue to relate outputs to inputs—i.e. to believe in production functions. Until factors cease to have their rewards determined by bidding in quasi-competitive markets, I shall adhere to (generalized) neoclassical approximations in which relative factor supplies are important in explain-

paradigm as RSRP (Ricardo, Sraffa, Robinson, and Pasinetti). This classification, however, leaves Wicksell out of the picture, since he figures importantly on both sides.

⁹ In this essay the views expressed are mine alone and should not necessarily be imputed to any other neoclassical theorist.

¹⁰ This statement allows for much more than the Leontief-type fixed-proportions production functions, which do not possess unique partial derivatives.

ing their market remunerations . . . a many-sectored neoclassical model with heterogeneous capital goods and somewhat limited factor substitutions can fail to have some of the simple properties of the idealized J. B. Clark neoclassical models. Recognizing these complications does not justify nihilism or refuge in theories that neglect . . . microeconomic pricing.

C. The Neo-Keynesian Paradigm

The neo-Keynesian paradigm is somewhat more difficult to describe both because it is more complicated and because the *weltanschauungen* differ, at times substantially, among those who subscribe to this general view. For example, Kaldor and Nell argue that market imperfections and institutions must be taken into account, frequently within a disequilibrium framework. Mrs. Robinson, on the other hand, seems at times perfectly willing to accept perfect competition and a "golden age" as descriptive of the relevant economic milieu.

Despite individual differences, however, there is a common core that unites the neo-Keynesians. First, and certainly foremost, they concentrate on an *aggregate* theory of distribution that is seldom, if ever, related to relative commodity and factor prices. Instead, this group emphasizes capital accumulation, growth, and technological progress—and some mysteriously given level of investment—as the chief determinants of the distribution of income between "capitalists" and "workers." "In the process," as Nell remarked [14, 3], "they came both to discard much conventional theory and to reinterpret Keynes substantially, bringing the *General Theory* (with its emphasis on aggregates) a good deal closer to the *Treatise on Money* (with its emphasis on distribution)."

The paragraph above serves to stress the importance attached to *aggregates* in the neo-Keynesian paradigm and the concomitant reliance placed upon accounting identities rather than behavioral relations. A second aspect of the paradigm is the absolute rejection of the concept of margi-

nal productivity, especially the marginal productivity of "capital." This, in turn, leads naturally enough to rejecting a relation (equality) between the rate of interest and the rate of return. To do all this requires a peculiar version of marginal productivity in which the stock of capital is aggregated into a single value and the marginal product is defined as the first derivative of net output with respect to "it." To quote Solow (23, 424]:

I do not hold such a theory, and neither does anyone else I know. It is true that Wicksell made such a slip late in his life and never corrected the error, and Metzler made the same mistake and did correct it. But I should have thought the matter had been set straight long ago.

Perhaps the best way to describe the neo-Keynesian paradigm is to emphasize the chief ways in which it differs from the neoclassical paradigm. First, the neo-Keynesian paradigm (via Ricardo and Sraffa) emphasizes the interdependence of production rather than the interdependence of markets. That is, the neo-Keynesian paradigm emphasizes technological and institutional relations rather than commodity and factor market relations.

Second, the neo-Keynesian paradigm rejects the neoclassical possibilities of substitution, either in factor combinations or commodity composition. Yet it should be added that in the neo-Keynesian view, the introduction of new commodities or new technological possibilities does not constitute substitution at the margin [14, 5].

Finally, the neoclassical paradigm regards the consumer as sovereign. In the words of Nell [14, 6]:

In the new vision the consumer is cut down to size from the start. His preferences count for little. Markets are not supposed naturally to be stable, or to engender optima. Prices are determined largely, and in simple models, wholly from the supply side. The choice of industrial techniques depend (sic) on prospective profits, which in turn depend largely upon aggregate demand and the state of the labor market.

In what would be a peroration if it did not occur in the middle of the manuscript, Nell [14, 6-7] says that

A fundamental difference can be seen when we consider the *purposes* of the two visions. The basic constituents of the old vision [i.e., neoclassical theory] are consumers and firms, agents whose optimizing behavior, individually or in the aggregate, the equations of the model describe. In particular, maximizing behavior is what the theory is all about, and the *object of theory, by and large*, is to predict such behavior and its consequences.

By contrast . . . the new vision [i.e., the neo-Keynesian paradigm] is primarily interested in structure, in the patterns of dependency between established institutions, in how the system hangs together, and works or fails to work . . . the prediction of what *will* happen is not the goal. The new vision is concerned to see how an economy keeps going, what is *supposed* to happen, and from that to discover what makes it break down. . . .

III. KALDOR'S NEO-KEYNESIAN PARABLE

As indicated in the previous section, a person's paradigm conditions his theorizing, which may either be simplistic or sophisticated. In the remainder of this essay, simplistic theory is our exclusive concern. Further, following Samuelson, we shall refer to these simplistic theories as parables. It should be borne in mind, however, that both neoclassical and neo-Keynesian parables have their sophisticated counterparts; indeed, most of the current literature is devoted to sophisticated theory.

While it is generally recognized that Sraffa, Mrs. Robinson, and Kaldor were the driving forces behind the neo-Keynesian paradigm, the explicitly *aggregative* character of the resulting theory first emerged clearly in Kaldor's "alternative" theory of distribution [7]. It also shows the influence of Keynes on the paradigm by blending *The Treatise* with *The General Theory*.

Kaldor's theory is composed of two parts: (a) accounting identities relating conventionally defined aggregates—income (Y), saving (S), investment (I), profits (P) and wages (W); and (b) the non-classi-

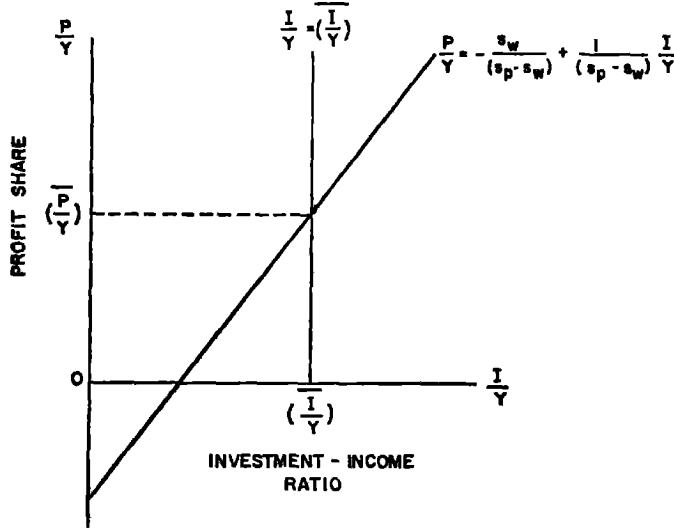


FIGURE 2.

cal assumption that there are two classes, workers and capitalists, who have different marginal (and average) propensities to save. Thus the aggregate marginal propensity to save is potentially a variable inasmuch as it is a weighted average of the marginal propensities to save of workers (s_w) and capitalists (s_p). Following Keynes of *The Treatise*, Kaldor assumed that the marginal propensity to save of capitalists exceeds that of workers; further, following Keynes of *The General Theory*, Kaldor assumed that investment is an exogenously given constant. Armed with these definitions and assumptions, Kaldor purported to establish Keynes' conclusions that there is a "remarkable constancy" of relative factor shares and the capital-output ratio.

Kaldor's model is represented by Figure 2.¹¹ The investment-income ratio is plotted

¹¹ To derive Figure 2, let us use the notation introduced in the text. $I = \bar{I}$ is a parameter of the system, which gives rise to the vertical line labelled (\bar{I}/\bar{Y}) .

National income at factor cost, by definition, is

$$Y = P + W. \tag{1}$$

Given Kaldor's assumption that $0 \leq s_w < s_p \leq 1$, total desired saving is

on the abscissa; and since investment is given as an exogenous constant, the investment "function" is given by the vertical line labelled (\bar{I}/\bar{Y}) . The slanted line represents the relation between the relative share of profit in national income and the investment-income ratio. It is, therefore, a "sort of" saving function. Their intersection determines the equilibrium profit share (\bar{P}/\bar{Y}) and, accordingly, the wage share $(\bar{W}/\bar{Y}) = 1 - (\bar{P}/\bar{Y})$.

$$S = s_p P + s_w W. \tag{2}$$

Thus the aggregate desired saving ratio (S/Y) is,

$$s = S/Y = s_p(P/Y) + s_w(W/Y) = (s_p - s_w)P/Y + s_w. \tag{3}$$

In equilibrium saving must equal investment *ex ante* as well as *ex post*. Thus equation (3) may be written

$$s = S/Y = I/Y = (s_p - s_w)(P/Y) + s_w. \tag{4}$$

Solving equation (4) to express the profit share as a function of the investment-income ratio yields

$$\frac{P}{Y} = -\frac{s_w}{(s_p - s_w)} + \frac{1}{(s_p - s_w)} \frac{I}{Y}. \tag{5}$$

From equation (5) it is obvious that a solution exists if, and only if, $s_p > s_w$, which is the Keynes-Kaldor assumption.

The equilibrium depicted in Figure 2 is stable. If *ex-ante* saving exceeds *ex-ante* investment, the wage share must rise until saving and investment are equal *ex post*. That is, income is redistributed from the high savers to the low savers until total saving equals the exogenously given level of investment.

Two aspects of this parable are worth noting. First, this is a full-employment model, not a Keynesian model of *The General Theory* variety. In Keynes' analysis, when saving does not equal investment *ex ante*, income and employment change so as to establish *ex-post* equality. In Kaldor's model, on the other hand, income is given at the full-employment level by the multiplier, and investment is somehow exogenously given so as to be consistent with full employment and thereby validate the model. With the assumption of given but different saving propensities as between capitalists and workers, the only way in which adjustment can be achieved is through a change in relative factor shares. But this is not an *analytical* conclusion; it merely follows from the identities with which the model begins.

Second, Kaldor's model is somewhat like Keynes' model in *The Treatise* in that it displays the "widow's cruse" effect: entrepreneurs earn what they spend and workers spend what they earn. To see this suppose a moving equilibrium in which P/Y is a constant. Now let capitalists suddenly become less thrifty; that is, there is a parametric downward shift in s_p . At the prevailing distribution, desired saving is less than full-employment investment. Thus saving must increase; and the only way in which it can be accomplished in Kaldor's parable is by a redistribution of income from workers to capitalists.

Kaldor's parable is certainly not the only neo-Keynesian parable. For example, Mrs. Robinson's *Accumulation of Capital* is another parable, as is Sraffa's *Production of Commodities by Means of Commodities*. However, my object here is not to describe

all parables; it is only to illustrate the *nature* of the parables involved. For the same reason, the next section ignores Clark, Wicksteed, Marshall, Walras, etc. Attention is only devoted to the Samuelson parable as modified by Hicks.

IV. A NEOCLASSICAL PARABLE: SAMUELSON AND HICKS

The parable in Section III above contains many heroic assumptions and oversimplifications. Yet I think the discussion is a fair representation of the economists under consideration, although it may not be a fair representation of their more sophisticated models or of the thinking of the newer advocates of the neo-Keynesian paradigm. The same statements hold with equal force for the neoclassical parable discussed below.

A. Samuelson's Surrogate Production Function

In 1962 Samuelson [18] set out to show that the existence of fixed proportions and heterogeneous capital goods does not necessarily invalidate neoclassical capital theory.¹² To that end, he assumed that there are many, but not an infinite number, of alternative fixed-proportions productive processes that may be used to produce a *common* consumption good and the *particular* capital good used by the process in question. For example, the Alpha process may be used to produce the consumption good and the Alpha-type capital equipment. The same assumption, *mutatis mutandis*, holds for all other processes.

The *crucial* assumption in Samuelson's model is that for each process, the production function for the capital good is identically the same as the production function for the consumption good. Thus, for example, if it takes x units of labor and y units of capital to produce one unit of the con-

¹² Solow [20] simultaneously presented an alternative validation of neoclassical theory. Solow's work is not discussed here. For an exposition and extension, see [2, 280-92].

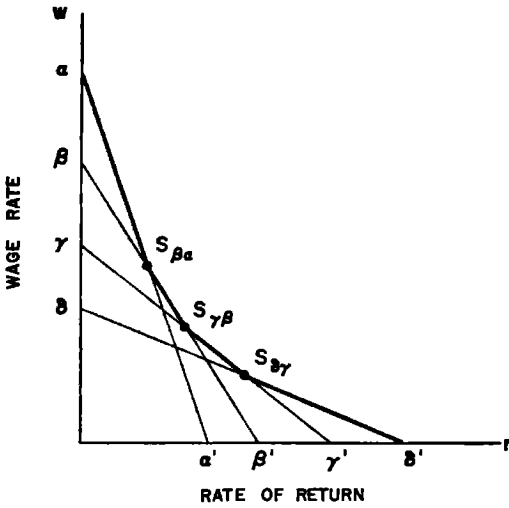


FIGURE 3.

sumption good, it also takes precisely x units of labor and y units of capital to produce one unit of the capital good. Consequently, the capital and consumption goods are technologically, and therefore economically, identical. For all practical purposes, this assumption takes us back to the one-sector model in which commodity price need not be introduced explicitly.

Now recall the example above and consider Figure 3.¹³ In equilibrium with fixed

¹³ Samuelson's parable may be set out in simple algebraic form. Let M , C , K , and L represent machines of a given type, C the consumption good, and K and L capital and labor. Consider the Alpha process and let α_L and α_K be the same as the x and y used in the text. For the Alpha process, Samuelson's special assumption about factor coefficients allows one to write the production functions as

$$M = C = \min((1/\alpha_K)K, (1/\alpha_L)L). \quad (1)$$

Assume that neither factor is redundant in either sector (economic efficiency). Thus in the capital-good sector we have

$$M = (1/\alpha_L)L_M, K_M = (\alpha_K/\alpha_L)L_M. \quad (2)$$

Quasi-rent in the capital-good sector is

$$M - wL_M \quad (3)$$

since the prices of the capital and consumption goods are identical. Using equation (2) in (3), the rate of return in the capital-good sector, which competition assures us is the same as in the consumption sector and which is also the same as the

proportions, average and marginal products are equal. Since it takes x units of labor to produce a unit of output, $1/x$ is the average and marginal product of labor; similarly, $1/y$ is the average and marginal product of capital. Plot these two points as α and α' respectively in Figure 3 (this may be done by the assumption of profit maximization or competitive imputation). Connecting α and α' by a straight line generates the Alpha-process factor price frontier, whose slope is obviously the negative of the capital-labor ratio for that process (i.e., $0\alpha = 1/x$, $0\alpha' = 1/y$, so the slope $0\alpha/0\alpha' = -y/x = -K/L$).

Repeating this procedure for techniques Beta, Gamma, Delta, . . . , gives rise to a series of process factor-price frontiers, whose outer envelope (the heavily-shaded locus in Figure 3) is the grand factor-price frontier. In most respects it is exactly like the factor-price frontier in the J. B. Clark model; more specifically, the wage rate and output per head vary inversely with the rate of return, the slope of the frontier is the negative of the capital-labor ratio, and its Marshallian elasticity gives the ratio of relative shares.

The only difference lies in the "switch points" labelled $S_{\delta\gamma}$, $S_{\gamma\beta}$, and $S_{\beta\alpha}$. Consider the Delta and Gamma processes at the switch point $S_{\delta\gamma}$. Each process is equally profitable, so presumably some entrepreneurs will have Delta outfits, others Gamma outfits. In this special case, however, the switch points make no difference. The aggregate capital-labor ratio is perfectly

$$\tau = \frac{M - wL_M}{K_M} = \frac{1}{\alpha_K} - \frac{\alpha_L}{\alpha_K} w. \quad (4)$$

Inverting equation (4) gives the process factor-price frontier:

$$w = (1/\alpha_L) - (\alpha_K/\alpha_L)\tau. \quad (5)$$

The Marshallian elasticity of equation (5) is the ratio of relative shares:

$$-\frac{dw}{d\tau} \frac{\tau}{w} = \frac{\alpha_K \tau}{\alpha_L w} = \frac{\tau K}{wL}. \quad (6)$$

determinate at the switch points since it is a weighted average of the capital-labor ratios of the two processes (the weights, of course, being the proportion of the two types of outfits in the aggregate mix).

The grand factor-price frontier is what Samuelson calls the Surrogate Production Function. Under his particular set of assumptions, it displays all the properties of the Clark neoclassical fairy tale.

B. A Small Deviation from Samuelson: The Hicks Parable¹⁴

It has been stressed that the *crucial* assumption underlying Samuelson's parable is that the factor coefficients are the same in the consumption and capital sectors. Hicks employed the same set of assumptions as Samuelson, with one small but critical exception. Hicks assumed that the capital-labor ratios are the same in the consumption and capital sectors but that the *absolute magnitude of the coefficients differ*.¹⁵

This slight change makes a world of difference, as illustrated in Figure 4 in which only two processes are shown. For reasons that I cannot explain verbally,¹⁶ the ordinate

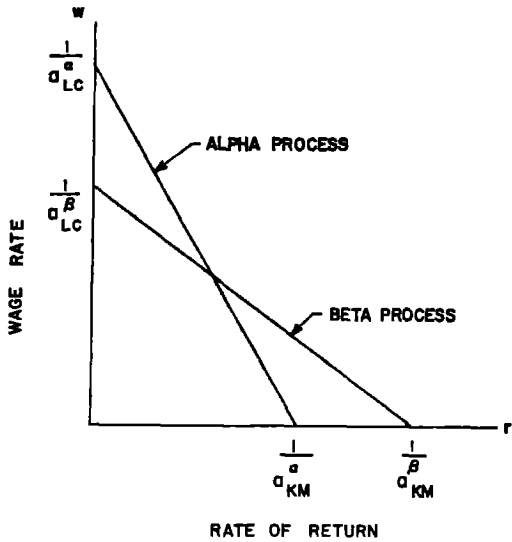


FIGURE 4.

intercepts are not *the* average products of labor. These intercepts are the average products of labor in the consumption sector. Similarly, the abscissa intercepts are the average products of capital in the machinery sector. Thus the slope of the process frontier is *not* the aggregate capital-labor ratio nor is its elasticity the ratio of aggregate relative shares.

in the model. Let p be the price of machines in terms of consumption goods. Perfect competition requires equality between price and unit cost. Hence

$$p = \alpha_{LM}w + \alpha_{KM}\tau p, \tag{4}$$

$$1 = \alpha_{LC}w + \alpha_{KC}\tau p. \tag{5}$$

Solving equation (5) for the price of machines gives

$$p = 1 - \alpha_{LC}w/\alpha_{KC}\tau. \tag{6}$$

Substituting equation (6) in equation (4) and solving for w in terms of τ gives the equation of the factor-price frontier:

$$w = 1 - \alpha_{KM}\tau/\alpha_{LC} + A\tau. \tag{7}$$

Obviously, in the Samuelson-Hicks parables, A is singular. Thus in the Hicks case, the factor price frontier reduces to

$$w = (1/\alpha_{LC}) - (\alpha_{KM}/\alpha_{LC})\tau, \tag{8}$$

which is represented by the straight lines in Figure 4.

¹⁴ The same model was independently developed by several writers at about the same time Hicks' book [6] appeared. Several other names could have been used in lieu of Hicks.

¹⁵ In the notation of the previous example, let $1/x$ and $1/y$ be the average products of labor and capital respectively with the Alpha process, $1/x'$ and $1/y'$ for the Beta process. Hicks assumed that $y/x = y'/x'$, but $x \neq x'$ and $y \neq y'$.

¹⁶ The general model, and Hicks' special case, can be given an easy algebraic representation. Consider only the Alpha process, in which the production functions are

$$C = \min((1/\alpha_{KC})K_C, (1/\alpha_{LC})LC), \tag{1}$$

$$M = \min((1/\alpha_{KM})K_M, (1/\alpha_{LM})LM). \tag{2}$$

The determinant of the technology matrix is

$$A = \alpha_{LM}\alpha_{KC} - \alpha_{LC}\alpha_{KM}, \tag{3}$$

so that production in the machinery sector is labor intensive or capital intensive relative to production in the consumption sector according as $A \geq 0$.

Since the two sectors (in the general model) are technologically distinct, they are economically distinct as well. Thus there must be output prices

In sum, the Hicks parable alerts one to the possible complications that may arise when heterogeneous capital goods are introduced in the model. Even in the absence of "real" Wicksell Effects (see below), the factor-price frontier may not yield the neoclassical relation between factor proportions and relative factor prices.

Consider Figure 4 again. The object is to show that we can no longer make *absolute* statements about capital intensity as Böhm-Bawerk could with his "average period of production" and as Samuelson could with his "grand factor-price frontier." Visually, $1/a_{LC}^{\beta} > 1/a_{LC}^{\alpha}$. Hence $a_{LC}^{\beta} > a_{LC}^{\alpha}$. Since $a_{LC} = L/C$, we can unequivocally say that the Beta technique is labor intensive relative to Alpha in the *weak* sense that the labor-output ratio in the consumption sector is greater when Beta is used than when Alpha is used. But that is all that can be said; in particular, it is impossible to draw an inference concerning the relative capital-output ratio in the consumption sector.

Now since Beta is labor intensive relative to Alpha (in the consumption sector), we should very much like to say that Alpha is capital intensive relative to Beta. As a matter of fact we can in all cases in which the individual process factor-price frontiers are straight lines. From the abscissa in Figure 4 it is apparent that $1/a_{KM}^{\beta} > 1/a_{KM}^{\alpha}$, which implies that $a_{KM}^{\alpha} > a_{KM}^{\beta}$. The capital-output ratio in the capital-good sector is greater with Alpha technique than with Beta. So again, in a *weak* sense we may say that Alpha is capital intensive relative to Beta in the production of machines. But nothing can be said about the relative labor-output ratio in the capital-good sector.

C. Conclusion

Hicks' parable is certainly not as simple or straightforward as Samuelson's. Nonetheless, at least the technique that is labor intensive in one sector is less capital intensive in the other. Brown [1] has pushed this analysis further to define a broad criterion

for capital intensity uniqueness as producers change from one technique to another. So long as this condition holds, most neoclassical results follow. Further, Ferguson [2, 266-9] demonstrated that irrespective of capital intensity uniqueness, sectoral relative shares are determinate; and Ferguson and Allen [3] proved that given plausible behavior of relative output price, there is a broad spectrum of rates of return for which the neoclassical results must hold. Nevertheless the Cambridge Criticism is valid in the sense that one cannot legitimately postulate *a priori* the existence of a unique relation between capital intensity and the factor-price ratio.

Before turning to something more positive, I should like to set the criticisms of neoclassical theory in historical perspective.

V. HISTORICAL PERSPECTIVE: THE WICKSELL EFFECTS

I think it is fair to say that during his productive life, Wicksell was largely overlooked by American and English economists. A superficial reason is that most of his work appeared in Swedish, and even his books (in German) were not translated until the mid-1920's. There are more important reasons than this, however.

At the microeconomic level, there was an intense interest in developing theories of imperfect competition to match Knight's rigorous development of the theory of perfect competition. More important still, the Great Depression brought about a change of interest from full-employment stationary states to disequilibrium unemployment or equilibrium underemployment.

A. The Price Wicksell Effect: Capital Valuation and Capital Reversal

The Great Depression and the war years led to a two-decade hiatus in controversies on capital theory. Yet the controversies might well have continued through the early 1900's had it not been for the almost unintelligible polemics exchanged between

Böhm-Bawerk and J. B. Clark. As early as 1893 Wicksell [24] had given hints to what later became known as the "price" Wicksell Effect; and in 1901, he [25] gave both mathematical and graphical proofs of the foundations of this Effect.¹⁷

The generally accepted meaning of the price Wicksell Effect is that it is an explanation of why the *existing* capital stock must be revalued when *additions* to that stock are made. In Wicksell [25], the meaning was more narrow, appearing in the following relation: the rate of interest is not equal to the marginal product of capital because of the "wage absorption" of capital. This aspect of the effect has been given a clear interpretation by Lange [10, 185].¹⁸

¹⁷ The historically interested reader should compare the graphs in Wicksell [24, 122] and [25, 180]. While these graphs purport to illustrate the same thing, there are two notable differences, both of which help to explain the price Wicksell Effect.

¹⁸ Following Wicksell [25, 178-80], a simple mathematical formulation may be given for the circulating capital model. By assumption, the value of output per worker (W) is a continuous function of the investment period (t):

$$W = f(t). \tag{1}$$

Given a wage rate V_0 and an interest rate ρ , competition assures that

$$W = V_0 e^{\rho t}. \tag{2}$$

From (2), the first-order condition for maximizing the internal rate of return is

$$\rho' = t(W'/W) - (\ln W - \ln V_0) = 0. \tag{3}$$

In passing we should note that equations (2) and (3) jointly imply Jevon's formula for the rate of interest (i.e., the increase in the total product divided by the total product, or $\rho = W'/W$).

The above result applies to a single firm; but it can be extended to an analysis of social capital by dropping the assumption that the wage rate is given. Wicksell was not entirely successful in this; to fill the void, he had to assume that the equilibrium value of social capital (K) or the subsistence fund is equal to the value of labor services (at the *constant* firm price!) plus the interest that accrues over the investment period.

Under this assumption, equation (2) gives

$$K = V_0 \int_0^t e^{\rho x} dx = \frac{W - V_0}{\rho}. \tag{4}$$

Next, differentiation of equation (2) yields

An increase of money capital increases the net product of the economic system only in so far as it leads to an increase of real capital. However, money capital is used to purchase not only real capital goods (equipment) but also labour. The increase in wages resulting from a transfer of labour from the direct to indirect use absorbs a part of the money capital saved and causes real saving to be smaller than monetary saving. This effect is counterbalanced by the fall in the rate of interest releasing some money capital which has been hitherto used for interest payments and which can now be invested in the purchase of real capital.

Clearly, the price Wicksell Effect can generally be either positive or negative. That is, an increase in money saving and investment can lead either to an increase or decrease (positive or negative, respectively) in the value of real capital. Indeed, in the circulating capital model, the price Wicksell Effect *must be* positive (the situation that was assumed by early neoclassical theorists). Only when fixed capital is introduced can there be a negative price effect, or what is frequently called capital reversal. The latter is illustrated in Figure 5.¹⁹

When there are two outputs in a model (machines and consumption goods), there must be a relative price. Let p be the price of machines in terms of consumption goods. Thus the productivity function $f(t)$ must be multiplied by p to obtain the value of output per worker in the machine sector.²⁰

$$dV_0/V_0 = -td\rho. \tag{5}$$

Differentiating equation (4) with respect to K and substituting equation (5) yields the Wicksell Effect as it appeared in Wicksell:

$$dW/dK = \rho + (K - V_0 t)(d\rho/dK). \tag{6}$$

Since $d\rho/dK < 0$ and $K > V_0 t$, $dW/dK < \rho$. That is, the marginal product of social capital is always less than the rate of interest. This result led Wicksell [25, 180] to comment that "This proves that the . . . theorem of von Thünen is not correct, if by 'the last portion of capital' is meant an increase in social capital."

¹⁹ This discussion is based on Wicksell's review of Åkerman, which appeared in 1923. It is translated as Appendix II in Wicksell [25]. The graph is an adaptation of one employed by Metzler [11].

²⁰ Following Åkerman, Wicksell assumed that machines are produced by labor only.

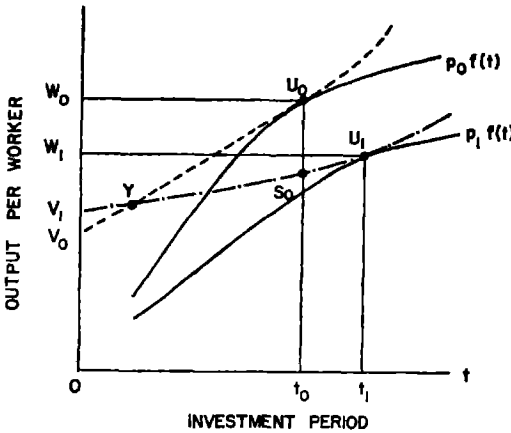


FIGURE 5.

Thus in Figure 5, $p_0f(t)$ and $p_1f(t)$ represent two value productivity curves where $p_0 > p_1$. Given the wage rate OV_0 , equilibrium is reached at U_0 , where $OV_0U_0t_0$ is the capital invested per worker, and the value of output per worker measured in consumption goods is OW_0 .

Now let new voluntary savings arise. The wage rate rises from OV_0 to OV_1 and the rate of interest falls as the investment period is extended to Ot_1 . Although the physical quantity of durable capital per worker rises, its price per unit (p_1) must fall inasmuch as its marginal product falls in the production of consumption goods. This is shown by the new productivity curve $p_1f(t)$, which lies below the original curve. Now the value of capital per worker is smaller in the new equilibrium than in the initial equilibrium. Whether or not this actually happens depends upon (a) the relative change in the price of capital (i.e., upon the elasticity of substitution of capital for labor in the consumption sector), and (b) the change in the number of workers in the capital sector.

The increase in capital per worker is the area $t_0S_0U_1t_1 + V_1YV_0 - U_0YS_0$; since we have constructed $U_0YS_0 > V_1YV_0$, the increase in value is less than $t_0S_0U_1t_1$, the amount of capital actually used to extend the period of production. Since the rate of interest is equal to the marginal product of

new machines divided by the value of new machines and the marginal social product of capital is equal to the same marginal product divided by the increase in value of all machines, the rate of interest is less than the marginal product of social capital. This is explained in Figure 5 by the losses on existing capital occasioned by the increase in capital. The result may go either way; however, "except by accident, the rate of interest cannot be described as the marginal product of [social] capital in the sense that wages... are the marginal product of labor" [11, 301].

In summary, the accumulation of capital relative to labor will increase the wage rate and reduce the rate of return. This leads to the revaluation of capital; and when fixed capital equipment is included in the model, it may lead to capital reversal or a negative price Wicksell Effect.

B. The Real Wicksell Effect

What Mrs. Robinson [15] originally called the real Wicksell Effect never, in fact, appeared in the works of Wicksell (see [34]). Recently, however, it has occupied a more important role in the Cambridge Criticism of neoclassical capital theory than has the price Wicksell Effect. Just as the price Wicksell Effect, the real Effect can be positive or negative. A positive effect reinforces the conclusions of neoclassical theory, while a negative effect will tend to undermine them.

In more recent years, the real Wicksell Effect has become better known as the reswitching or double switching of techniques. This phenomenon is illustrated in Figure 6, in which the Beta process is a Hicks-type technique and production with Alpha process is labor intensive in the machinery sector relative to the consumption sector.

Consider Figure 6. Since $a_{KM}^\beta > a_{KM}^\alpha$, the Beta process is capital intensive relative to the Alpha process. At very high rates of return and very low wage rates ($r > r_2$),

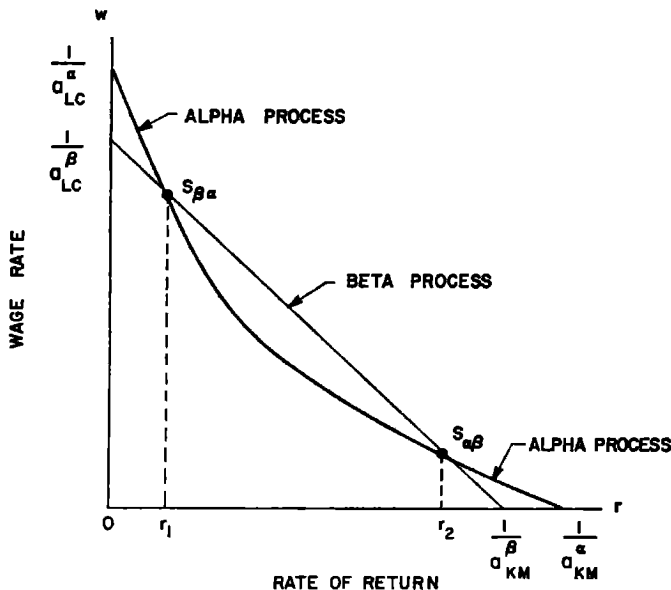


FIGURE 6.

entrepreneurs adopt the less capital intensive process Alpha. As the wage rate rises and the rate of return falls beyond the switch point $S_{\beta\alpha}$ ($r_1 < r < r_2$), entrepreneurs correctly switch to the more labor-intensive technique (Beta). However as the rate of return continues to fall and the wage rate rises, a point $S_{\beta\alpha}$ is reached. Thereafter, for low rates of return ($r < r_1$) and high wage rates, entrepreneurs readopt the more labor-intensive process Alpha. Such a technological situation implies a lower output per head and a lower permanently-sustainable consumption stream after the rate of return falls below the critical value $r = r_1$. This economic reorganization, as we have said, may invalidate some of the results of neoclassical capital theory.

VI. CONCLUSION: WHAT IS CAPITAL THEORY ALL ABOUT?²¹

Everyone knows, or has strongly suspected, that capital theory is difficult. There is a superficial reason for this in that so much of the literature of capital theory has

²¹ The good parts of this section are plagiarized from Solow (21); the bad parts are original.

been mired in polemics and semantics. There is a more fundamental reason, however. Capital theory necessarily involves time; and time involves expectations and uncertainty, although we generally abstract from them by assuming a stationary state or a golden age growth path. All of this has been stressed in the foregoing pages; in self exculpation, I can do no better than to pass along Solow's [21, 21] admonition: "One should not slay the theoretical messenger for bringing the bad news that the world is complicated."

We are, it would seem, in a quandary. The proponents of the neo-Keynesian paradigm have nothing positive to offer except a dubious story about distribution. The advocates of the neoclassical paradigm have a positive theory to offer, one with far-reaching results and implications. However, there is no *a priori* supposition that the required technological conditions exist.

Must one then turn to intertemporal utility-maximizing models that push technology into the background or to purely monetary models that dispense altogether with technological considerations? I shall

suggest that the answer is "No" and offer two grounds for substantiating it. One turns upon the empirical usefulness of the neoclassical parable, the other upon a newer theoretical view of capital theory.

A. *The Parable and the Econometricians*

If we desire, we can play a game of intellectual make-believe in which there exists a mythical economy that conforms in all respects to the J. B. Clark parable. This is certainly no worse than the make-believe games of childhood, and it is preferable to the make-believe games many adults play. In this fairy-tale land there is a fairy god-mother who solves a set of simultaneous equations; and the results show that we *can* live happily ever after. More specifically, (a) the wage rate and the rate of return are equal to the marginal productivities of labor and capital respectively; (b) the wage-rate of return ratio varies directly with the capital-labor ratio; (c) the relative share of labor varies directly or inversely with the capital-labor ratio according as the elasticity of substitution is less than or greater than unity; (d) output per head varies directly with the capital-labor ratio; and (e) therefore, the permanently-sustainable consumption stream varies directly with the capital-labor ratio. The moral of the story, of course, is that the accumulation of capital relative to labor is socially desirable.

But to empirically-minded economists such as Douglas and Solow, the parable has meant something more. In particular, it offers a set of hypotheses that can be subjected to statistical examination and evaluation. Assume the existence of an aggregate production function, such as Cobb-Douglas or CES, that meets the requirements of the Clark parable. In such circumstances, do the conventionally defined aggregates furnished by the OBE and other government statistical agencies tend to confirm or reject the inferences of the neoclassical parable? Without documentation, which is readily avail-

able, I will assert that the answer is "Confirm"; and these data are also in accord with what Kaldor refers to as the "stylized facts" of modern capitalism.

In summary, economists are confronted with two facts that are indeed stylized: (a) the real world is not the world of the J. B. Clark parable; and (b) the real world is too complicated and too filled with intricate interrelations to be analyzed, however milli-milli second computers may become. Some simplifying assumptions must be made. Another stylized fact is that the simplifying assumptions of neoclassical theory have enjoyed enormous empirical success, regardless of the other stylized fact that these assumptions are not *a priori* defensible.

B. *Capital Theory without Capital*

If there is a single issue that has dominated this paper, it can be summarized as "What is capital theory all about?" These have many answers or implications of answers, but all of these have involved a central theme: capital must be *measured* if capital theory is to be coherent and consistent. Some economists have used proxy measures, such as Böhm-Bawerk's average period of production or Champernowne's chain index number; some have used absolute money magnitudes; some have debated whether (for example) houses should be classified as capital; finally, some economists such as Knight and Mrs. Robinson, have argued that capital cannot be measured at all, or at least not consistently.

Throughout, however, the theme has dominated. Capital theory is not capital theory unless capital can be measured because otherwise a capital-labor ratio cannot be determined and related to relative factor and commodity prices and to average labor productivity. Most economists have realized that individual pieces of capital equipment cannot be independently valued; and even if they could, the conditions under which the individual magnitudes could be summed

to give an aggregate capital stock are very demanding.

The situation appeared almost hopeless for aggregate neoclassical theory until a seminal breakthrough by Solow [21; 22] established the grounds for resurrecting aggregate capital theory. He proved that under certain weak assumptions the rate of interest, however defined, must equal the social rate of return on investment.²² Solow's argument can be put in a very simple form. Suppose that by sacrificing a unit of consumption today in favor of investment, a person or a society can receive 1.06 units of consumables a year from today. Allow for any sort of market imperfections you wish within a capitalist system. Arbitrage, or the existence of a marginal profit maximizer, guarantees that the rate of interest is six percent.

Solow's framework will accommodate many explanations of the origin, nature, and necessity of interest, if one feels impelled to account for these. It may be Böhm-Bawerk's "superiority of present over future goods," Cassel's "waiting," Fisher's "time preference," or the much-used "inherent productivity of capital." All of this makes no difference and little sense. Arbitrage is a fact of life, "stylized" if you like, in a capitalistic system; and arbitrage guarantees that the rate of interest must equal the social rate of return. All of the *essential* inferences of neoclassical theory follow from this, including inferences concerning distribution. The real beauty and achievement of Solow's theory, of course, is that these

inferences can be drawn without resort to value measures of capital, the capital-labor ratio, the capital-output ratio, and the incremental capital-output ratio. As an unabashed neoclassical economist, I both believe and hope that Solow's redirection of capital theory away from capital *per se* presages the wave of the future in both theoretical and econometric research on this side of the Atlantic.

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²² The proof is not repeated here. In sketchy form it may be found in [21] and, more rigorously, in [22]. Mathematically, Solow's conditions require the existence of a positive root of a polynomial whose degree depends upon the duration of the planning horizon. Nell [12; 13] has argued that such a root may not exist; and there is a certain validity to his argument. However, under a very broad range of assumptions concerning the technology matrix, Solow's results hold; and they always hold if production is subject to variable proportions.

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