**1THE BIELEFELD SCHOOL OF ECONOMICS, POST KEYNESIAN ECONOMICS, AND DYNAMIC COMPLEXITY**

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Abstract:

The Bielefeld School of economics emerged in the 1990s, led by economists located at or regularly visiting the University of Bielefeld in that period and the following decades, with Peter Flaschel as arguably its central leading figure based at that university. This school of drew especially on the work of Richard Goodwin and his nonlinear dynamical models of macroeconomic growth and fluctuations. His work in turn drew on both Keynes and Marx as well as Schumpeter. Besides these influences the school would also eventually add inventory adjustment models due to Lloyd Metzler to model endogenous fluctuations with associated income distribution dynamics with economic growth. While drawing on both classical and Keynesian sources, these models differ from modern New Keynesian models by eschewing rational expectations as well as equilibrium, emphasizing ongoing disequilibrium adjustment. While they have some similarities to Post Keynesian models, there has been relatively little interchange or interaction between the two schools, with some in the Bielefeld group disdaining Post Keynesians for a perceived lack of rigor in some of their models, although there are several sub-schools of Post Keynesian economics, with some more similar to the Bielefeld School in approach than others. Probably the clearest area of overlap and similarity involves models exhibiting dynamic complexity, irregular endogenous fluctuations. Indeed one Post Keynesian tradition derives from nonlinear dynamical models due to Kaldor, which resemble those of Goodwin., the main foundation for the Bielefeld School models.

1. **Introduction**

The relationship between the Bielefeld School of economics and Post Keynesian economics is fraught with misunderstanding and often disdain. This looks to be a somewhat curious matter given that on many matters the two schools share common viewpoints. This is especially the case regarding broader approaches to policy, with both supporting fairly strong amounts of government intervention in the economy to stabilize tendencies to endogenous fluctuations and stagnation, as well as generally supporting moves to increase the equality of income and wealth distributions in predominantly market capitalist economies. Both also agree on central theoretical ideas, especially ones that can be found in the work of Keynes. Probably the most important one is that both disagree with the idea of rational expectations and general equilibrium that predominate in much of modern macroeconomic modeling. Both see agents behaving on forms of adaptive expectations with poor ability to forecast the future and with economies usually in disequilibrium states rather than equilibrium ones. In this they both view the New Keynesian School that uses models that assume both rational expectations and general equilibirium, while allowing for rigidity of prices and wages that can lead to less than full employment outcomes, as not truly following the ideas of Keynes himself, who rather emphasized fluctuations of investment as the leading source for macroeconomic fluctuations, especially downturns.

Both schools of thought also emphasize issues of income distribution more than most other current macroeconomic modelers. While New Keynesian and New Classical models tend to assume that income distribution is driven by factor income distribution based on marginal productivity theory, both the Bielefeld School and the various branches of Post Keynesians see income distribution as driven by power relations between classes and not arising from marginal products of factors of production. In this regard they both draw ultimately on the work of Karl Marx, although usually mediated through later figures such as Kalecki (1943) and Goodwin (1967). One of the figures in both schools more inclined to acknowledge the influence of Marx was Peter Flaschel (2009), arguably the main founder of the Bielefeld School.

Despite these similarities and overlaps, there has been relatively little direct contact or communication between members of the schools, with occasional exceptions (Asada, 2001; Chiarella and Di Guilmi, 2011). To some degree this has been a somewhat one-sided matter, with most Post Keynesians largely unaware of the work of the Bielefeld School. This has been to some degree due to disdain coming from members of the Bielefeld School, who while recognizing agreement on various theoretical and ideological issues have viewed the Post Keynesians as lacking sufficient rigor and clarity in their models. Thus they seem not to have made much effort to communicate their work to Post Keynesians by, for example, publishing papers in the journals run by Post Keynesians such as the *Journal of Post Keynesian Economics*, the *Review of Keynesian Economics*, or the *Cambridge Journal of Economics*, preferring often more mainstream journals such as *Macroeconomic Dynamics* or the *Journal of Macroeconomics* or the *Journal of Economic Dynamics and Control*, with appearances in somewhat more heterodox journals more likely to be in the *Journal of Economic Behavior and Organization* or *Metroeconomica*, although the latter has also been an outlet for certain branches of Post Keynesian economics, notably the neo-Ricardian School following Piero Sraffa. In any case, It seems that the economists of the Bielefeld School have not made much effort to make the Post Keynesians aware of their work. There has also been perhaps more of a tendency by the people in the Bielefeld School to present much of their work in books rather than articles, although the Post Keynesians have also been more likely to do this than most conventional economists, perhaps out of frustration at being largely excluded from publishing articles in the most recognized of top journals..

This disjuncture also partly reflects the rather different histories of the two broad schools. Post Keynesian economics arguably appeared in the reasonably immediate aftermath of Keynes himself, led initially at Cambridge University in particular by Joan Robinson in the 1950s and becoming a fully self-conscious school in the 1970s, especially with the founding of the *Journal of Post Keynesian Economics*, although already at that point it was split into several competing sub-branches. The Bielefeld School, with this term only occasionally used and initiated by this author (Rosser, 2005), only developed in the 1990s and more strongly following 2000, with its members applying several different labels to the models that they were developing, including among others Keynes-Wicksell-Goodwin models, Keynes-Metzler-Goodwin models, and Keynes-Marx-Schumpeter models, among others. They never started their own journals and have remained a much smaller group than the Post Keynesians.

With the passing of two of its leading developers, first Carl Chiarella and more recently Peter Flaschel, both of whom were among those who sometimes expressed disdain to this author for a reputed lack of rigor of the Post Keynesians, it is appropriate to reconsider this relationship. Given the many similarities, are there more fundamental overlaps where the two look much closer to each other. One such involves the role of dynamic complexity and its emergence from nonlinear dynamical systems. Both schools have drawn on nonlinear dynamical systems that were developed in the 1940s and 1950s by such figures as Nicholas Kaldor (1940) and Richard Goodwin (1951) that drew heavily on the work of John Maynard Keynes, with the original of these a model of Michal Kalecki (1935, 1937) that actually predated important work of Keynes (1936). Goodwin in particular is a figure acknowledged and admired by both schools of thought, especially the Bielefeld School. Arguably the Bielefeld side has focused more on such models that can exhibit chaotic dynamics and other such dynamic complexities. But the Kaldorian branch of the Post Keynesians have also investigated such phenomena, and Rosser (1991, 1998, 2006, 2021) has argued that the inherent tendency of macroeconomic systems to such dynamic complexity is a fundamental basis for the argument of the American branch of Post Keynesians led by Paul Davidson (1996) that radical uncertainty is the most important idea that Keynes adumbrated and the most important foundation of Post Keynesian economics, even as Davidson himself largely dismissed ideas of complexity economics. Nevertheless, this looks to be the area where the two schools come closest together in terms of their approaches and models.

1. **The Emergence of the Bielefeld School of Economics**

The Bielefeld School of Economics gradually emerged from the 1980s into the 1990s with arguably its full florescence coming after 2000. As its name implies, the central place for it was at Bielefeld University in Bielefeld, Germany. The founder and initial central figure there was Peter Flaschel, with his 1984 paper on “Some stability properties of Goodwin’s growth cycle model,” which indeed highlighted the crucial influence of the work of Richard Goodwin on pretty much all of the subsequent models developed by the school. This would draw initially on his nonlinear multiplier-accelerator model (Goodwin, 1951), his predator-prey model of labor-management distributional dynamics (Goodwin, 1967), but later would include his longer run analysis that added Schumpeterian technological change elements in the idea of the economy as an “evolutionary pulsator” (Goodwin, 1986) and his study of chaotic macroeconomic dynamics (Goodwin, 1990). Goodwin’s multiplier-accelerator model drew on Keynes and immediate successors such as Harrod (1936), while his distributional dynamics model was inspired more by Marx (1954), although ironically the equivalent of the predators in that model were the workers while the prey were the capitalists, with workers preying on profits (Goodwin, 1967). Coming out of this the first label for models at the Bielefeld School would be “Keynes-Wicksell-Goodwin” (KWG).

Besides Flaschel, who would remain at Bielefeld for his entire career, many other participants in the school were on the faculty for some period of time, including Willi Semmler, Reiner Franke, Gangolf Groh, and Peter Greiner, or were post-docs such as Christian Proaño, although some of these would have joint appointments elsewhere or would move to other institutions later. Yet others would visit for repeated extended periods of time, including Carl Chiarella, Toichiro Asada, as well as for shorter periods Peter Skott and Gang Gong, with these people coauthoring in various combinations a large number of papers and books, with many of the papers initially appearing as Working Papers out of Bielefeld University. This is perhaps the reason why it is reasonable to label this body of work and its authors, the “Bielefeld School.”

Flaschel (1993) published a book by himself that laid out more fully the basic KWG model and would go on to publish another 16 books, mostly coauthored, not counting volumes he edited or coedited, with the final one in 2021 just before his death (Chiarella et al., 2021). In the 1990s Flaschel began to coauthor with others on this project, initially with Carl Chiarella whose home base was the University of Technology in Sydney, Australia (Chiarella and Flaschel, 1996a,b, 2000a,b) and then with his Bielefeld colleagues Will Semmler and Reiner Franke on a book (Flaschel et al., 1997), with Semmler having a joint appointment at the New School in New York and Franke later moving to Bremen. Prior to joining Flaschel in his enterprise, both Semmler (1986) and Chiarella (1986, 1990) had been focusing on complex dynamics in nonlinear macroeconomic models, while Franke (1992, 1996) was working on adding the inventory dynamic adjustment model of Metzler (1941) to what had been the KWG model. This would eventually lead to the expanding Bielefeld group to change the name of their core model to being Keynes-Metzler-Goodwin or KMB (Franke and Asada, 1994; Asada et al., 2003, Chiarella et al., 2005). In turn, it was Flaschel (2009), influenced yet again by Goodwin, who initiated the move on relabeling the core model to be Keynes-Marx-Schumpeter or KMS, with this becoming associated with the push by him especially for adopting the *flexicurity* approach to policy (Flaschel and Greiner, 2011, Asada et al., 2011).

1. **Core Elements of the Bielefeld Model**

As just noted, numerous models were developed by this group, with them changing over time and also changing their labels. Thus it may be misleading to identify any of them as being a core model of the group that can bear the label “Bielefeld model,” with more arguably it the case that all of them should be labeled “Bielefeld models.” Nevertheless we shall attempt here to summarize crucial elements appearing in most of these models, with the emphasis perhaps more on the KMG version, while noting some of the changes made later, and again noting that the KMG version was essentially the KWG version with the important addition of the Metzlerian inventory dynamics element, a crucial part of the disequilibrium adjustment dynamics part of the later models. Again, this group would emphasize their view that the economy is fundamentally in constant disequilibrium as a central way their view differed from the more conventional New Classical and New Keynesian models that emphasize general equilibrium, ultimately in its dynamic stochastic form, or DSGE models. While the approach would be interestingly expanded to include open economy models (Asada et al., 2003), we shall here stick to considering a closed economy model, with the international elements basically adding conventional approaches following Dornbusch (1976), although doing so with more than one country obviously increases the possibility for more complex dynamics appearing in the models. It must also be noted that while they share many common features, these different Bielefeld models also differ substantially in the detail and numbers of variables and dimensions involved in each of them, with many of them going off on various tangents with different assumptions, such as turning a KMG model into a KGMT one by adding a Taylor rule monetary policy to a KMG model (Charella et al., 2005). In the case of Asada et al. (2003) they went from a t0-dimenaional model in their closed economy version to a 14-dimensional one in their open economy version one, with Proaño (2011) further studying this approach for exchange rate dynamics.

A central feature of all these models is that they emphasize a conflict within themselves of stabilizing and destabilizing features, in contrast to more conventional models that overwhelmingly involve largely stabilizing features. While they sometimes allow for exogenous shocks to initiate or amplify fluctuations a la Frisch, their focus is on how the models endogenously generate fluctuations, most often simply limit cycles arising from Hopf bifurcations, but sometimes more erratic even chaotic fluctuations. The models will often have tendencies to local destabilization, but then will have both upper and lower bounds that prevent these instabilities from “flying off the handle” and rather converting them into generating some form of fluctuating pattern. In this they follow the example of Goodwin. In contrast to the more conventional Keynesian models, it is not usually rigidity of wages or prices that bring about the possibility of involuntary unemployment or other undesirable macroeconomic outcomes. Nor is the only source of more serious instability most likely to come from a financial sector, when such a sector is added to such models beyond a basic LM curve or Taylor policy rule. Instabilities arise in the investment sector as well as in wage and price dynamics, these due to both nonlinearities and lags. The latter are important because of agents not having rational expectations.

Nonlinearities in investment functions are a regular source of local instability, as for example when a Kaldor (1940) type investment function is used. This function relating investment to output contains both destabilizing and ultimately stabilizing aspects, tending to instability in intermediate regions but then bounded on both the upper and lower ends providing stabilizing limits to fluctuations. Models with Metzlerian inventory adjustment dynamics provide ambiguous effects, both destabilizing and stabilizing, with this depending on the degree of lags and the degree of disjunctures allowed between expectations and reality, which can also depend on how far from a steady state the system might be. Wage and price dynamics can also be both destabilizing or destabilizing, although again ultimately bounded, whether drawing directly on Goodwin’s approach or the related one due to Rose (1967) used in some of these models.

All of this extends what is usually an ISLM core to their models (Chiarella et al. 2005). The models usually feature households, firms, and government. Households provide labor and earn wages. They also have wealth in the form of money, bonds, and equities, the latter two generating interest and dividend income streams. They determine consumption in the ISLM frame. Firms produce according to a fixed coefficient technology with capital stock and labor with technology changing by changing labor productivity. Firms also provide the two forms of investment, building capital stock and also inventory investment exhibiting Metzlerian lagged adjustment as firm expectations do not match reality generally. In many of their models utilization of the capital stock is also an important element, and another not usually entering most other models. Government engages in both fiscal and monetary policy.

A crucial area where Bielefeld models seriously differ from others is in their wage-price dynamics. A price-cost markup is usually assumed, drawing on Kalecki (1943), with introducing this to Bielefeld models due to Asada (1994). Especially contrasting with other approaches is the use of two Phillips curves, one for prices and one for wages, thus linking to employment, which is ultimately determined by aggregate output. The Phillips curves operate within an endogenous “inflation climate” that varies endogenously. Wage determination often draws on a model of Blanchard and Katz (1999) that includes positing a reservation wage. The models assume accounting consistency. In Chiarella et al. (2005) this generates an “intensive form model” providing a real balance ratio, a real wage rate, an expected sales ratio, capital per head, an inventory ratio, and an inflation climate.

Regarding which effects are stabilizing, destabilizing, or ambiguous depends on parameter values in this formulation. Stabilizing effects include the return differential in investment, utilization in the price Phillips curve, and weight of current inflation in the price Phillips curve. What is destabilizing are utilization in fixed investment, employment rate in the wage Phillips curve, weight of current inflation in the wage Phillips curve, and interest elasticity of money demand. Ambiguous are wage share in both of the Phillips curves, adjustment speed of the inflation climate, weight of adaptive expectations in inflation climate, adjustment speed for expected sales, and stock adjustment speed (Chiarella et al., 2005, p. 499). It is notable that the two Phillips curves tend to conflict regarding being stabilizing versus destabilizing.

In the very similar single country KMG model found in Asada et al. (2003, pp. 513-514) it is noted that the model on the real side exhibits a stabilizing Keynes Effect working from wage changes through interest rates, a stabilizing Pigou Effect working from wage changes through a real balance effect on consumption, possibly stabilizing Normal Rose Effects that operate from real wage changes through investment and consumption changes depending on their adjustment speeds as well as generally destabilizing Adverse Rose Effects that go through the same channels but reflect sluggish wage and price adjustments, destabilizing Mundell Effects that work from wage changes through the inflation climate, destabilizing Fisher Debt Effects that work from wage changes through real debt ratios, as well as potentially destabilizing accelerators of the Harrod type operating through fiscal policy, the Kaldor type operating through a nonlinear investment function, and then Metzler type inventory type. On the financial side destabilizing financial accelerator mechanisms operate through capital gains on long term bonds, through equities, and through portfolio effects on money demand. Disposable income effects are stabilizing.

Regarding Flaschel’s work on Bielefeld topics, in the final decade of his life this largely followed two strands. One was to more deeply update a Keynesian dynamic macroeconomics (Chiarella et al., 2014; Semmler et al., 2015) and also to move more directly into policy analysis and advocacy. The latter involved his advocacy and expansion of *flexicurity* policies coming out of Denmark (Kreiner and Svarer, 2022). This coalesced with his reformulation of the KMG model as the Marx-Keynes-Schumpeter (MKS) model (Flaschel, 2009) where he initially presented his flexicurity arguments, followed by more discussions elsewhere (Flaschel and Greiner, 2011; Flaschel, 2012; Chiarella et al., 2021). He followed up on his analysis of Goodwin’s predator-prey class struggle model (Goodwin, 1967), but then openly dug into its roots in Marx (1954), emphasizing the dehumanizing aspects of this for workers. The Keynes part remained pretty similar, but he combined Schumpeter’s analysis of creative destruction, something necessary for the technological advance of economies (Schumpeter, 1934) with Schumpeter’s call for a move to a form of “competitive socialism” in advanced market capitalist economies (Schumpeter, 1942). The original Danish idea was to combine labor market flexibility on both hiring and firing as well as labor organizing, with a solid social safety net for workers. Flaschel added further elements, including having government serve as an “employer of first resort” to guarantee full employment, along with reforms to the educational system, and the use of pension funds for use in real capital investment for smoothing business cycles. This idea continues to have much appeal to many, especially in the European Union, even as it has faced criticism for not necessarily being able in practice to guarantee a full social safety net for workers rapidly when a flexible labor market can be quickly introduced, leading possibly to workers losing jobs without proper support in some societies (Tangien, 2011).

1. **The Varieties of Post Keynesian Economics**

In contrast to the Bielefeld School, the Post Keynesians have long spent lots of time categorizing themselves and separating into various competing sub-groups that have wrangled with each other at times, even making efforts to expel each other from being considered part of the school. Indeed, the differences between some of these sub-schools are so great that it can be seriously questioned whether it is even meaningful to speak of there being a group that can be called “Post Keynesian economics” (or “post-Keynesian economics” as it is spelled in most nations outside the US). However, one thing that is clear is that the rather large set of economists who consider themselves to be Post Keynesian do not recognize the Bielefeld School to be a part of their highly heterogeneous group, and barely even note the work of most of the members of the school, despite considerable overlap and agreement on various approaches as well as policy views. And with a few exceptions, the feeling seems to have been mutual, with most of the Bielefelders ignoring the work of the Post Keynesians and often dismissing them for being insufficiently rigorous in their approach.

Largely due to the diversity of the views among the sub-schools, it is hard to define what constitutes Post Keynesian economics. In a sense it may be easier to define it in a negative way: economists who are substantially influenced by the work of Keynes but who do not follow the mainstream Keynesian schools. The first of these, was once labeled “neo-Keynesian economics” and now more likely to be called “Old Keynesian economics,” associated with Paul Samuelson, Robert Solow, and James Tobin, among others. They generally adopted the ISLM approach that had been developed soon after Keynes published his *General Theory* in 1936 by Hicks (1937) and Hansen (1953). However, in contrast to those in the Bielefeld School they emphasized equilibrium outcomes rather than disequilibrium analysis. They also saw involuntary unemployment as arising from sticky prices and wages. They also made no effort to link models of short-term fluctuations with those of longer run growth, and they assumed that income distribution was determined by marginal productivity theory, with wage-price relations determined by only a price-Phillips curve. They also largely ignored inventory dynamics issues. Their policy approach tended to focus on conventional fiscal and monetary policy, with central banks able to exogenously control money supply. Agents had adaptive expectations, and the economy was fundamentally stable, with this a central difference with the Bielefeld School. And while the neo-Keynesians disagreed about policy with the classical monetarists of their time such as Milton Friedman, there was more overlap and agreement regarding their respective models than they always admitted or recognized.

This older version of conventional Keynesian economics would be superseded in the 1980s by the New Keynesian School of economics, led by such figures as George Akerlof, Gregory Mankiw, and Michael Woodford. This school emerged after the triumph in the 1970s and early 1980s of the New Classical School led by Robert Lucan and Thomas Sargent, which added rational expectations to classical monetarism, so the New Keynesians also replaced adaptive expectations with rational expectations. However, they introduced mechanisms for how prices or wages might have some stickiness through such mechanisms as menu costs or slowly changing wage agreements. This approach would also follow the New Classicals to adopt the dynamic stochastic general equilibrium (DSGE) approach with these features that would allow for involuntary unemployment that could lead to the need for active fiscal and monetary policy as the neo-Keynesians had advocated. Widely used versions of this came ro be based on Smets and Wouters (2003). Despite its failure to forecast or model very well the Great Recession of 2007-09, variations of this model currently dominate academic macroeconomics and much of policymaking as well, often adding an expanded financial sector allowing for some kind of market failure.

Both the Bielefeld School and the various branches of the Post Keynesians reject not only rational expectations, but much else in this model. Aside from rejecting rational expectations, the various branches of Post Keynesians differ from conventional Keynesian models in different ways as these different sub-schools differ from each other. By 1988 Hamouda and Harcourt (1988) identified three competing sub-schools of Post Keynesian thought: an “American” sub-school that others would label as “fundamentalist” or “Marshallian” or “Keynes-Post-Keynesian,” led prominently by Paul Davidson, who had founded the *Journal of Post Keynesian Economics*; the Sraffian or “neo-Ricardian” sub-school, which had many Italians in it such as Piero Sraffa, and a “Kaleckian” sub-school, largely based in Britain, which followed Michal Kalecki and included Joan Robinson in her later years, long identified as the first person to use the term “post-Keynesian,” along with others such as Malcolm Sawyer and to a large extent Harcourt as well, although he often tried to be a “synthesizer” who would make peace among the competing schools, with the fundamentalists and the Sraffians most in conflict. Of these three, the Bielefeld School would probably be most sympathetic to the Kaleckians, given that many of their models rely on Kalecki markup models as part of their wage-price relations.

Leading the American fundamentalists, who often focused on the work of Keynes himself and correctly interpreting him, Davidson (1994, 1996) tried to impose a narrow view of what the school consisted of. The supreme notion was an emphasis on fundamental uncertainty as an ontological phenomenon that underlay the endogeneity of money and its role in the economy. Davidson not only criticized the Sraffians and the Kaleckians, but also those suggesting that fundamental uncertainty could be founded on the ubiquity of complex nonlinear dynamics in the economy (Rosser, 1998, 2006), with, of course, the Bielefeld School also deeply involved in studying such dynamics, although they did not debate this matter with Davidson or his followers. Davidson’s views gradually developed through the 1970s and 1980s, with him using Keynesian fundamental uncertainty as a heavy bludgeon against both rational expectations (Davidson, 1982-83), but also against the more conventional neo-Keynesian approaches to the analysis of risk such as those advocated by Tobin (1958) who saw it as quantifiable. Davidson also expressed disdain for the ISLM model and much of econometric analysis.

At the opposite end were the Sraffians, who were arguably the first Post Keynesian group to have an intellectual showdown in the 1950s and 1960s with the neo-Keynesians in the Cambridge capital controversies over the nature of capital and the usefulness of the marginal productivity theory of income distribution (Harcourt, 1972). While their most influential work was Sraffa’s (1960) *Production of Commodities by Commodities*, which contained discussion of various capital theory paradoxes such as reswitching, it had been Joan Robinson (1954) who had initiated the debate over the nature of capital with her article, “The Production Function and the Theory of Capital.,” with her initially more of a Sraffian, even as she moved more towards the Kaleckians later. The Cambridge, Massachusetts side would admit intellectual defeat at the crucial moment (Samuelson, 1966) at the hand of the Cambridge, England side. But somehow this did not stop neoclassical economists from continuing to use the models they had been previously using aggregate production functions with the rate of profit equaling the marginal product of aggregate capital and not exhibiting any paradoxical behavior. Followers of Sraffa would proceed to work on economic models exhibiting long-run steady state equilibria with elements drawn on models of Ricardo, and largely ignored the role of money in the economy or uncertainty. Conflicts between them and the American fundamentalists reached a fever pitch during the 1980s. The Sraffian approach also does not look too much like that of the Bielefeld School either.

Although Kalecki (1935, 1937) had developed a nonlinear dynamical model of the economy early on, his followers among Post Keynesians mostly ignored that model and focused on his later work (Kalecki, 1943) with his emphasis on monopolistic competition allowing firms to set prices, which they did based on markups reflecting their degree of monopoly power (Blecker, 1999; Sawyer, 2001). It has long been argued (King, 2002) that Kalecki actually anticipated most of the work of Keynes, with his followers claiming he did a better job of developing the important ideas of Keynes than Keynes did, a view that puts off Davidson and the fundamentalists. Again, this group shares more with the Bielefeld School than the other two on some matters, and some of those involved in the Bielefeld School were involved in this branch of the Post Keynesians, most notably Peter Skott (2012), who is arguably more of a Post Keynesian than a Bielefelder, although one person who may actually be in both schools. Asada (1994) introduced Kaleckian ideas into the Bielefeld School, but has been largely ignored by the Post Keynesians.

Marc Lavoie (2014, pp. 38-42) argues that more recently two further branches of Post Keynesians have appeared. One is the Institutionalists, drawing on the work of John Kenneth Galbraith, who helped found the *Journal of Post Keynesian Economics*. (Galbraith, 1978). Given his famous analysis in *The Great Crash* (Galbraith, 1955), those who focus on financial fragility among Post Keynesians are put into this school by Lavoie, which would include Hyman Minsky (1972). Lavoie also includes those who worry about details of financial institutions, including the neo-chartalists who also strongly emphasize endogenous money like the Davidson fundamentalists (Wray, 1998). The neo-chartalists have since gained much attention as the advocated of modern monetary theory (Wray, 2012; Kelton, 2020). Curiously, on the matter of employment policy, their advocacy of a government guarantee of a job (Tcherneva, 2020) resembles the flexicurity proposals of Flaschel of the Bielefeld School. However, the Bielefeld School has put less emphasis on speculative bubbles and crashes than one finds among some of the Institutionalist Post Keynesians such as Minsky, although some have studied his work (Chiarella and Di Guilmi, 2011).

This brings us to the fifth school Lavoie identifes, the Kaldorians. Lavoie initially emphasizes that these people emphasize open economies, but then he also brings in such matters as path dependence and hysteresis (Kaldor, 1966, 1972; Cornwall, 1972; Setterfield, 1993), while somehow ignoring Kaldor’s (1940) work on nonlinear investment. But this is probably even more than the Kaleckian group the one that looks to be where the Bielefeld School people would feel at home. Indeed, Lavoie places their hero, Richard Goodwin in this group. Another figure he places in the group is Peter Skott (1981, 1989), who is also part of the Bielefeld School.

Which brings us to how thoroughly the Post Keynesians have ignored the Bielefeld School as a group. Lavoie (2014, p. 7) lists a full 21 different kinds of “heterodox economics.” None of these can be linked at all to the Bielefeld School under any label. In this comprehensive book, few are cited, although Skott is 16 times, who is clearly accepted as being a Post Keynesian. But beyond him only Flaschel, Semmler, and Franke are cited, the first two twice and the latter once, with none of these linked or any suggestion of any connection between them or Skott, save one. Flaschel is cited at one point for his drawing on Marx to look at income distribution changes in economies over time, while the other citation is worth quoting as it is the one that also mentions Skott and suggests why some of those in the Bielefeld School tended to disdain the Post Keynesians for a lack of rigor and made little effort to publish in their journals or get their attention (Lavoie, 2014, p. 347):

“The method of analysis to be employed is comparative dynamics. A number of post-Keynesian and heterodox economists (Peter Flaschel, Steve Keen, Peter Skott, Barkley Rosser, Lance Taylor) have for some time insisted that dynamic analysis ought to be conducted with the tools of differential equations and non-linear dynamics, on the grounds that these tools better reflect the world as we know it. Still, most of what follows will rely on comparative dynamics based on linear relations.”

1. **Forms of Complexity Economics**

There have been over 40 forms of complexity that have been identified (Rosser, 1999, 2021). However, some of these are never used in economics, and of those that can be, several of them are really variations of each other, meaning that this list can be reduced for practical purposes to a much shorter one. As with Post Keynesian economics, there is not agreement on a general definition that covers all the forms of complexity that have been identified. However, one widely spread suggests that it involves a group of entangled relationships in which one observes phenomena of emergence in which somehow the whole is greater than the sum of the parts (Day, 2007). This suggests a deep element in the nature of these relationships that is not just there being lots of parts that interact somehow. In this regard, it is widely argued that complexity is different from mere complicatedness (Israel, 2005), although some have used the word “complexity” in effect as a label for something merely complicated, as for example describing the many interconnections that exist in the US economy (Pryor, 1995).

Among the broader forms of complexity that are thought to be relevant to studying economic systems it is generally accepted that there are at least three: computational, hierarchical, and dynamic. The first of these is the one that includes the largest number of specific forms that appear on the longer lists of types of complexity, and we are not going to go through all of them here, with there being numerous forms of computational complexity. The very idea that some systems may be “calculable” was crystallized with the concept of recursiveness by Church (1936) and Turing (1937), with the latter in particular realizing that Gödel’s Incompleteness theorem means that some systems are not recursive, that a computer program that tries to solve one of them will simply run forever in an endless do loop and thus not computable. This is the foundation of the idea of computational complexity, with this the highest level when a program will run forever. Indeed, after work by Solomonoff (1964), Kolmogorov (1965), and Chaitin (1966). From there work came measures of degrees of computational complexity generally related to the length of time it takes a program on a Turing machine to halt, although there are variations on this. It has been shown that many fundamental ideas of economics are not actually computable (Velupillai, 2000, Landini et al., 2020; Rosser, 2020, 2021). It is recognized that there are various levels of computational complexity, with linear systems at the lowest level and generally viewed as not complex. Between that bottom and the top of non-computability are the levels of polynomial complexity (P) and non-polynomial complexity (NP), with it widely thought the latter is fundamentally different from the former and generally more computationally complex. However, since John Nash (1955) first discovered the problem it has not been proven that they are indeed not really the same. Costa and Doria (2016) have studied systems on their borderline and economic implications therefrom, drawing on work of Maymin (2011).

Another form of complexity that is recognized to have applicability to economics is hierarchical complexity. This was first posited by Herbert Simon (1962) who applied it initially more to ecological hierarchies in evolutionary systems. But he also recognized that it had relevance to economics and to managerial hierarchical systems as well. However, neither this type nor computational complexity are all that useful to understanding the relationship between the models of the Bielefeld School and those of Post Keynesian economics.

What may be useful for this question is our third broad type of complexity, dynamic. Day (1994) provides a definition of this as being systems that endogenously generate time paths that are not exponential or limit cycles or smoothly converging on a steady state. Rosser (1999) has identified four sub-categories of such dynamically complex systems, labeled the “four C’s” following derisive wisecracks by Horgan (1997). The four C’s are cybernetics, catastrophe, chaos, and agent-based complexity (originally called “broad tent complexity” by Rosser in 1999). But indeed there are more kinds of complex macrodynamics beyond the four C’s such as those involving fractal basin boundaries (Lorenz, 1992). As it is, most of the Bielefeld School models are nonlinear systems with many of them having been shown to exhibit dynamic complexity of one sort or another, including endogenously irregular chaotic dynamics (Chiarella and Flaschel, 2000a,b). And while self-conscious Post Keynesians have less frequently studied such systems, some have (Blatt, 1983). This then may be an area where they may be some overlap for at least portions of each of these schools.

1. **Dynamic Complexity Models Across the Schools**

Now we come to the point that a potential sharing of both the Bielefeld School and Post Keynesian economics across most of their variations lies in the use and relevance of models exhibiting dynamic complexity of various sorts. As has been noted, various figures in the Bielefeld School had already been studying complex macrodynamics prior to the emergence of the school itself in the various coauthored works of its members (Semmler, 1986, 1994; Semmler and Sieveking, 1993; Chiarella, 1986, 1990). Thus, unsurprisingly from an early time in the emergence of the school work appeared showing the possibility of chaotic dynamics in their models (Chiarella and Flaschel, 1996a,; Flaschel et al., 1997), with this an ongoing theme from then on in much of their work. The key nonlinear part of these early models drew on the predator-prey class struggle model of Goodwin (1967), which was initially shown capable of generating chaotic dynamics by Pohjola (1981) and Semmler (1986). It was also understood early on by this group that such dynamics could arise from Metzlerian inventory adjustments (Metzler, 1941), with Zhang (1989) the first to show possible chaotic dynamics arising from such a model, with this picked up then by Franke and Lux (1993). As it was Chiarella and Flaschel (1996b) had Metzler elements in their model that showed possible chaotic dynamics and this combined approach followed up in Flaschel et al. (1997, 2008). So the Bielefeld School were intensively studying complex dynamics in their models from basically their initial emergence with this a regular ongoing theme.

It must be admitted that there has been much less emphasis on this matter by most of the modern Post Keynesian economists. However, it is the case that all five of the strands of Post Keynesian economics recognized by Lavoie (2014) are based on models that can show such dynamics or that certain deep issues they address can be further highlighted and better understood by considering them in light of dynamic complexity.

On this latter point let us consider the matter of probably the branch of Post Keynesian economics apparently most hostile to the idea that dynamic complexity has any relevance, the American fundamentalist branch, and more particularly its leader, Paul Davidson (1996). He has argued that the most important idea of Keynes in Post Keynesian economics is that of fundamental uncertainty, which Davidson argues must be viewed as ontologically based on the inevitable non-ergodicity of economic systems that must be assumed axiomatically. Davidson (1996, p. 492) dismisses chaotic dynamics in particular as relevant because many (although not all) models of chaotic dynamics are ergodic. While he recognizes that the phenomenon of sensitive dependence on initial conditions (the “butterfly effect”) central to chaotic dynamics undermines rational expectations and forecastibility in systems, he argues that this is merely a matter of epistemology rather than ontology, thus essentially an epiphenomenon arising from fundamentally classical models that are not truly Keynes-Post-Keynesian (his preferred label). Rosser (1998, 2006) has countered this with the argument that not just chaotic dynamics but various other forms of complex dynamics as well can indeed serve as an effective foundation for the Keynesian concept of fundamental uncertainty. While what is going on may not be ontological in the sense of Davidson, the fact that It is impossible to fully forecast models with such dynamics makes them “effectively ontological” even if they are ultimately epistemological and in systems that may be ergodic. Interestingly, Lavoie (2014, pp. 76-77) recognizes this argument that I made and quotes me on the matter of this being “effectively ontological.” Beyond this is the problem that Davidson has overstated portions of his argument, especially regarding the role of non-ergodicity as the crucial foundation for Keynesian fundamental uncertainty as discussed by Rosser (2016).

Regarding the Post Keynesian branch at the extreme opposite end from the Davidsonian fundamentalists, the Sraffian neo-Ricardians, there has also been a lack of attention paid to complex dynamics, unsurprising given that much of their analysis has involved comparing alternative long-run steady states. However, when possible links between their models and complex dynamics have been shown there has been less of a tendency by adherents to this view to contest such connections. The main problem, unsurprisingly, is that such connections involve moving away from this long-run comparing of steady states to considering explicitly dynamic models that exhibit phenomena studied by the Sraffians, especially the capital theory paradoxes that were at the center of the Cambridge controversies in capital theory that rose out of the work of Sraffa (1960). An example of this is due to Rosser (1983), which considered such dynamics in a model that allowed for smooth substitutability of factors of production but that exhibited the reswitching phenomenon presented in Sraffa (1960) and admitted to be possible in a wide array of models by Samuelson (1966). Rosser showed that in this model the reswitching element of it leads to the appearance of catastrophic dynamic discontinuities. It must be noted that while Rosser’s model was different, its essential features had been presented in a model by Garegnani (1970), and that the deep insight that discontinuities could appear in a model with apparently smooth technology had been made by Pasinetti (1969). A model that shows both reswitching and chaotic dynamics is due to Day and Walter (1989). But then Flaschel (2014) produced a critique of the neo-Ricardian approach.

Regarding the Kaleckian branch, much of the work in the Post Keynesian part of this has focused on his microeconomic foundation involving some monopoly power of firms and their related use of markup pricing, an element also appearing in many of the Bielefeld models, and thus something the two schools share even without appealing to complex dynamics. But Kalecki (1935, 1937) was the first to pose a nonlinear dynamical macroeconomic model of growth and cycles, with the nonlinearity appearing in an investment function of output and investment. Curiously, Kaldor’s (1940) nonlinear dynamical model also used such a formulation, although with more specifically Keynesian elements in the rest of it. While Lavoie has Kalecki and Kaldor as the basis for competing branches of Post Keynesian economics, those branches rely on different parts of their work, Kalecki’s markup pricing model (Kalecki, 1943) and Kaldor’s (1966, 1972) models showing hysteretic path dependence tied to increasing returns. In any case, the Kaldor (1940) variation on Kalecki’s model was first shown to be capable of generating catastrophic discontinuities by Varian (1979) and of possibly generating chaotic dynamics by Dana and Malgrange (1984), with Lorenz (1992) using it to show possible fractal basin boundaries.

Regarding the Institutionalist branch the obvious place to see complex dynamics is in the matter of models of financial fragility, especially those based on the work of Minsky (1972). The very first application of catastrophe theory to economics (Zeeman, 1974) modeled stock market crashes with heterogeneous agents. Keen (1995) would show chaotic dynamics possible in a model specifically based on Minsky’s work. That financial intermediation can generate chaotic dynamics in financial markets was shown by Foley (1987) and Day and Huang (1990). While the Bielefeld School has largely stayed away from modeling dynamics of speculative bubbles, many of their models have allowed for financial intermediation, with this becoming a possible source of complex dynamics as in Chiarella and Flaschel (1996a).

When it comes to the Kaldorian branch of Post Keynesians, we have again this issue of what ideas of Kaldor does one see it drawing from. Lavoie (2014) emphasizes work drawing on his emphasis on increasing returns and path dependence and hysteresis (Kaldor, 1966, 1972; Cornwall, 1972; Setterfield, 1993). But as already noted, Kaldor (1940) developed one of the first nonlinear dynamics Keynesian models that has long been shown to be capable of various complex dynamics, with Skott (1981, 1989) contributing to this. While Bielefeld School participants have not done so particularly, the increasing returns side of Kaldor has been shown by others to be capable of generating complex dynamics of various types, with Brian Arthur (1994) arguing that increasing returns are the most fundamental source of complex dynamics. However, this aspect has not been pursued particularly by the more clearly Post Keynesian Kaldorians. While Lavoie (3014, p. 42) identifies this author as one of a group of “key senior authors” (along with Philip Arestis, Geoff Harcourt, John King, and Edward Nell) who do “not fit neatly into one of these [five] strands” it happens to be the case that when Lavoie first made public presentations of this five branch set of categories he placed me into the Kaldorian one.

While Lavoie only briefly mentions him without explanation, it would seem (Lavoie, 1014, p. 41) that he places Goodwin also into this fifth category of Kaldorian Post Keynesians. Here we have a crucial figure of importance to both the Bielefeld School and the Post Keynesians. The aspect of his work that most clearly strongly overlaps is his development of a nonlinear multiplier-accelerator model (Goodwin, 1951). He was not the first to do so, with Samuelson (1939) having done so in the less well known version of it that has the nonlinearity in the consumption function. Goodwin has it in the investment function driven by the accelerator part of the model, and in that his model somewhat resembled that of Hicks (1950). Hick’s model was suggested to be capable of producing chaotic dynamics by Blatt (1983) and shown more formally to be by Hommes (1991). Puu (1989) showed in a variation of the Hicks model how one could have cyclical dynamics that showed both catastrophic and chaotic dynamics, what Abraham called a “chaostrophe.” Goodwin (1990) himself would study chaotic dynamics in his own models, but it is a curiosum that the very first finding of chaotic dynamics in any economic model was by Strotz et al. (1953) studying Goodwin’s 1951 model, although when they found endogenous irregular dynamics in it they did not understand what they had found. In any case, with complex dynamics inherent in the models of Goodwin, we see probably the clearest place where the Bielefeld and Post Keynesian schools overlap and potentially reconcile.

1. **Conclusions**

We have considered the development and relations between two schools of economic thought, the Bielefeld School and the Post Keynesian school, both of them distinctive from more conventional approaches to macroeconomics to varying degrees. While similar in views on some matters, they have kept apart, with members of the former sometimes disdaining the latter for a claimed lack of mathematical rigor, while to a substantial degree the latter have barely been aware of the former. While the latter much larger school has been around since possibly as far back as the 1940s or 1950s and is split into several sub-groups, the former is much smaller and only emerged in the 1990s, largely centered on Bielefeld University in Germany, where several of its members have been located, especially central leading figure the late Peter Flaschal, and most others have at least visited there at times. Indeed, the former is barely aware of itself being a defined group, this label for it only having been used since 2005 (Rosser, 2005), while the latter has long been aware of itself and had journals devoted to it and long running debates among its sub-groups regarding its nature. Lavoie (2014) has identified five sub-groups of the Post Keynesians: fundamentalists, Sraffians, Kaleckians, institutionalists, and Kaldorians. Both schools have long been inspired by the work of Keynes, but also to varying degrees by Michal Kalecki and Richard Goodwin, the latter especially important to the Bielefeld School. While the former has also been influenced by Piero Sraffa, Paul Davison, and Hyman Minsky, the latter has been more so by Karl Marx, Lloyd Metzler, and Joseph Schumpeter, while both have generally agreed that market capitalist economies tend to instability and inequality and favor substantial amounts of government intervention into the economy to in order correct these problems.

After presenting several varieties of complexity economics, this paper has argued that something that they substantially share is an openness to models exhibiting dynamic complexity, defined as being endogenously irregular in their time paths, although the Bielefeld School has been more consciously concentrated on this than the Post Keynesians. Nevertheless the author of this paper sees this perspective as a fruitful area for dialogue and commonality between the two schools fairly broadly, with this commonality the main focus of this paper.

I shall conclude this paper on a personal note, reminiscing regarding my own efforts to get some of the members of each of these schools to communicate more with each other and to recognize the similarities of their views, with hopefully this leading to more interaction and mutual support and work along these lines. Each side has tended to favor their own distinct conferences and locations, with them rarely attending these of each other. While many members of the Bielefeld School have largely been located in Germany and Japan, while many Post Keynesians have been in Great Britain or Italy, both have had some in Australia and the US, although generally in different universities in the latter two, with the New School in New York one of the few having people from both at it. This author has observed that one regular conference where members of both schools have regularly spoken has been the Eastern Economic Association, but they have long tended to participate in different sessions there, only occasionally visiting ones dominated by each other, or to occasionally participate in conferences dominated by one or the other. This paper is thus part of a long effort by this author to overcome this gap and increase communication and understanding between these two related approaches to understanding macroeconomic phenomena.

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