

Modeling Disequilibrium Market Economy

Xiaochuan Song

San Diego Mesa College

I. Introduction

Macroeconomics has undergone a dynamicization process and become operational and computable. Equipped with sophisticated mathematical theory and modern computing technology, contemporary economic theory is now framed in an elegant and scientific fashion. The problems are stated exactly and explicitly, and the analysis is conducted rigorously in compelling terms. The dynamic programming method is routinely used to model an optimal intertemporal equilibrium economy “with a wide variety of possible technologies, information structures, and stochastic disturbances” (Lucas 1987). However, when used to explain reality, it must be assumed that economic agents possess perfect knowledge of stochastic properties about the entire future, and they have to be perfectly coordinated in making their sequential optimal strategies against one another and nature indefinitely.

Moreover, economic changes of overwhelming importance in our discipline are explained in terms that are not and can not be explained – some external random shocks imposed on technology, or preferences, or government policy error, or a combination thereof. Further, most models are devoted to securing a desired outcome of a dynamic economy – equilibrium (without specifying the mechanism of how the economy achieves an equilibrium state, which is often of considerable interest), but the fundamental fact that economic transactions occurring out of equilibrium is not modeled at all.¹

The economic reality challenges economists for a better explanation about the way market economies work in the real world, and thus calls for a more realistic model of a market economy. As a small step in this direction, we are working on a dynamic disequilibrium model which differs from the established models mainly in the following respects:

First, our model gives more explicit recognition of the fact that economic agents do not make once and for all consistent, optimal strategies with perfect foresight. On the contrary, we assume that they make procedural optimal decisions in an adaptive fashion, revising their decisions and modifying their behaviors period after period, according to subsequently revealed information. Second, our model takes explicit account of the fact that economic changes are driven by some intrinsic forces through the interplay of bounded rational economic actors, and various recursively connected feedback relationships. Finally, because Bargaining-Negotiation-Bidding processes are not pervasive in the real world,

¹ For an appraisal of contemporary economics, see Kaldor (1985), Simon (1986), and Day (1984, 1987, 1992a, and 1992b).

equilibrium prices can not govern the behaviors out of equilibrium. We explicitly model the price formation processes and their corresponding adjustment mechanisms, which must emerge to sustain disequilibrium, and to assure the normal workings of a market economy.² In short, we try to build a more realistic model of how the market economy works in disequilibrium!

Specifically, we develop a computable multi-sector disequilibrium model by using the recursive programming method that can accommodate a wide class of economic settings.³ Economic systems, socio-cultural traditions and institutional structures vary in different societies, providing different constraints, opportunities, and challenges for their economic actors. However, the fundamental process of economic change is the same: “The state of economy at any time depends on the past evolution of the system, and any action taken in the present time must be conditioned by the evolving state and must change the environment within which future actions are conceived and executed” (Day and Cigno 1978). It is this ethological dynamic process that forms the point of departure in our model.

II. The Background

This attempt originates from our dissatisfaction with most of the current multi-sector modeling practices based on the general equilibrium theory. These models are carried out with great care in a simple structure with no distinction between model and algorithms. The purpose is to obtain a good approximation of what real world market interactions generate. However, some extra features have to be added to the economy. Asymptotic stability has to be superimposed on the dynamic adjustment process, which has been the basis of comparative static analysis, even though it has been shown that nonconvergence and fluctuations occur robustly almost everywhere (see Goodwin 1982, Grandmont 1987, Barnett, Geweke and Shell 1987, Barnett, Kirman and Salman 1992, Day and Chen 1993, Day 1994).

The classical treatments along this line are given in Koopmans (1951). The first contribution to the applied general equilibrium model is the input-output analysis pioneered by Leontief (1953, 1966). Leontief’s model captures the crucial elements of the interrelatedness of production arising from the flow of intermediate goods among the sectors. The major disadvantage of the model is its equality constraints. As there is no endogenous make-or-buy choice that the model can simulate, a great deal of flexibility is lost. The model’s cost-determined price, independent of demand side, also fails to include market feedback relationships through the price mechanism.

² Day (1992b) derived a disequilibrium existence theorem by arguing that, “Disequilibrium mechanisms are necessary for the existence of an economy.” The ever-growing number of market mediators is probably the best proof of the theorem. The fundamental role of market mediators is to mediate disequilibrium. If disequilibrium were to be ignored, these “middlemen” would be put out of work.

³ A rigorous discussion and many applications of the recursive programming method can be found in Day and Cigno (1978).

The most influential applied general equilibrium model is the Computable General Equilibrium (CGE) model (see Dervis, De Melo and Robinson 1982). The model describes a situation where millions of agents independently maximize their own welfare functions and jointly, but inadvertently, determine an outcome that can be affected only indirectly by the policy maker. All prices must adjust until the million decisions made in the production sphere of the economy are consistent with the million demand decisions made by households and other autonomous decision makers. Even neoclassical economists didn't believe this was the way economies really worked. Rather, they conceived of it as an outcome of the adjustment process (Day 1992b).

On the basis of this equilibrium miracle, CGE model builders try to find numerical solutions to the model without modeling the dynamic process. Many algorithms are designed to compute the desired outcome of this unspecified process, but the solution strategies and algorithms are so ungrounded in the real world that the model builders have to warn against the confusion between properties of an algorithm and properties of an economy: "The CGE model is formulated as an equilibrium model and one should place no significance on the actual path the model economy follows during iterations designed to find the equilibrium" (Dervis, De Molo and Robinson 1982). Unfortunately, this practice has led to many serious misleadings in its macroeconomic implications.

The idealized description of economic dynamics by new classical economists is even farther removed from reality. The expectations of the economic agents are so magically consistent with one another and their decisions are so perfectly coordinated that everyone is satisfied. Consequently, these agents have nothing to learn, no incentive to modify their rules of behavior and no tendency to deviate from the optimal trajectory even as subsequent events unfold. Clearly, this type of model can not be applied to any real world situation. The applied general equilibrium model builders have to adopt a practical solution, which "gives up the notion of intertemporal equilibrium" and "represents a retreat from the ambitious attempts of earlier planning models at determining intertemporally efficient or optimal paths" (*ibid.*). As Weintraub once stated, "The equilibrium story is one in which empirical work, ideas of facts and falsification, played no role at all" (*ibid.*).

The limitations lie in their motivations. The assumptions of general equilibrium theory were originally chosen in order to secure a desired result. An initial stage of the analysis is in the nature of "scaffolding, ... it has to be erected before the permanent building can be built, but will be removed step by step as the permanent building nears completion. [However, this] process has definitely been backwards not forwards in the sense that the present set of axioms are far more restrictive than those of the original Walrasian model" (Kaldor 1985). The main motive of contemporary economics seems to be the pursuit of economic theory for its own sake - the construction of more advanced theoretical models rather than the practical motive of discovering methods or policies to improve the performance of the

economy. Therefore, “if Mahomet can not go to the mountain, then the mountain must be brought to Mahomet” (*ibid.*).

What we really need to do is to shift our interests and outlook from checking whether the “facts” fit into the general framework of the received theory to investigating whether the received theory corresponds to reality, or whether the propositions derived from them can be verified empirically. Kaldor pointed out, “I am sure that empirical research of the right kind will, in time, considerably improve our knowledge of how modern market economies work. But it will require new methods of research that would make greater use of knowledge gained through personal contact and on-the-job investigations, and less on the testing of formal models through statistics and econometrics. There is an enormous amount of empirical research going on but it is stifled by operating within the framework of established theory” (*ibid.*).

In our modeling, we make some effort along this line of thought⁴. Our plan is to develop a multi-sector disequilibrium model as a useful operational tool of analysis to portray and project the dynamic process of real world economic change. The recursive programming method provides a realistic, flexible and practical class of models for our purpose. It is realistic because it “explicitly recognizes that economic decisions are taken not at the same time but sequentially and suboptimally. Each decision is conditioned by previous decisions, and complete information about the entire future is seldom incorporated in the optimizing procedure and explicit choice is conditioned by behavioral rules” (Day and Cigno 1978). It is flexible because we can always add a specific inequality constraint reflecting a particular feature of an economy without upsetting the overall consistency of the system, or the ability to obtain a solution. It is practical because it models real world economic processes by “decomposing large complex decision problems into smaller, simpler, approximate, or local decision problems which are modified by feedback on the basis of behavioral rules, convenient computational formulae and observed changes in the decision making environment” (*ibid.*).

III. The Model Specification

The model economy is made up of several important economic sectors and each sector consists of many more or less similar economic agents. Each agent plays various games with one another and against nature by employing its own strategies. The agents follow different workable decision rules that allow for choices among alternatives, and that can be implemented within various constraints. As a result, the entire economic game is characterized by imperfect coordination of its players with each agent planning in a disequilibrium situation based on severely circumscribed information about the other agents’ past behavior and projected plans.

⁴ Along this promising line of research, Song recently developed a two-sector disequilibrium dynamic model, and a two-sector adaptive economizing growth model with some interesting analytical results (see 宋小川 2003, 2004a, 2004b; Song 2003).

Each agent adapts to the perceived present state and to imperfectly anticipated future states. As time goes on and as subsequent events unfold, new plans are conceived on the basis of new information, new experiences, and newly observed phenomena. Old data is then updated and old plans revised or discarded in favor of a new optimal plan. This adaptive suboptimal dynamic process is analogous to Bayesian decision theory, but can be modeled in a computationally operational manner.

For modeling purposes, we choose a representative agent for each sector and pursue an activity analysis if it is plausible on the ground of common business practice. In general, a firm's behavior is guided by a procedural optimizing model⁵ subject to various constraints. That is, as a partial informed suboptimizer, the firm makes only a one period decision each time. In doing so, it follows some cautious behavioral rules, which reflect various feedback relations, accumulated experiences, and unfolding information, and then makes adjustments step by step, period after period as time and the economy evolve.

A firm's plan consists of production, investment, and resource allocation activity levels, which are subject to physical, technical and behavioral constraints. These activities and constraints form a feasible region, namely the production possibility set. Some of the constraints such as natural resources are relatively fixed. Many other constraints are the irreversible outcomes endogenously determined by past activities of various economic agents, including the given firm. Accordingly, there are three feedback relationships facing each firm through which all economic actors interplay with one another. Most often they interact myopically and inconsistently, modifying the feasible region from one period to the next, providing us with a vivid picture of a dynamic process with the driving forces within the intricate system.

Intra-sector Feedback

By intra-sector feedback, we mean the recursively connected feedback within a firm during the sequential decision making process. These feedback relations enter through the firm's production, investment and financial activities. The production activity of a firm is limited by its capacity that can be expanded or depreciated by its past investment and production activities. Present production and investment activities expand or contract future capacity as well. A firm's activity levels are also limited by financial resources modified by retained earnings, borrowing and savings, which are the results of the firm's past production, investment, and financial activities. Present financial resources, working as a budget constraint, more or less determine the firm's future financial positions.

Inter-sector Feedback

This is a cross-sector feedback, which enters in an essential way, capturing the interrelationship among firms through the intermediate goods exchange chain. The activities of each firm are constrained by input

⁵ Day (1992b) summarized seven distinct modes of action that govern economic behavior: optimizing (procedural rational choice), experimentation (trial and error), imitation, obedience to authority and tradition, unmotivated search, habit (haberation), and hunch.

resources, which are the other firms' products from the last period. These activities will in turn constrain other firms' activities in the same way for the next period. Inter-sector feedback also comes in through governmental activities. Government expenditures on R & D and infrastructures improve technology by changing activity coefficients and raising the firms' overall productivity. At the same time, government regulations imposed on a firm shrink the feasible region of profit-making opportunities. Government tax and subsidy policies, which are based on a firm's activity levels, substantially change the firm's resource allocation and financial situation. The financial sector can change a firm's budget constraint by controlling its ability to raise funds externally. The credit-rationing rule is generally designed according to a firm's past performance and relative financial requirements.

Market feedback

The market is nothing but an arena where all economic actors play their roles. The key function of the market is to provide a flexible framework for economic adaptation. The market signals the imbalance of a particular good to the producer and consumer. Then, the firm adjusts its quantity and price accordingly. In the real world, market mediators carry out most of the adjustment functions through their inventory accumulations and depletions. These middlemen operate inventory, order-back-log and price-adjustment processes that buffer uncoordinated and most often inconsistent plans between consumers and producers. Working capital availability is the channel through which market feedback operating through demand side, modifies a firm's behavior. The past prices determined in the market through the tatonnement process determine the past profit and therefore current financial positions and budget constraints of a firm. The past market prices of the other firms' products determine the current resource allocations, activity levels and financial position of the given firm. The market works continuously in disequilibrium as firms adapt their behaviors to unfolding prices and changing inventories.

We finally develop a hypothetical multi-sector economy that consists of six sectors: agriculture, manufacturing, energy, construction, finance, and government. Each sector has a representative agent with its own sequence of recursively connected, behaviorally conditioned, suboptimization structures. The six sectors interact with one another based on some technological connections and plausible cross sector feedback relations as described before. The activities of the first four sectors are represented by the procedural linear programming models, one for each sector. The activities of the financial and government sectors are represented by behavioral equations involving feedback connections.

The agricultural sector provides one final good, grain for consumers; two intermediate goods, fiber for the manufacturing sector and construction materials for the construction sector. The manufacturing sector provides two final goods, consumer durable goods and non-durable consumer goods; one capital good, machinery for the first four sectors; one intermediate good, construction materials for the construction sector. The energy sector provides one final good, civil energy for consumers; one intermediate good, industrial energy for the first four sectors. The construction sector provides one final good, housing for consumers; one capital good, plants for manufacturing and energy

sectors. The financial sector provides financial services for the other sectors. The Government sector provides public services for the other sectors by levying taxes on all products as well as taxing wage incomes.

This is a closed economy with six sectors and eleven goods. The prices of all goods are determined in the domestic markets mediated by middlemen through a disequilibrium tatonnement process. The market demand and supply, productivity changes, and some institutional elements jointly determine factor income in an adaptive way. A detailed model structure is available upon request.

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