Money and financial institutions

Lecture 1: A Nontechnical Overview

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Preamble

- I wish to cover 68 years of work that can be broken conveniently into four overlapping parts:
- 1948-1961 when I was working primarily with game theory applied to oligopolistic structure and behavior when I first became concerned with the essentially unsatisfactory state of both micro- and macro-economics in their treatment of economic dynamics.
- 1961-1971 when I had decided that the apparently intractable problem that I wished to pursue was the development of a decent strategic microeconomic theory of money.

- The period 1971-2016 was when I finally managed to get through `The Looking Glass' that permitted me to see the parallel worlds of the physical world of production and consumption and the financially guided economy. This began with my basic insight on how to recast the general equilibrium exchange economy as a playable game in strategic form (that I named `a strategic market game') and to solve it for its noncooperative equilibria (NCE)

- The NCE was used not because I liked this solution, but because it provided a way to show how the competitive Equilibria (CE) of the general equilibrium system (GE) could be related with the NCE of a process model.

- The fourth period has been from 2001-2016 and the work was much influenced by my interaction with colleagues at the Santa Fe Institute.

- It was around 2001 that I started to perceive that even at a high level of abstraction finding the appropriate process models to match the general equilibrium class of models was not enough.

- Government, default and innovation had to be covered and the distinction between principal and fiduciary behavior had to be stressed along with the shift in emphasis from the tight equations of equilibrium to the inequalities that limit the domain of dynamics but **do not specify the equations of motion.**

- Dynamics of any sort requires institutions or organisms as the carriers of process, be it behavioral, strategic or merely random. A static description of efficient price allocation for many goods and services can be presented with what appears to be a highly abstract and beautiful mathematical structure that does not need or consider either money or disequilibrium.

- My guess was that the necessity for money and financial institutions to carry economic process could be shown at the same level of axiomatic treatment as general equilibrium.

- A skeptic might ask why it is even worth doing. The answer is that although there are some underlying invariant properties in political economy that are amenable to a highly abstract description and analysis, there is an intermediate stage between this theory and its applications. It involves investigation of minimal process models.

- The concept of minimal institution can be defined and this enables us to construct minimally complex process models that resolve the debate about the existence of both competitive and planned price systems.

- Although there are several minimal price formation mechanisms associated with any exchange economy the numbers are not large as soon as the game model involves two periods or more and encompasses general information conditions the handful of strategic games explodes in a hyper-astronomical number of cases each of which requires detailed specification before it is amenable to analysis and they are amenable exhaustive analysis.

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- The underlying abstraction of general equilibrium theory tell us a great deal about the power of the price system in the structure of an exchange economy; but it tells us very little operationally about behavior as it does not deal in process.

- As soon as there are two periods or more the whole Pandora's Box of institutional models explodes and any model that one wishes to analyze calls for considerable specification of both the institutional structure to lay out the feasible set of outcomes from any process and the behavioral assumptions needed to specify equations of motion

- When I finally appreciated the implications of what I called Mathematical Institutional Economics I realized that there was an enormous task ahead to lay out the models containing the logic for the invention of the institutions and instruments and then start to analyze these many disparate but related models.

- The construction of a viable theory of money and financial institutions calls for the assembly of a vast jigsaw puzzle of interrelated aspects of the physical economy and its financial control by synthetic legal persons known as corporations acting as fiduciaries for their ultimate owners, the legal natural persons.

- As the key concern is dynamics a natural way to think of all models constructed is that each should be a playable experimental game. As anyone who has debugged an experimental game knows, this condition imposes a completeness and consistency test on every model.

- Over the course of the last 43 years I have given several lectures on my game theoretic approach to the theory of money and there are still in the audience a few who at Cowles have heard parts of a much told tale. This contains my wrap up comments.

A Little History and Context

- I have planned three essays, one essentially non-technical giving an overview with some personal commentary, while the other two will provide a moderately technical sketch of the structure and many of the pieces that had to be fitted together.

- I graduated from High School with a scholarship to the University of Toronto in general proficiency stressing History and English I was interested in politics and was concerned with bettering the world. I contemplated going into Political Science or Economics. On further reflection I decided that although I was probably a mediocre or poor mathematician, if I went into Mathematics and Physics, I might acquire some techniques and knowledge that would help analytical thought.

- I was convinced that at the undergraduate level, the Social Sciences in the 1940s were rudimentary. If I were to go into politics, I thought that I needed some form of economics or political science, but I felt that this could be obtained later at graduate school or possibly law school or I could read the basic books myself

- I registered in Mathematics and Physics suspecting that I risked failure, but I managed to crawl through with a distinctly mediocre performance. However it did what I wanted. I simultaneously realized that I was never going to be a mathematician, but that I had an appreciation of good mathematicians and I began to understand the aesthetics of good mathematics and the concept of a careful experiment in elementary physics.

- While browsing in the library in 1948, I picked up in the new purchases section, The Theory of Games and Economic Behavior. I took it out, read it with much excitement and little understanding and decided to do a review of it for my class in Economic Theory. The mathematics was unfamiliar and the approach was far different from anything I had seen, but it seemed to provide the right approach to a serious mathematization of economic statics. I decided to apply to Princeton saying that I wanted to study the theory of games.

- It is my belief that graduate students learn not only from their mentors, but from their fellow students. Furthermore the learning is not merely academic.
- In the Economics Department the students who impressed me intellectually were Tom Whitin, Otto Eckstein, Gary Becker and few others. There were, however no students to talk with about game theory in the Economics Department.
- In the Mathematics Department matters were considerably different, the students I knew and with whom I interacted were Marvin Minsky, John McCarthy, John Nash, Lloyd Shapley and later, to a lesser extent Herbert Scarf and Ralph Gomory. Among the others slightly more senior who I met who impressed me were Richard Bellman, Sam Karlin, Alan Hoffman and Harlan Mills.

- When Nash beat Shapley and me in the production of a variable threat two person fair division model, I suggested to John that we apply it to a duopoly model and contrast it with the Cournot-Nash solution (Mayberry, Nash and Shubik, 1952). When Shapley and I discussed, what was to be eventually called the core solution I suggested that, in essence Edgeworth's discussion of the shrinkage of the contract curve could be regarded as the convergence of the core under replication.
- From the start of my interest in game theory, I found that the description of the amount of information required in well defining a game and knowledge of the rules of the game was often unreasonable. I noted this in an early article on information and competition (Shubik, 1952).

- I embarked on a long term collaboration with Lloyd Shapley, primarily on cooperative game theory. Early I developed great respect for Lloyd's pioneer work on both the core and the value as different solution concepts for an n-person game in coalitional form. In particular I felt that the application of the value to voting offered considerable insights into voting structures and we were both surprised and delighted at the speed with which our article on a power index was published (Shapley and Shubik, 1954).

A RULE IN GAME THEORY APPLICATION

- Different applications require different basic aspects of game theory
- The information structure and the details of the rules of the game appeared to matter considerably for the study of games in strategic and extensive forms. As I had become interested in oligopolistic competition and this seemed to be a natural theory to use in the study of oligopolistic competition, I decided to use noncooperative theory for my thesis (which eventually become a book: *Market Structure and Behavior*, Shubik, 1959).

It was while working on my thesis that four questions occurred to me.

1. The first concerned the number of competitors in a market.
2. The second concerned the role of institutions.
3. The third involved the treatment of economic dynamics and
4. The fourth involved the goals of the firm, bankruptcy and contingent outcomes.

- From an economic point of view a key feature in considering the replication of players in a market was that a *quantitative difference could cause a qualitative difference.* In particular with only few players the noncooperative equilibrium analysis seemed to depend heavily on information and threats. With many players the noncooperative equilibrium became a better model of reality as communication and organization costs made the anonymous market model a better representation of actuality as numbers increased.

- In economic dynamics, institutions mattered, the economics institutions are the carriers of economic process. At least in the short run, they can be regarded as given by the rules of the game. These thoughts led me to coin the term `**Mathematical Institutional Economics.'** Some felt this to be an oxymoron, a contradiction in terms, but to me it meant that in considering process one needed to clothe abstraction with the richness and relevance of institutional detail.

- Many years later I was able to build the appropriate models stressing the idea of a "minimal institution" as the simplest mechanism required to be identified with a specific economic function.

- The last point that concerned me then and even now was how to account for default and bankruptcy. The firm had to decide how to trade off the worth of profits against the probability of going bankrupt. The basic problem that faces any financial intermediary is selecting the reserves deemed adequate to fulfill its fiduciary responsibilities to at least two different constituencies. They are its customers and its stockholders.

MONEY IN MICROECONOMICS

- In 1961, I started to worry about the lack of a decent theory of money in microeconomics. I told Oskar Morgenstern that I had found my problem. He expressed enthusiasm over the problem and doubt that anyone would make much headway in the next decades.

- A basic theme in in my work through the 1960s and into the 1970s was to understand the price system from a game theoretic point of view. The convergence of the core and value cooperative solutions applied to market games indicated that the price system was called for by more considerations than pure competition.
- In December 1970 I reviewed the various game theoretic solutions which would converge under replication towards the price system and brooded over why I had not been able to obtain a model for the noncooperative equilibrium.
- I also reconsidered my work on the theory of money where I had wasted some ten years trying to get a decent model incorporating money. I made a conscious decision to abandon looking for a theory of money.I decided that I should devote all of my time to completing the work with Shapley on game theory solutions that converged to an efficient price system. The major missing item was the Cournot-Nash non-cooperative model

- In 1967 in a joint paper with Shapley we had succeeded in embedding a one-sided noncooperative game where one group of players was strategic, but the other merely accepted a price as though they faced a competitive market. We showed convergence as the number of players increased. Independently Gabseiwicz and Vail (1972) obtained a similar model. Neither model treated all agents symmetrically, but a fully satisfactory model should have been able to do so.
- Having abandoned my efforts on a theory of money I went back to trying to build the symmetric closed economy Cournot model. I decided to try to build an n-person symmetric game with n commodities where each player would be a monopolist holding only one good.

- There had to be n independent strategy sets, but there were only n-1 independent prices. If one insisted that all players were to denominate prices in terms of a specific commodity, then the player whose commodity is selected plays a nonsymmetrical role. I overcame this difficulty by considering a somewhat different game with n monopolists trading in an n+ 1^{st} commodity where each monopolist held one unit of his special good and a supply of the $n+1^{st}$ good. I set the price of the $n+1^{st}$ good equal to one and had all strategies denominated in terms of the $n+1^{st}$ good.
- I decided to switch to a quantity strategy model rather than a price strategy model. I nevertheless kept the n+ 1 commodity and had each individual offer some amount of his good for sale and attempt to purchase the other goods by offering quantities of the $n+1^{st}$ commodity. I then tried this out on a specific model and considered the replication of the model with k players of each type and let k become large.
- The example was tractable; I could calculate a specific noncooperative equilibrium and show that it moved toward the Pareto optimal surface as k became large.

- I took my preliminary model to Shapley who constructively tore it to bits in many different ways. After each tearing up it was possible to rebuild and strengthen it. In particular Lloyd was quick in pointing out that if no one offered a commodity for sale, but the n+1st commodity had been bid for it, as price was defined as a ratio of two quantities.

- Some weeks after Shapley and I had agreed that this was the appropriate model that provided an intrinsically symmetric game in strategic form that could show the convergence of some noncooperative equilibria formed by Cournot quantity strategies to competitive equilibria it dawned on me that it was sufficient to obtain the symmetry of the player strategy sets by introducing the extra good in a way that it was in adequate supply and well distributed among the agents; furthermore the extra commodity could be interpreted as a money. This construction had imposed a set of constraints on the optimization that was not present in the general equilibrium model which had only wealth constraints. This model had cash flow constraints as well as the wealth constraints.

- I had been looking at the solution to my second most important problem, the Cournot convergence and it provided the key insight into the study of money, the problem I had decided to abandon. To this day, I cannot understand how I could have worked for so long without even considering the connection.

- The extra commodity that enabled me to treat the agents symmetrically did so utilizing the minimal number of markets. It was a store of value or a good like any other good, but it was distinguished strategically. Logically there could be many monies but not with fewer markets. Many years later we investigated strategic market games with any number of monies.

- I realized this model provided the key to the development of a theory of money and financial institutions. When I saw the connection I said to my wife, “I have managed to go through the Looking Glass. This result is the key to the development of a theory of money.” I added that I thought that it would take years to develop and that I might not be bright enough or live long enough to carry it out. It almost did not matter because finally, at least for me, the general map was there.

- A satisfactory theory of money and financial institutions requires as necessary (but not sufficient conditions) the following

1. A completely well-defined process model must be built. A good test of this is that the model can be simulated or played as a game.
2. Money and different forms of credit and credit issuers have to be carefully defined and distinguished.
3. Bankruptcy, insolvency and reorganization must be accounted for in a fully dynamic context.
4. The noncooperative equilibrium solution is not adequate for the next steps in our understanding. Learning models and a serious study of the formation of expectations is called for
5. Good theory deals with invariant properties of a system. The invariant properties in political economy are in function, not form.

- deals with invariant properties of a system. The invariant properties in political economy are in function, not form. The institutions that deliver the functions such as saving or insurance or division of labor are in constant flux and unlike in physics the predictability of the overlying dynamics is, at best extremely short term and calls for ad hoc macroeconomic models applied to a specific economy for a relatively short time period such as a year or two at most. General equations of motion will never be available, but this neither rules out basic understanding of function, nor valuable advice provided from short term detailed applied models to help provide short term economic guidance

- My remaining remarks are devoted to a brief, possibly cryptic, enumeration of many of the items that must be and have been, in part, assembled to present an overall understanding of a theory of money and financial institutions.
- They are broken into several parts that include:
- Money and markets,
- Credit,
- Fiduciary players, controllers and minimal institutions;
- Innovation, public goods and exogenous risk

- Solutions, their role and relationship with behavior;
- Solutions intent and behavior in games with minimal information;
- The connection between application and theory where all solutions are behavioral.
- THERE IS NO DICHOTOMY BETWEEN GAME THEORY AND GE APPROACHES ON THE ONE HAND AND BEHAVIORAL APPROACHES ON THE OTHER
- THE INVARIANCE LIES IN THE EXITENCE OF BASIC ECNOMIC FUNCTIONS FOR EVERY LEVEL OF COMPLEXITY OF A SOCIETY, AND
- THE PERMANENT FLUX IS PRESENT IN THE EVOLUTION AND CHANGES OF THE INSTITUTIONS SUFFICIENT TO PROVIDE THEM