Hayek, Hicks, Radner and Three Equilibrium Concepts:
Sequential, Temporary, and Rational Expectations

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July 6, 2018

Abstract: Along with Erik Lindahl and Gunnar Myrdal, F. A. Hayek was among the first to realize that the necessary conditions for intertemporal, as opposed to stationary, equilibrium could be expressed in terms of correct expectations of future prices, often referred to as perfect foresight. Subsequently, J. R. Hicks further elaborated the concept of intertemporal equilibrium in *Value and Capital* in which he also developed the related concept of a temporary equilibrium in which future prices are not correctly foreseen. This paper attempts to compare three important subsequent developments of that idea with Hayek's 1937 refinement of his original 1928 paper on intertemporal equilibrium. As a preliminary, the paper explains the significance of Hayek's 1937 distinction between correct expectations and perfect foresight. In non-chronological order, the three developments of interest are: (1) Roy Radner's model of sequential equilibrium with incomplete markets as an alternative to the Arrow-Debreu-McKenzie model of full equilibrium with complete markets; (2) Hicks's temporary equilibrium model, and an important extension of that model by C. J. Bliss; (3) the Muth rational-expectations model and its illegitimate extension by Lucas from its original microeconomic application into macroeconomics. While Hayek's 1937 treatment most closely resembles Radner's sequential equilibrium model, which Radner, echoing Hayek, describes as an equilibrium of plans, prices, and price expectations, Hicks's temporary equilibrium model would seem to have been the natural development of Hayek's approach. The now dominant Lucas rational-expectations approach misconceives intertemporal equilibrium and ignores the fundamental Hayekian insights about the meaning of intertemporal equilibrium.

Keywords: intertemporal equilibrium, temporary equilibrium, rational expectations, perfect foresight, Arrow-Debreu-McKenzie model, Hayek, Lindahl, Myrdal, Hicks, Bliss, Radner, Muth, Morgenstern, Lucas, Alchian

JEL codes: B2, B3, B4, E0, E3

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I   The Concept of Intertemporal Equilibrium

        Equilibrium is an essential concept in economics. While equilibrium is an essential
concept in other sciences as well, and was probably imported into economics from physics, its
meaning in economics cannot be straightforwardly transferred from physics into economics. The
dissonance between the physical meaning of equilibrium and its economic interpretation required
a lengthy process of explication and clarification, before the concept and its essential, though
limited, role in economic theory could be coherently explained.

        As the concept of equilibrium had originally been imported from physics at some point in
the nineteenth century, economists probably thought it natural to think of an economic system in
equilibrium as analogous to a physical system at rest, in the sense of a system in which there was
no movement, or in the sense of all movements being repetitive. But what would it mean for an
economic system to be at rest? The obvious answer was that prices of goods and the quantities
produced, exchanged and consumed would not change. If supply equals demand in each market,
and if no exogenous disturbance (e.g., in population, technology, tastes, etc.), there would seem
to be no reason for the prices or quantities to change in that system. But the conception of an
economic system at rest was understood to be overly restrictive, because of the large, and
perhaps causally important, share of economic activity – saving and investment – that is
predicated on the assumption and expectation that prices and quantities do not remain constant.

        The model of a stationary economy at rest in which all economic activity simply repeats
what has already happened before did not seem satisfying or informative to economists, but that
view of equilibrium remained dominant in the nineteenth century and for perhaps the first quarter
of the twentieth. Equilibrium was not an actual state that an economy could achieve, it was an
end state that economic processes would move toward if allowed to play themselves out without
further disturbance. This idea of a stationary timeless general equilibrium is found in the writings
of the classical economists, especially Ricardo and J. S. Mill who used the idea of a stationary
state as the end-state towards which natural economic processes were driving an economic
system.

        This, not very satisfactory, concept of equilibrium was undermined when Jevons,
Menger, Walras, and their followers began to develop the idea of optimizing decisions by
rational consumers and producers. The notion of optimality provided the key insight that made it
possible to refashion the earlier classical equilibrium concept into a new, more fruitful and
robust, version.

If each economic agent (household or business firm) is viewed as making optimal choices, based on some scale of preferences, and subject to limitations or constraints imposed by their capacities, endowments, technologies, and the legal system, the equilibrium of an economy can be understood as a state in which each agent, given his subjective ranking of the feasible alternatives, is making an optimal decision, and each optimal decision is both consistent with, and contingent upon, those of all other agents. The optimal decisions of each agent must simultaneously be optimal from the point of view of that agent while being consistent, or compatible, with the optimal decisions of every other agent. In other words, the decisions of all buyers of how much to purchase must be consistent with the decisions of all sellers of how much to sell. But every decision, just like every piece in a jig-saw puzzle, must fit perfectly with every other decision. If any decision is suboptimal, none of the other decisions contingent upon that decision can be optimal.

The idea of an equilibrium as a set of independently conceived, mutually consistent, optimal plans was latent in the earlier notions of equilibrium, but it could only be coherently articulated on the basis of a notion of optimality. Originally framed in terms of utility maximization, the notion was gradually extended to encompass the ideas of cost minimization and profit maximization. The concept of an optimal plan allowed a uniquely economic idea of equilibrium to be formulated, not in terms of stationarity, but in terms of the mutual consistency of optimal plans. Once equilibrium was conceived as the mutual consistency of optimal plans, the unnecessary restrictiveness of defining equilibrium as a stationary system became apparent, though it took decades before an intertemporal dynamic definition was articulated.

An optimal plan may be carried out, not just at a single moment, but over the course of time. Indeed, the idea of an optimal plan is, at the very least, suggestive of a future that need not simply repeat the present. So, once the idea of equilibrium as a set of mutually consistent optimal plans was grasped, it was to be expected that the concept of equilibrium could be formulated in a manner accommodating the existence of change and development over time. But incorporating change and development into an equilibrium framework of optimality required an extended process of further intellectual reflection before the idea of equilibrium could be formulated in a way that allowed the passage of time to have significance beyond a mere name assigned to one of the *n* dimensions in vector space.

This paper examines the slow process by which the concept of equilibrium was transformed from a timeless or static concept into an intertemporal one by focusing on the pathbreaking contribution of F. A. Hayek who, along with Erik Lindahl and Gunnar Myrdal, was the first to articulate the concept. Beyond explaining his initial articulation of the concept, I examine three noteworthy, but very different, derivative versions of the intertemporal equilibrium: (1) Roy Radner's technically more sophisticated version of Hayek's 1937 articulation an equilibrium of plans, prices, and price expectations, (2) J. R. Hick's temporary equilibrium, and (3) Robert Lucas's rational-expectations equilibrium.

Before discussing these three versions of intertemporal equilibrium, I summarize in section two Hayek's seminal 1937 contribution clarifying the necessary conditions for the existence of an intertemporal equilibrium. Then, in section three, I elaborate on an important, and often neglected, distinction, first stated and clarified by Hayek in his 1937 paper, between perfect foresight and what I call contingently correct foresight. That distinction is essential for understanding the distinction between the canonical Arrow-Debreu-McKenzie (ADM) model of general equilibrium, and Roy Radner's 1972 generalization of that model as an equilibrium of plans, prices and price expectations, which I describe in section four.

Radner's generalization of the ADM model captured the spirit and formalized Hayek's insights about the nature and empirical relevance of intertemporal equilibrium. But to be able to prove the existence of an equilibrium of plans, prices and price expectations, Radner had to make assumptions about agents that Hayek, in his philosophically parsimonious view of human knowledge and reason, was unwilling to accept. In section five, I explore how Hicks's concept of temporary equilibrium, clearly inspired by Hayek, though later credited by Hicks (1965) to Erik Lindahl (1929 [1939]), provides an important bridge connecting the pure hypothetical equilibrium of correct expectations and perfect consistency of plans with the messy real world in which expectations are inevitably disappointed and plans routinely – and sometimes radically – revised. The advantage of the temporary-equilibrium framework is to provide the conceptual tools with which to understand how financial crises can occur and how such crises can be propagated and transformed into economic depressions, thereby making possible the kind of business-cycle model that Hayek tried unsuccessfully to create. But just as Hicks unaccountably failed to credit Hayek for the insights that inspired his temporary-equilibrium approach, Hayek failed to see the potential of temporary equilibrium as a modeling strategy to combine the theoretical discipline of the equilibrium method with the reality of expectational inconsistency across individual agents.

In section six, I discuss the Lucasian idea of rational expectations in macroeconomic models, mainly to point out that, in many ways, it simply assumes away the problem of plan expectational consistency with which Hayek, Hicks, Radner and others who developed the idea of intertemporal equilibrium were so profoundly concerned.

II   Hayek and the Concept of Intertemporal Equilibrium

Because current, and otherwise identical, goods and services in the future can be treated as economically distinct goods and services, defining the conditions for an intertemporal equilibrium is formally almost equivalent to defining the conditions for a static, stationary equilibrium. Just as the conditions for a static equilibrium could be stated in terms of equalities between marginal rates of substitution of goods in consumption and in production to their corresponding price ratios, the conditions for an intertemporal equilibrium could be stated in

terms of equalities between the marginal rates of intertemporal substitution in consumption and in production and the corresponding intertemporal price ratios (Bliss 1975).

The formal identity between the necessary conditions for a static equilibrium and the necessary conditions for an intertemporal equilibrium is fully preserved in the ADM model in which there is a complete set of forward markets covering all contingent events. However, that formal identity cannot be maintained when there is an incomplete set of markets, because without a complete set of markets agents cannot all optimize based on their *common knowledge* of actual prices. When forward markets are incomplete, agents must optimize based not only on their common knowledge of actual prices but on *unknown* future prices about which agents must form *expectations*. Thus, unlike the static model or the quasi-static ADM model, in a minimally realistic intertemporal model, marginal rates of substitution cannot be equated with ratios of known actual prices, but must be equated with ratios of *unknown expected* prices or with ratios of *unknown expected* prices to known actual prices. It therefore follows that unless all economic agents have the same expectations of the future prices in terms of which they formulate their optimal plans, those plans cannot be mutually consistent.

Although the first English exposition of the concept of intertemporal equilibrium was offered by Hayek (1937), the concept came to be widely known to the economics profession through the work of J. R. Hicks (1939) in which he distinguished between a full dynamic equilibrium in which expectations are correct and a temporary equilibrium in which expectations of future prices need not be correct while current prices always adjust to clear current (spot) markets.[1] Despite a general acknowledgment in his preface of the contribution of Hayek to the ideas presented in Value and Capital, Hicks made no specific acknowledgment of Hayek's, or, for that matter, of any other author's, contribution to the idea of intertemporal equilibrium.

A quarter of a century later when Hicks (1965) revisited the idea of temporary equilibrium, he belatedly acknowledged Erik Lindahl's (1929 [1939], 1930 [1939]) influence, again without mentioning Hayek in this context. However, Hicks (1933 [1982]) had credited Hayek (1928 [1984]) for developing the idea of an intertemporal equilibrium first suggested by Frank Knight (1924) without mentioning Lindahl. And, finally, Hicks (1983) credited Myrdal for the idea of temporary equilibrium and Lindahl "for how (formally at least) to string my temporary equilibria together." Interestingly, Lindahl himself cited Hayek's 1928 paper as

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[1] Flow demands and flow supplies need not be equal, but accumulation or decumulation of stocks is voluntary in the sense that, given the future price expectations of stock holders, stock holdings increase or decrease by the amounts desired. See Hicks (1982, 232)

> What makes the difference is that on the flexprice method it is insisted that the producer will only accumulate stocks if he thinks that the price he will be able to get, by selling them in some future period, will be better (in spite of the costs of holding) than what he could get by selling now; so in this sense the accumulation is *voluntary*. If the behaviour of all markets is interpreted in this manner, the system is regarded as being *in equilibrium* all the time. . . . The flexprice method is a *temporary equilibrium* method.

making a contribution similar to his own, though that should not be taken as evidence that Hayek deserves credit for priority over Lindahl in developing the concept. In any event, Myrdal's original contribution goes back to 1927, so his claim to priority might be stronger than either Hayek's or Lindahl's, and there is no doubt that three initially developed their ideas independently.[2]

The definitive articulation of the concept of intertemporal equilibrium is now widely accepted to be the Arrow-Debreu-McKenzie (ADM) general-equilibrium model. But the ADM model has a legitimate claim to being a model of intertemporal equilibrium, the extremely restrictive set of assumptions upon which it is based render that claim somewhat tenuous inasmuch as all economic decisions are taken before the clock starts ticking; the transactions executed once the clock does start simply follow a pre-determined script. In the ADM model, the passage of time is a triviality, merely recording the sequential execution of production and consumption actions previously decided upon. The ADM model performs this feat by gathering that *all* agents from all time periods at time zero with property endowments in hand ready and willing to transact –conditional on the determination of an equilibrium price vector allowing all optimal plans to be simultaneously executed over the entire duration of the model -- in a complete set of markets (including state-contingent markets covering the entire range of contingent events that will unfold in the course of time the outcomes of which could affect the wealth or well-being of any agent with the probabilities associated with every contingent event known in advance).

Just as identical goods in different physical locations or different time periods can be distinguished as different commodities that can be traded at different prices for delivery at specific times and places, identical goods can be distinguished under different states of the world (ice cream on July 4, 2017 in Washington DC at 2pm only if the temperature is greater than 90 degrees). Given the complete set of state-contingent markets and the known probabilities of the contingent events, an equilibrium price vector for the complete set of markets would give rise to optimal trades reallocating the risks associated with future contingent events and to an optimal allocation of resources over time. Although the ADM model is an intertemporal model only in a limited sense, it does provide a benchmark describing the characteristics of a set of mutually consistent optimal plans executed over the course of time.

The seminal work of Roy Radner (1972, 1979, 1982) in relaxing the extreme assumptions of the ADM model puts Hayek's contribution to the understanding of the necessary conditions

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[2] Milgate (1979) was perhaps the first to draw attention to Hayek's key role in developing the idea of intertemporal equilibrium in terms of the consistency of decentralized optimal plans and to document Hayek's claim to priority in introducing the concept to economists. See Currie and Steedman (1989) for an illuminating and insightful comparison of the evolution of Hayek's and Lindahl's understanding of intertemporal equilibrium between 1928 and 1939.

for an intertemporal equilibrium into proper perspective. At an informal level, Hayek had addressed the same kind of problem that, possessing far more powerful analytical tools than were available to Hayek, Radner was addressing: under what conditions could an economy with an incomplete set of markets be said to be in a state of intertemporal equilibrium? In an economy lacking the full set of forward and state contingent markets describing the ADM model, intertemporal equilibrium cannot be predetermined *before* trading even begins, but must, if such an equilibrium obtains, unfold as time passes. Outcomes might be expected, but they would not be predetermined.

Echoing Hayek, without, to my knowledge, referring to Hayek, Radner describes his intertemporal equilibrium under uncertainty as an equilibrium of plans, prices, and price expectations. Even if it exists, the Radner equilibrium differs from the ADM equilibrium, because, without a full set of markets, agents can't fully hedge against, or insure, all the risks to which they are exposed. The distinction between ex ante and ex post is not eliminated in the Radner equilibrium, though it is eliminated in the ADM equilibrium.

Additionally, because all trades in the ADM model have been executed before "time" begins, it seems impossible to rationalize holding any asset whose only use is to serve as a medium of exchange. In his early writings on business cycles, Hayek (1927 [1933]) questioned whether the holding of money could be explained in a model of full equilibrium, suggesting that monetary exchange, by severing the link between aggregate supply and aggregate demand characteristic of a barter economy as described by Say's Law, is the cause of systematic deviations from the intertemporal equilibrium. Patinkin (1965) "solved" the problem of explaining why money would be held in a general-equilibrium setting by way of an ad hoc assumption that quantity of real money balances held is an argument in household utility functions.

Hayek suggested that progress in analyzing economic fluctuations would be possible only if the Walrasian equilibrium method could somehow be extended to accommodate the existence of money, uncertainty, and other characteristics of the real world while maintaining the analytical discipline imposed by the equilibrium method and the optimization principle. It proved to be a task requiring resources beyond those at Hayek's, or probably anyone else's, disposal at that time. But it would be wrong to fault Hayek for having had the insight to perceive and frame a problem beyond his capacity to solve. What he may be criticized for is believing that he had in fact grasped the outlines of a solution when in fact he had perceived some aspects of the solution and offered seriously inappropriate policy recommendations based on that incomplete understanding.

In *Value and Capital*, Hicks also expressed doubt that the business-cycle fluctuations could be analyzed using a model of intertemporal equilibrium. He therefore proposed the method of temporary equilibrium as an alternative approach for analyzing fluctuations. The essence of

the temporary-equilibrium method is to analyze the behavior of an economy under the assumption that all markets for current delivery (spot markets) clear, while recognizing that demand and supply in spot markets depend not only on current prices but upon expected future prices, and that the failure of current prices to equal what they had been expected to be may cause economic agents to revise or abandon the optimal plans that they had previously chosen based on expectations that turned out to be disappointed. In the *Pure Theory of Capital*, Hayek (1941) briefly considered the temporary-equilibrium method as a possible modification of the Walrasian method that he had earlier proposed in *Monetary Theory and the Trade Cycle.* But after a brief critical discussion of the method, he dismissed it for reasons that remain obscure.[3] Hayek's dismissal of the temporary-equilibrium method seems in retrospect to have been one of his worst theoretical -- or perhaps, meta-theoretical -- blunders.

Decades later, C. J. Bliss (1983) showed that both the holding of an asset purely for its services as a medium of exchange and the existence of financial intermediaries (private banks) that supply financial assets held only to serve as a medium of exchange can be rationalized in a temporary-equilibrium framework. A temporary-equilibrium model with financial intermediaries allows not only the existence of private suppliers of a medium of exchange to be modeled in a straightforward way, but also makes it possible to specify general conditions under which the system of financial intermediaries to break down. The key variables of course are the expected-price vectors subject to which the plans of individual households, business firms, and financial intermediaries are being optimized. What Bliss showed is that there may be sets of expected-price vectors for which the existence of a temporary equilibrium cannot be proved using the standard fixed-point approach that has routinely been used in existence proofs since the existence proofs by Arrow, Debreu and McKenzie. The potential non-existence of a temporary equilibrium implies that absolute price flexibility in current markets may not, even in principle, achieve a temporary equilibrium, because there is no vector of current spot prices that solves the system of temporary-equilibrium equations. Price flexibility cannot lead to an equilibrium that does not exist.

Thus, price expectations are, necessarily, equilibrating variables. But although we can think of an economic mechanism whereby appropriate price adjustments in response to observed excess demands or excess supplies could plausibly lead to equilibrium, there is no corresponding economic mechanism that whereby expected prices adjust in a way that could plausibly lead to equilibrium.

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[3] Hayek's rather sketchy discussion of the temporary equilibrium method describes it as an application of Marshallian partial equilibrium, which suggests that Hayek may have been misled by Hicks's note to Chapter IX in which Hicks refers to Marshall's assumption of constant marginal utility of money to assume away complications arising from the problem of "false trading" at non-equilibrium prices in the temporary equilibrium framework. The Marshallian assumption was largely a side issue, but a hurried reading may have caused Hayek to misunderstand what Hicks was driving at. This seems a rather implausible explanation for Hayek's apparent confusion, but I am unable to come up with any alternative hypothesis to account for Hayek's misunderstanding

Modern macroeconomics continues to neglect the temporary-equilibrium method; macroeconomists have instead generally adopted the rational-expectations methodology, a methodology that elevates question-begging into a fundamental axiom of rationality. The crucial error in the rational-expectations methodology was to misunderstand the role of the comparative-statics method developed by Samuelson (1947). The role of the comparative-statics method is to isolate the pure theoretical effect of a parameter change under a *ceteris-paribus* assumption. Such an effect could be derived only by comparing two equilibria under the assumption of a locally unique and stable equilibrium before and after the parameter change. Thus, all the refutable theorems of microeconomics using the method of comparative statics are derived under the assumption that all markets but the one under analysis are in equilibrium. If macroeconmoics requires microfoundations, microeconomics equally requires macrofoundations without which the method of comparative statics is unavailable. But the method of comparative statics is completely inappropriate for analyzing most macroeconomic problems, which are precisely concerned with the failure of the economy to achieve, or even to approximate, the unique and stable equilibrium state posited by the comparative-statics method.

Moreover, the original empirical application of the rational-expectations hypothesis by Muth (1961) was concerned with the behavior of a single market populated by well-informed specialists who could be presumed to have well-founded expectations of future prices implicitly conditional on a stable macroeconomic environment. Under conditions of macroeconomic instability, it is doubtful that the accumulated knowledge and experience of market participants enables them to form accurate expectations of the future course of prices even in those markets about which they have expert knowledge. While the rational-expectations hypothesis, considered as a positive hypothesis of how traders in a market actually form expectations, clearly has empirical relevance and support, that relevance presumes stable market conditions under which markets can be assumed to be operating in the neighborhood of an equilibrium. For many of the problems addressed by macroeconomists, that assumption is neither relevant nor appropriate.

III   Correct versus Perfect Foresight in Intertemporal Equilibrium

In the previous section, I discussed Hayek's seminal insight into the meaning of intertemporal equilibrium. His breakthrough was to see that an equilibrium can be understood not as a stationary state in which nothing changes, but as a state in which decentralized plans are both optimal from the point of view of the individuals formulating the plans and mutually consistent, so that the individually optimal plans, at least potentially, could be simultaneously executed. In the simple one-period model, the plans of individuals extending over a single-period are constrained by the necessary equality for each agent between the value of all planned purchases and the value of all planned sales in that period. A single-period or stationary equilibrium, if it exists, is characterized by a set of prices such that, under the optimal plans corresponding to that set of prices, the total amount demanded equals the total amount supplied for each product. Thus, an equilibrium price vector has the following properties: (a) every

individual is choosing optimally, and (b) those individually optimal choices are mutually consistent. The mutual consistency of those choices is manifested in the equality of the total amount demanded and the total amount supplied of each product in that single period.

In an intertemporal context, the prices on the basis of which optimal plans are chosen cannot be just those prices at which transactions are currently being executed; the relevant set of prices must also include expected future prices at which currently planned transactions will be executed. Because even choices about transactions today may depend on the expected prices at which future transactions will take place, expected future prices affect not only future demands and supplies they also affect current demands and supplies. So the problem posed by the concept of intertemporal equilibrium is how to generalize the single-period notion of an equilibrium as a vector of all currently observed prices of goods and services into a multi-period context in which the equilibrium price vector includes the prices of goods currently traded and the expected prices of goods that agents plan to buy or sell in the future.

But insofar as optimal plans depend on expected future prices, those optimal plans can be mutually consistent only if they are based on the *same* expected future prices; if their choices are based on different expected future prices, then expectations cannot all realized. If the expectations of at least one agent, and probably of many agents, will necessarily be disappointed, the plans of at least one agent, and probably of many agents, will not be optimized relative to the actual future prices, and will therefore have to be revised.

The recognition that the mutual consistency of optimal plans requires individuals to accurately foresee the future prices upon which their optimal choices are conditioned suggests that individual agents must be endowed with remarkable capacities of foresight. To assume that all individual agents would be endowed with the extraordinary ability to foresee correctly all the future prices relevant to their optimal choices of intertemporal plans seemed an exceedingly unrealistic assumption on which to premise an economic model.

Concluding that the concept of intertemporal equilibrium was entirely contingent on the wildly unrealistic, indeed self-contradictory, assumption of perfect foresight, Oskar Morgenstern (1935 [1976]) launched a strident attack against the concept.

> The impossibly high claims which are attributed to the intellectual efficiency of the economic subject immediately indicate that there are included in this equilibrium system not ordinary men, but rather, at least to one another, exactly equal demi-gods, in case the claim of complete foresight is fulfilled. If this is the case, there is, of course, nothing more to be done. If "full" or "perfect" foresight is to provide the basis of the theory of equilibrium in the strictly specified sense, and in the meaning obviously intended by the economic authors, then, a completely meaningless assumption is being considered. If limitations are introduced in such a way that the perfection of foresight is not reached, then these limitations are to be stated very precisely. They would have to be

so narrowly drawn that the fundamental aim of producing ostensibly full rationality of the system by means of high, de facto unlimited, foresight, would be lost. For the theoretical economist, there is no way out of this dilemma. In this discussion, "full" and "perfect" foresight are not only used synonymously, but both are employed, moreover, in the essentialIy more exact sense of limitlessness. This expression would have to be preferred because with the words "perfect" or "imperfect", there arise superficial valuations which play no role here at all.

Continuing in this vein, Morgenstern tried to support his contention that perfect foresight was a self-contradictory concept by positing an example that would figure in Morgenstern's later development of game theory with his collaborator John von Neumann (Von Neumann and Morgenstern 1944)[4]

> Sherlock Holmes, pursued by his opponent, Moriarity, leaves London for Dover. The train stops at a station on the way, and he alights there rather than traveling on to Dover. He has seen Moriarity at the railway station, recognizes that he is very clever and expects that Moriarity will take a faster special train in order to catch him in Dover. Holmes' anticipation turns out to be correct. But what if Moriarity had been still more clever, had estimated Holmes' mental abilities better and had foreseen his actions accordingly? Then, obviously, he would have traveled to the intermediate station. Holmes, again, would have had to calculate that, and he himself would have decided to go on to Dover. Whereupon, Moriarity would again have "reacted" differently. Because of so much thinking they might not have been able to act at all or the intellectually weaker of the two would have surrendered to the other in the Victoria Station, since the whole flight would have become unnecessary. Examples of this kind can be drawn from everywhere. However, chess, strategy, etc. presuppose expert knowledge, which encumbers the example unnecessarily.

> One may be easily convinced that here lies an insoluble paradox. And the situation is not improved, but, rather, greatly aggravated if we assume that more than two individuals-as, for example, is the case with exchange-are brought together into a position, which would correspond to the one brought forward here. Always, there is exhibited an endless chain of reciprocally conjectural reactions and counter-reactions. This chain can never be broken by an act of knowledge but always only through an arbitrary act-a resolution. This resolution, again, would have to be foreseen by the two or more persons concerned. The paradox still remains no matter how one attempts to twist or turn things around. Unlimited foresight and economic equilibrium are thus irreconcilable with one another. But can equilibrium really take place with a faulty, heterogeneous foresight, however, it may be disposed? This is the question which arises at once when an answer is sought. One can even say this: has foresight been truly introduced at all into the consideration of equilibrium, or, rather, does not the theorem of

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[4] Düppe and Weintraub (2016) have recently documented the importance of the contribution made by Morgenstern's research assistant, Abraham Wald, who was in fact his mathematical guide and mentor, and arguably was deserving of co-authorship of *The Theory of Games and Economic Behavior* and thus recognition as a co-founder of game theory.

equilibrium generally stand in no proven connection with the assumptions about foresight, so that a false assumption is being considered?

Zappia (1999) suggests that it was Morgenstern's attack on the notion of intertemporal equilibrium and perfect foresight that prompted Hayek (1937) to offer his classic articulation of the idea. The point that Hayek clarified in his 1937 version is that correct foresight is not an assumption from which the existence of an intertemporal equilibrium can be causally deduced; there is no assertion that a state of equilibrium is the result of correct foresight. Rather, correct foresight is what defines "intertemporal equilibrium" in economic theory. Morgenstern's conceptual error was to mistake a tautological statement about what would have to be true if an intertemporal equilibrium were to obtain for a statement about what would cause an intertemporal equilibrium to actually come into being. Or, as Hayek (1937 41-42) put it,

> Correct foresight is then not, as it has sometimes been misunderstood, a precondition which must exists in order that equilibrium may be arrived at. It is rather the defining characteristic of a state of equilibrium. Nor need foresight for this purpose be perfect in the sense that it need extend into the indefinite future, or that everybody must foresee everything correctly. We should rather say that equilibrium will last so long as the anticipations prove correct, and that they need to be correct only on those point which are relevant for the decisions of the individuals.

It is also interesting to note that the subsequent development of game theory in which Morgenstern played such an important role, shows that under a probabilistic interpretation of the interaction between Holmes and Moriarity, there could be an optimal mixed strategy that would provide an equilibrium solution of repeated Holmes-Moriarity interactions. But if the interaction is treated as a single non-repeatable event with no mixed strategy available to either party, the correct interpretation of the interaction is not that the idea of correct foresight makes no sense, but that there is no equilibrium solution to the interaction. If there is no equilibrium solution, then it is precisely the absence of an equilibrium solution that precludes the existence of correct foresight. The existence of equilibrium is thus a necessary condition for correct foresight, not the other way around.

IV   Roy Radner on the Equilibrium of Plans, Prices, and Price Expectations

In this section, I discuss Radner's treatment of an equilibrium of plans, prices, and price expectations (EPPPE) and its relationship to Hayek's conception of intertemporal equilibrium, of which Radner's treatment, in my view, is a technically more sophisticated version. Although I have seen no evidence that Radner was directly influenced by Hayek's work, Radner's conception of EPPPE seems to be an updated and enhanced version of Hayek's conception of an intertemporal equilibrium as a state in which agents, independently formulating their own optimal plans based on the observed current prices – their common knowledge – and conditional

on unobserved but expected future prices, carry out those plans as intended. While currently observed prices are common knowledge – not necessarily a correct description of economic reality, but a convenient simplifying assumption – the future prices that individual agents expect to observe are subjective knowledge based partly on common knowledge but also on private knowledge and on whatever methods with which they form expectations of future prices.

If an agent has chosen an optimal plan given current and expected future prices, that plan will not be changed unless the agent acquires new information that renders the existing plan sub-optimal relative to the new information. Otherwise, there would be no reason for the agent to deviate from an optimal plan. The new information that could cause an agent to change a formerly optimal plan would either affect the preferences of the agent, the technology available to the agent, or would somehow be reflected in current prices or in expected future prices. But it seems improbable that there could be a change in preferences or technology that would not also be reflected in current or expected future prices. So, absent a change in current or expected future prices, there would seem to be almost no likelihood that an agent would deviate from a plan that was optimal given current prices and the future prices expected by the agent.

The mutual consistency of the optimal plans of independent agents therefore turns out to be equivalent to the condition that all agents observe the same current prices – their common knowledge – and have exactly the same forecasts of the future prices upon which they have relied in choosing their optimal plans. Even should their forecasts of future prices turn out to be wrong, at the moment before their forecasts of future prices were changed or disproved by observation, their plans were still mutually consistent relative to the information on which their plans were chosen. The failure of the equilibrium to be sustained may be attributed to a change in information rendering the formerly optimal plans sub-optimal given the change in information. But until the new information became available, the mutual consistency of optimal plans at a (perhaps fleeting) moment signified an equilibrium state. Thus, what defines an intertemporal equilibrium in which current prices are common knowledge is that all agents base their optimal plans on the same expectations of future prices.

There are fundamental differences between the Arrow-Debreu-McKenzie (ADM) equilibrium and the EPPPE. One difference worth mentioning is that, under the standard assumptions of the ADM model, the equilibrium is Pareto-optimal, and any Pareto-optimum allocation, by a suitable redistribution of initial endowments, could be achieved as a general equilibrium (two welfare theorems). These results do not generally hold for EPPPE, because, in contrast to the ADM model, it is possible for agents in EPPPE to acquire additional information over time, not only passively, but by devoting resources to produce or acquire information.

Devoting resources to obtaining information can cause inefficiency in two ways: first, by creating non-convexities (owing to start-up costs in information gathering activities) that are inconsistent with the uniform competitive prices characteristic of the ADM equilibrium, and

second, by creating incentives to devote resources to produce information whose value is derived from profits in trading with less well-informed agents. The latter source of inefficiency was discovered by Jack Hirshleifer (1971) in a classic paper.

But the feature of Radner's EPPPE that I want to emphasize here -- and what radically distinguishes it from the ADM equilibrium -- is its fragility. Unlike the ADM equilibrium which is established once and forever at time zero of a model in which all production and consumption starts in period one, the EPPPE, even if it ever exists, is momentary, and is subject to unraveling whenever there is a change in the underlying information upon which current prices and expected future prices depend, and upon which agents, in choosing their optimal plans, rely. Time is not just, as it is in the ADM model, an appendage to the EPPPE, and, as a result, EPPPE can account for many phenomena, practices, and institutions that are left out of the ADM model.

The two most relevant differences in this context are the existence of stock markets in which shares of firms are traded based on expectations of the future net income streams associated with those firms, and the existence of a medium of exchange supplied by private financial intermediaries known as banks. In the ADM model in which all transactions are executed in time zero, in advance of all the actual consumption and production activities determined by those transactions, there would be no reason to hold, or to supply, a medium of exchange. The ADM equilibrium allows for agents to borrow or lend at equilibrium interest rates to optimize the time profiles of their consumption relative to their endowments and the time profiles of their earnings. Since all such transactions are consummated in time zero, and since, through an undefined process, the complete solvency and the integrity of all parties to all transactions is ascertained in time zero, the probability of a default on any loan contracted at time zero is zero. As a result, each agent faces a single intertemporal budget constraint at time zero over all periods from 1 to n. Walras's Law therefore holds across all time periods for this intertemporal budget constraint, each agent transacting at the same prices in each period as every other agent does.

Once an equilibrium price vector is established in time zero, each agent knows that his optimal plan based on that price vector (which is the common knowledge of all agents) will be executed over time exactly as determined in time zero. The future income streams from each firm being known in advance, there is no reason for ownership shares in firms to be exchanged.

The ADM equilibrium describes an economic process very different from Radner's EPPPE, because in EPPPE, agents have no reason to assume that their current plans, even if they are momentarily both optimal and mutually consistent with the plans of all other agents, will remain optimal and consistent with the plans of all other agents. New information can arrive or can be produced, necessitating revisions in plans.

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Because even equilibrium plans are subject to revision, agents must take into account the solvency and credit worthiness of counterparties with whom they enter into transactions. The potentially imperfect credit-worthiness of at least some agents enables certain financial intermediaries (aka banks) to provide a service by offering to exchange their debt, which is widely considered to be more credit-worthy than the debt of ordinary agents, with agents seeking to borrow to finance purchases of either consumption or investment goods. Many agents seeking to borrow therefore prefer exchanging their debt for bank debt, bank debt being acceptable by other agents at face value. Moreover, because the acquisition of new information is possible, agents have reason to engage in speculative trades of commodities or assets. Such assets include shares of firms, and agents may revise their valuations of those firms as they revise their expectations about future prices and their expectations about the revised plans of those firms in response to newly acquired information.

I discuss the special role of banks at greater length in the following section on temporary equilibrium. But for now, I just want to underscore a key point: in the EPPPE, unless all agents have the same expectations of future prices, Walras's Law need not hold. The proof that Walras's holds depends on the assumption that every agent buys or sells each commodity at the same price at which every other transactor buys or sells that commodity. But in the intertemporal context, in which only current, not future prices, are observed, plans for current and future prices are made based on expectations about future prices. If agents don't share the same expectations about future prices, agents making plans for future purchases based on overly optimistic expectations about the prices at which they will be able to sell, may make commitments to buy in the future (or commitment to repay loans to finance purchases in the present) that they will be unable to discharge, thereby violating Walras's Law. Reneging on commitments to buy in the future or to repay obligations incurred in the present may rule out the existence of even a temporary equilibrium in the future.

Finally, let me add a word about Radner's terminology. Radner (1987, 312) writes:

A trader's expectations concern both future environmental events and future prices. Regarding expectations about future environmental events, there is no conceptual problem. According to the Expected Utility Hypothesis, each trader is characterized by a subjective probability measure on the set of complete histories of the environment. Since, by definition, the evolution of the environment is exogenous, a trader's conditional probability of a future event, given the information to date, is well defined.

It is not so obvious how to proceed with regard to trader's expectations about future prices. I shall contrast two possible approaches. In the first, which I shall call the perfect foresight approach, let us assume that the behaviour of traders is such as to determine, for each complete history of the environment, a unique corresponding sequence of price system[s]. . .

Thus, the perfect foresight approach implies that, in equilibrium, traders have common price expectation functions. These price expectation functions indicate, for each date-event pair, what the equilibrium price system would be in the corresponding market at that date-event pair. . . . [I]t follows that, in equilibrium the traders would have strategies (plans) such that if these strategies were carried out, the markets would be cleared at each date-event pair. Call such plans *consistent*. A set of common price expectations and corresponding consistent plans is called an *equilibrium of plans, prices, and price expectations*.

My only reservation about Radner's formulation is his definition of equilibrium in terms of the intrinsic capacity of the traders to predict prices rather than the correctness of those expectations. For purposes of defining EPPE, what enables or allows traders to predict future prices correctly is irrelevant; whether they are possessed of the correct model of the economy or they are just lucky and have randomly all formed the same expectations of future prices does not matter for that instant when all individual expectations are in accord.

But pursuing the idea that agents have implicit or explicit models of how the economy works, Radner also formulates an alternative version of his perfect-foresight approach in which agents don't all share the same information. In such cases, it becomes possible for traders to make inferences about the environment by observing that prices differ from what had been expected.

The situation in which traders enter the market with different non-price information presents an opportunity for agents to learn about the environment from prices, since current prices reflect, in a possibly complicated manner, the non-price information signals received by the various agents. To take an extreme example, the "inside information" of a trader in a securities market may lead him to bid up the price to a level higher than it otherwise would have been. . . . [A]n astute market observer might be able to infer that an insider has obtained some favourable information, just by careful observation of the price movement. (p. 313)

The ability to infer non-price information from otherwise inexplicable movements in prices suggests to Radner to a particular concept of rational expectations equilibrium.

[E]conomic agents have the opportunity to revise their individual models in the light of observations and published data. Hence, there is a feedback from the true relationship to the individual models. An equilibrium of this system, in which the individual models are identical with the true model, is called a rational expectations equilibrium. This concept of equilibrium is more subtle, of course, that the ordinary concept of equilibrium of supply and demand. In a rational expectations equilibrium, not only are prices determined so as to equate supply and demand, but individual economic agents correctly perceive the true relationship between the non-price information received by the market participants and the resulting equilibrium market prices. (p. 313)

Though this discussion is very interesting from several theoretical angles, as an explanation of what is entailed by an economic equilibrium, it misses the key point, which is the one identified by Hayek (1937). An equilibrium corresponds to a situation in which all agents have identical expectations of the future prices upon which they are making optimal plans given the commonly observed current prices and the expected future prices. If all agents are indeed formulating optimal plans based on the information that they have at that moment, their plans will be mutually consistent and will be executable simultaneously without revision as long as the state of their knowledge at that instant does not change. How it happened that they arrived at identical expectations -- by luck chance or supernatural powers of foresight -- is irrelevant to that definition of equilibrium. Though acknowledging that, under the perfect-foresight approach, he is endowing economic agents with a wildly unrealistic powers of imagination and computational capacity, Radner seems not to have grasped that no assumption about the capacities of agents to understand how the economy works is necessary for a *definition* of EPPPE.

> Although it is capable of describing a richer set of institutions and behavior than is the Arrow-Debreu model, the perfect-foresight approach is contrary to the spirit of much of competitive market theory in that it postulates that individual traders must be able to forecast, in some sense, the equilibrium prices that will prevail in the future under all alternative states of the environment. . . .[T]his approach . . . seems to require of the traders a capacity for imagination and computation far beyond what is realistic. . . .
>
> These last considerations lead us in a different direction, which I shall call the bounded rationality approach. . . . An example of the bounded-rationality approach is the theory of temporary equilibrium. (pp. 313-14)

By eschewing any claims about the rationality of the agents or their computational powers, one can simply talk about whether agents do or do not have identical expectations of future prices and what the implications of those assumptions are. When expectations do agree, there is at least a momentary equilibrium of plans, prices and price expectations. When they don't agree, the question becomes whether even a temporary equilibrium exists and what kind of dynamic process is implied by the divergence of expectations. That it seems to me would be a fruitful way forward for macroeconomics to follow. In the next section, I discuss some of the characteristics and implications of a temporary-equilibrium approach for macroeconomics.

V   Hayek and Temporary Equilibrium

In discussing intertemporal equilibrium, I have been emphasizing that the defining characteristic of an intertemporal equilibrium is that all agents share the same expectations of future prices – or at least the same expectations of those future prices on which they are basing their optimizing plans – over their planning horizons. At a given moment at which agents share the same expectations of future prices, the optimizing plans of the agents are consistent, because none of the agents would have any reason to change his optimal plan as long as price

expectations do not change, or are not disappointed as a result of prices turning out to be different from what they had been expected to be.

The failure of expectations about future prices to be realized would therefore signify that the information available to agents in forming their expectations and choosing optimal plans conditional on those expectations had been superseded by new information. The arrival of new information can thus be viewed as a cause of disequilibrium, as can any difference in information among agents. The relationship between information and equilibrium can be described as follows: differences in information or differences in how agents interpret information lead to disequilibrium, because information differences lead agents to form divergent expectations of future prices.

Now the natural way to generalize the intertemporal equilibrium model is to allow for agents to have different expectations of future prices reflecting their differences in how they acquire, or in how they process, information. But if agents have different information, so that their expectations of future prices are not the same, the plans on which agents construct their subjectively optimal plans will be inconsistent and incapable of implementation without revision. Unfortunately, this generalization seems incompatible with the equilibrium of optimal plans, prices and price expectations described by Hayek and Radner.

So the question that I want to explore is how to reconcile the absence of equilibrium of optimal plans, prices, and price expectations, with the intuitive notion of market clearing that we use to analyze asset markets and markets for current delivery. If markets for current delivery and for existing assets are in equilibrium in the sense that prices are adjusting in those markets to equate demand and supply in those markets, how can we understand the idea that the optimizing plans that agents are seeking to implement are mutually inconsistent?

The classic attempt to analyze this intermediate situation, which partially is, and partially is not, an equilibrium, was made by J. R. Hicks (1939) who, following Myrdal and Lindahl, used the term "temporary equilibrium" to describe a situation in which current prices are adjusting to equilibrate supply and demand in current markets even though agents are basing their choices of optimal plans to implement over time on divergent expectations of future prices. The divergence of the price expectations on the basis of which agents choose their optimal p folans makes it inevitable that some or all of those expectations won't be realized, and that some, or all, of those agents won't be able to implement the optimal plans that they have chosen, without at least some revisions.

In his early writings on business-cycle theory, Hayek proposed analyzing business cycles as deviations from an equilibrium path. The problem -- which Hayek acknowledged -- with this approach is that the tools of equilibrium analysis were well-suited to analyze the equilibrium path of an economy, but could not easily be deployed to analyze how an economy performs

when the consistency between individual plans characteristic of equilibrium states, renders those plans both sub-optimal and inconsistent and hence incapable of implementation. Moreover, cyclical deviations from an equilibrium path tend not to be immediately self-correcting, but rather seem to be cumulative.

Hayek ([1927] 1933, 1931) attributed the tendency toward cumulative deviations from equilibrium to the lagged effects of monetary expansion, which cause cumulative distortions in the capital structure of the economy, leading at first to an investment-driven expansion of output, income and employment, followed by cumulative contractions in output, income, and employment. But Hayek was unable to realize his goal of using the methods of equilibrium analysis to provide a compelling explanation of business-cycle fluctuations, so that his monetary theory of the cycle remained largely distinct from, if not inconsistent with, the equilibrium analysis.

In retrospect at least it seems that the Hicksian temporary-equilibrium construct would have been the appropriate theoretical framework within which to formulate a monetary analysis of the business cycle consistent with equilibrium analysis. The temporary-equilibrium framework could have provided Hayek with the bridge he required to bring the tools of an intertemporal equilibrium analysis to bear on the essentially disequilibrium phenomenon of a business-cycle downturn.[5]

I now try to explain how the temporary-equilibrium method makes it possible to understand the conditions for a cumulative monetary disequilibrium. I make no attempt to outline a specifically Austrian or Hayekian theory of monetary disequilibrium, but perhaps others may find it worthwhile to do so.

As noted in the previous section, agents are certainly aware that their price expectations may not be realized, and that their plans may have to be revised. Agents also recognize that, given the uncertainty underlying all expectations and plans, not all debt instruments (IOUs) are equally reliable. The general understanding that debt – promises to make future payments -- must be evaluated and assessed makes it profitable for some agents to specialize in debt assessment. Such specialists are known as financial intermediaries. And, as also noted previously, the existence of financial intermediaries cannot be rationalized in the ADM model, because, with contracts being made in period zero, there can be no doubt that the equilibrium exchanges

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[5] Keynes (1936) was also seeking to bridge the gap between the tools of equilibrium analysis and a disequilibrium phenomenon. But instead of pursuing an intertemporal equilibrium approach, Keynes fell back on a single-period multiplier analysis with appendages such as the marginal efficiency of capital that were explicitly forward-looking but remained in the background of his single-period equilibrium framework. Laidler (1998) insightfully explores these issues at length.

planned in period zero will be executed whenever and exactly as scheduled, so that, at time zero, all promises to pay in the future are equally good and reliable.

For our purposes, a particular kind of financial intermediary -- banks -- are of primary interest. A key function of a bank is to assess the quality of the IOUs offered by non-banks, and to select from the IOUs offered to them those that are sufficiently reliable to be accepted by the bank. Once a prospective borrower's IOU is accepted, the bank exchanges its own IOU for the non-bank's IOU. Non-banks generally do not accept the IOU of another non-bank, at least not on terms as favorable as those on which the bank offers in accepting an IOU. In return for the non-bank IOU, the bank credits the borrower with a corresponding amount of its own IOUs, which, because the bank promises to redeem its IOUs for the numeraire commodity on demand, is generally accepted at face value.

Thus, bank debt functions as a medium of exchange even as it enables non-bank agents to make current expenditures they could not have made otherwise if they can demonstrate to the bank that they are sufficiently likely to repay the loan in the future at agreed upon terms. Such borrowing and repayments are presumably similar to the borrowing and repayments that would occur in the ADM model unmediated by any financial intermediary. In assessing whether a prospective borrower will repay a loan, the bank makes two kinds of assessments. First, does the borrower have sufficient income-earning capacity to generate enough future income to make the promised repayments that the borrower would be committing himself to make? Second, should the borrower's future income, for whatever reason, turn out to be insufficient to finance the promised repayments, does the borrower have collateral that would allow the bank to secure repayment from the collateral offered as security? In making both kinds of assessments the bank has to form an expectation about the future -- the future income of the borrower and the future value of the collateral.

In a temporary-equilibrium context, the expectations of future prices held by agents are not the same, so the expectations of future prices of at least some agents will not be accurate, and some agents won't be able to execute their plans as intended. Agents that can't execute their plans as intended are vulnerable if they have incurred future obligations based on their expectations of future prices that exceed their repayment capacity given the actually realized future prices. If they have sufficient wealth -- i.e., if they have asset holdings of sufficient value -- they may still be able to repay their obligations. However, in the process they may have to sell assets or reduce their own purchases, thereby reducing the income earned by other agents. Selling assets under pressure of obligations coming due is almost always associated with selling those assets at a significant loss, which is precisely why it is usually preferable to finance current expenditure by borrowing funds and making repayments on a fixed schedule than to finance the expenditure by asset sales.

Now, in adjusting their plans when they observe that their price expectations are disappointed, agents may respond in two different ways. One type of adjustment is to increase sales or decrease purchases of particular goods and services that they had previously been planning to purchase or sell; such marginal adjustments do not fundamentally alter what agents are doing and are unlikely to seriously affect other agents. But it is also possible that disappointed expectations will cause some agents to conclude that their previous plans are no longer sustainable under the conditions in which they unexpectedly find themselves, so that they must scrap their old plans, replacing them with completely new plans instead. In the latter case, the abandonment of plans that are no longer viable given disappointed expectations may cause other agents to conclude that the plans that they had expected to implement are no longer profitable and must therefore be scrapped.

When agents whose price expectations have been disappointed respond with marginal adjustments in their existing plans rather than scrapping and replacing them with new ones, a temporary equilibrium with disappointed expectations may still exist, and that equilibrium may be reached through appropriate price adjustments in the markets for current delivery despite the divergent expectations of future prices held by agents. Operation of the price mechanism may still be able to achieve a reconciliation of revised but sub-optimal plans. The sub-optimal temporary equilibrium will be inferior to the allocation that would have resulted had agents all held correct expectations of future prices. Nevertheless, given a history of incorrect price expectations and misallocations of capital assets, labor, and other factors of production, a sub-optimal temporary equilibrium may be the best feasible outcome.

But here is the problem. There is no guarantee that, when prices turn out to be very different from what they were expected to be, the excess demands of agents will adjust smoothly to changes in current prices. A plan that was optimal based on the expectation that the price of widgets would be $500 a unit may well be untenable at a price of $120 a unit. When realized prices are very different from what they had been expected to be, those price changes may lead to discontinuous adjustments, violating a basic assumption -- the continuity of excess demand functions -- necessary to prove the existence of an equilibrium. For example, a small change in price may be just sufficient to trigger the bankruptcy of one or more business firms or households in which case the quantity response to that small price change becomes discontinuous at that point. Once output prices reach some minimum threshold, the best response for some firms may be to shut down, the excess demand for the product produced by the firm becoming discontinuous at the threshold price. The firms shutting down operations may be unable to repay loans they had obligated themselves to repay based on price expectations that are later disappointed. If ownership shares in firms forced to cease production are held by households that have predicated their consumption plans on prior borrowing and current repayment obligations, the ability of those households to fulfill their obligations may be compromised once those firms stop paying out the expected profit streams. Banks holding debts incurred by firms or households that borrowers cannot service may find that their own net worth

is reduced sufficiently to make the banks' own debt unreliable, potentially causing a breakdown in the payment system. Such effects are entirely consistent with a temporary-equilibrium model if actual prices turn out to be very different from what agents had expected and upon which they had constructed their future consumption and production plans.

Sufficiently large differences between expected and actual prices in a given period may result in discontinuities in excess demand functions once prices reach critical thresholds, thereby violating the standard continuity assumptions on which the existence of general equilibrium depends under the fixed-point theorems that are the lynchpin of modern existence proofs. My argument follows that of Bliss (1983) who suggested, as I did above, that the divergence of individual expectations implies that agents will not typically regard the debt issued by other agents as homogeneous. Bliss therefore posited the existence of a "Financier" that would scrutinize the plans of prospective borrowers to determine if the plan underlying the prospective loan sought by a borrower would likely generate sufficient cash flow to enable the borrower to repay the loan. The role of the Financier is to ensure that the plans that firms are seeking financing in order to implement are not based on wildly unrealistic or divergent expectations of future prices, thereby avoiding a situation in which expectations must inevitably be disappointed.

I am unsure how to understand the function that Bliss's Financier is supposed to perform. Presumably the Financier is meant as a kind of idealized companion to the Walrasian auctioneer rather than as a representation of an actual institution, but the resemblance between what the Financier is supposed to do and what bankers actually do is close enough to prompt the question why Bliss chose an obviously fictitious character to weed out business plans based on implausible price expectations rather than have the role filled by more realistic characters that do what their real-world counterparts are supposed to do. The key distinction, I think, is that Bliss's Financier would be positioned to assess the price expectations of all borrowers in contrast to the actual bankers that are aware typically aware of only a small and probably not representative subset of the expectations of the entire universe of borrowers. Only a fictitious Financier would actually have access to the price expectations underlying all requests for financing and would then be better able to weed out or force a revision of those expectations that were most extreme and most inconsistent with "mainstream" expectations.

But from the perspective of positive macroeconomic and business-cycle theory, the explicit introduction of banks that, while intermediating between ultimate borrowers and ultimate lenders, provide a medium of exchange – based on convertibility either into a real commodity or into a fiat base money – seems to be a promising way to think about how a dynamic economy may, under some circumstance, function at or near a temporary equilibrium, but may, under other circumstances, become dysfunctional. This perspective would capture the potential for monetary disruptions caused by the lending and money-creating activities of private banks that was a central concern of Hayek while also providing an explicit rationale for those money-

creating operations by private banks that, in Hayek's business-cycle writings, seemed to be largely if not entirely destabilizing.

In the real world, we observe economies that sometimes appear to be functioning, from a macroeconomic perspective, reasonably well with high levels of employment, increasing per capita output and income, and reasonable price stability. At other times, these economies do not function well at all, with high unemployment and negative growth, sometimes with high rates of inflation or with deflation. Sometimes, these economies are beset with financial crises in which there is a general crisis of solvency, and even apparently solvent firms are unable to borrow. A macroeconomic model should be able to account in some way for the diversity of observed macroeconomic experience, and the explanation for the difference should itself be empirically testable.

The temporary equilibrium paradigm seems to offer a theoretical framework capable of accounting for this diversity of experience and for explaining at least in a very general way what accounts for the difference in outcomes: the degree of congruence between the price expectations of agents. When expectations are reasonably consistent, the economy is able to function at or near a temporary equilibrium which is likely to exist. When expectations are highly divergent, a temporary equilibrium may not exist, and even if it does, the economy may not be able to find its way toward the equilibrium. Price adjustments in current markets may be incapable of restoring equilibrium inasmuch as expectations of future prices must also adjust to equilibrate the economy, there being no market mechanism by which equilibrium price expectations can be adjusted or restored.

This, I think, is the insight underlying Axel Leijonhufvud's (1973) idea of a corridor within which an economy normally tends to stay close to an equilibrium path. However, if the economy drifts or is shocked away from its equilibrium time path, the stabilizing forces that tend to keep an economy within the corridor cease to operate at all or operate only weakly, so that the tendency for the economy to revert back to its equilibrium time path is either absent or disappointingly weak.

The temporary-equilibrium method, it seems to me, might have been a path that Hayek could have taken in pursuing the goal he had set for himself: to reconcile equilibrium-analysis with a theory of business cycles. Why he ultimately chose not to take this path is a question that, for now at least, I will leave to others to try to answer.

VI   Hayek and Rational Expectations

In this section, I focus on a particular kind of intertemporal equilibrium: rational-expectations equilibrium. It is noteworthy that in his discussions of intertemporal equilibrium, Roy Radner assigns a meaning to the term "rational-expectations equilibrium" very different

from the meaning normally associated with that term. Radner describes a rational-expectations equilibrium as the equilibrium that results when some agents can make inferences about the beliefs held by other agents when observed prices differ from what those agents had expected prices to be. Agents attribute the differences between observed and expected prices to information held by agents better informed than they are, revising their own expectations accordingly to correspond to the information that would have justified the observed prices.

There is a famous historical instance of inferring otherwise unknown or even secret information from publicly available data about prices. In 1954, one very rational agent, Armen Alchian, was able to identify the chemicals used to make the newly developed hydrogen bomb by finding those companies whose stock prices had risen too rapidly to be otherwise explained. Alchian, who spent almost his entire career at UCLA, for many years also consulted at the nearby Rand Corporation, wrote a paper for Rand listing the chemicals used in making the hydrogen bomb. When news of his unpublished paper reached officials at the Defense Department – the Rand Corporation having been started as a think tank by the Department of Defense to do research for the Defense Department – the paper was confiscated from Alchian's office at Rand and destroyed.[6]

But Radner also showed that the ability of some agents to infer the information used by other agents to cause prices to differ from the prices that had been expected does not necessarily lead to an equilibrium. The process of revising expectations in light of observed prices may not converge on a shared set of expectations of the future based on commonly shared knowledge. Radner's result actually reinforces Hayek's insight that although expectations are equilibrating variables there is no economic mechanism that tends to bring expectations toward their equilibrium values. There is no feedback mechanism, corresponding to the normal mechanism for adjusting market prices in response to perceived excess demand or excess supplies, operating on price expectations. The heavy lifting of bringing expectations into correspondence with what the future holds must be done by the agents on their own; the magic of the market goes only so far.

Although Radner's conception of rational expectations differs from the more commonly used meaning of the term, his conception helps us understand the limitations of the conventional "rational expectations" assumption in modern macroeconomics, which is that the price expectations formed by the agents populating the model should be consistent with the predictions of the model about what future prices will be. In this very narrow sense, rational expectations is a necessary property of *any* model. If one assumes that the outcome expected by agents is the

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[6] See Newhard (2014) for an account of the episode and a reconstruction of Alchian's event study.

equilibrium predicted by the model, then, under those expectations, the solution of the model ought to be the equilibrium of the model. If the solution of the model is somehow different from what the agents in the model expect, then something is wrong with the model.

What kind of model would have the property that correct expectations turn out not to be self-fulfilling? A model in which correct expectations are not self-fulfilling is a nonsensical model. But there is a huge difference between saying (a) that a model should have the property that correct expectations are self-fulfilling and saying (b) that agents populating the model understand how the model works, and, based on their knowledge of the model, form expectations of the equilibrium predicted by the model.

Rational expectations in the first sense is a minimal consistency property of an economic model; rational expectations in the latter sense is an empirical assertion about the real world. You can make such an assumption if you want, but you can't credibly claim that it is a property of the real world. Whether it is a property of the real world is an empirical question; it is not a methodological imperative. But the current sacrosanct status of the rational-expectations postulated in modern macroeconomics has been achieved largely through methodological tyrannizing.

In his 1937 paper, Hayek was very clear that correct expectations are logically implied by the concept of an equilibrium of plans extending through time. But he also understood that correct expectations are not a necessary, or even descriptively valid, characteristic of reality. Hayek also conceded that we don't even have an explanation in theory of how correct expectations come into existence. He merely alluded to the empirical observation – perhaps not the most realistic description of empirical reality in 1937 – that there is an observed general tendency for markets to move toward equilibrium, implying that over time expectations do tend to become more accurate.

It is worth pointing out that when the idea of rational expectations was introduced by John Muth (1961), he did so in the context of partial-equilibrium models in which the rational expectation in the model was the rational expectation of the equilibrium price in a particular market. The motivation for Muth to introduce the idea of a rational expectation was the cobweb-cycle model in which producers base their decisions about how much to produce for the following period on the currently observed price. But with a one-period time lag between production decisions and realized output, as is the case in agricultural markets in which the initial application of inputs does not result in output until a subsequent time period, it is easy to generate an alternating sequence of boom and bust, with current high prices inducing increased output in the following period, driving prices down, thereby inducing low output and high prices in the next period and so on.

Muth argued that rational producers would not respond to price signals in a way that led to consistently mistaken expectations, but would base their price expectations on more realistic expectations of what future prices would turn out to be. In his microeconomic work on rational expectations, Muth showed that the rational-expectations assumption was a better predictor of observed prices than the assumption of static expectations underlying the traditional cobweb-cycle model. Muth's rational-expectations assumption was thus based on a realistic conjecture of how real-world agents would actually form expectations. In that sense, Muth's assumption was consistent with Hayek's conjecture that there is an empirical tendency for markets to move toward equilibrium.

So, while Muth's introduction of the rational-expectations hypothesis was an empirically progressive theoretical innovation, extending rational-expectations into the domain of macroeconomics has not been empirically progressive, rational expectations models having consistently failed to generate better predictions than macro-models using other expectational assumptions (Carlaw and Lipsey 2012). Instead, a rational-expectations axiom has been imposed as part of a spurious methodological demand that all macroeconomic models be "micro-founded." But the deeper point –one that Hayek understood better than perhaps anyone else -- is that there is a difference in kind between forming rational expectations about a single market price and forming rational expectations about the vector of *n* prices on the basis of which agents are choosing or revising their optimal intertemporal consumption and production plans.

It is one thing to assume that agents have some expert knowledge about the course of future prices in the particular markets in which they participate regularly; it is another thing entirely to assume that they have knowledge sufficient to forecast the course of all future prices and in particular to understand the subtle interactions between prices in one market and the apparently unrelated prices in another market. It is those subtle interactions that allow the kinds of informational inferences that, based on differences between expected and observed prices of the sort contemplated by Alchian and Radner, can sometimes be made. The former kind of knowledge is knowledge that expert traders might be expected to have; the latter kind of knowledge is knowledge that would be possessed by no one but a nearly omniscient central planner, whose existence was shown by Hayek to be a practical impossibility.

The key – but far from the only – error of the rational-expectations methodology that rules modern macroeconomics is that rational expectations somehow cause or bring about an intertemporal equilibrium. It is certainly a fact that people try very hard to use all the information available to them to predict what the future has in store, and any bit of information not previously possessed will be rapidly assessed and assimilated, and will inform a possibly revised set of expectations of the future. But there is no reason to think that this continuous process of information gathering and processing and evaluation leads people to formulate correct expectations of the future or of future prices. Indeed, Radner proved that, even under strong

assumptions, there is no necessity that the outcome of a process of information revision based on the observed differences between expected and actual prices leads to an equilibrium.

So it cannot be rational expectations that leads to equilibrium. On the contrary, rational expectations are a property of equilibrium. To speak of a rational-expectations equilibrium" is to speak of a truism. There can be no rational expectations in the macroeconomic setting except in an equilibrium state. Outside of equilibrium, expectations cannot be "rational" in the sense in which that term is used in macroeconomics. Failure to grasp that point is what led Morgenstern astray in thinking that the Holmes-Moriarty story proved that equilibrium was a nonsensical concept; all he showed was that Holmes and Moriarty were playing a non-repeated game with no equilibrium solution.

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To think about rational expectations as if it somehow results in equilibrium is nothing but a category error, akin to thinking about a triangle being caused by having angles that add up to 180 degrees. That the angles of a triangle add up to 180 degrees doesn't cause the triangle; it is a property of being a triangle.

Standard macroeconomic models are typically so highly aggregated that the extreme nature of the rational-expectations assumption is effectively suppressed. To treat all output as a single good (which involves treating the single output as both a consumption good and a productive asset generating a flow of productive services) effectively imposes the assumption that the only relative price that can ever change is the wage, so that all but one future relative prices are known in advance. That assumption effectively assumes away the problem of incorrect expectations except for two variables: the future price level and the future productivity of labor (owing to the productivity shocks so beloved of Real Business Cycle theorists).

Having eliminated all complexity from their models, modern macroeconomists, purporting to solve micro-founded macromodels, simply assume that there are just a couple of variables about which agents have to form their rational expectations. The radical simplification of the expectational requirements for achieving a supposedly micro-founded equilibrium belies the claim to have achieved anything of the sort. Whether the micro-foundational pretense affected -- with apparently sincere methodological fervor – by modern macroeconomics is merely self-delusional or a deliberate hoax perpetrated on a generation of unsuspecting students is an interesting distinction, but a distinction without practical importance.

VII   Conclusion

Four score years since Hayek explained how challenging the notion of intertemporal equilibrium really is and the difficulties inherent in explaining any empirical tendency toward

intertempral equilibrium, modern macroeconomics has succeeded in assuming all those difficulties out of existence. Many macroeconomists feel rather proud of what modern macroeconomics has achieved. I am not quite as impressed as they are.

REFERENCES

Bliss, C. J. 1975. *Capital Theory and the Distribution of Income*. Amsterdam: North Holland.

Bliss, C. J. 1983. "Consistent Temporary Equilibrium." In *Modern Macroeconomic Theory*, edited by J. P. Fitoussi. Oxford: Blackwell.

Carlaw, and R. G. Lipsey. 2012. "Does History Matter? Empirical Analysis of the Evolutionary versus the Stationary Equilibrium Views of the Economy." *Journal of Evolutionary Economics* 22(4):735-66.

Currie, M. and I. Steedman. 1989. "Agonising over Equilibrium: Hayek and Lindahl." *Quaderni di storia dell'economia politica* 7(1): 75-99.

Düppe, T. and E. R. Weintraub. 2016. "Losing Equilibrium: On the Existence of Abraham Wald's Fixed-Point Proof of 1935." *History of Political Economy* 48(4):635-55.

Hayek, F. A. 1928 [1984]. "Intertemporal Price Equilibrium and Movements in the Value of Money." In Money, Capital and Fluctuations: Early Essays, edited by R. McCloughry. London: Routledge.

Hayek, F. A. 1927 [1933]. *Monetary Theory and the Trade Cycle*. London: Jonathan Cape.

Hayek, F. A. 1937. "Economics and Knowledge." *Economica* New Series 4(13):33-54.

Hayek, F. A. 1941. *The Pure Theory of Capital*. Chicago: University of Chicago Press.

Hicks, J. R. 1933 [1980]. "Equilibrium and the Trade Cycle." *Economic Inquiry* 18(4):523-34.

Hicks, J. R. 1939. *Value and Capital*. Oxford: Oxford University Press.

Hicks, J. R. 1965. *Capital and Growth*. Oxford: Oxford University Press.

Hicks, J. R. 1983. *Classics and Moderns*, vol. 3 of *Collected Essays on Economic Theory*. Cambridge, MA: Harvard University Press.

Hirshleifer, J. 1971. "The Private and Social Value of Information and the Incentive to Reward to Inventive Activity." *American Economic Review* 61(4):561-74.

Keynes, J. M. 1936. *The General Theory of Employment, Interest, and Money*. London: Macmillan

Laidler, D. 1998. *Fabricating the Keynesian Revolution*. Cambridge: Cambridge University Press.

Leijonhufvud, A. 1973. "Effective Demand Failures." *Swedish Journal of Economics* 75(1):27-48.

Lindahl, E. 1929 [1939]. "The Place of Capital in the Theory of Price." In *Studies in the Theory of Money and Capital*. London: George, Allen & Unwin.

Lindahl, E. 1930 [1939]. "The Rate of Interest and the Price Level." In *Studies in the Theory of Money and Capital*. London: George, Allen & Unwin.

Milgate, M. 1979. "On the Origin of the Notion of Intertemporal Equilibrium." *Economica* New Series 46(181):1-10.

Morgenstern, O. 1935 [1976]. "Perfect Foresight and Economic Equilibrium." In *Selected Writings of Oskar Morgenstern*, edited by A. Schotter, pp. 169-83. Princeton: Princeton University Press.

Muth, J. 1961. "Rational Expectations and the Theory of Price Movements." Econometrica 29(3):315-35.

Myrdal, G. 1927. Prisbildningsproblemet och Foranderligheten (Price Formation and the Change Factor). Stockholm: Almqvist & Wicksell.

Newhard, J. 2014. "The Stock Market Speaks: How Dr. Alchian Learned to Build the Bomb." *Journal of Corporate Finance* 27:116-32.

Patinkin, D. 1965. Money, Interest, and Prices: An Integration of Monetary and Value Theory, 2nd edition. New York: Harper and Row.

Radner, R. 1972. "Existence of Equilibrium of Plans, Prices, and Price Expectations." *Econometrica* 40 (2):289-303.

Radner, R. 1979. "Rational Expectations Equilibrium: Generic Existence and the Information Revealed by Prices." *Econometrica*, 47: 655-678.

R. Radner. 1982. "Equilibrium Under Uncertainty." In *Handbook of Mathematical Economics* edited by K. J. Arrow and M. Intriligator, pp. 923-1006. Amsterdam: North-Holland. 923-1006.

Radner, R. 1987, "Uncertainty and Equilibrium." *New Palgrave Dictionary of Economics*. London: Macmillan.

Samuelson, P. J. 1947. *The Foundations of Economic Analysis*. Cambridge: Harvard University Press.

Zappia, C. 1999. "The Assumption of Perfect Foresight in Hayek's Theory of Knowledge."
    Revue d'Economique Politique 109(6):833-46.