



# **A Method for Theoretical Innovation in Economics**

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## Abstract

How can more theoretical innovation in economics be stimulated? Clues to the answer can be derived from the work of theorists who have been recognised for their innovative contributions to economic theory and from the philosophy of scientific progress. This paper takes the view that scientific progress is propelled by the need to address unsolved problems. From problem theory it is derived that these unsolved problems are generated by inconsistent assumptions and slows down theoretical progress for as long as such problems remain unsolved. Gifted economic theorists intuitively recognise logical inconsistencies, and employ various abductive reasoning strategies to find assumptions that remove these inconsistencies. Their research often produces new inconsistencies, and so triggers further theoretical innovation by others. A rational reconstruction of the seminal work of Nobel Prize winners Kydland and Prescott (1977) provides a running illustration, and shows that an understanding of the structure of economic problems can allow more economists to deliver innovative theoretical work.

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## 1 Introduction

Economic science will not advance without the efforts of theoretical innovators and the many theorists who elaborate and refine these conceptual innovations and so integrate it into the mainstream body of knowledge. It is the task of those who award prizes like the Nobel Prize in Economics to determine whose innovative work initiated lasting major theoretical progress in economics (Lindbeck, 1999). This is a difficult task already. It is even more difficult, if not impossible, to predict which theoretical innovations will be integrated into the body of knowledge and to know how to stimulate the emergence of more such innovations (Stigler, 1983:538).

This paper derives suggestions, from the work of two Nobel Prize winners, on how to recognise areas ripe for major theoretical innovation and how to generate such innovation. By following these suggestions, progress in economic theory may proceed faster by directing innovative effort to the most appropriate areas. It may also assist individual economic theorists to deliver more innovative research in their field.

The suggestions made in this paper are familiar to economists, and are centered on problems. Trained economic theorists commonly acknowledge the centrality of problems in economic science by stating the problem that their research is designed to address. Economic theories are offered as reasoned solutions to conceptual problems, and the importance of a theory is judged by its problem-solving abilities (Spearmur, 1991:41, Laudan, 1977:109). It is therefore possible to rationally reconstruct the development of economic theory as a history of problems, indicating the centrality of problems in the progress of economics.

If problems are central to theoretical progress, one would expect gifted economic theorists to be those who have an intuitive understanding of the general structure of economic problems. Viner (1937:109) confirmed this in his survey of trade theory in the "pre-scientific stage" of economic theory: "...such progress as

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\*I would like to acknowledge Alain Kabundi and Eric Schaling for bringing to my attention the possibility of applying problem theory to the innovative theoretical research of Nobel Prize winners in Economics

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occurred was due almost solely to a small group of capable writers, able to analyse economic problems more acutely and logically than their predecessors. . . "

Why an understanding of economic problems makes some theorists more effective than others can be explained by the fact that a perception of the structure of problems in a field determines how a problem is represented. Representation in turn determines the methods used in solving such problems. Gifted theorists have different problem representations in mind and are more likely to focus their efforts using more appropriate methods, and so develop theories that will be seen as advances and that stand a better chance of being integrated with the existing body of knowledge.

Theoretical innovation in economics may therefore occur through the use of a problem-based approach. The purpose of this paper is to develop a problem-based method for theoretical innovation by deriving conclusions from the work of two Nobel Prize winners with the aid of problem theory. The ideas in the paper could have been illustrated by means of the work of most award-winning economists who offered theoretical advances in economics. Due to the limitations of space, a focus was chosen in the form of Nobel Prize winners Finn Kydland and Edward Prescott's seminal research in monetary economics. By deriving conclusions from the actual practice of gifted economic theorists, it is shown that the method developed in this paper is implicit in the work of such theorists, and can be replicated by others to accelerate innovation in economic theory.

A note to prevent misunderstanding: this paper does not offer a new theory of scientific progress. While the paper is rooted in existing theories of scientific progress, it has a more practical emphasis than the work often found in the philosophy of science. However, it may be useful to briefly place the ideas of this paper in a philosophical context. Some of the most influential philosophers of science, specifically Popper, Kuhn, Lakatos and Laudan, recognised the role that problems play in the progress of science. The premise of this paper is Popper's (1972:258) view that progress in science occurs as scientists proceed from solved problems to unsolved problems. Popper explained that science progresses through an iterative process of conjectured solutions to unsolved problems (resulting in theories) and refutations (falsification of these theories). Unfortunately, Popper never gave much practical advice on how to derive the appropriate conjectures that can be developed into innovative theories. Kuhn, Lakatos and Laudan similarly provided little hands-on guidance on how to create the new paradigms or research programmes that might lead to progress in economic theory. This paper provides a method for increasing the rate of theoretical innovation in economics.

## 2 Problems in science

Science advances from problem to problem. Without problems there would be no way of knowing whether science matters, whether it is approaching the ever-elusive truth. Stigler (1983:535) pointed out that without unsolved problems, science would become sterile, since unsolved problems motivate scientists to generate and pursue new ideas. Viewing science from the perspective of problems, offers the most promising way to understand its progress and how scientists can contribute to this progress (Giunti, 1988:439).

Scientific problems are essentially problems in the sphere of existing ideas (Popper, 1992:8-9). When human ideas are incomplete or conflict with each other, they create doubts that unsettle our set of beliefs, which is similar to the view that pragmatists such as Dewey and Peirce held about problems. The word problem is derived from the Greek word *problema*, associated with some kind of impediment (Hattiangadi, 1978:353). The unsolved problems of a theory cast doubt on the ideas of that theory, and so may impede further theoretical advances. These unsolved problems often attract the attention of some theorists and motivate them to generate new ideas that can remove the doubts that impede theoretical progress.

Progress in the theory of monetary policy was (at the time of Kydland and Prescott's seminal article) driven by a number of critical problems, including the problem of whether rules or discretion was the best foundation for monetary policy. The theoretical analysis of the competing views were inconclusive (Argy, 1988:155) thereby hindering further theoretical progress, until Kydland and Prescott (1977) reframed the problem as that of time inconsistency and changed the nature of the debate (Schaling, 1995:58). With

the problem reframed, progress in the theory of monetary policy accelerated as the new problem suggested original directions for theoretical and empirical research that led to innovative solutions to the problem.

### 3 Problems as sets of inconsistent assumptions

Theories are solutions to problems, as well as attempts to capture the complexity of reality in the simplest possible form. To reduce this complexity to a theory, scientists make assumptions. Knowledge as represented by scientific theories is therefore limited and tenuous, since no theory can capture the complexity of reality perfectly. Also in monetary policy theory, where Kydland and Prescott made their contribution, limited knowledge is a key stumbling block (McCallum, 1997:8-10).

Beliefs, in the form of assumptions, are needed to fill the gaps in our understanding of reality due to uncertainty and imperfect knowledge. As new problems are discovered in existing theories, and as reality itself changes, different or additional assumptions are needed. As a result scientific knowledge and ideas changes over time and inconsistencies may gradually appear in the assumptions. This is compounded when reality changes in response to economic theorists' models and discoveries, for example when previously known empirical regularities disappear as they are exploited by policymakers (see for example the literature on performativity e.g. MacKenzie, 2006). It may also happen that the logical consequences of known assumptions conflict with beliefs or logical consequences not yet made explicit, so that inconsistencies may exist without immediately being apparent. Yet another source of inconsistent assumptions is when rival theories with competing views and different sets of assumptions are developed to address an existing problem. For example, those who argue for discretion will argue from a set of assumptions that are inconsistent with some of the assumptions of those who argue for a policy rule. If there were no inconsistent assumptions, a discipline would have no conceptual problems, and there would be no incentive to pursue theoretical progress.

Logical consistency within the vast number of assumptions and derived statements in economic theory is not likely to be achieved. Cherniak (1984:755-756) demonstrates that it would take an ideal computer twenty billion years to determine the logical consistency of only 138 well-defined statements. Consider how long it took the economics profession to even see the logical inconsistency between just four known assumptions from which Arrow's Theorem was derived, and Arrow's two initially unsuccessful attempts in 1951 and 1962 to correctly prove the existence of the inconsistency (Denzau & North, 1994:26). The literature on the time inconsistency problem alone consists of more than 138 assumptions and statements, and many of them are not well-defined. It is inevitable, therefore, that numerous logical inconsistencies exist in the field of monetary policy theory.

Competing views, whose assumptions are inconsistent with each other, were responsible for the rules versus discretion debate in monetary policy theory. This debate originated in the 19th century with the Currency and Banking Schools. The Currency School favoured rules and their ideas were further developed by many theorists, including proponents of rational expectations theory. The Banking School favoured discretion, whose views later found support in optimal control theory. Kydland and Prescott (1977:474) pointed out that the role of expectations in agents' decision-making was logically "inconsistent with the assumptions of optimal control theory", thus maintaining the problem.

When there are logical inconsistencies in a set of beliefs, a contradiction will follow. Any statement can be derived from inconsistent assumptions, including statements that contradict each other, also known as the principle of *ex falso quodlibet* in classical logic (Tomassi, 1999:120). This makes any set of inconsistent assumptions valueless since all courses of action can be derived from such a set, and will give no guidance on how to achieve certain ends. For example, a set of inconsistent assumptions about monetary policy will generate the logically contradictory conclusion that the central bank should use discretionary policy and a policy rule. At best, this leads to indecisiveness and movement between extremes; at worst it leads to actions that aggravate the problem. In other words, inconsistent beliefs impede the achievement of goals, and thus constitute a problem.<sup>1</sup> A contradiction therefore places a constraint on possible solution activity.

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<sup>1</sup>This applies to theorists engaged in scientific activity, which is the focus of this paper. It may not be always be the case in the case of exchange activity on markets. In markets inconsistent beliefs about the future (e.g. so-called bulls and bears) are

Imperfect theories, with inconsistent assumptions, inevitably generate further problems or gaps that need to be addressed by additional or different assumptions and the development of new theories. The time inconsistency problem, for example, created new unsolved problems of institutional design, timing and the credibility-flexibility trade-off. These problems motivated theorists such as Barro and Gordon (1983), Rogoff (1985), Walsh (1995) and Haubrich and Ritter (2000) to generate new ideas to solve them. As old problems spawn new problems, the resulting theoretical development may follow a path that is reminiscent of “technological trajectories” (Dosi, 1988:1128).

In short, unsolved scientific problems are not only impediments to the advancement of theory, but also create incentives for theorists to pursue theoretical advances. One can describe such problems as contradictions or conflicts generated by logically inconsistent beliefs (Hattiangadi, 1978:357). The conflicting nature of economic problems is also evident from the fact that economic problems are often represented as trade-offs (conflicts between means or ends as is evident from Phelps’ work), but also as dilemmas (much appearing in the theory of economic policy), paradoxes (as Kydland and Prescott did) or knowledge gaps created by inconsistencies (which led Stiglitz to his theoretical innovations).

The inconsistencies that cause problems mean that such problems can be logically structured as contradictions in the form of a destructive dilemma. The generic representation is as follows:

$$\begin{aligned}
 G &\supset R \cdot R \supset A \\
 G &\supset R'' \cdot R'' \supset \sim A \\
 &\therefore \sim R \vee \sim R'' \\
 &\therefore \sim G
 \end{aligned}$$

In the above generic representation of a problem,  $G, R, R'', A$  and  $\sim A$  are statements.  $G$  is a common objective,  $R$  and  $R''$  are different requirements that need to be satisfied to achieve the objective, and  $A$  and  $\sim A$  (not- $A$ ) are apparently conflicting actions to satisfy the requirements. The conditional statement  $G \supset R''$  can now be translated as: if goal  $G$  is to be achieved then requirement  $R''$  must be satisfied. All four conditionals will only be plausible if they are supported by certain assumptions.

$A$  and  $\sim A$  are believed to be logical opposites, so both cannot simultaneously be true, in other words  $\sim (A \wedge \sim A)$ . In the generic representation, if we derive both  $A$  and its negation  $\sim A$ , then either  $R$  or  $R''$  must be false. Since  $R$  and  $R''$  are both derived from  $G$ , and one of them is false,  $G$  cannot be true. The existence of a contradiction therefore causes the truth of all statements to be in doubt, and thus the underlying assumptions are of little use in the pursuit of truth. When doubt enters, a problem appears, calling for an inquiry into our beliefs (Backhouse, 1998:193-194).

However, several philosophers have pointed out that not all scientific problems can be described as contradictions arising from inconsistent beliefs (Giunti, 1988:421-439; Nickles, 1981:94; Wettersten, 2002:487-536). This description fails in the case of empirical problems (problems that can be solved by collecting more data or explaining the data) but is better suited to describing conceptual problems (problems due to inconsistencies and incompleteness in our theories, classifications and concepts).

An understanding of conceptual problems must precede an understanding of empirical problems. Empirical problems are derived from conceptual problems, but conceptual problems do not always follow from empirical problems (Nickles, 1981:93). For example, the early empirical problem of measuring central bank independence (such as Alesina, 1989) emerged from the conceptual problem of time inconsistency. Science aims to give us a coherent and complete picture of the world at a conceptual level, so the main task of scientists is to solve conceptual problems. Since this paper aims to develop a method for stimulating theoretical innovation in economic science, it will explore only conceptual problems. The next two sections will explain how inconsistent assumptions structure economic problems.

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necessary if any exchange is to take place.

## 4 Logical representation of the fundamental problem

All scientific fields emerge from a fundamental conceptual problem or question, which can be represented as a contradiction. As scientists attempt to address the fundamental problem, new problems appear in a tree-like hierarchical structure (Hattiangadi, 1979:53-61). As mentioned above, this process is similar to Dosi's (1988) notion of technological paradigms and trajectories – with the fundamental problem playing the role of the paradigm and the trajectory being the result of new problems arising from the solution of old problems. The closer a scientific problem is to the fundamental problem in its field, the more critical it is to the progress of that field. The solutions to critical problems contribute more to the solution of the fundamental problem.

From one perspective, the fundamental problem in economic science centres on how to utilise scarce means, with alternative uses, to achieve specified ends (Robbins, 1952:16). From attempts to solve this fundamental problem, critical problems such as imperfect competition, asymmetric information, institutions and macroeconomic stabilisation arose. Kydland and Prescott's (1977, 1982) work directly addressed the critical problem of macroeconomic stabilisation.

Using the fundamental contradiction in economics (derived from the scarcity problem) as an example, one can also show an alternative graphic representation. Such a representation makes the logical structure clearer. This visual perspective of the logical structure of problems is derived from Goldratt (1994:22) and in Figure 1 its representation is applied to one of many possible versions of the fundamental economic problem.

Figure 1 implies that there is a common objective in economic science which is to find ways to increase human welfare ( $G$ ). On the one hand, if this objective is to be achieved, then it is argued that deliberate steps need to be taken to improve the state of the economy as a whole ( $R$ ) which implies intervention of some kind of authority (positive action). On the other hand, it may be argued that to increase welfare it is necessary that agents be allowed to exercise choices that are in their own interest ( $R''$ ), which necessitates that the market works without interference (negative action). The result is a problem, because interference in the market ( $A$ ) is in direct conflict with letting the market work freely ( $\sim A$ )<sup>2</sup>.

Statements  $R, R'', A$  and  $\sim A$  are a logical consequence of certain assumptions. The graphic representation makes it easier to locate these assumptions. The assumptions are implicit in the connectives labelled I to IV, and in connective  $\Phi$  which indicates a logical contradiction. The assumptions cause the problem because they either lead to conflicting statements (assumptions in connectives I, II, III or IV) or because they lead to the belief that a contradiction exists (assumptions in connective  $\Phi$ ). The assumptions can be made explicit by asking those who agree with the conditional connectives (I to IV) to explain why one particular statement follows from another statement, or asking those who believe in connective  $\Phi$  why they believe  $A$  and  $\sim A$  are not compatible. To explain and justify the conditional statements of connectives I to IV, one would need to make further statements which will lead one to find the beliefs underlying each connective. One may also ask why it follows that interference is in conflict with the free working of the market, and so find the beliefs that maintain connective  $\Phi$  (e.g. beliefs relating to the nature of freedom, interference and institutions). Following such a process, it is possible to find the assumptions that provide structure to the problem, as demonstrated in the next section.

Theorists from one competing view will look at one side of such a contradiction and not agree with the conclusions. For example, some theorists will challenge the statement that interference is necessary to improve the state of the total economy, and proceed to give several reasons for their view. When they do so, they are identifying and challenging the assumptions that underlie the logic of logical connective II, thereby demonstrating that beliefs were what cause this problem and maintains it. A different set of beliefs may resolve this particular problem.

The assumptions cause the problem either because they lead to conflicting statements (connectives I, II, III or IV) or because they lead to the belief that a contradiction exists (connective  $\Phi$ ). Beliefs can lead to a

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<sup>2</sup>One of the critical problems that emerge from this dualistic representation is the role of institutions. Theories of institutions show that the opposing sides are not necessarily in conflict and so offer one way of addressing the fundamental problem. By nurturing and establishing appropriate market-supporting institutions, government can shape the state of the economy ( $R$ ) while at the same time letting the market work more freely ( $\sim A$ ) (see for example Rodrik, 2000:5).

contradiction only if at least one of them is inconsistent with one other belief. For example, under connective II one may find an assumption that only an overarching authority can possess sufficient knowledge of the economy to direct agents to make globally optimal choices. However, under connective IV one may find an assumption that the market mechanism enables individual agents to bring about outcomes as if they possessed the collective knowledge of all agents. The two underlying assumptions are inconsistent, and thus lead to contradictory conclusions.

## 5 Logical representation of the rules vs discretion problem

Kydland and Prescott reframed the problem of monetary policy in such a way that it changed the nature of the rules-discretion debate and made the case for policy rules stronger. Kydland and Prescott (1977:474) noted that Friedman's (1948) statement of the monetary policy problem did not succeed in settling the debate, since he accepted the problem as framed by the competing view. Friedman did this by taking on the key assumption of the competing view (advocates of discretion) that economic planning is a "game against nature". Friedman argued that without a rule, policymakers will be tempted into excess activism due to ignorance about the state of the economy and the timing and magnitude of the effects of policy (states of nature).

Kydland and Prescott formulated their problem as a paradox, integrating the theoretical developments at the time in the fields of game theory and rational expectations as well as the Lucas critique. They showed that the paradox arises because economic planning is in fact not only a "game against nature" but also "a game against rational economic agents" (Kydland and Prescott, 1977:473). To see how Kydland and Prescott's statement of the problem was different from previous statements, it will help to consider the possible logical structure of the monetary policy problem as they framed it.

In Table 1 the problem is structured as a set of logical statements, rather than graphically (as in Figure 1). The belief operator  $B$  is added here to indicate that not all theorists will agree with both sides of the contradiction. To simplify,  $x$  and  $y$  are two groups of theorists with competing views and inconsistent beliefs. Group  $x$  argues for discretion and group  $y$  argues for rules.  $Bx$ , then stands for " $x$  believes that..." The role that belief plays in causing the problem is thereby recognised, acknowledging the possibility that the statements may be open to challenge. Since conflicting beliefs may exist within the mind of one theorist, it is likely to be the case that  $x \cap y \neq \emptyset$ .

On the one hand,  $x$  believes that if the social objective function is to be maximised, it is necessary to select the best policies given the current state of the economy. Selecting such policies would imply the continuous use of discretionary policy. This side of the paradox assumes that economic planning influences only states of nature. On the other hand,  $y$  believes that to maximise the social objective function, it is necessary select the best decision given how agents form expectations and make choices. To do this, policymakers need to follow a policy rule. This side of the paradox assumes that economic planning influences the states of agents. A case for both discretionary policy and a policy rule can be argued given the objective function, but both  $x$  and  $y$  believe that discretionary policy is in contradiction to a policy rule.

What made Kydland and Prescott's (1977) work so useful, is the clarity with which they made the assumptions of both sides explicit, then showed how those assumptions structured the problem, and finally argued from those assumptions. They brought to the surface at least twenty assumptions underlying the four conditional connectives of the problem as it is expressed in Table 1. Table 2 identifies only some of the assumptions they identified that support each of the connectives. Later reviews of the rules-discretion debate, such as Clarida, Gali and Gertler (1999) and critics, such as Blinder (1997) and Haubrich and Ritter (2000), made further assumptions explicit.

Connective I contains assumptions that mainly support the argument that states of nature affect the social objective function, while connective III contains assumptions that support the conclusion that the states of agents affect the social objective function. The assumptions underlying connective II mainly relate to notions that policy actions are necessary and sufficient to optimise economic performance. Underlying connective IV are assumptions relating to the effect of policy on agents and how agents respond to policy. The opposing

horns of the destructive dilemma seem logical in isolation given their assumptions, but when juxtaposed the two horns appear contradictory. The logical contradiction is generated because the assumptions of connectives I and II are inconsistent with those of connectives III and IV.

Now we can see why Friedman's use of ignorance of the timing and magnitude of policy effects as an argument for a policy rule could not settle the rules-discretion debate. It led to a different statement R" and a different set of assumptions under connectives II and IV. In such a case, statement R" will be different from what it was in Table 1, and probably read 'Select best decision given the expected future state of the economy' which assumes that policy is a game against nature.

Kydland and Prescott's (1977) article would not have been as significant if it had simply reframed the problem and made its assumptions explicit. The reframed problem with its explicit assumptions enabled Kydland and Prescott, and those who followed, to reason to new ideas that revolutionised monetary policy.

## 6 Conceptual problems as sources of theoretical progress

Most economic theories are deduced from a set of beliefs or assumptions, using the tools of classical logic and or the mathematics derived from it. Theoretical progress occurs when existing beliefs are replaced by new beliefs that allow innovative ideas to emerge that lie outside the accepted body of knowledge. Since deduction from an unchanging set of assumptions will always lead to the same ideas, innovation cannot result from pure deductive thinking (involving classical logic). For a solution to be innovative, it must not be deducible from the current state of art (Redelinguys, 2000:271) or from a succession of previous decision-making events (Rizzello, 1999:132). Schumpeter (1954:41) suggested that the same is true of theoretical innovation in economics "... of which the sources is not to be found in the facts, methods, and results of the pre-existing state of the science."

Innovative solutions or theories are derived from new or different assumptions, which are discovered by challenging known logical relationships and so lead to a more consistent set of assumptions. New assumptions, as Einstein explained, emerge from "leaps of conjecture" (involving abductive reasoning) which are only later related to existing theories and real world phenomena through logic (Holton, 1979:319). This explains why many innovations appear logical in hindsight.

If conceptual problems exist as a result of existing assumptions being inconsistent, then one method for theoretical progress is to challenge the assumptions that maintain the problem with a view to generating one or more new assumptions. From these new assumptions, innovative ideas can be derived. If these innovative ideas are successful, they will result in dissolving the contradiction by synthesising the conflicting sides (Redelinguys, 2000:272; Savransky, 2000:60-62; Nonaka & Toyama, 2002:995). The dissolution of a contradiction may also reveal itself as a dilemma resolved, a paradox explained, a trade-off eliminated or a debate between competing views settled (Hattiangadi, 1979:67-68).

The structure of a problem as represented in Table 1, suggests three strategies of abductive reasoning that may be used to synthesise conflicting sides (see Table 3). One strategy involves finding assumptions that directly reconcile the opposing actions (i.e. assumptions that reconcile  $A$  and  $\sim A$ ). The other two strategies do so indirectly by finding assumptions that allow a specific action ( $A$  or  $\sim A$ ) to satisfy its opposing requirement.

Abductive reasoning can be described as the creative process of generating new hypotheses (or assumptions in this case) to explain anomalies or facts that are surprising given existing beliefs. Abductive reasoning, as a method for generating new ideas, has been proven and substantially improved by researchers in computational philosophy and artificial intelligence since it was proposed by the pragmatist philosopher Charles Peirce (Paavola, 2006). It possesses a clear logical structure and can thus provide a systematic strategy for reasoning to new ideas.

When looking for new hypotheses or assumptions, theorists can actively provoke their emergence by deliberately proposing phenomena that are surprising given the current theory. Each surprising phenomena can be derived from the structure of the problem and provides the basis for a different abductive reasoning strategy. The three phenomena in Table 3 would have been regarded as surprising given the theory at the



time of Kydland and Prescott's article, so proposing them would initially have required a stretch of the imagination. However, if any of the surprising phenomena could be made plausible, then the contradiction would be resolved. So each surprising phenomena served to provoke open-minded theorists into actively generating assumptions or hypotheses that would have made any one of the surprising phenomena plausible given the state of the theory at the time.

Finding assumptions that made the three surprising phenomena plausible, required abductive reasoning. The arguments listed in Table 3 could not be deduced given the known logical relationships around the time of Kydland and Prescott's article, so pure deduction at that time would not have led to the innovation that occurred later. However, once the synthetic assumptions were found, it was a matter of mathematical deduction from these assumptions to develop theories that could be integrated into the existing body of knowledge.

Kydland and Prescott's work constitutes successful theoretical innovation, since they brought to the surface the inconsistent assumptions underlying the rules-discretion debate, challenged those assumptions and thus triggered innovative theoretical work along the lines of the three strategies in Table 3. Kydland and Prescott (1977) themselves employed the  $R \supset \sim A$  strategy. They showed that discretion is suboptimal relative to the policy rule. The policy rule ( $\sim A$ ) is therefore the best decision given any state of the economy ( $R$ ) in the long run.

Innovation in monetary policy theory did not stop with the research of Kydland and Prescott. They set the scene for a burst of innovation. By framing the problem of monetary policy, they created new contradictions that directed further innovative empirical and theoretical research. It is through this later innovation in the field of economic policy that the real impact of their research was experienced.

Time inconsistency highlighted a new contradiction (in the form of the trade-off between credibility and flexibility) in monetary policy theory, and attempts to address this trade-off spurred much of the innovation that followed. The basic idea behind the trade-off is that the central bank can increase its flexibility to stimulate employment (e.g. by sending ambiguous signals) at the cost of losing credibility. It can only raise its credibility by sacrificing flexibility.

The credibility-flexibility trade-off raised the issue of the role of the central bank. Central bank independence gained importance as a way to resolve the time inconsistency problem and so to improve the trade-off between credibility and flexibility. Rogoff (1985:1169) employed the strategy  $R'' \supset A$  when he argued that the problem can be resolved if a central bank chair, with a greater inflation aversion than society as a whole, is appointed. In this way, optimal discretionary policy ( $R''$ ) may be followed, while the best decisions are made given decision-making by agents in society ( $A$ ). In an attempt to address the problem raised by Rogoff's proposal, Lohmann (1992:273) suggested a "nonlinear" policy rule and a sharing of the costs of discretionary policy. Also in the spirit of the  $R'' \supset A$  strategy was the idea of optimal contracts for central banks as first suggested by Walsh (1995:163-164), where the remuneration the government awards to the central bank declines in proportion to the inflation rate. A vast amount of empirical literature on central bank independence also emerged soon thereafter from the theoretical work (see for example Alesina and Summers, 1993).

Incentive contracts naturally led to the idea of inflation targeting, which has been adopted by over twenty countries since 1989. Inflation targeting has also created its own contradictions and thus spawned extensive empirical and theoretical research (see for example Bernanke, Laubach, Mishkin and Posen, 2001; Ball and Sheridan, 2003).

Some theorists employed the  $A \wedge \sim A$  strategy. Haubrich and Ritter (2000:782) identified one of the assumptions that maintained the conviction that a policy rule and discretionary policy cannot be used together. The assumption is that choosing a policy rule is irrevocable, or that the choice between  $A$  and  $\sim A$  is an all or nothing choice. They pointed out that choosing discretion today does not prevent a policymaker from choosing commitment tomorrow. Waiting to commit has value and this led them to reframe the problem as an intertemporal choice problem and to use a new approach (from the perspective of options) to analyse the problem. Blinder (1997:12) also used the  $A \wedge \sim A$  strategy when he stated that in reality the choice is not only between fine-tuning (discretion) and no tuning (rule), but that the alternative of "coarse tuning" exists. As is the case with conceptual problems, he also pointed out that vague meanings (in this case the

meaning of "no fine-tuning") maintain the problem.

## 7 Conclusion

While most gifted economic theorists are adept at using the tools of formal analysis (such as classical logic and mathematics), it is not in the formal analysis that one finds the reason for the quality of their contributions. Instead, such theorists are able to identify the critical problems that make a contribution towards resolving the fundamental problem of economic science.

While necessary, formal analysis is not sufficient to someone hoping to contribute to theoretical progress in economics. Like Kydland and Prescott, such work is delivered when one takes time to frame the critical problems in a way that assumptions, and especially the inconsistent assumptions, are made explicit.

Once the assumptions are brought to the surface, resourcefulness and imaginative thinking are required to question the assumptions that appeared beyond doubt before, and to generate new synthetic assumptions that reconcile the contradiction inherent in the critical problem. Formal analytical tools are then used to make the ideas appear logical in hindsight by connecting the innovation to the existing body of knowledge. The effort is successful when the contradiction or trade-off is resolved, and when the new assumptions direct further innovative theoretical and empirical research by others. Trade-offs that once seemed rigid constraints on economic activity may suddenly dissolve as new knowledge is created as a result.

Logical contradictions and inconsistent assumptions are often seen as the enemies of theoretical progress, and the tools of classical logic and mathematics are designed to eliminate them. Yet, if human assumptions were not inconsistent, there would be no problems, and no need for scientists. Inconsistent assumptions are the friends of scientific innovation, and scientists who are adept at using such assumptions to their advantage, are likely to deliver more innovative work.

Unfortunately, no formal analytical tools exist at this stage that can direct theorists in this kind of creative effort, although this paper suggested a starting point for the development of such tools. Further research in the application of abductive reasoning and non-classical logic to economics can build on this paper to develop a set of tools to extend the innovative capability of economists and the economics profession.

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**Table 1: Framing the inconsistency problem in monetary policy**

Connective I	$Bx(G \supset R)$
Connective II	$Bx(R \supset A)$
Connective III	$By(G \supset R'')$
Connective IV	$By(R'' \supset \sim A)$
Connective $\Phi$	$Bx[\sim(A \wedge \sim A)]$ $By[\sim(A \wedge \sim A)]$

*Let  $G$  = 'Maximise social objective function';  $R$  = 'Select best decision given current state of economy';  $A$  = 'Discretionary policy';  $R''$  = 'Select best decision given decision-making by agents';  $\sim A$  = 'Policy rule'*

**Table 2: Assumptions that structure the time inconsistency problem in Kydland and Prescott (1977)**

Connective I	"...agreed-upon, fixed social objective function..." (p.473), "...current outcomes and the movement of the system's state depend only upon... the current state..." (p.474), "...expectations depend in some mechanical ad hoc way upon [the] past..." (p.478)
Connective II	"...current outcomes and the movement of the system's state depend only upon current and past policy decisions..." (p.474), "...effect of $\pi_2$ [future policy] upon $x_1$ [agents' current decisions] is zero..." (p.476), "...decision rules of agents as given..." (p.481)
Connective III	"...agreed-upon, fixed social objective function..." which is a function of policies and agents' decisions (p.475), "Changes in the social objective function... have an immediate impact upon agents' expectations... and... current decisions" (p.474)
Connective IV	"...current decisions of economic agents depend in part upon their expectations of future policy actions" (p.474), "...expectations are rational..." (p.478), "...policy rule [affects] the optimal decision rules of the economic agents" (p.474)

**Table 3: Three abductive reasoning strategies to find synthetic assumptions**

Strategy	Explanation in terms of time-inconsistency paradox
$R \supset \sim A$	How can the best decision given current state of economy be selected by following a policy rule? (new connective)
$R'' \supset A$	How can the best decision given the decision-making by agents be selected, by following discretionary policy? (new connective)
$A \wedge \sim A$	How can both discretionary policy and a policy rule be followed? (invalidate connective $\Phi$ )

```

graph LR
    G[G] --> R[R]
    G[G] --> R2[R'']
    R[R] --> A[A]
    R[R] -.-> NA[~A]
    R2[R''] -.-> A[A]
    R2[R''] --> NA[~A]
    A[A] -.-> NA[~A]
    
```

**Figure 1: The fundamental problem in economic science**

