



Austrian themes and the Cambridge capital theory controversies

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Abstract

While Austrian economists and their models were only indirectly involved in the Cambridge capital theory controversies that came to a dramatic head in 1966, certain ideas argued for by the Cambridge, UK side were prefigured in some work by Austrian economists, especially F.A. Hayek in his 1941, *The Pure Theory of Capital*, which he wrote largely as a result of earlier debates with both Sraffa and Keynes. This paper recounts the roots of the capital theory debates coming out of the nineteenth century, the arguments among Keynes, Sraffa, and Hayek, Hayek's analysis that undermined traditional Austrian views of capital, the Cambridge controversies themselves, and then how various groups followed up in the aftermath, including neoclassicals, neo-Ricardians and Post Keynesians, and various groups of Austrians, who were themselves slow to recognize the full implications of Hayek's work and its relation to the Cambridge capital theory controversies. A final point is that among both those following Sraffa and Joan Robinson more as well as those following Hayek more, some have seen the issues leading to broader complexity approaches to capital theory and economic dynamics.

Keywords Capital theory · Reswitching · Capital reversal · Roundaboutness · Heterogeneous capital · Complexity

JEL classification B24 · B25 · E12 · E14

1 Introduction

The Cambridge controversies in the theory of capital came to a major head in 1966 after a series of debates between economists based in Cambridge, MA., led by Paul Samuelson (1962, 1966) and Robert Solow (1955–56, 1962), and ones in Cambridge,

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England, led by Piero Sraffa (1960) and Joan Robinson (1953–54, 1956). At its heart was whether in comparing equilibrium states, there is a negative relation between the rate of profit and the aggregate capital-labor ratio. The Cambridge, England side argued that this was not the case in general and won the debate by demonstrating that the phenomenon of reswitching can only be ruled out for the aggregate capital case by making extreme assumptions, such as ones that would also make the Marxian labor theory of value true even in a neoclassical context.

However, certain Austrian economists had earlier become aware of the possibility of there not being a well-ordered such relationship, most notably in F.A. Hayek's 1941 *The Pure Theory of Capital*, which was not cited or discussed by those involved in the mid-1960s debates, even though some of the models used in those debates as examples were of a semi-Austrian form (Samuelson 1962; Cohen and Harcourt 2003). This paper discusses these relations between these strands of argument about capital theory, and how Austrian and Sraffian views agree on critiquing neoclassical aggregate capital theory, even as they disagree on many other things.

More specifically, this paper discusses the followups on all sides to the main debates that happened in the 1960s, including neoclassical, Post Keynesian, and Austrian. Austrian contributions continue up to the present time with efforts to pose alternatives to the traditional "roundaboutness" argument following Yeager's (1976) contribution and including the idea to focus on duration as suggested by Lewin and Cachanasky (2018). A recent theme of those discussing capital theory by various schools has focused on complexity theory as providing a useful perspective, with those doing so along Austrian lines including Lavoie (1989), Vaughn (1999), Caldwell (2004), Horwitz (2008), Koppl (2009), Harper and Endres (2010, 2012), Rosser (2012, 2015), and Lewin (2014). While these newer approaches provide promise and new ideas, the deepest problems of capital theory remain ultimately unresolved.

2 Roots of the controversy

The roots of the controversy go to the deepest roots of the theory of capital. While certain early classical political economists such as Adam Smith saw capital as standing with labor and land as a distinct input to production and independent source of value, the exact nature of its role and contribution was not clearly laid out. This would be followed by a period in the nineteenth century when labor was raised to the most important position with Ricardo's labor theory of value, which would undergo much further development by Marx. Both of them, as well as their various followers, did not dismiss an important role for produced means of production and the real capital investment that was the producing of those produced means of production as a central process in long run economic growth and transformation. But labor reigned supreme and ultimately alone as the source of value, with capital being relegated to being merely indirect labor, and with Marx its role as the central mechanism in the social relation between the capitalist and the proletarian laborer whose surplus value was exploited by the capitalist became the most important fact about capital. All of this fit into a view where demand only determined quantities, not values, with labor on the supply side supremely determining value, capital being merely indirect labor, and land rent essentially a residual, although land clearly important in production.

The neoclassical revolution upended much of this, with several of those participating emphasizing the demand side and especially marginal utility as the prime source of value, especially Jevons and Menger. Although Senior (1836) had made previously some initial arguments along these lines, focusing on abstinence as the source of a wages fund that supposedly underlay capital investment, both Jevons (1866 and Menger (1888)) began to discuss the role of capital as involving time, especially “waiting.” Jevons followed more directly in the line of Senior’s earlier argument, while Menger emphasized the role of stages of production and relations between goods. For Menger his emphasis on the relations between goods derived from his desire to impute the value of capital from the marginal utility of final consumption goods, but this led him to focus on the time pattern of the stages of production of goods from primary through intermediate to final ones.

Menger’s approach laid the groundwork for von Böhm-Bawerk’s (1889) Austrian argument for time as the foundation of the value of capital with his concept of “the roundaboutness of production.”¹ While he cast back to Senior, it was the matter of the Mengerian stages of production that was the immediate inspiration for this formulation, which would become the standard view among Austrian economists until Hayek. Böhm-Bawerk would draw on it to directly challenge Marx’s labor theory of value, with this roundaboutness of production, how much time it took to produce the goods needed to produce a final good, as the basis for capital providing a role in the determination of value independent of labor, although the system can in effect be broken down into a model of indirect labor. But Böhm-Bawerk emphasized how the use of this indirect labor takes time.

If capital is really waiting and interest is the price of waiting, then interest becomes the price of capital in this Austrian view. Presumably then there should be an inverse monotonic relation between the rate of interest and this roundaboutness, if indeed interest reflects the scarcity of capital. The first figure to challenge this relationship was von Bortkiewicz (1906–07). He did not specifically suggest that there might be non-monotonicity in this relationship. Rather he argued that there was no relationship at all; that the supposed link between roundaboutness and rate of interest was simply vacuous, that value depends on the technical means of production quite independently of the rate of interest. As discussed by Gehrke and Kurz (2006) Sraffa would come across von Bortkiewicz and his “dictum” in the late 1940s, which he saw as justifying his own view first conceived in 1931 that indeed the relationship might not be monotonic. Von Bortkiewicz posed his argument as criticizing Böhm-Bawerk directly.²

Regarding the roots of these controversies another matter moving beyond the Austrian formulation of capital as roundaboutness was John Bates Clark’s (1891) formulation of aggregate capital, with its marginal product as determining the rate of profit. This would become the centerpiece of the broader theory of the factor distribution of income as determined by the marginal products of each factor. Of course as long

¹ Petri (2016) provides a good discussion of the development of these ideas from Senior to Böhm-Bawerk through Jevons and Menger. Menger’s views on capital went through various stages with him at times emphasizing aggregate capital.

² While Sraffa was thinking through these ideas from the 1920s on, he would not publish his main argument until his famous 1960 *Production of Commodities by Means of Commodities: A Prelude to a Critique of Economic Theory*. The record of the development of these ideas is kept in his papers, with Kurz (2013, pp. 59–60) providing the citations from Sraffa’s papers for these key insights.

as constant returns holds, this theory neatly accounts for all factor income, although this breaks down if constant returns does not hold. Even as Clark's theory has faced much criticism since, with some of the most serious criticisms arising due to the controversies in the theory of capital, it remains in practice today the dominant view as seen in the use of aggregate Cobb-Douglas production functions in DSGE models, which rarely recognize the problems associated with Clark's view. Anticipating later arguments, Veblen (1908) challenged Clark's view as simply wrong in basing income distribution arguments purely on technology.

The other foundation at the level of roots for the later controversies was the clarification provided by Knut Wicksell (1911). Following Clark's formulation of aggregate capital, Wicksell foresaw the problem associated with aggregating over heterogeneous capitals in that one was dealing with a sum of values, with those each having prices. Thus aggregate capital is ineluctably a value, not a strict quantity as Clark conceived. This means that when the rate of interest changes, one has both price and quantity effects in terms of measuring the response of aggregate capital, and Wicksell understood that the price changes might complicate the simple Clarkian neoclassical story of a simple relationship between the rate of profit and the aggregate capital-labor ratio, even as he did not work this realization out to its fuller implications.

3 Sraffa and Hayek on business cycles: Arguing about Keynes

The most important players in this controversy involving Austrians and the non-Austrian critics of the conventional neoclassical story as told by Clark were Piero Sraffa and Friedrich Hayek. They never directly addressed each other on the core capital theory controversies, with this paper an effort to bring their views on that matter together. But the development of their respective ideas arose at least partly out of an earlier and famous debate they did have directly, which arose from Keynes's interpretation of Wicksell's ideas in his *Treatise on Money* (Keynes 1930). Hayek (1931a) argued that Keynes (1930) misused Wicksell's concept of the natural rate of interest (Wicksell 1898). Hayek followed this up with his codification of Austrian business cycle theory in *Prices and Production* (Hayek 1931b), which drew on both Wicksell (1898) and his mentor, von Mises (1912). Drawing on his triangles approach (Garrison 2001), Hayek argued that business cycles arise from central banks pushing market interest rates below (triggering booms) and above (triggering recessions) Wicksell's natural rate of interest (Caldwell 2004).

Keynes appointed Sraffa to review this book (Sraffa 1932a), with Hayek (1932) and Sraffa (1932b) rejoinding. Hayek had argued that the natural rate arose from a barter economy condition on present versus future prices of commodities, with Sraffa arguing that there were many of these, one for each commodity, previewing later arguments regarding heterogeneous capital. Later Lachmann (1956) would argue that these should all be equal in a full intertemporal equilibrium,³ but Hayek (1937) retreated to emphasize the importance of information and expectations, opening the door to his

³ Later Cowen (1983) would argue that Lachmann's point held only in a monetary economy where there would be a common rate of return, whereas Sraffa's point would hold in a strictly barter general equilibrium.

later concerns (Caldwell 2004), while turning to the implications of heterogeneous capital, especially after Keynes (1936) published his *General Theory* (Hayek 1941).

4 Hayek's contribution to the Cambridge capital theory controversy

Caldwell (2004) has documented that the debate over capital theory was the great break in Hayek's thought. In responding to Sraffa he moved into the area of information economics, with his later thoughts on this topic gaining him his trip to Stockholm in 1974. But in trying to overcome the success of Keynes's *General Theory* he ended up substantially abandoning what had become the Austrian view of capital theory, even as later Austrians would rediscover his critique (Lachmann 1986; Lewin 1999; Garrison 2006) and move it into the current era. Nevertheless, Caldwell notes that Hayek's main contribution to the controversy came in what is probably the least-read book by Hayek (1941), especially among Austrian economists, his *The Pure Theory of Capital*, on which he spent great effort. If it was not much read among Austrians, it was even less read among those involved in the main rounds of the Cambridge controversies in the theory of capital debates in the 1960s, even as some would use Austrian-influenced models (Samuelson 1966), although his contribution would be recognized much later (Cohen and Harcourt 2003), if somewhat grudgingly.

Essentially Hayek recognized that among heterogeneous capital goods it was in general impossible to generate an unequivocal aggregate capital good measure by the traditional method of invoking "roundaboutness" or waiting (Hayek 1941, pp. 76–77, 140–146, 191–192, 266–267). He recognized that complicated time patterns of net returns over time made using such a measure impossible, that the measure was itself endogenous to the interest rate, with this essentially being a matter inherent in Wicksell's analysis of price effects. It also followed the arguments of von Bortkiewicz and Sraffa, although the latter had not published these arguments and it is unclear how aware of von Bortkiewicz's arguments he was, with Wicksell being the much more definite influence, although Hayek himself worked through these arguments himself, presenting diagrams based on highly complicated examples of irregularities in time patterns of net returns.⁴

A clear statement of Hayek's position is the following (Hayek 1941, p. 144):

"...the amount of waiting involved in a particular investment is not simply proportional to the length of the investment period and the value of the input invested, but is dependent on the rate of interest. In consequence, when we compare two different investment structures, it will not always be possible even to say, on purely technical grounds, which of them involves the greater amount of waiting. At one set of relative values, for the different kinds of input and at one rate of interest, the one structure and at a different set of values or a different rate of interest, the other structure, will represent the greater amount of waiting, or will be "longer" in the sense in which this term has been commonly used."

⁴ It must be noted that Irving Fisher (1930) was also aware that irregular time patterns of net returns could complicate his analysis of the "rate of return" as such irregularities, notably negative net returns in future periods, could lead to "multiple roots" in his analysis and thus ambiguity.

So much for the roundaboutness theory of capital, at least as it had been formulated by Böhm-Bawerk and understood by Austrian economists and others since his time.⁵ Unsurprisingly this led Hayek to turn away from this endeavor forever, with his fellow Austrians largely ignoring his efforts until much later.

5 The Cambridge capital theory controversies briefly revisited

Capital-reversal involves a situation where in comparing equilibrium states, a higher rate of interest or profit is associated with a higher ratio of capital to labor than the expected negative relationship. It appears that the possibility of this was first realized by Piero Sraffa (1936), who communicated this in a letter to Joan Robinson in 1936 (Cohen and Harcourt 2003, p. 203). Preceding Hayek, this realization was seen in the context of comparing different techniques with different capital structure. Robinson did not immediately follow up on this insight, although she would do so later.

Prior to dealing with the question of such paradoxes as capital-reversal, Robinson (1953–54) would in effect follow up on Hayek's 1941 arguments regarding the problem of defining capital clearly when it is heterogeneous in her famous paper, "The Production Function and the Theory of Capital," the publication of which Harcourt (1969, 1972) would identify as the opening shot in what he labeled "the Cambridge controversies in the theory of capital," with Cambridge, England on one side and Cambridge, Massachusetts on the other. She noted that in a world of heterogeneous capital goods, the only way to have an aggregate measure of the capital stock was to add up the values of these different kinds of capital goods, as lathes cannot be directly added to computers. But the values of these capital goods are endogenous to the rate of interest and thus the rate of profit. Thus any effort such as that of Clark or Cobb and Douglas to try to explain the rate of profit as arising from the marginal product of an aggregate capital is a hopelessly circular enterprise, with David Champenowne (1953–54) making a similar argument at the same time. The key to the problem is that different capital goods have different time patterns of their making and use, meaning that their relative present values shift as the interest rate changes, essentially the same issue that drove Hayek to abandon the idea of a general meaning of "roundaboutness" or waiting being able to define the amount of aggregate capital.

Robinson would extend the critique and revive the old point made to her by Sraffa with a "curiosum"⁶ that would be labeled *reswitching*. This phenomenon again involves comparing steady-state equilibria at different rates of profit and the nature of which techniques would maximize profits at each rate.⁷ This curiosum showed that it was possible for a technique to be the most profitable at separate rates of profit while some other technique was most profitable at intermediate rates of profit. This immediately implies the paradoxical capital-reversal phenomenon that Sraffa told Robinson

⁵ Steele (2014) notes that Hayek (1941) recognized priority of Frank Knight (1936) in making a similar argument. Among the first in the Sraffian camp to recognize what Hayek had done was Steedman (1994).

⁶ Robinson would label this "the Ruth Cohen curiosum" after an actual student of hers, although it appears that the student did not have much to do with developing the idea, if any at all.

⁷ That these phenomena generally involve comparing steady-state equilibria would later lead Robinson to dismiss the whole exercise as only mattering in "logical time" rather than the more important "historical time," thus rendering reswitching to be "unimportant" (Robinson 1975).

about in 1936, although capital-reversal can occur without reswitching. Robinson first reported the “Ruth Cohen Curiosum” in her *The Accumulation of Capital* (Robinson 1956). The idea was further discussed when Sraffa (1960) finally published his *Production of Commodities by Means of Commodities: A Prelude to a Critique of Economic Theory* after a 35 year effort, and which came to be viewed as the definitive presentation of these arguments from the Cambridge, England side.

This stream of arguments led to responses from Cambridge, Massachusetts. Among the first to do so was Robert Solow, who initially responded to the 1953–54 articles by Robinson and Champernowne challenging the reasonableness of aggregating capital. Solow’s concern was driven by his effort to carry out empirical studies of aggregate production functions containing aggregate capital. He recognized the problems that could arise due to Wicksell effects (Solow 1955-56), but in effect he appealed to the usefulness of the aggregate one commodity model for empirical studies of growth and technical change, as well as distribution (Solow 1956, 1957). Later Solow (1963) would follow Fisher (1930) and emphasize the rate of return and its relation to savings and growth rates.

Looking at the full panoply of critiques coming from Robinson and Sraffa, Paul Samuelson (1962) attempted an end run around the whole issue on a more theoretical note by conjuring up his “surrogate production function.” This model supposedly solved the heterogeneous capital goods problem, but it did so by making an assumption that would also solve the Marxian transformation problem of going from labor values to prices, namely that the capital-labor ratio for each type of capital good be identical. It is curious that in his studies of this matter (Samuelson 1962, 1966) Samuelson would use models that reduced to time patterns of labor use that somewhat resemble older Austrian models and in which Wicksell effects would manifest themselves.

The debate came to a head following the publication of a paper by a Samuelson student (Levhari 1965), who argued that reswitching was ruled out for entire economies due to a nonsubstitution theorem, which turned out to be false. This was shown in several papers (Pasinetti 1966; Morishima 1966; Garegnani 1966) in a famous symposium in the November, 1966 issue of the *Quarterly Journal of Economics*. Samuelson (1966) in his “A Summing Up” agreed with the Cambridge, England critics that the Levhari theorem was false. After reviewing the issues he declared that “scholars are not born to live an easy life.” Neither Sraffa nor Hayek were involved in this debate directly, although Sraffa was the main mentor for Pasinetti and Garegnani, who would later lay out more detailed analyses of the issues involved (Pasinetti 1969; Garegnani 1970).

6 The aftermath: Neoclassical arguments

The longer run neoclassical response to this 1966 showdown has been simply to ignore the whole thing (Cohen and Harcourt 2003). Indeed, this ignoring has largely happened in fact to such an extent that few graduate programs today even mention the debate at all and probably a majority of younger economists are unaware of it and do not know there ever was an issue. This is certainly the case among most macroeconomic modelers who use the DSGE approach, which simply assumes economies can be suitably modeled based on a Clark-Solow type aggregate production function with

aggregate capital, well-behaved, often simply assuming the Cobb-Douglas or CES form with no caveat or mention that doing so might involve any problem whatsoever along the lines raised in the controversy. This amounts to a neoclassical victory in practice on the ground, if an indefensible one.

Prior to the falling of this effective curtain of silence on the whole matter, at least three other responses have been seen. One is essentially that of Samuelson, who effectively accepted that it was pointless to try to defend the idea of aggregate capital. He had already admitted this in earlier writings, even as he made efforts leading up to the 1966 debacle to provide some ways to prop up the Clark story. So he retreated to declaring that capital must be viewed as heterogeneous, with returns for each type determined in general equilibrium. Bliss (1975) summarized this view and accepted that even at the disaggregated level one could not guarantee monotonic relations between returns and scarcities for inputs to production in a general equilibrium framework. All of this was further aggravated by recognizing the problems raised by Sonnenschein-Mantel-Debreu and the general lack of any reasonable stability conditions (Hahn 1984). And while many of these points are taught in graduate courses, that is usually in microeconomics courses, with these matters simply ignored when one moves over to the macro side and starts simply assuming that one has a solid microfoundation when one assumes an economy can be usefully modeled by assuming that it can be represented by an aggregate neoclassical production function of the Clarkian type such as Cobb-Douglas. The wiser neoclassicals also end up being ignored.

Two other neoclassical responses have involved trying to justify ignoring these matters, one on theoretical grounds, and the other on empirical grounds. The strongest of the theoretical arguments were made by Burmeister and van Long (1977). This involved distinguishing between “regular” and “non-regular” economies, with the former exhibiting the characteristic that rates of interest and steady state consumption paths are inversely related, thus preserving the parable story. They then argued that under certain conditions, the measure of adjustment paths to non-regular economy outcomes is zero, thus implying that one might expect only to see regular economy outcomes in which the conventional account holds. In particular they consider comparative static changes in rates of interest assuming that the Correspondence Principle of Samuelson (1941) holds. They find that regular economies have saddle point stable adjustments compared to non-regular ones, which leads to the measure zero outcome for the set of adjustment paths to non-regular economies. They declare this to be “almost too good to be true,” but in fact this saddle point stability itself is itself highly unstable not really providing a solid solution to this “Hahn problem.”

The third approach is to argue that capital theoretic paradoxes are empirically rare to the point of irrelevance, essentially the argument of Solow. As it is, empirical examples of reswitching have been found for specific techniques involving delayed costs (Albin 1975; Prince and Rosser 1985; Asheim 2008), with all of those cases involving delayed environmental costs. A more general empirical test is due to Han and Schefold (2006) who examined input-output tables for nine OECD economies. They constructed 496 technique envelopes for these and found one that showed reswitching while 11.3% showed capital reversal. This shows that while a minority of cases, capital reversal can exist, even as its possibility is simply ignored by most modern macroeconomic modelers.

7 The aftermath: The post-Keynesians Split

It was Joan Robinson who coined the term “post-Keynesian,” a term that initially applied to the Cambridge, UK-based group, and who also played an already important role in the Cambridge capital theory controversies. However, in the aftermath of the 1966 showdown, divisions would appear among this group over methodology and other matters. Some of these involved the capital theory controversies themselves. These debates would later lead to a deep split within the group, with one group being the neo-Ricardian followers of Sraffa, while their strongest critics would be the largely US-based followers of Paul Davidson, with those in Cambridge, UK going in various directions, with many caught somewhere in between.

Ironically it was Joan Robinson herself who opened the debate by criticizing the method of making comparisons between long run steady state equilibria in her “The Unimportance of Reswitching” (Robinson 1975), an approach she herself had followed in much of her earlier work (Robinson 1956). She posed the more theoretical “analytical time” used in such comparisons unfavorably with the “historical time” she came to prefer that did not rely on such comparisons, but rather focused on considering dynamic trajectories of actual economies instead. For her this meant moving beyond the concerns of the controversies, while certainly not adopting a neoclassical approach.

She, as well as such associates at Cambridge University as Geoffrey Harcourt, did not follow up this criticism with any broader critique of the neo-Ricardians or any effort to remove them from the broader post-Keynesian camp. The sharper split came in the 1980s with the Davidson-following Americans emphasizing such issues as uncertainty (Davidson 1982-83) and the role of money on effective demand while eschewing comparisons of long run steady states, arguing that the neo-Ricardian Sraffians were following a classical approach.⁸ While not fully dismissing the significance of the capital controversies, this group largely focused on other issues, but asserted themselves as being the true “Post Keynesians,” removing the hyphen in the label and capitalizing the “Post.” That some of them would consider the neo-Ricardians not to be Post Keynesian (or post-Keynesian) at all was symbolized by the absence of any neo-Ricardians in *The New Guide to Post Keynesian Economics* (Holt and Pressman 2001), in contrast to the earlier *A Guide to Post-Keynesian Economics* (Eichner 1978), which had both some of them as well as the hyphen in the label. This division continues intellectually, although more recently both groups have been present on editorial boards of journals and represented in various volumes on Post Keynesian and post-Keynesian economics.

In turn many of the neo-Ricardian followers of Sraffa continued to write about and study the issues arising from the capital theory controversies (Garegnani 1978; Kurz and Salvadori 1995; Petri 2016; Dvoskin and Petri 2017). Steedman (1977) famously turned the Sraffian analysis into a critique of the orthodox Marxist labor theory of value. Pasinetti (1981, 1993) would extend the Sraffian approach to consider economies from the perspective vertical relations across sectors as seen in input-output relations.

⁸ It must be noted that many neo-Ricardian Sraffians accept that they follow a classical approach (Kurz 2013), while still maintaining links to the British-based post-Keynesian group, who did not follow the Americans in this dispute.

8 The aftermath: Yeager and an Austrian approach

Austrian economists were not direct participants in the 1960s Cambridge capital theory controversies, even though Samuelson used an Austrian-style model in his “A Summing Up” of 1966. It was an example showing somewhat complicated time patterns of labor input for output that allowed for reswitching to occur, and Samuelson labeled it an “Austrian model.” It very much resembled the sort of examples that Hayek presented in his 1941 *The Pure Theory of Capital* when he discerned that there was no well-defined measure of roundaboutness of production that could be inversely related to the rate of interest. Curiously, Samuelson also identified his Austrian example as being “neoclassical,” with, of course, the founder of Austrian economics, Carl Menger, widely being considered also a founder of neoclassical marginalism, even if most more recent Austrians have eschewed that label. So the Austrians got dragged in by Samuelson to also represent a version of neoclassicism, even if they might have preferred not to have that “honor.”

Anyway, it took some time for any Austrian or semi-Austrian economist to pay any serious attention to the controversy, with most still ignoring even Hayek’s work undermining more traditional Austrian views of capital. Among the first to do so, although arguably only partly an Austrian economist, was Leland Yeager in “Toward Understanding Some Paradoxes in Capital Theory” (Yeager 1976).⁹ He explicitly identified his effort as drawing on the Austrian tradition even as he used it to try to prop up the Clarkian neoclassical parable. Yeager accepted the general outcome of the 1966 showdown that showed the general possibility of reswitching as well as the broader capital reversal phenomenon. He also was aware of the problems raised for standard roundaboutness ideas raised by Hayek in 1941. He accepted the argument that it was essentially meaningless to speak in terms of aggregate capital at all. Rather like Burmeister and van Long and others he in effect attempted to dismiss the paradoxes by arguing that they did not matter from the perspective of a deeper view, and Yeager and Burmeister (1978) teamed up to reply when some of Yeager’s arguments were challenged (Rosser 1978).

In particular, Yeager argued that the focus should be on different units, dollar-years. If such a unit is used then no paradoxes appear. There is a monotonic negative relationship between the rate of interest and capital as measured using these units, thus allowing the rate of interest to again play the role of a scarcity price for capital measured in this way. This measure seems to be a reincarnation in new form of Böhm-Bawerk’s old roundaboutness conception of capital that both Sraffa and Hayek had dismissed. A crypto-Austrian theory saved the day for the neoclassical story.

This analysis is correct as it stands. The question becomes how general and compelling it is. Yeager’s colleague at Auburn, Roger Garrison (2006) would revisit the question of the capital theory paradoxes and especially praised Yeager’s solution. Ironically Garrison would also indicate a reason to see his solution as limited. This was the fact that the rate of interest is simply the reciprocal of Yeager’s dollar-years

⁹ This paper received an award for being the best paper published in 1976 in *Economic Inquiry*. The editor (Robert Clower) was not pleased when it was discovered that the paper contained an error (Rosser 1978).

measure. Hence Yeager's argument is ultimately tautological, although there certainly has been a long tradition in economics of people making tautological arguments that are then raised up to be of supposed great import.¹⁰

Yeager's prize winning paper was marred by a curious error. At a certain point he declared, "In capital theory, discontinuity or discreteness of available techniques is necessary for the ambiguity that in turn breeds paradox" (Yeager 1976, p. 344). This statement was false as shown by Rosser (1978) who constructed "an eccentric reswitching model" that exhibited smooth substitutability across techniques along its outer envelope wage-profit frontier while also exhibiting the reswitching phenomenon.¹¹ Yeager and Burmeister (1978) replied that indeed Yeager had been in error on this point while nevertheless arguing that the capital theory paradoxes were not all that important in the end. The underlying point had been made previously by Pasinetti (1969) who noted that "For vicinity of two techniques on the scale of variation of the rate of profit does not imply closeness of the total values of their capital goods." Rosser (1983) later used his example to show that discontinuities in dynamic trajectories can arise even when the underlying model exhibits smooth continuity.

9 More Austrians in the aftermath: The wanderings of Lachmann and Shackle

Two students of Hayek from the early 1930s at the London School of Economics (LSE), Ludwig Lachmann and G.L.S. Shackle would eventually provide alternative Austrian responses to the capital theory paradoxes, with both of them arguably wandering intellectually between Cambridge, England and Vienna, Austria while doing so, with Shackle arguably going over eventually more to the post-Keynesian camp (Shackle 1967; Carvalho 1983)) while Lachmann would remain ultimately in the Austrian camp (Lewin 2014) with his deep admiration for Kirzner (1966), even as he put a foot in the post-Keynesian camp (Lewis and Runde 2007).

For both Lachmann and Shackle their general response to the capital theory controversies is to emphasize the subjectivist element of the Austrian tradition, with both of them also linking this to the subjectivist element in the work of Keynes. They take Hayek of *The Pure Theory of Capital* seriously and they see him as ultimately in league with Keynes and some of his followers, especially those such as Davidson (1978) emphasizing radical uncertainty in Keynes, with both of these strands contradicting the established classical and neoclassical paradigm coming from Pareto and Pigou in particular. Lachmann (1956) effectively becomes the first Austrian to deal with Hayek's (1941) emphasis on heterogeneous capital against Böhm-Bawerk, arguing that it is capital structure that matters at the level of the firm, with the subjective counterparts in the entrepreneur's mind of the actual physical forms of capital as being

¹⁰ While it was meant to apply to the making of obvious and unrealistic assumptions, Joan Robinson's wisecrack made in numerous talks although never appearing in print about "a magician who put a rabbit into a hat in full view of the audience, and then expected great applause when he pulled it out again."

¹¹ While at the time Rosser was unaware of it, Garegnani (1970) had previously constructed a different example that also exhibited the same phenomenon.

central in action through capital investment.¹² Aggregate capital as the sum of already sub-aggregated funds at the firm level is effectively an epiphenomenon of secondary importance.

Shackle (1967) sees the figures of Sraffa and Robinson and Keynes as undermining “the Great Theory” of general equilibrium and rationality. His particular contribution came with his more fully subjectivist *kaleidics* (Shackle 1972), which fits well with Lachmann’s subjectivist interpretation of Hayekian heterogeneous capital, albeit with an even greater emphasis on fundamental uncertainty.

It would be Lachmann (1986) who would draw on Shackle and also explicitly note the Cambridge capital theory controversies as he set out to create an Austrian-oriented synthesis that drew on Sraffa and Keynes as well as von Mises and Hayek in contrast to the neoclassical view not only of Pareto but of Solow (1963), with Böhm-Bawerk kept in his place as essentially a classical in his view of capital. The subjectivity of *verstehen* in the analysis of capital structures is paramount. In this view, Lachmann also noticed the split between the Post Keynesians and the neo-Ricardians as exemplified by Garegnani, with the latter seen as an objectivist throwback with their revival of a classical approach. In this later formulation by Lachmann, Hicks (1977) would become an influential figure with his later turn towards more of an Austrian perspective important. In effect, this later work of Lachmann provided the foundation for later Austrians who would take capital theory seriously in light of both the Hayek and Sraffian critiques of neoclassical capital theory.

10 The struggles of the post-Lachmann Austrians and the turn to complexity

Lachmann forced later Austrians to take heterogeneous capital theory, following Hayek in particular, but also mindful of the Cambridge capital theory critique, even as most wished to put the latter aside to some extent (Lewin 1999; Garrison 2001, 2006; Lewin and Cachanasky 2018). To the extent Keynes has been accepted it has been both as a follower of Wicksell and for his subjectivism. Garrison (2001) wrestled with these issues, well aware of both the Cambridge capital controversies as well as Hayek and Lachmann on heterogeneous capital, but attempting to revive Austrian business cycle theory in its Hayek version that followed von Mises (Hayek 1931b), replete with its famous triangles. While aware of Wicksell, this older view drew heavily on Böhm-Bawerk and implied aggregate capital ideas. Garrison (2006) would fall back on Yeager (1976) to justify this revival. This has continued to be a central problem for subsequent Austrian macroeconomists trying to maintain the older Austrian business cycle theory.

A recent effort to deal with this issue is due to Lewin and Cachanasky (2018). They suggest use of the idea of *duration* as a measure of sensitivity to interest rate changes, an idea long used by financial market practitioners for considering the sensitivity of investment portfolios to interest rate changes, with the idea initially introduced by Frederick Robertson Macaulay (1938). It can be viewed as a semi-elasticity of the

¹² While Lachmann and Shackle saw the subjectivity of heterogeneous capital in plans as crucial and also as drawing on both Hayekian and Keynesian traditions, some later Austrian followers of this strong subjectivism would reject Keynes as retaining an emphasis on aggregate capital (Horwitz 2011).

present value of a cash flow with respect to the discount factor $1 + r$. This duration must be modified by weights on the various elements in the cash flow and can also be viewed as a “balance point” of the group of cash flows that constitute the whole (Koppl 2014). This is intriguing, but it also appears to depend on some limiting assumptions, most importantly that there is a linear relation between bond yields and bond prices. It is unclear that this can be maintained for the sorts of irregular flow patterns that have long lain behind the capital theory paradoxes.

An alternative that relied heavily on subjectivism and drew on later ideas of Hayek from *The Sensory Order* (Hayek 1952) explicitly argued that heterogeneous subjective capital implied a complexity view of economic dynamics (Hayek 1967; Shackle 1972; Lachmann 1986; Lavoie 1989; Vaughn 1999; Caldwell 2004; Horwitz 2008; Koppl 2009; Harper and Endres 2010, 2012; Lewis 2012; Rosser 2012, 2015; Lewin 2014).¹³ Hayek’s complexity view drew on his psychological views and awareness of the infinite regress implied by efforts at self-consciousness, with this also implying limits on the ability to centrally plan an economy (Koppl and Rosser 2002). This also was linked to his ideas on spontaneous order and emergence (Hayek 1948), with these becoming major ongoing themes in Austrian economics. The heterogeneity of capital is central to this complexity, especially as it manifests itself ultimately in subjective form where the planning of investment and the formation of expectations becomes mired in potentially infinite introspection, and action leads to emergence into spontaneous order subject to evolutionary dynamics. Hayek has even been seen to support the agent-based modeling agenda found at the Santa Fe Institute (Vriend 2002). However, whether this turn fully resolves these deep controversies and contradictions remains to be seen, with Bowles et al. (2017) arguing that Hayek’s spontaneous order may not work out as well as he and his supporters think.

11 Final remarks

Something that both the broad Post Keynesian school, including Sraffian neo-Ricardians as well as the more subjectivist American and other branches, share with the Austrians, at least those who have thought about capital theory since the mid-1930s, is a sharp criticism of the use of aggregate capital in aggregate production functions that is so common in much of current neoclassical theory and modeling. This is despite important neoclassical theorists recognizing that there are problems with this approach.¹⁴ Elements of their criticisms have been quite similar.

Recent developments on the Austrian side have involved proposing use of the duration concept as a replacement for roudaboutness (Lewin and Cachanasky 2018)

¹³ Rosser (2006) shows that complexity based on nonlinear dynamics is central to the immediate post-Keynesian macroeconomics modeling done by Kaldor (1940), Goodwin (1951), and others, with this providing a possible unifying element across the contending schools of Post Keynesian thought.

¹⁴ Samuelson (1966) noted that Solow showed both sides of this contradiction, accepting the critique of aggregate capital in theory, the “red wine” Solow, while using it in his empirical work, the “white wine” Solow. Samuelson said that he preferred the “red wine” Solow of theory, and that when Solow did his “white wine” empirical work he was on a “busman’s holiday,” even as most current neoclassical macroeconomists who rely on Solow’s empirical aggregate production functions are not even aware of his own acceptance of the theoretical critiques of this work.

as well emphasizing heterogenous capital as involving complexity ideas ultimately drawing on Hayek and Lachmann (Lavoie 1989; Vaughn 1999; Caldwell 2004; Horwitz 2008; Koppl 2009; Harper and Endres 2010, 2012; Rosser 2012, 2015, and Lewin 2014).

That said, clearly deep differences between these broad schools remain over ideology, the role of government, social dynamics, and many other things, even as they converge on some approaches arising from the capital theory controversies such as complexity economics. The unresolved nature of these disputes show up in ongoing unresolved disputes regarding the nature of capital itself, which can be characterized by the following from Rosser (1991, p. 125):

“What really is capital and what it means for value, growth, and distribution? Is it a pile of produced means of production? Is it a dated labor? Is it waiting? Is it roundaboutness? Is it an accumulated pile of finance? Is it a social relation? Is it an independent source of value? The answers to these questions are probably matters of belief.”

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