Implications of Dynamic Decision Making Research on Monetary Policy Making at the Federal Reserve

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Abstract

Study of Dynamic Decision Making (DDM) has been devoted to understanding the behaviors of decision makers facing dynamic decision making tasks. DDM involves decision tasks embedded in complex systems, the structure of which is not fully known to the decision makers. Previous DDM research mainly took an experimental approach, attempting to explain how people make dynamic decisions and how to improve DDM outcomes. This study examined implications of the laboratory findings on a real DDM case: decision making behavior of monetary policy makers at the Federal Reserve. DDM theories were used as a framework to understand the monetary decision making behavior. From analysis of the Federal Open Market Committee (FOMC) meeting transcripts, this study suggests that policy makers face a difficult decision making environment that many DDM studies have associated with negative task performance, but unlike typical decision makers described in the DDM literatures, the FOMC members develop ways to tackle the difficulties. Observation of the FOMC decision making behavior suggests decision makers in the real world may be more competent than expected by the DDM theories. Based on the findings, this article also proposes new topics for future DDM study.

Key words
Dynamic decision making, complex problem solving, monetary policy, Federal Reserve

Introduction

Decision making is difficult, especially when it involves an environment with high-risk and high-consequence decisions. To make matters worse, decision tasks are often embedded in complex systems so that the outcomes of decisions are not always clear to decision makers. Decision makers rarely examine all possible decision alternatives and their consequences to pick the best decision (Simon 1947/1997). The decision makers may attempt such perfection, but still they are inevitably constrained by time, space, and the intellectual capacity of their mental models.

There has been a stream of research, merged from different disciplines, devoted to understanding of behaviors of decision makers facing dynamic decision making tasks. The definition of dynamic decision making (DDM), or complex problem solving (CPS), somewhat differs among the researchers. However, they generally share a view that DDM tasks are embedded in complex systems, the structure of which is not fully known to decision makers. Structure of system and intervention made by decision makers independently and interactively cause dynamic changes in the system. DDM research primarily uses an experimental approach, and the majority of the research takes place in cognitive psychology. Recently system dynamics contributed to the field through experiments using simulation models or microworlds (Rouwette, Größler et al. 2004). By exploring factors influencing DDM outcomes in controlled settings, previous DDM studies explain how people make dynamic decisions (descriptive) and how to improve the DDM outcomes (prescriptive) (Hsiao and Richardson 1999).

This study is different from previous DDM studies in that it attempts to examine implications of the laboratory findings on a real DDM case: i.e., decision making behaviors of monetary policy makers at the Federal Reserve. Monetary policy is a typical DDM task, yet monetary decisions received scarce attention from behavioral and process-oriented perspectives. In this paper, DDM theories will be used as a framework to understand monetary decision making behavior. First, factors that may influence performance of monetary decisions will be identified using DDM theories. Then, it will be followed by an examination of whether the typical decision making behavior predicted by the DDM theories manifest in the Federal Reserve.

The goal of this study is to expand our understanding of monetary decision making behaviors, and to address external validity issue of laboratory-based DDM findings, as well as to suggest new areas for future DDM research.

DDM Theories and Research Questions

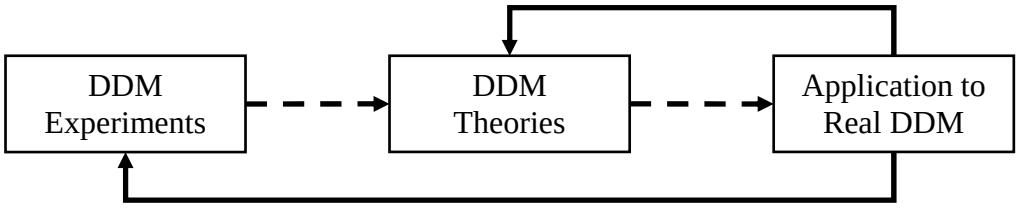
Two literature reviews (Hsiao and Richardson 1999; Rouwette, Größler et al. 2004) provide a helpful survey of previous DDM studies. These reviews are different from other DDM literature reviews in that they were written from the system dynamics perspective. Hsiao and Richardson's review includes not only DDM studies in system dynamics but also DDM experiments carried out by cognitive psychologists. Hsiao and Richardson refer to DDM research as a body of studies based on the DDM tasks as defined by Edward(1962)'s three criteria: (a) a series of decisions are necessary, (b) these decisions are interdependent,

and (c) the task environment changes both autonomously and as a function of the decision maker's actions. According to Hsiao and Richardson, goal of these studies is to better understand human decision making behavior and improve performance of dynamic decision makers. In comparison to Hsiao and Richardson's, the study by Rouwette et al. focuses more on simulator studies in system dynamics. They define simulators as "computer-based simulation games of real world scenarios… (that operates) with a reduced level of detail compared with reality (p.352)." Both reviews identified independent and dependant variables of each DDM experiment and categorized the study into groups. Dependent variables of DDM studies mainly have been task performance, either optimizing an indicator or reaching a target. Independent variables vary from decision maker characteristics, decision tasks characteristics, to decision-making interface characteristics. The contribution of Hsiao and Richardson and Rouwette et al. is that by synthesizing the various findings in the empirical studies, they tried to construct theories of DDM. Theory building in DDM is still in progress, because there are many gaps in the dependent-independent variable matrix, and generalizability of experimental studies in real DDM cases has been frequently questioned (For example, Mackinnon and Wearing 1980; Funke 1995).

This paper takes a different approach toward DDM research. It attempts to understand the behavior of real decision makers, the Federal Open Market Committee (FOMC) at the Federal Reserves, with insights gained from previous DDM laboratory studies. Application of DDM theories to a real case will not only expand our understanding of how people make real dynamic decisions, but it will also generate a useful discussion on areas in the DDM research that need to be studied in the future. (See Figure 1)

DDM theories discussed in this study center around the "misperception of feedback theory (Sterman 1989)." The misperception of feedback theory suggests that when people are faced with decision making tasks embedded in complex systems, performance of the decision maker deviates from the optimal performance due to cognitive limitations in perceiving the system's complexity. Sterman emphasized time delays and the feedback structure of the system as the major sources of complexity. In addition to the misperception of feedback theory, this study brings in other relevant DDM theories or experiments (for example, Brehmer 1995; Döner and Wearing 1995) that help interpretation of the FOMC decision making behaviors.

Figure 1. Theory Application & Improvement



This study examines three research questions. First, what are the characteristics of the decision making environment of the Federal Reserve? Second, in such an environment, what are the behaviors of the decision makers as predicted by the DDM theories? Finally, does the observation of the monetary decision making behaviors generate consistent results with the DDM theories? If not, what does this mean in terms of DDM theories?

Data and Methodology

Monetary policy qualifies as a DDM task. According to Edwards (1962) who specified three criteria for DDM, first, the monetary policy involves a series of decisions. The Federal Reserve Board examines and adjusts its policy stance at regular intervals. Second, the current policy outcome is always dependent on the outcome of previous monetary policies. The outcome of previous policy may not be known at the time of current policy making, but still the impact of the current policy will be blended with that of the previous policies. Finally, monetary policy changes the economic environment which becomes the base condition for future decisions. In addition to the decision makers' intervention, there are other factors, both known and unknown to the decision makers that may change the state of the economy.

Major monetary decisions are made by the Federal Open Market Committee (FOMC) at the Federal Reserve. Seven members of the Federal Reserve Board of Governors and five of the twelve presidents of regional Federal Reserve Banks constitute the FOMC. The FOMC meets eight times a year to discuss the current and prospective economic situation and design monetary policy accordingly. The main tool for FOMC to control money supply is the open market operation. The open market operation involves buying and selling of the U.S. government and federal agency securities.

After each FOMC meeting, the FOMC releases a policy directive that states the monetary decision made at the meeting briefly with the background for the decision. However, this press release does not provide data rich enough for the study of decision making behaviors of the FOMC. The press release contains the final decision framed in carefully selected language designed to minimize unintended public interpretation of the FOMC policy. In order to get a better sense of the decision making dynamics, this study examined verbatim transcripts of the FOMC meetings. With a five-year lag, the FOMC is required to release the verbatim transcripts of its meetings, and the transcripts provides rich qualitative data of decision making processes and mental models of the FOMC members that lead to the policy.

The Federal Reserve Chairman Alan Greenspan, once said;

> "I must say that before I attended FOMC meetings, I had a different view of what constitutes the nature of policy, because I used to read the directives and I couldn't for the life of me figure out what in the world they were talking about. But now, given the few FOMC meetings I've attended, I am realizing what it is." (FOMC 1988a:35)

The transcripts offer researchers an access to the debate and discussions of monetary policy makers inside the FOMC meetings, and despite the lack of non-verbal cues,

the transcripts allow researchers to experience some of what Greenspan has figured out by attending the meetings.

For this study, the data from March and May 1988 FOMC meetings was used. The FOMC members called this period a "precarious" and "skittish" period (FOMC 1988a) because they were facing greater than "normal" uncertainties in the environment and challenges were emerging against the current policies within the committee. The data selection was based on the assumption that instability in the decision making environment would generate richer dialogues that reveal more of the decision making dynamics. However, it must be noted that the analysis of this study is based on a very limited scope of data, and in order to gain greater generalizability of the findings, future studies must explore the transcripts from other time periods.

The open coding method of Strauss and Corbin (1998) was used to systematically conceptualize patterns in the decision making environment and decision makers' behavior. According to Strauss and Corbin, open coding requires data to be broken down into discrete parts, closely examined, and compared for similarities and differences. In this study, the data was first micro-analyzed and coded with no theoretical framework involved. Then as concepts and phenomenon emerged from data, relevant DDM theories were introduced to organize the findings. The data was then examined again with the lens of the selected DDM theories.

DDM Analysis of the FOMC Case: The Environment and Behavior

Many DDM studies discuss the influence of system complexity and information availability on task performance. System complexity and information deficiency are some of the environmental factors identified by the DDM researchers as negatively associated with the decision outcome.[1] For example, the misperception of feedback theory lists feedback, time-delays, and nonlinearities as sources of complexity in the system that may hinder decision maker's task performance (Sterman 1989).

The FOMC data reveals that the decision environment of the FOMC is very complex and, as predicted by the DDM theories, such complexity creates difficulty in the decision making process.

In the following section, the decision making environment of the FOMC will be discussed in detail with reference to relevant DDM studies. It will also be demonstrated that the FOMC decision makers show behaviors quite different from the typical DDM decision makers as described by the theories.

Time Delays

Time delays are the one of the most significant aspects of the monetary decision making environment. Delays refer to the time lag between initiation of action and its effect. Since adjustment of macroeconomic variables take years, if not decades, delays exist

[1] The independent variables can be largely divided into decision environment factors and decision maker factors, although other categorizations may be used (Buchner 1995; Funke 1995; Hsiao and Richardson 1999; Rouwette, Größler et al. 2004).

between the time a monetary policy is implemented and the time the effect of the policy is fully realized.

Time delays create difficulties for the FOMC decision makers. In the May 1988 meeting, the committee members argued over whether to take another tightening move after the previous contraction policy in March. The problem was that they were not sure whether the economy had "absorbed" the increased money growth from the March expansion or the effect of the intervention was delayed in the system and was still about to happen. In the May transcript, the following statements[2] were made;

> "The markets probably are vulnerable if we move too far too fast. On the other hand, they're vulnerable if we delay too long. I don't know what the precise, perfect timing for this kind of action is." (FOMC 1988b: 4)

> "I don't think we know at this stage what has happened on the money growth that would be anticipated from the moves we have made." (FOMC 1988b: 7)

> "We have had these two tightening moves in very recent weeks and I'm not sure that the markets have fully digested those moves. I'd be very surprised if the real economy has taken them into account or if the monetary aggregates have begun to reflect them." (FOMC 1988b: 8)

Without knowing whether the current state is a result of the last decision or the effect of it is yet to come, any further intervention has a risk of overreaction. Yet, the decision maker cannot postpone the current decision, because time delays in the system require them to make decisions in advance.

DDM studies have identified time delays in the system as a major barrier against improved task performance. According to Sterman (1989; 1994), delays in the system have a negative influence on task performance, because they slow the learning loop and reduce learning gained in each cycle. If a decision maker is unaware of delays in the system, he or she can implement a policy that is either an overly-aggressive correction or a counter-correction and create instability in the system. Paich and Sterman (1993) found in a simulation experiment involving delays and feedback that decision makers not only failed to manage the system, but frequently made the situation worse by their own actions. Brehmer (1990) showed in his experiment with dispatching decisions of a fire-fighting unit that the subjects performed worse when a delay was introduced to the task. He found out that his subjects were able to detect the delay, but being unable to figure out how to deal with it, they ignored it and acted as if there was no delay. Brehmer and Allard (1991) elaborated the fire-fighting experiment to show delays inhibit learning and adaptation. In sum, delay is negatively associated with the decision performance for the following reasons: decision makers fail to learn, they cannot perceive delay, and they overreact to the problem; when they do perceive delay, they either ignore it or fail to develop appropriate strategies.

The FOMC decision makers understand well that the system they are dealing with is a complex one with significant time delays. Unlike the decision makers in Brehmer (1990)'s experiment, the FOMC members explore many possibilities of delays before

[2] Although names are not identified, the statements quoted in this paper from the FOMC transcripts are made by various committee members.

deciding upon a monetary policy. Much of the meeting time is spent on discussing the state of the system, rather than on designing a policy. While they are not fully free from the misperception of the feedback, their explicit discussion about the system's complexity expands their understanding of the system and prevents an overreaction that might destabilize the system. The following quotes from the FOMC meetings show the decision makers' effort to deal with the problem of delays:

> "If you deal with every one of those, you're going to be chasing your tail, I think. If you tighten up against a relative price shock, then you're going to potentially overshoot; as that filters through the economy, then it's going to create an overreaction on the downside at some point, and then you're going to be trying to work it back up." (FOMC 1988b: 27)

> "The relationship between price and money has been a very tough one to grab. In fact, we have created such huge lags between money and prices that it gets you to wondering whether you're leading the next cycle or lagging the previous one." (FOMC 1988b: 35)

> "One thing we have learned from the 1970s experience is that if we are going to stabilize the economy and prevent inflation from blowing up again, we have to be wiling to act before it is clear that inflationary pressures are here. If we wait until we see wages escalating or prices escalating on a broad scale, we will have a momentum that is going to be very difficult to turn around." (FOMC 1988a: 51)

Discovering the major time delays in the system would allow the FOMC to "soft-land" the economy, by minimizing the system oscillation due to intervention. But how would the DDM theorists interpret the behaviors of the FOMC? Sterman (1994) would suggest that the effort of the FOMC to discover the time delay is extremely important for improved task performance, but due to the limitation of human cognitive ability, the model developed from a loose discussion will still be insufficient. Sterman argues that decision makers would have better chance of overcoming the misperception of feedback, if they use virtual worlds, or simulation models, to assist their reasoning. In a similar context, Brehmer (1995) argues that decision makers may discover the correct nature of time delays, but they are likely to fail to develop strategies consistent with their findings. On the other hand, Berry and Broadbent (1984) found out verbalization of knowledge has some positive influence on task performance. In that regard, the discussion about time delays itself can make one's knowledge explicit, and when combined with other decision makers' explicit knowledge, the collective knowledge may generate a positive influence on the decisions made.

Limited Information

Another characteristic of the monetary policy environment is that information available for decision making is very limited. The FOMC decision makers receive staff analysis of current and future economic status before they attend the meeting. However, as in the case of many DDM environments, the data available to the FOMC decision makers are "estimates based on sampled, averaged, and delayed measurement" (Sterman, 1994). As a result, the FOMC must make decisions based on incomplete information.

There are problems with the estimated data. First, the estimation can be very wrong when there is a shift in the trend. For example, estimated GDP can be very different from the actual GDP if the economy is at the peak or at the bottom of the economic cycle and is about to experience a shift in the trend. The trend can also be disrupted by various exogenous factors such as changes in politics and foreign policy. The discrepancy between the actual state and the estimated state leads to difficulty in decision making and generates feeling of anxiety among the decision makers. The second problem is that very different policies may be needed within a margin of error of the estimates. For example, estimates can have the margin of error between positive and negative values, and if that's the case, the error on the positive side may require an expansion policy while the error on the negative side may require a contraction policy.

The following quotes from the FOMC transcripts demonstrate the difficulty expressed by the committee members about the lack of information:

> "Steve McNees reminded me yesterday that the average miss in GNP forecasts made in the first quarter is plus or minus 1-1/2 percent. It seems to me that if we miss on the upside this time, we could have some really serious problems with price pressures in manufacturing." (FOMC 1988a: 38)

> "If you back out the natural rate from our recent experience it suggests that what we built into our forecast—if you take the price expectations being developed in the usual way—could be a natural rate that is around 4-4.5 percent. That is the calculation; but we don't really think that the natural rate is that low." (FOMC 1988a: 40)

> "It is conceivable that the NAIRU may be lower or that excess capacity in terms of current costs may be still larger in general. I would hate for us to make an assumption and start crying wolf, and then stop crying wolf at the point where the whole thing blows up on us." (FOMC 1988a: 41)

Limited information is characteristic of systems with time delays. Döner and Wearing (1995) emphasized that in a dynamic system, future prediction and advance action is needed, but it is not an easy task. Döner and Wearing found that when people are faced with a situation where they lack sufficient information to make a good judgment, they focus on information that they believe to be important without knowing what is critical information. They also found that some decision makers get obsessed with data collection, wasting time without really knowing whether it is worth it to spend the time. Sterman (1994) also suggested that when not enough information is given, decision makers fail to perceive the feedback in the system correctly, and they blind themselves by selectively looking at information which is neither important nor consistent with their mental model.

Unlike the typical decision maker with insufficient information described in the DDM studies, the FOMC exhibits different behavioral patterns. First, as mentioned in the previous section, the FOMC decision makers participate in an intensive discussion to identify missing information critical for the decision task at hand. Economic estimates and analysis provided by the Federal Reserve's staff researchers serve only as an anchoring point, and the FOMC decision makers discuss how the real economy may deviate from the estimates.

Second, the FOMC develops a set of cues that can complement the information deficiency. These information cues are indirect indicators of macroeconomic variables the

FOMC is interested in, but the data on those indirect indicators are more readily available than macroeconomic variables such as GDP or the Consumer Price Index. An example of such indicator is inventory accumulation, as Chairman Greenspan mentions in the following quote:

> "The thing we have to be a little careful about is that we recognize that at some point, whenever you get a situation which is as uniformly positive as this, it turns. It's only a question of when it turns. The thing that's bothering me slightly about the outlook as I look at it – not in the negative sense but in the confirmation sense – is that, at this particular stage in the cycle, if we are running into the type of acceleration and inflationary process which is at the forefront of our concerns, I think we should now begin to get some significant inventory accumulation. We have all the forces in place for it: namely, intermediate prices beginning to move and general awareness of aggregate demand. Yet we are not seeing either." (FOMC 1988b: 1)

Because inventory information can be accessed with a shorter time lag but is at the same time closely related to the production and consumption trend in the economy, the level of inventory receives much attention during the FOMC discussions. The following quotes capture this;

> "When we look at capacity – and the Fed is the official source of these data – capacity is a very dubious concept. You really don't know whether or not you have run into capacity until you have some objective measures of the inability to meet customer orders. And the lead times on the deliveries on materials haven't really expanded all that much." (FOMC 1988a: 41)

> "The list of items that purchasing managers report in short supply has lengthened considerably." (FOMC 1988a: 41)

> "I am beginning to hear a phrase that I haven't heard in a great many years, namely, double ordering."(FOMC 1988a: 42)

Over time, the FOMC accumulated a set of information cues that they trust. When an indicator loses its tie to the macroeconomic variable the FOMC is interested in, the committee discards the indicator and look for a new one.

Finally, the decision makers frequently rely on data from informal source. Called "uncle-asking," this is more like a culture within the committee. During the meetings, the members share anecdotal information that they collected from regional bankers, factory owners, or managers in a firm. By sharing these stories, the FOMC members get a sense of how the economy is doing without actually looking at the GDP or CPI. The following shows how the members bring in informal information to the decision making:

> "We have been hearing for some months now about the improvement in the machine tools business form various people in the district. Earlier this week we saw some articles on the improvement that is taking place in that industry." (FOMC 1988a: 42)

> "The most common comment that one hears is that labor markets are very tight: it's hard to attract unskilled workers." (FOMC 1988a: 43)

Often this informal information comes from a very small set of data and the data source is rarely revealed:

> "We have *several* firms, primarily in metals, that have reported that they are at capacity levels: they simply can't produce anything else. *One* of those firms is considering some kind of expansion at this point." (FOMC 1988a: 46)

> "I checked with two of the big three automakers on the price pressure issue and said "I'm reading all this stuff in the paper; what's really going on?" One of them, who had just talked to their purchasing agents last week, said that in terms of what they are actually paying, they are not seeing this."(FOMC 1988a: 50)

It is not difficult to imagine generalizations based on such a small set of data would not earn much credibility from academics. But it is interesting to note that the FOMC decision makers talk more about these anecdotal stories than formal statistics models in the meeting, and the informal information plays a significant role in filling gaps in the data.

Unlike typical decision makers who only use a few cues and spend a short decision making time when faced with complex tasks (Sterman, 1994), the FOMC decision makers strive hard to explore and learn more about the system complexity and to make good decisions. In order to avoid paying attention to biased information, the FOMC decision makers disclose individual members' mental models and check their soundness through "go-around-the-table" discussions where everyone is required to state his personal position with rationales that support the position. During the discussion, the group builds a composite mental model of the system- the FOMC's collectively perceived structure of the system- and through the process of organization learning, the composite mental model is modified and stabilized. Some part of the composite mental model is so stable that it almost becomes a culture of the organization that is rarely questioned. Abolafia (Forthcoming) describes such process as follows: "they intuit from ambiguous data, they argue over interpretations, they compromise, and they knit together solutions."

Paich and Sterman (1993) suggested expanding a mental model to find important cues and feedback helps task performance. The FOMC not only expanded the mental model by finding additional information cues, but also by actively seeking and utilizing informal information. However, since the indicators the FOMC pays attention to come from the group's composite mental model, the validity of the indicators depends on the validity of the FOMC's composite mental model. Likewise, the validity of anecdotal information would depend on the representativeness of such information.

Complex Causal Structures

In addition to time delay and information deficiency, the decision environment of the FOMC is composed of complex causal structures. It is complex in terms of the number of variables in the system as well as the feedback relationships among them. Abundance of feedback loops and confounding relationships makes it difficult for the decision makers to understand the nature of the given state of the economy and to design intervention.

One of the greatest confounding variables in the FOMC's policy making is market psychology. The FOMC is not the only decision maker in the system. Very much like the FOMC, market participants look at changes in the economy, try to understand the forces behind the changes, and take appropriate actions. Market psychology is so powerful that it can shape and move the economy. Therefore, it is very important for the FOMC to identify

whether a problem in the economy stems from economic fundamentals or from market psychology as they may require different interventions. The following quotes illustrate how the FOMC members try to separate market psychology from the economy's fundamental movement and to figure out its implication on the policy design:

> "Sterilizing intervention can have only a short effect and would be meaningful only to the extent that you can alter the psychology of the portfolio adjustment process. And with the huge stock of assets out there, psychology is not an irrelevant consideration because you can get very substantial moves for [unintelligible] period of time with no change in fundamentals." (FOMC 1988a: 7)

> "I don't think we – I was around this place in the 1970's – sufficiently understood that the inflation psychology had become so strong in this country that small moves in interest rates were shrugged off. Moves in interest rates that previously would have had a big impact on the market had no discernable impact at all. We were very slow to recognize that." (FOMC 1988a: 15)

Market psychology confuses the policy makers not only by influencing the economy but also by reacting to the FOMC policy. Whenever the FOMC announces a policy change, the market participants strive hard to figure out the FOMC's intention behind the policy. By doing so, the market gets an idea of the future economy that the FOMC wants to shape, and it strives to make an early movement accordingly. This market reaction has a significant power to amplify or offset the intended policy effect. Therefore, when the FOMC designs a policy, it needs to predict how market psychology would interpret its policy intention and include that into the policy function. The problem is that it is not always easy to predict market psychology, and missing it in the policy design can add instability to the system. Market psychology is one major source of "counterintuitive behavior of social systems (Forrester 1971)" or "policy resistance (Meadows 1982)." That is why the FOMC devotes itself to creating policy directives that send out clear signals to markets.

Complexity in the system creates uncertainty in the decision making process. The FOMC decision makers experience confusion and anxiety, as expressed in the following quotes:

> "I'm not against the intervention – it just seems to be that we have to think the thing through a little more carefully than to just say 'well, let's intervene and see what happens.'"
> (A speaker responding to the remark) "I think that you are raising an important question that has no good answer." (FOMC 1988a: 6)

> "Either we see the fed funds rate as a signal to the markets or we see the rate as a signal to us. If we are trying to get both types of signals out of the same number, or we perhaps get the two of them confused." (FOMC 1988a: 13)

> "Overall, I must say that I'm very satisfied with what has actually happened. And so I'm torn here. We have a procedure, but I don't really fully understand why it is producing the good results—the results that I like." (FOMC 1988a: 13)

> "So you have that little thing that goes up and down. It's like a little boat, and you have enormous waves bobbing it up and down. We don't know: we say as long as we stay two feet above water, we're fine." (FOMC 1988a: 21)

The FOMC's problem of complex causal structure is the center of what is suggested by the misperceiption of feedback theory. Sterman (1994) describes the problem as "the number of variables that might affect the system vastly overwhelms the data available to rule out alternative theories and competing interpretations (p.302)." The complexity that arises from existence of confounding variables also poses a problem, because it requires a mental simulation that exceeds decision maker's capability. Berry and Broadbent (1987) found in their experiment that people are not very good at dealing with implicit system structures. They found decision makers focus on salient structures and fail to learn about non-salient structures. Therefore, it can be inferred from their research that when decision environments are complex with many non-salient relationships, decision makers would perform far from the optimal. In addition, there are other studies (e.g. Ashby 1956; Brewer 1975) that suggest complexity of the system is a negative factor for decision performance.

On the other hand, Mackinnon and Wearing (1980) found that complexity of the system does not necessarily lead to lower task performance. Discussing their experimental results and referring to the concept of entropy in physics, Mackinnon and Wearing suggested "connections between elements of a system, and the indirect connections formed over time, may be a source of stability." Although Mackinnon and Wearing's study seems to propose an opposite view on the relationship between system complexity and decision making, their assumption is in fact consistent with the DDM theories in that human intervention is more likely to be flawed in a complex system.[3] It is consistent with counterintuitive behavior of social systems and policy resistance hypotheses. In a complex system, an intervention is frequently met by strong balancing loops in the system that nullify the intervention or generate side effects.

Richardson, Andersen et al. (1994) also suggested complexity may not necessarily lead to lower performance. They identified the difference between operator logic (simple associative networks and strategies) and designer logic (detailed, complex structural understanding), and suggested that performance can be improved only by improvement in operator logic. According to the operator logic hypothesis, understanding of complex designer logic does not necessarily leads to better task performance. Richardson et al.'s theory can explain why in some DDM experiments task performance improved without decision maker's gaining in system knowledge (example, Paich and Sterman 1993).

What are the behavioral patterns created in the decision making environment with complex causal structures? Sterman (1994) points out that only a few decision makers incorporate any feedback loops when they make decisions. But here in the case of the FOMC, there is evidence of the monetary policy makers working hard to understand feedback structures in the system. They reflect on ramifications of the feedback loops on the effect of monetary policy. Capturing all the relevant complexity may not be possible for FOMC decision makers, but as they discuss possible complicating factors, they elaborate their mental models. Döner and Wearing (1995) found that decision makers who have a cognitive style with an elaborate network of causal relations outperform those who has not.

In order to better understand structure of the system, the FOMC actively utilizes expert knowledge within the committee. Learning process in monetary policy making is

[3] Mackinnon and Wearing (1980)'s suggestion is based on the assumption that human intervention is more likely to generate inferior outcome than laissez-fair approach.

slow due to the nature of the decision environment. However, over the history of monetary intervention, the FOMC has slowly accumulated expert knowledge. The seven members from the Board of Governors serve for fourteen years on the FOMC. Many of the FOMC members have experience in different positions at the Federal Reserve prior to their appointment on the FOMC. Expert knowledge helps analyzing the current economic situation by comparing it to the similar situations in the past. It is also useful in predicting the consequences of a monetary policy. Although no two economic situations are exactly the same, past experience broadens the decision makers' mental models and minimizes the misperception of feedback. The following quotes from the meetings are examples of such behavior:

> "I didn't attend the meetings, but I spend a good portion of my time as director of research [at the Philadelphia Reserve Bank] on 1979 issue, trying to widen the funds rate bands. We went through a lot of the things that some of us alluded to here when the base argument came up two months or three months ago." (FOMC 1988a: 15)

> "But how is that different from a borrowing target? I'm just saying that the borrowing approach has the same problem with it. If you agree that was a problem in 1979, a borrowing target would present the exact same problem." (FOMC 1988a: 16)

> "I remember so many times sitting around this table when this was the apparent stage of a business cycle where traditionally we have made our largest mistakes. So I think we ought to move now." (FOMC 1998b: 8)

Past experience is informal and anecdotal, but it has a powerful influence on the FOMC's decision as in the case of the anecdotal information collected from informal sources.

One of the things the FOMC learned from experience is how to deal with market psychology. The committee found out that in order to minimize unintended reaction from the market, it is critical to send out the right kind of message. The FOMC decision makers are extremely careful about how to frame a policy, and they do their best to maintain consistency in their signaling. Trust in the signals has became a very important part of FOMC policy: sometimes the FOMC chooses to follow the market expectation to retain credibility in their policy intention even when the economy requires other kinds of policy (Kelton 2005).

Some DDM research suggest that task performance can be improved by task expertise and experience (Berry and Broadbent 1984; Sanderson 1989). On the other hand, Paich and Sterman (1993) argue that while learning improves performance, the most part of such learning is trial-and-error learning rather than system level learning. They also suggested that experience can lock people's view and influence negatively on the performance. Döner and Wearing (1995) also argued that schema has both positive and negative effects on task performance. It is important to note, however, the findings of the DDM experiments are based on task expertise and experience operationalized as a short-term training relevant to the task or as educational background, and therefore, the implication of these studies on the FOMC may need further examination.

Competing Goals and High Consequences

A societal decision maker is a person who makes risky decisions for others (Lichtenstein, Gregory et al. 1990). Decision making environments of societal decision makers are often characterized by multiple and conflicting goals and high consequences for the decisions. In this section, the discussion will focus on these two factors: competing goals and high consequences.

Monetary policy influences various economic actors in the society with different goals. However, despite different stakeholder interests, the FOMC remains relatively neutral. The decision makers at the FOMC focus more on overarching goals of economic prosperity and stability, and there is not much evidence in the data that members seek their own or specific groups' interests in policy making.[4] Even the regional presidents of the Federal Reserve Banks put the overall performance of the economy on top of their own regional benefit. Independence of the Federal Reserve guaranteed by the law also seems to foster such culture. However, even when the FOMC decision makers look at the big picture, the committee members must pursue inherently conflicting goals of monetary intervention: to promote economic growth and to stabilize price levels. The former is usually achieved by the expansion policy while the latter is related to a contraction policy. When the economy is clearly overheating or is in a recession, selecting one goal over the other is not so difficult. However, when the position of the economy in the business cycle is not clear, the priority of the conflicting goals become questionable.

In March and May 1988, the price stability received more attention than economic growth, but the consensus on the goal priority was achieved after a long debate. The conflicting goal structure leads to the FOMC's frequent discussion on its priority in policy making. The following quotes from May 1988 meeting show how ambiguous the goal priority is to the FOMC members:

> "I don't know how this Committee would vote on that, but I remember several years ago Chairman Volcker asked us what we thought the objective was and half of us voted for price stability alone; half voted the other way; and he didn't vote and didn't break the tie. But I think that (price stability) is the ultimate objective, and I hear more and more people around here saying that. (FOMC 1988b: 24)"

> "*If* our objective is price stability, then we ought to begin to pursue that objective aggressively. (FOMC 1988b: 5)"

Döner and Wearing (1995) used a miroworld simulation where decision makers were asked to improve the general quality of living in the virtual society without specific instruction on clear objectives or guideline for performance measurement. The researchers believed that task given without a clear goal resembled the real decision making environment better than task given with clear goals. They found that the subjects spent an unnecessarily long time for defining goals, but often failed to consider goal conflicts. They also found the decision makers tended to focus more on easy to tackle problems than important problems.

[4] It could be argued that influence of political interests on monetary policy making exists beneath the surface, but this may be a topic of another study.

Whether or not the FOMC's long discussion on the goal priority improves the task performance requires further study. However, the FOMC members show a few other behavioral patterns not discussed by Döner and Wearing. To avoid much confusion in the policy objectives, the FOMC has framed the goals in a hierarchical structure. The goals are categorized into ultimate, intermediate, and operational goals, and lower level of goals serve as a means to achieve higher level goals. The lower level goals are more flexible than the higher level goals, and they provide more hands-on objectives for the decision makers.

Other than Döner and Wearing, there has not been much study within the DDM literature on how the decision maker's goal structure influences the task performance. The FOMC case suggests that goal structure could be a significant predictor of the task performance, and the future DDM research may experiment on multiple or conflicting goals as independent variables.

In addition to the competing goal structure, the FOMC faces decisions that involve high consequences. Monetary policy affects the wealth of individuals and the nation. Throughout the FOMC meetings, the members frequently express their belief in monetary policy and its impact on the economy. The Chairman Greenspan once stated, "I don't think anybody denies that monetary policy is effective (FOMC 1988a: 6)." The scope and the depth of influence of monetary policy create feeling of responsibility in the decision makers. It put a psychological burden on the members, and because of that, they exhibit various types of emotions such as caution and anxiety. This can be seen in the following quotes:

> "It is a question that there is no obvious or easy answer to; but it seems to me that we have to ask it rather than continue intervening willy-nilly and hoping that will solve the problem. I'm not against the intervention – it just seems to me that we have to think the thing through a little more carefully than to just say "well, let's intervene and see what happens." (FOMC 1988a: 6)

> "I'd rather stand up like a man, and do what we have to do." (FOMC 1988a: 12)

> "I think that tells me that we're sort of on a knife edge, policy-wise. We can make mistake on the downside or the upside here. But we have to take some risk. My personal view is that there may be more upside risk, in terms of the beginnings of some pressures indicated by conditions in the financial markets and in the other real economic data. But I think we ought to be very cautious at this point, because there are downside risks, as has been pointed out. I think the stock market is very uneasy about the situation." (FOMC 1988a: 52)

Relationship between task performance and high consequence involved with decisions has not been thoroughly studied by DDM researchers. From the FOMC case, high consequences of decision results in various behavioral patterns that are intended to alleviate the burden. It also seems true that high consequence decisions make the decision makers pay greater attention to precision of the decision. These are topics future DDM studies can examine.

The most notable aspects of the FOMC's decision making rule are a "go-around" survey and majority voting. In every decision the FOMC makes, the FOMC takes a go-around survey, which requires each person to state his or her final opinion and reveals the rationale for the position even if it is just a repetition of what previous people have said. As mentioned briefly in the previous section, this process makes each person's mental model

more explicit and leads to the construction of a composite mental model. The goal is to build consensus before they take the final vote. On every decision or on conflicting opinions, the FOMC members take the majority vote. Majority voting seems like a rather unscientific way to design a monetary policy. It may be rational in terms of the number of people satisfied with the final decision, but it is loosely related to the optimal decision.

For the FOMC decision makers, consensus building and majority voting are effective ways to deal with uncertainty and the consequences involved with their decisions. The process generates confidence in the composite mental model. Because selection of policy objectives, application of informal information and task expertise all require the decision makers' judgment, the consensus building and majority voting alleviate the tension the decision makers may feel from the uncertainties and the high consequences of their decision. The process shifts the burden from the individuals to the group.

This is a part of the decision making behavior that previous DDM research has not examined. Does consensus building have positive influence on DDM tasks in group settings? Can majority voting generate better outcomes than other decision making models in high-uncertainty, high-consequence environment? These will be interesting topics for future DDM study.

Finally, the FOMC case suggests the group decision making may be quite different from individual decision making. DDM studies in the past focused mainly on individual cognitive process. However, many important decisions in the real world involve a team of decision makers. While this study attempted to apply previous DDM theories to the FOMC case, because the unit of analysis is different, it is questionable whether the studies based on the individual decision makers have validity in the group decision making settings. Therefore, it is important for future DDM studies to experiment with group decision makers and build appropriate theories on the topic.

Conclusions

This article attempted to find implications of DDM studies on understanding monetary policy making at the Federal Reserve. By analyzing the FOMC meeting transcripts, the decision making environment and behavior of the FOMC were identified. The main characteristics of the decision making environment was the system's complexity due to time delays, limited information, complex causal structure, conflicting goal structure and high consequences of the decision outcome. The previous DDM studies supported the negative influence of time delays, information deficiency, and complex causal structures on the task performance. Although most DDM studies suggested decision maker's cognitive limitation in perceiving and overcoming such complex decision environments, the FOMC demonstrated behavior patterns different from the DDM predictions. They actively explored the system complexity by vigorous discussion, and developed a set of information cues that can supplement the missing information. The FOMC also tried to expand the mental model by readily bringing in informal information and their task expertise. Abolafia (Forthcoming) refers to this as a "sensemaking" process in which actors make ongoing

efforts to interpret their environment and place diverse bits of ambiguous information into a framework.

Success of the FOMC's coping behavior is hard to measure. The dependent variable of such a study would be performance of the monetary intervention. However, because monetary decisions are embedded in a system that is so complex, it is hard to determine whether a change in the economy is a result of a monetary intervention or not. Even if we are sure the state of the economy is the result of the monetary policy, we cannot conclude the success or failure of the policy, because as in the case of many public policy cases, different people place different value in monetary policy. Since definition and measurement of the dependent variable is not an easy task, we cannot fully conclude the observed behavior of the FOMC decision makers resulted in better performance. However, what we can conclude is that their behavior is different from the typical decision maker's behavior discussed in the DDM literature. This study showed that the FOMC members are aware of their limitations as decision makers, and rather than ignoring the complexity or turning to a self-created image of the system and quick-fixes, they try hard to understand the complexity and make best of what they have.

The examination of the FOMC's decision making environment revealed factors that seemed to influence the decision outcome yet have not been studied in the DDM literature. Competing goal structure and high decision consequence seem to shape a substantial part of the FOMC's behavior. Under this environment, the FOMC adopted consensus building and majority voting process, which are rather unexpected decision rules for generating the optimal policy. Dependence on such decision making rules seems to be due to the fact that these processes shift the burden from the individual decision makers to the decision making group. The environmental factors and the behavioral patterns demonstrated by the FOMC suggest interesting areas for future DDM research.

In addition, this study suggests DDM research needs to identify differences between group versus individual decision makers. For example, studies on implicit and explicit knowledge (for example, Berry and Broadbent 1984) revealed that decision maker's explicit verbalizable knowledge is different from the decision maker's implicit knowledge used for the decision making. In other words, these studies argue that it may not be possible to infer decision maker's decision models from his or her verbal account of the strategy. Would the same theory hold for the group decision making model where the decision is made during discussions among the group? DDM studies on group decision making will contribute to understanding the dynamics and decision outcome of a group that could be quite different from the case of individual decision makers.

Decision making is not easy. But it is possible to improve the quality of our decisions. We see the possibility from the case of the FOMC. Previous DDM studies contributed to our understanding of human decision making behaviors, but the researchers were passive about applying experimental finding to real DDM cases. Such attitudes were mainly due to the questions regarding the external validity of laboratory settings. However, this study that suggests analysis of real DDM case using laboratory findings not only helps understanding decision making behaviors in the real world but also generate sound discussion for improving theory building process in DDM studies.

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