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A Call for Building Credible Brackish-Water Open Macroeconomic Models

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Essays/Commentary

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ABSTRACT

The recent experience of macroeconomists in their inability to foresee and avert the prolonged global recession called into question the credibility of their economic theories and models. This paper is an attempt at introspection. The paper reviews the developments in macroeconomic theory and models and offers suggestions on what could have gone wrong with the prevailing macroeconomic theories and models. It suggests that there are dangers in following the mainstream models if such models are not based on empirical credibility in respect of fitting the real-life data they are supposed to explain. It suggests the limitations of statistical methods used in macroeconomic modeling and in the criteria used to establish their credibility and offers some suggestions to overcome those limitations. It brings to the fore the fact that what are now termed institutions "too big to fail" have not been modeled adequately by economists. The paper also suggests the importance of treating economies as open economy models with external sector and as truly dynamic with investment and growth.

KEY WORDS Global Recession; Macroeconomic Policy; Empirical Credibility of Models; Saltwater Economics; Sweetwater Economics

About two years ago, a friend of mine asked me if I had any solution for the economic problem of prolonged recession in the United States. I explained to him that one of the reasons for the current business cycle in the United States is that the

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Democratic and Republican parties choose policies that are broadly demand-side (saltwater) economics and supply-side (sweetwater) economics respectively, irrespective of whether the economy is in equilibrium or in a situation of excess supply or excess demand. If you add to this situation an independent monetary authority that is led for a prolonged period by a strong believer in supply-side economics, then the situation could become much worse, as demonstrated by the current prolonged recession in the United States. As a solution, I advocated a brackish-water open macroeconomic approach. I defined "brackish-water open macroeconomic approach" as one that (1) recognizes that economics depends on both supply and demand; (2) realizes that the economy could be in a state of disequilibrium or an undesired equilibrium (with either an excess demand or an excess supply); (3) recognizes the need for state intervention through economic policy aimed mainly at moving the economy from disequilibrium or undesired equilibrium toward the desired equilibrium growth path without creating its own disequilibrium; (4) recognizes the openness of the economy and its dependence on the external sector; and (5) makes the market and nonmarket (mainly state) forces work together with a common goal to move the economy toward the desired growth equilibrium.

Kocherlakota (2010) said quite frankly:

> During the last financial crisis, macroeconomists (and I include myself among them) failed the country, and indeed the world. In September 2008, central bankers were in desperate need of a playbook that offered a systematic plan of attack to deal with fast-evolving circumstances. Macroeconomics should have been able to provide that playbook. It could not. Of course, from a longer view, macroeconomists let policymakers down much earlier, because they did not provide policymakers with rules to avoid the circumstances that led to the global financial meltdown.

The entire economics profession is currently in disarray, and economists are wondering if their theories and models are good at all. Introspection is the call of the day. We must be able to clearly describe our scientific approach to design macroeconomic policies; otherwise, our undefined or ill-defined approaches will define ours as an unscientific profession. This paper is a small attempt toward outlining such a scientific approach by taking a bird's-eye view of developments in macroeconomics and outlining some methods to establish greater credibility for macroeconomic theory and models.

Before I present my views, I will briefly trace developments in macroeconomic theory and practice and the validation of macroeconomic theory with econometric tools, while acknowledging the limitations of such tools. This being a preliminary attempt at giving such an outline, there is no attempt made here to illustrate the suggested method with an empirical verification.

In the next section, I present a brief review of evolution of the mainstream macroeconomic theory and policy. This review draws heavily from Kocherlakota (2010) and Woodford (1999). I offer my own interpretation of underlying forces that operate in bringing about that revolution. In the third section, I give a sketch of some peripheral macroeconomic developments. The fourth section raises a few methodological and institutional problems associated with quantitative macroeconomic policy decisions, and in the fifth section, I highlight the need for unbiased and credible macroeconomic policies based on empirically tested and validated models.

THE EVOLUTION OF MAINSTREAM MACROECONOMIC THEORY AND POLICY

In the 1960s and '70s, debates between the Keynesians and the Monetarists occupied our thoughts and discussions in classrooms, journal articles, and academic conferences. A very brief review of that scene is useful for the young economists in whose hands the future economic policy making lies. "Macroeconomics" as a term did not exist until after World War II and into the early 1950s. Instead, economists studied the subject matter either as a part of what was then called the quantity theory of money or as the theory of business cycles. Around the time of World War II and after the Great Depression, macroeconomic theory emerged as put forth by Keynes (1936). Keynes argued that monetary policy breaks down if there is a liquidity trap that gives rise to equilibrium below the full-employment level and that the situation could be improved through a fiscal policy by stimulating the economy with government spending. This prescription was a significant departure from the existing classical theory, particularly because of the concept of "sticky wages" that Keynes postulated. The new theory broke the dichotomy between the real sector and the monetary sector assumed by the classical theory. One might argue that the sticky-wages argument or the distinction between money wages and real wages is an arbitrary artifact introduced by Keynes to justify his policies of state intervention; however, it is more reasonable to argue that Keynes brought more realism into economic modeling by introducing wage contracts and the inflexibility of money wages in the short run due to such contracts. Keynes incorporated some new concepts and constructs into mainstream economic theories that would validate what he observed in the real world. One might even wonder if he owed much of his ideas to Adolf Hitler's successful economic policies, as within four years of taking over as the chancellor of Germany in 1933, Hitler drastically reduced unemployment through public works (Weber 2011).

As economics is not an experimental science, and as macroeconomic data were not well developed, macroeconomists tended to develop their theories, methods, and models governed more by a herd behavior than by a scientific method. (For more on herd behavior in economics, see Banerjee (1992) and Kumar (2003).) Over the years, economists interpreted Keynesian theory as giving the state a much higher role than in the classical theory and as assigning fiscal policy a higher status than monetary policy. The debate between the old and new theories thus turned out to be a debate between the

dominance of fiscal versus monetary policy. The prescription to create additional demand to move the equilibrium from a lower level of employment and output to higher levels of the same has come to be known as demand-side economics, eventually metamorphosing into what is now known as saltwater economics.

Such herd behavior had to be tempered with scientific concerns so the profession could maintain its standing within the professional academic community. Macroeconomic theories needed to be integrated and made consistent with the highly acclaimed and accepted neoclassical microeconomic theory, but also with empirical evidence in order to lead to further developments of Keynesian macroeconomic theory. Klein (1947) provided credibility to Keynesian theory by showing micro-foundations of Keynesian macroeconomics. Several economists, including Klein, provided empirical evidence to the various structural equations of the Keynesian model (Patinkin 1975).

Friedman opposed the Keynesian theories and adhered instead to the quantity theory of money, maintaining first the neutrality of money and later the position that monetary policy is better than fiscal policy. He also advocates Say's law that supply creates its own demand (in the long run). He maintained that one can create investment and growth (in the long run) through credit and an increase in money supply. Keynes retorted that in the long run, we are all dead—implying that the long run was too long and that we cannot depend on the markets alone—and advocated his demand-side policies.

As the Keynesian theory was already well grounded and widely accepted with micro-foundations and empirical verification, Friedman used the main features of Keynesian theory intact but modified them in form and empirical substance. He was very good in his knowledge of scientific methodology and statistical theory of misspecification analysis. What better way is there of exploiting Keynes than to use Keynes's own criticism of Tinbergen's econometric method? Keynes remarked, "For example, suppose three factors are taken into account, it is not enough that these should be in fact *verae cause;* there must be no other significant factor. If there is a further factor, not taken account of, then the method is not able to discover the relative quantitative importance of the first three. This means that the method is only applicable where the economist is able to provide beforehand a correct and indubitably complete analysis of the significant factors" (Keynes 1939:560).

Thus, Friedman knew that he could modify some of the equations in the Keynesian system by adding new variables (correlated with already existing ones) so as to alter the impact of the existing variables in ways that supported his ideological viewpoint. To wit, he introduced permanent income as an additional variable to reduce the impact of the Keynesian multiplier effect, as will be demonstrated in the next paragraph.

Suppose, as postulated by Friedman, that the true consumption function must use permanent income in addition to current income. This is equivalent to saying that the Keynesian consumption function is misspecified by omitting a relevant variable (the permanent income) that is positively correlated with the included variable (the current income). This misspecification introduces a positive bias in the estimate of marginal

propensity to consume, the bias being the regression coefficient of the omitted variable (positive) multiplied by the (positive) correlation between the omitted variable (permanent income) and the included variable (current income). In this way, Friedman argued that the Keynesian marginal propensity to consume is an overestimate of the true marginal propensity to consume. In other words, Friedman argued that the Keynesian multiplier is an overestimate. (For misspecification analysis in regression, see Gujarati 2003:511).)

Friedman also modified the Phillips curve that related inflation to unemployment. His specification of the Phillips curve also involved adding a new variable. Anyone today with a minimal amount of knowledge in econometrics, can see that the modified equations with additional explanatory variables will have better explanatory power (Gujarati 2003:217) and that omitting correlated variables could generate biases in coefficients of other variables in the model (as demonstrated above). By his choice of additional variables, Friedman could articulate his point of view quite successfully, making the best use of Keynes's own methodological criticism against Tinbergen's econometric method. Using this technique, Friedman achieved his goal of toppling the Keynesian theory from the top position. Friedman's theory came to be known as supply-side, or sweetwater, economics. The Social Science Research Council (SSRC) econometric model and the MIT–Federal Reserve Board (FRB) model were pressed into service to provide the needed empirical support in favor of or against these models. As one model cannot be used to verify another model, a combined model was formulated that accommodated both theories to be tested (Cooper and Fisher 1974), but then the model became so large and the macroeconomic data so inadequate that econometric evidence supported both models!

Friedman's ideas were further boosted by Lucas's rational expectations hypothesis. Although the closed-economy Keynesian models could not explain the worldwide stagflation experienced in the 1970s, this hybrid monetarist model could; thus, the so-called new classical theory, which assumed market-clearing, rational optimization behavior with rational expectations, became the mainstream macroeconomic theory. As can be seen, this was through herd behavior among the economists and not by any empirical verification and vindication. (For a distinction between various prevailing macroeconomic theories, see Greenwald and Stiglitz (1987).)

These different versions of the macroeconomic models are closed macro models of a single economy that ignored the openness of the economy. It is clear that when the United States experienced stagflation in the 1970s, the US economy was quite open, with imports of manufactured goods from Japan, China, and Korea, and oil from the Middle East. It is surprising that within the mainstream of macroeconomic theory, no one thought until 1985 of explaining the worldwide stagflation using the Keynesian macroeconomic model with exogenous shocks coming from an open economy. Michael Bruno and Jeffrey Sachs (who were conducting research on that topic at the National Bureau of Economic Research (NBER) and the World Bank in 1985) could explain global stagflation employing a Keynesian model but with exogenous oil shocks of the 1970s.

Their work seems to have been mostly ignored by mainstream macroeconomists in the United States. It is surprising that despite the balance of payment deficits accruing during the postwar period and the warnings that Triffin (1960) gave on a weakening dollar, the mainstream macroeconomists did not consider explaining stagflation employing an open economy macro model.

The new classical macroeconomic synthesis is a full integration of short-run disequilibrium dynamics in which an aggregate demand adjusts to a *predetermined* potential output under the assumption that the economic agents optimize their behavior with expectations of the future (a dynamic general equilibrium model). When stochastic shocks to the system are introduced, it becomes a stochastic dynamic general equilibrium model. The real business cycle model goes a step further and tries to explain what could cause the shocks to the system (i.e., supply-and-demand shocks). Such stochastic dynamic general equilibrium models have been able to explain the output, consumption, and investment growth in a number of closed economies (Prescott 1986). Such stochastic dynamic general equilibrium models are also used to study the effect of fiscal policies on output, employment, and saving (Auerbach and Kotlikoff 1987). As the new classical model of the Friedman school already incorporated major elements of the Keynesian model, the real business cycles (RBC) model is the present-day mainstream macroeconomic paradigm for closed economies. This mainstream macroeconomic model erroneously assumes that all people form expectations that are consistent with the model, and hence those expectations will be realized—under the very unrealistic assumption that this is the only true model. Those who subscribe to this model are in a make-believe economic world!

Let us further discuss other things that are wrong with this model. First, economists themselves do not agree on a common model, and hence their expectations cannot be rational. To prove this statement, one need only look to the recent global financial crisis that was not predicted by economists and their models. Second, it is quite obvious that different people have different information on how the economy (or a part of it) works and therefore do not all have the same expectations. Consequently, expectations in real life are not rational expectations as defined by economists. Third, people behave and make economic decisions on the basis of how they think other people will behave. When people have differing information, they behave differently and expect others to behave differently. This model does not take into account the decisions leading to long-term investments leading to growth.

If a macroeconomic model has to represent a real economy, it may have to be an open economy model with investment and growth. It must consider how the politics and economics interact with each other. It must also allow for the possibility of different people to form different expectations, only some of which will be realized. It may also need to consider how certain large institutions, such as banks and non-banking financial institutions, function. I will discuss some of these extensions in the next section.

THE EVOLUTION OF PERIPHERAL MACROECONOMIC THEORIES AND POLICIES

There are three kinds of peripheral macroeconomic theories and policy research, each with its own supporters. First, there are some groups of economists that pursue macroeconomics from entirely different perspectives than the mainstream. Their perspectives and approaches could still be relevant and meaningful under some circumstances. For this reason, there also exist side by side with such groups some others that follow heterodox methods, combining ideas from different groups. Prominent examples are different shades of post-Keynesian macroeconomists and monetarist economists who still stick to extreme ideologies, even when the mainstream has switched to a new classical synthesis.

Second, a few economists follow some analogies from other fields of science such as physics and statistics. These economists do not have many followers.

The third group consists of those who feel that the mainstream models do not adequately care for a certain institutional detail of some major part of the economy, and so they try to develop the model to take that part into consideration. These unconventional approaches do not have majority following and so have not yet become a part of the mainstream, not necessarily because their approach is rejected by scientific criteria but because of lack of popularity.

Post-Keynesian Macroeconomics

There are those who believe that some classical ideas such as capital accumulation, personal wealth, and income distribution must be a part of macroeconomic theory. Those who belong to the Post-Keynesian Cambridge School pursue this track. There are several papers along this line in the *Cambridge Journal of Economics, Review of Political Economy,* and the *Journal of Post-Keynesian Economics.* One may also see a recent review by Harcourt (2006).

Statistical Approaches to Macroeconomics

The neoclassical economics school is built around the classical mechanics paradigm of physics. Georgescu-Roegen (1971) took an alternative route and built an alternative economic theory based on the second law of thermodynamics. Masanoi Aoki's school uses analogies from statistical physics and introduces very useful concepts of strategic interactions between different types of economic agents (Aoki 2002; Aoki and Yoshikawa 2006). Kumar (2002) uses a temporary equilibrium as the micro-foundation, replaces rational expectations with the assumption that there are different types of individuals with different types of privileged information that generate stochastic individual responses. George Soros also points to this fact of different people having different expectations based on different information and knowledge on the working of the economic system. The reader may refer to the Institute for New Economic Thinking,

established by George Soros. (See in particular the following link: http://ineteconomics .org/sites/inet.civicactions.net/files/INET%20C@K%20Paper%20Session%201%20-%20Soros_0.pdf.) Kumar then uses Edgeworth-type aggregation of stochastic individual responses to arrive at a joint lognormal distribution of macroeconomic variables using Edgeworth's central limit theorem. The net result is a vector autoregressive (VAR) macroeconomic model of Sims. Thus, he explains the observed statistical pattern of macroeconomic variables through a combination of economic and statistical principles in a truly Edgeworthian perspective and justifies a VAR model of Sims.

Adding Details that Matter

The recent prolonged recession and the failure of the financial system forced the US government to back certain financial institutions and a major auto manufacturer. Government officials justified this action under the principle that the companies in question were too big to fail. If the companies are too big to fail, the macroeconomic models must incorporate within them the institutional details on how the financial sector functions, how the large manufacturing sector functions, and how these institutions interact and control the political decision-making process, including the regulatory wing of the federal government. Although some of these details are dealt with in a peripheral way in macroeconomics literature, they are not integrated well enough to make the macroeconomic models credible for economic policy. These are discussed below.

Integrating Detailed Financial Sector into a Macroeconomic Model

As a result of the recent financial crisis, we are now coming to realize that economists' inability to forecast the extent of the crisis and to take corrective steps is due to inadequate modeling of the institutional details of the financial intermediation sector (Kocherlakota 2010; Woodford 2010). The existing models until recently have envisaged the banking sector as one that performed only financial intermediation by taking deposits and advancing loans. Banks' role as large corporations with non-banking functions in high-risk areas, their raising of capital through borrowed funds from mortgage-backed securities as well as deposits, their dependence on the housing market and the insurance market, and their exposure to government regulation and politics have historically not been taken into account. Adrian and Shin (2010a, 2010b) and Woodford (2010) address these issues.

Political Business Cycles

There are other economists who strongly believe that macroeconomic policy cannot ignore interaction between economics and politics, and as such, they would like to introduce politics into the macroeconomic model. Extensive literature on political business cycles takes this approach. It started with a pioneering paper by Nordhouse (1975). The works of Hibbs (1977, 1994), Alsena (1988), and Rogoff (1990) are quite

significant on this subject. They employ a macroeconomic model with employment and inflation as the target variables and with monetary and fiscal policies as instruments. The bipartisan models of Hibbs, Alsena, and Rogoff assume that a politician makes opportunistic policy decisions to maximize the chance of winning elections under the assumption that voters form expectations about the future performance of the politician on the basis of such policies. These models assume that voters form such expectations regarding the decisions to be made by both party candidates and choose the party whose policies they prefer. Drazen (2001) generalizes the earlier models by adding a monetary sector and by incorporating an independent monetary authority. These models are empirically tested, and the experience with these models is summarized in the papers by Alsena (prior to 1988) and Drazen (prior to 2000). These models explain pre and post-election business cycles.

Open Economy Macroeconomic Models for Single Country

With increasing capital flows and trade flows between countries, there has been an increasing interest in open economy macro models. The standard investment saving-liquidity preference money supply (IS-LM) model has been modified with aggregate demand, including net exports. This is popularly known as Mundell-Fleming-Dornbush model. The closed static IS-LM model has been made open using the Mundell-Fleming approach. This approach links the national income to domestic absorption (consumption expenditure plus government expenditure plus investment expenditure) to the current account deficit (exports minus imports) and extends the Keynesian IS-LM analysis via stock-flow equilibrium of the capital market with capital mobility between countries. (For a good discussion of the Mundell-Fleming model, one may refer to Frenkel and Razin (1987).) The Mundell-Fleming model becomes a dynamic one through the addition of disequilibrium adjustment equations with rational expectations by Dornbush (1976) (the so-called "overshooting model"). The International Monetary Fund (IMF) pioneered the research into this kind of open macroeconomic model to explain the balance of payment situations arising in various countries. (See Rogoff (1990, 2002) and Obsfeld (2001) for an excellent review of this research.) With the availability of open macroeconomic models, there was a natural curiosity among the economists as to whether the macroeconomic policy framework of a single country could be extended to the question of macroeconomic policy games between countries. If game theory as a tool and multilateral agencies as institutions had been in existence in the late 1920s, the Great Depression could have been avoided and competitive devaluations and competitive tariffs could have been prevented. This is because game theory tells us that cooperative game solutions can improve the solution obtained through noncooperative behavior.

Game Theoretic RBC Models for Macroeconomic Policy Coordination

Rational expectations and game theoretic approach were brought into the literature on monetary and fiscal policies by Kydland in 1975. In this paper, Kydland demonstrates the inferiority of the noncooperative Nash equilibrium as compared to a

cooperative solution. He interprets the policy maker as the dominant player and the typical individual citizen as the nondominant player. In a subsequent 1977 paper, Kydland shows that in such a game with a dominant player, the open loop control policy is time inconsistent, and he attributes this to a lack of credibility. He also establishes that to get time consistency, one must go for a feedback-control policy. Kydland and Prescott (1977) use the concept of rational expectations and argue for the advantage of rule-based policies to create a rational expectations equilibrium solution.

One can apply the above differential game framework with the monetary authority and the fiscal authority being the two players of the game. It can then be argued that if the monetary authority is truly independent and if one obtains the noncooperative solution with each policy maker having his own objective function, the corresponding Nash equilibrium is Pareto inferior to a cooperative solution. Petit (1989) established this result using differential games with Italian illustration.

The creation of the European Union (EU, or Economic and Monetary Union, EMU), with 11 asymmetric European countries coming under one central European Bank and one common monetary policy, raised interesting questions regarding coordinating the fiscal policies of the 11 countries with the common monetary policy. Aarle, Engwerda, and Plasmans (2002) examine the impact of fiscal policies of member countries with their own labor market distortions on the stability and growth of the EMU. They identify the need for coordination, such as the stability and growth pact (SGP) that the EMU has. They use a differential game model employing Mundell-Fleming-Dornbush type of model. Aarle et al. (2002) examine the coalition formation in EMU using such a model. Canzoneri, Cumby, and Diba (2005) present second-generation macroeconomic policy coordination games that use microeconomic foundations of macroeconomics with market imperfections (monopolistic competition).

Sometimes, macroeconomic policies and multilateral institutions arise in a vacuum of a suitable theory. For example, the emergence of the EMU and the formation of G-6, G-8, and G-20 nations arose as a need was felt for macroeconomic policy coordination between countries. Kumar (1998, 2011) revives the interest in the problem of macroeconomic policy coordination by the application of differential game theory.

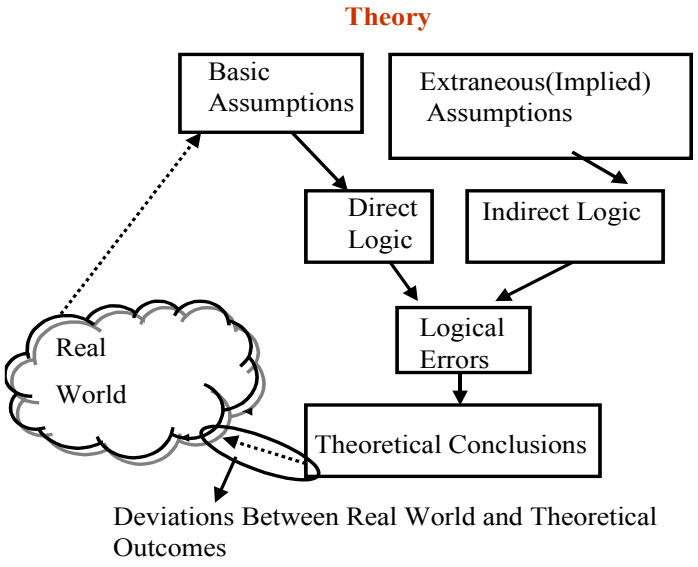
A STATISTICAL AGENDA FOR MACROECONOMIC MODELING

Although the macro models may appear to fit satisfactorily, they lack adequate statistical criteria to verify their credibility and suitability for basing macroeconomic policies on them. In fact, econometricians did not pay adequate attention to the concept and development of the best model and instead seemed to focus on demonstrating the usefulness of econometrics by showing that these methods validate the reigning micro- and macroeconomic theories. Econometricians thus tended to limit to confirmatory modeling and avoid exploratory modeling. They created their models based on an existing theory that could have been propped up through a herd behavior. There does not

seem to be any adequate effort within the macroeconomic modeling enterprise to minimize the errors in models and to adapt them to fit the real data.

Figure 1 illustrates the relation between the real-world economic situation and the theory. Basic assumptions are those that are economic in nature, including whether the variables are chosen and represented by a Keynesian model or a monetarist model. Extraneous or implied assumptions come from the tools being used, such as whether the relations between variables are representable by continuous parametric linear functions, continuous parametric nonlinear functions, piece-wise linear functions, nonparametric functions, and so on. Therefore, direct logic is that which is applied to the basic economic axioms or assumptions, whereas indirect logic refers to logical steps that depend on the extraneous mathematical assumptions. Economists pay little attention to this distinction and to minimizing the inaccuracies in theoretical models arising from inadequate mathematical assumptions.

Figure 1. Theory and the Real World



The above review of the evolution of mainstream and peripheral theories of macroeconomics and policy clearly identifies a few epistemological issues. First of all, as explained above, the mainstream model can only be an approximation, and a possibly crude one at that. Perhaps the mainstream macroeconomic model should be treated as only a general consensus model, and not necessarily a good and statistically credible one. The distinction between theory and practice is that theory is general and in practice one must adapt a theory to suit a given problem.

With increasing openness of economies due to globalization, and the increasing trade deficit of the United States, it is necessary to consider open macroeconomic models. As macroeconomic policies of different countries are dependent on each other, conflicts

and coordination between them should then be an endogenous part of the development of such macroeconomic models (Kumar 2011).

Recently, knowledge-based decisions employing business analytics have become more prevalent and credible in the business world. Business analytics squeezes as much information as possible from the data by using the most suitable model. In selecting the best fitting model, business analytics uses fundamental statistical principles of reducing the errors and error variance and employs the latest statistical techniques on data mining. Businesses do not buy economics or economic models or economic advice unless they are credible and show some dependable results. Similar standards must apply for macroeconomic theory and policy that use macroeconomic models.

While the macroeconomic debate has focused on which variables should be included in an economic model, rarely has it examined carefully the patterns in economic data that define both what variables should be utilized and in what functional form. Exploratory data analysis and data mining are some of the emerging areas in business analytics that can be put to use in macroeconomic modeling to discover these patterns in data. While discovering these patterns, one might even find that linear relations have to be replaced by nonlinear ones, and parametric relations replaced by nonparametric ones, or even functional relations replaced by algorithmic rules.

An econometric model is supposed to specify the joint distribution of all endogenous variables, given the predetermined variables. This is normally done by specifying the mean and variance of each endogenous variable in terms of other endogenous variables and the predetermined variables. The main objective of selecting the variables and the functional specification is to maximize the information on the unknown parameters of the joint distribution of all the endogenous variables. Here, the statistical concepts of information, information limit to variance, redundant information, sufficient information, sufficient statistics, and ancillary statistics are quite useful (see Tong, Kumar, and Huange (2011:430–33)). Econometric theory does not seem to have made the best use of these fundamental concepts of statistical inference and how best to employ them to extract the best possible information or signals from the economic data.

The model errors depend on aggregation errors, measurement errors (also known as errors in variables), or specification errors in specifying the equations of the model. In any statistical modeling exercise, the scientific criterion should be to minimize the extent of the error in the model. As macroeconomics deals with aggregate variables, one must pay attention to aggregation errors. One can measure the aggregation error by building models at smaller community levels and aggregating them to build aggregate models. The error sums of squares in the aggregated model must be much smaller than the sum of sums of squares of the component sub-models. Although both economy-wide and regional models have been built, no attempt seems to have been made to check the consistency of these models by comparing the model-predicted aggregates with actual observed aggregates. Nor have attempts been made to measure the possible extent of aggregation errors and to reduce them. Macroeconomic models for small areas like Standard Metropolitan Statistical Areas (SMSAs) and Bureau of Economic Analysis

Areas (BEAs) could provide the necessary insights to specify the macroeconomic models for a state or a nation.

Another major model error is measurement errors, or errors in variables. It is possible that the variables as actually measured differ from the economist's perception, and these differences may be compounded by further inconsistencies between regions. Economists often accept the data as given and do not question their accuracy.

Finally, we have equation errors, which may be associated with each equation of the model. The model error is the sum of the equation errors. For policy makers, different equations (referring to different endogenous variables) may have differing relevance to policy. In reducing the sum of squared equation errors, one must weigh the equation errors by the importance attached to those variables.

Just as game theorists use the term "sub-game perfection" in econometric model building, one may use the term "sub-model perfection," in which each sub-model is selected based on whether it is the best fit with the observed data. By sub-model, we mean each equation, each group of equations, and constituent sub-models, built over space and commodity or industry spectra. This concept becomes highly relevant in macroeconomic model building if one uses exploratory data analysis to determine patterns.

Kocherlakota's concerns about model inadequacy were prompted by the perception that, although the models may have qualitatively predicted the recession, they did not adequately indicate quantitative answers on the severity and acceleration of the recession and what corrective steps should be taken. Hence, the policy maker should be concerned with credible quantitative answers and not with incredible (sic) qualitative answers (Kocherlakota 2010). If the policy objective is to determine credible quantitative answers, model credibility in terms of minimizing the three types of errors deserves the highest priority in econometric research.

We have determined that more than one theory or model can explain the observed data, and when this happens, the selection of the appropriate model seems to be made more by the herd behavior of economists than by any scientific criteria of model fit and reduction of errors in modeling. The greater the degree of unexplained error variance in the model, the greater is the possibility that at least one other model can better explain the data. Hence, one must reduce the error variance in models to sharpen the theory. Macroeconomists seem to have an infatuation with mathematical and statistical theories and with models with much less emphasis on empirical verification and underlying process detail. A similar kind of situation resulted in the microeconomic theory of the firm based on Adam Smith's invisible hand principle, and competitive markets became irrelevant for business policy and business decisions in oligopolistic markets with managerial interventions (visible hand) through advertisement expenditure and managerial decisions. This gave rise to a managerial revolution (Chandler 1977). We now witness similar irrelevance of macroeconomic models due to a lack of credibility of macroeconomic theory and models, resulting in a call for a macroeconomic revolution to address the issue of differing degrees of empirical credibility.

How can such credibility be secured? Macroeconomic modeling has emphasized sticking to a model specification that is in conformity with the mainstream theory with an acceptable statistical fit. One should instead shift to a new paradigm of best fitting model specification. The specification can be improved by a proper choice of variables included, by selection of the functional form assumed for the equations of the model, and by using nonparametric functional forms. Some of these pattern-recognition and data-mining techniques have not been exploited fully by macroeconomists. Han and Kamber (2006) provide information on data mining, and Tong, Kumar and Huang (2011) outline a business analytic approach to econometrics.

The suitability of the macroeconomic model dictates the efficacy of a macroeconomic policy it produces. If the model is incongruous, the resulting policy will be ineffective; the degree of ineffectiveness depending on the degree of misspecification. Intuitively, some kind of a proximity theorem would apply, and the effectiveness of the policy would increase by reducing the error of the model. Quantitative model building is like a production activity. The objective of that production is a good model fit with least possible model error. (For information criteria in fitting models to achieve statistical credibility, see Chapter 10 in Tong, Kumar and Huang (2011), and also Bozdogan (2000). The quantity and quality of output achieved in macroeconomic modeling depends on the inputs used. With teamwork and coordination and through economies of scale and scope, one can achieve better modeling outcomes.

To achieve such economies of scale and scope, the necessary institutional mechanisms must be developed. Economic models must be built at local, state, national, national union, and global levels. Models built at a higher level of aggregation must be checked against their constituent parts at lower levels of aggregation. The necessary institutional support for building and verifying these models must be provided through the state budgets and through contributions by the constituent chambers of commerce and industry that are likely to benefit from such models. At the inter-country or global level, such efforts must be supported by the multilateral agencies such as the EU, the World Bank, and the International Monetary Fund (IMF). For the situation we are facing of prolonged global recession today, we need credible macroeconomic models of policy coordination that could be supported by the IMF and the World Bank.

A CASE FOR BRACKISH-WATER ECONOMICS

If a policy maker depends upon sweetwater economics or saltwater economics to generate the model and ensuing policies, and the true model is closer to a brackish-water one, this will lead to a policy intervention that generates its own disequilibrium dynamics over and above the naturally existing disequilibrium. Such disequilibrium dynamics generate their own expectations, which cause further deviations and accentuate the extent of the business cycle. The best way to dampen such cycles is not to use policy biases but to use brackish-water economic policies instead. Both political parties in the United States must develop a common platform and a consensus on what types of economic

policies are useful for the country to maintain its comparative advantage in the long run, and they must agree to provide bipartisan support for such policies.

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