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Wayne, James J.

Lawrence Cedar House LLC

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James J. Wayne
jjwinterpretation@gmail.com

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Abstract

The poor performance of macroeconomic models during the great recession of 2008 has forced many economists to re-examine macroeconomic theories, and search for creditable alternatives to the popular dynamic stochastic general equilibrium (DSGE) models. This paper derives a new macroeconomic model from recently published Fundamental Equation of Economics (FEOE) and applies the new model to answer a general question what causes economic crises. The macro model known as the indeterministic balance sheet plus (IBS+) model proposed in this paper for the first time turns out to be a special breed of accounting models. Different accounting models are more or less same in the way of handling empirical accounting data and flow of funds, and different in the way of forecasting the future. The IBS+ macroeconomic model takes the indeterministic view of the future balance sheets with the emphasis on probabilistic causalities, tail risks, economic reality described by balance sheet accounting, truthfully capturing the sectorial flow of funds and dynamics of economics, universally applicability, and a rock solid scientific theoretical foundation. The IBS+ model is very different from the popular dynamic stochastic general equilibrium (DSGE) models and agent-based computational economic (ACE) models. Through a side by side comparison, we prove that IBS+ model is superior to DSGE or ACE models in many ways. This paper concludes that DSGE models are probably intellectual dead ends, and economists should stop investing heavily with DSGE models and instead should replace DSGE models with IBS+ models. Economic crises have plagued humanity since the dawn of capitalism. Despite intense studies over last several hundred years, the questions about causes, forecasting, and prevention of economic crises remains unsolved. This paper proposes a classification of causes of economic crises using IBS+ models to analyze balance sheets of key economic sectors. Applying this classification to examine recent economic crises, we conclude that most economic crises are caused by mismanagement of balance sheets by key economic players. This paper suggests that economic crises are largely caused by inevitable misbehavior of humanity and not caused by any fundamental flaw of capitalism. Just like improving the individual health and personal hygiene is the key to prevent epidemic diseases in societies, the key to prevent future economic crises is to promoting financial disciplines and strengthening risk management of key players in economics. Because some economic crises can be caused by natural and man-made factors beyond the scope of economics like earthquakes and wars, the frequency of economic crises can be minimized by proper risk management practices but economic crises can never be completely eliminated. Historically, treating mismanagement of balance sheets as main causes of economic crises is a generalization of Austrian business cycle theory, Fisher's debt deflation theory, and Minsky's financial instability hypothesis.

1. Introduction

A forecasting model in science requires the model to be logically self-consistent, making forecast with reasonable accuracy, truthful abstraction of initial reality, capturing key dynamics accurately, and based on a sound theoretical foundation.

For example, Sir Isaac Newton proposed a solar system model in his book Principia based on laws of motion and law of gravity. Newton's model is an excellent example of what a scientific forecasting model should be. We are still using Newton's model today except that we are now using differential equations, which is mathematically equivalent to Newton's highly sophisticated geometric derivations.

Another example is Bohr model of atoms [1, 2]. Bohr model has all features of a scientific model except it has a weak theoretical foundation. Bohr proposed his atom model in 1913 while the full-blown quantum mechanics was established much later in 1925. Bohr model is a landmark achievement in the history of science. Even though Bohr model can give some highly accurate forecasts about Hydrogen atoms, we no longer use Bohr model today because it lacks a sound theoretical foundation by today's modern physics standard.

Should we hold the same scientific standard for forecasting models in social science? The central point of this paper is that we should because we can meet the same scientific standard with Physics Laws of Social Science (PLSS) [3, 4] and Fundamental Equation of Economics (FEOE) [5]. This paper shows that many popular forecasting models in macroeconomics like DSGE and ACE models are falling well short of the above scientific standard. The macroeconomic model that does meet the standard, which is proposed in this paper for the first time, is a special version of accounting models.

The second and third sectors of this paper describe the short outlines of PLSS and FEOE, which have been published earlier [3,4,5], in order to benefit the readers by making this paper more or less self-contained. The fourth sector derives a macroeconomic model from FEOE, and then we discuss many topics related to macroeconomic modeling. The fifth sector applies the macroeconomic model to analyze the causes of economic crises, which has been a long standing problem of economics. The last sector is the concluding remarks.

2. Five Physics Laws of Social Science

The starting point of scientifically answering fundamental questions in economics is the five physics laws of social science, which have been published elsewhere in a book [3] and an academic paper [4]. For the benefit of readability of this paper, we re-list five physics laws of social science in the following.

First Law – Law of Indeterminacy

> For a closed system, the outcome of any future event in the system is indeterministic. The quantum uncertainty of the future is the fundamental property of nature and cannot be overcome by any means.

Second Law – Law of Prediction

> For a closed system, any future event in the system can be and can only be predicted precisely to the extent of a joint probability distribution among all possible outcomes. The joint probability distribution function exists and is uniquely given by quantum mechanics.

Third Law – Law of Choice

> Actions, which are constrained by fundamental laws of physics, can be taken between time 0 and time T to modify the joint probability distribution function of time T of a closed system.

Fourth Law – Law of Information

> The complete historic information of any closed system cannot be recreated based on today's complete information. At any time step, new information is created and some historic information is lost permanently.

Fifth Law – Law of Equilibrium

> For a system under certain constrains, quantum uncertainties in the system will eventually push the system toward equilibrium states.

The explanation and discussion of these five laws can be found in the book [3] and the paper [4]. These laws are fundamental laws of physics, which are applicable to any system including any physical and biological systems, and human societies. Fundamental equation of economics is one application of these physics laws in economics.

3. Fundamental Equation of Economics

The details about Fundamental Equation of Economics can be found in the paper [5]. Fundamental Equation of Economics is the mathematical bridge connecting the current economic reality with all the future possibilities. Let φ be the unique and objective joint probability distribution function, law of prediction translates into the **Fundamental Equation of Economics (FEOE).**

$$\frac{\partial \varphi}{\partial t} = \mathrm{H}\,\varphi$$

Here H is an operator. In principal, for a closed system of human behavior and human society, H operator is precisely defined by quantum mechanics. At this stage, we do not know to define H exactly starting the atomic level interactions. However, we do know that H operator does exist and is uniquely defined because of law of prediction. For all practical purpose, as long as H exists and is uniquely defined, we could always

construct an approximate H operator from empirical data and physics laws, then compare the forecast against the future outcome. The difference between the outcome and expectation provides the needed feedback to further improve the forecasting models. The initial condition φ(t=0) reflects the existing economic reality. The Feynman-Kac equation for the option pricing theory can be viewed as a special case of FEOE.

For most applications of FEOE in economics, we can further specify the joint probability distribution function φ. In economics, we mainly concern about monetary matters. Since money always belongs to somebody with free wills, in most applications, the joint probability distribution function φ is simply the joint probability of possible values of assets in balance sheets. Therefore, FEOE describes the time evolution of the joint probability distribution of future valuation of assets and liabilities. The initial condition φ(t=0) reflects the economic reality of the existing assets and liabilities.

We must emphasize that FEOE and quantum economics is far more than just applying probability theory for the economic analysis. In physics, quantum mechanics is far more than just applying probability theory for the physics analysis. In the FEOE framework, the future joint probability distribution function is unique and objective, and can be forecasted precisely only at one moment. FEOE is the generalized Born's statistical interpretation in the human society.

4. A Macroeconomic Model Derived from Fundamental Equation of Economics

In this section, we first derive the indeterministic balance sheet Plus (IBS+) model for macroeconomics from physics laws of social science and the fundamental equation of economics. We show that IBS+ models to be universally applicable in any kind of economy, making forecasts with reasonable accuracy, truthful abstraction of reality, capturing dynamics accurately, and based on a sound theoretical foundation. Throughout this section, we make the side-by-side comparison between the popular dynamic stochastic general equilibrium DSGE and IBS+ models to prove that IBS+ models are superior in many ways and DSGE models fail short as a scientific forecasting model.

4.1 Indeterministic Balance Sheet Plus (IBS+) Model

The word "indeterministic" means that IBS+ models take indeterministic view of the future. On the theoretical side, the entire framework of physics laws of social science and FEOE is built on the concept of quantum indeterminancy. On the empirical side, macroeconomic phenomena are clearly indeterministic. For example, a macroeconomic shock of unknown magnitude was prevented in 1998 when a hedge fund known as Long-Term Capital Management was rescued by a group of major banks under the supervision of Federal Reserve. During financial crisis of 2008, investment bank Bear Sterns was rescued while Lehman Brothers was ordered to file bankruptcy. The failure of Lehman Brothers certainly brought the severity of the financial crisis into a new level. If financial giants Fannie Mae, Freddie Mac, and AIG were allowed to file bankruptcy, the path of macroeconomics would be certainly very different. In China, the central government activated massive stimulus programs in 2008 and 2009 to allow Chinese economy to avoid a recession. All these events were results of indeterministic conscious choices by economic players. Thus if the fundamental feature of macroeconomic phenomena are

indeterministic, a scientific forecasting model of macroeconomics must be indeterministic.

The word "balance sheet" means that IBS+ models use the balance sheet view of an economy. There are many perspectives of overall economy activities. National product, income, consumption, flow of funds, aggregated supply and demand, and aggregated balance sheets are all related and useful measures. However, for the forecasting purpose, FEOE firmly favors the balance sheet view of the economy for many reasons: (1) The ownership of productive properties is critical to understand of an economy. Balance sheets are owned by some people. When owners of balance sheets make choices with their free wills, it generates the indeterministic behavior of macroeconomics. Directly modeling choices in real economics allows IBS+ to avoid the artificial micro-foundations used in DSGE models. (2) The ownership structure of some economy is not always straight forward because the idea of respecting the private ownership is not universally shared in many countries. For example, officially largest banks in China are publicly traded companies and owned by shareholders. However, key lending and other key decisions of these largest banks are directed by the central government. Understanding these complicated ownership relationships are critical for modeling and forecasting Chinese economy. (3) Mismanagement of balance sheets is fundamental to understanding and forecasting economic crises. Mismanagement of balance sheets could result in bankruptcy, wastes, loan defaults, bad investments, liquidity crises, and many other economic hardships. (4) According to FEOE, the balance sheets play fundamental roles in economics. Balance sheets are fundamental economic units just like cells are basic units of biology and molecules are basic units of chemistry. (5) With the balance sheet view of economy, many other alternatives views are included in the background. In terms of stock flow terminology, balance sheet items are stocks while incomes and expenses are flows. To forecast the stock, the flow information is implied naturally.

The word "plus" means IBS+ models might need additional variables to a list of assets and liabilities on balance sheets depending the goals and designs of models. The accounting view of an economy is incomplete because there is considerable amount of relevant economic information that is not included by the normal balance sheet accounting. For example, while demographic information is essential for forecasting the employment rate, demographic data is not parts of regular balance sheet accounting. Another example, one way to look at an economy is that the economy could be viewed as collections of hundreds of interconnected markets, like housing markets, labor markets, etc. The market dynamics of these hundreds of markets is only partially captured by the balance sheet accounting. If some important markets like labor and housing market need to be explicitly included in the overall forecasting model, we have to apply indeterministic demand supply pricing (ISDP) models [5] to add these market forecasts.

To derive a macroeconomic model from FEOE is very straight forward. Choose a set of state variables that completely describe an economy. The definition of complete sets varies with goals of the models. And then construct the joint probability density for all future possible states.

Consider an economy consists of a set of balance sheets with different items of assets and liabilities. In order to limit the complexity of an IBS+ model, only key sectors,

assets, and liabilities are carefully chosen, and less important sectors, assets and liabilities are grouped into related aggregates.

Let $a_{ij}(t)$ be the monetary value of asset/liability *j* in the balance sheet *i* at time *t*. For a IBS+ model, $a_{ij}(t)$ will be called state variables because the state of an economy is uniquely defined by these variables. According to the law of prediction, the probability density function for the future value of each asset/liability f($a_{ij}(t)$) exits and precisely predictable.

For many macro applications, the balance sheet view of an economy is not complete without additional *k* state variables labeled as $b_k(t)$. For example, the future employment rate depends on economic activities, which are captured by the balance sheet accounting, and demographic dynamics, which is not part of the balance sheet accounting. At least two additional state variables working population $b_1(t)$ and the size labor force $b_2(t)$ are needed to model the future unemployment rate. Again according to the law of prediction, the probability density function for each additional state variable g($b_k(t)$) exits and precisely predictable.

For some applications, the joint probability density function for all state variables J($a_{ij}(t),\ b_k(t)$) need to be forecasted. The joint the probability density function captures all correlation relations between state variables.

To be consistent with FEOE, the IBS+ forecasting model is only complete with the predicted probability density functions for all state variables f($a_{ij}(t)$) , g($b_k(t)$) , and J($a_{ij}(t),\ b_k(t)$) . Mathematically, the joint probability density function J($a_{ij}(t),\ b_k(t)$) is logically related with the margin probability density function f($a_{ij}(t)$) and g($b_k(t)$) through copula functions.

4.2 A Simple Example of IBS+ Model for the World Economy

In this section, we will construct a simple macroeconomic model for the overall world economy as an illustration of the basics of IBS+ model. The simple goal for this model is to forecast the range of the possible sizes of the world economy 10 years from today.

The first step is to choose a set of state variables. The IBS+ model takes the balance sheet view of the overall world economy. The world economy can be viewed as one single aggregated balance sheet with all debts and derivative contracts in the world are cancelled out, and the remaining items on the balance sheets are assets like physical factories, buildings, gold bars, and etc. Since the task of modeling is to forecast scientifically how this world balance sheet grows and shrinks in next 10 years, to make it simple, we just aggregate all assets on the world economy balance sheet into one variable *w*, which is the net worth of the overall world economy.

The second step is to forecast the probability density distribution function of w for next 10 years.

$$w_t = w_{t-1} + sav_t + cg_t$$
$$sav_t = GDP_t - P_t$$

Where w_t is the world net worth at the end of period of time t, w_{t-1} the world net worth at the end of previous period of time t-1, sav_t and cg_t the saving and capital gains

during the period of time t, and GDP_t and P_t the world GDP and total world consumption during the period of time t.

For the sake of simplicity, we choose the saving rate, GDP growth rate, and the capital appreciation rate as three exogenous stochastic variables of the model, which can be determined empirically using the autoregressive method to capture the short momentum and the historic probability distributions. Now the IBS+ model is completely defined and the probability density distribution function of w for next 10 years can be computed numerically.

This simple model does satisfy the requirement of a scientific forecasting model which must be logically self-consistent, making forecasts with reasonable accuracy, truthful abstraction of initial reality, and based on a sound theoretical foundation, with the exception of failure of capturing dynamics accurately. The true dynamics of the world economy is too complicated for a simple model to capture.

For comparison, we could easily construct the simple IS-LM model [6] for the overall world economy, which is essentially a simplified version of popular DSGE models. However, we cannot say the IS-LM model satisfies the requirement of a scientific forecasting model. (1) IS-LM model treats the world economy as a state of static general equilibrium, which is not true at all. The world economy is constantly growing for most parts with few occasions of recessions. (2) Key causality relationships predicted by IS-LM are usually wrong empirically. For example, IS-LM says that the lower interest rate generates higher GDP growth. In recent years, most major economies in the world had record lows of interest rates. Yet we have seen below average growth rates of the world GDP. Many economists [6] use the recession of 1981 as a successful application of IS-LM model. However, IS-LM model provided no insight why it worked sometimes and did not in other time. (3) The IS-LM model has a shaky theoretical foundation of general equilibrium theory, which is not compatible with FEOE. (4) Most importantly, the IS-LM model is not based on anything from economic reality or empirical data. It is simply an economic fairy tale. Just like the ancient Greeks used the Sun god to describe movements in the solar system. For the world economy, the economic reality and empirical data are captured fully by the aggregated balance sheet of the world economy. (5) One of original model creators John Hicks later criticized the IS-LM models [7] "I accordingly conclude that the only way in which IS-LM analysis usefully survives – as anything more than a classroom gadget." and "When one turns to questions of policy, looking toward the future instead of the past, the use equilibrium methods is still more suspect." Unfortunately, IS-LM models continue to dominate the macroeconomic classrooms all over the world. Even world famous economists [8] are still formally applying IS-LM model to make serious policy recommendations.

4.3 Brief History of Accounting Models

The accounting view of economics is not something new. Our ancestors invented numbers in order to quantify food and other properties, which was the accounting view of their local economy. A 76,000 years-old engraved ocher plaque, discovered in South Africa, was considered by some researchers [9] as the earliest example of accounting in the ancient world.

When he criticized mercantilism in The Wealth of Nation in 1776, Adam Smith was taking an accounting view of economy and he said "the division of labor is the great cause of the increase of public opulence, which is always proportioned to the industry of the people, and not to the quantity of gold and silver as is foolishly imagined". In other words, Adam Smith correctly pointed out the wealth of a nation was the productive capacity of the country enhanced by the division of labor, which usually vastly outweighed the value of gold and silver of that nation. Translating Adam Smith's verb description into the language of mathematics, it becomes the equation

$$w_t = w_{t-1} + GDP_t - P_t + cg_t$$

which is the same equation that we used to describe the world economy equation. It is interesting to note that this accounting equation itself is simple but timeless much like Maxwell equations for electromagnetism. Adam Smith did not think this simple idea (or equation) was trivial. Otherwise, Adam Smith would not have devoted much of his book on the topic and put the title his book as "An Inquiry into the Nature and Causes of the Wealth of Nations". The accounting view of economy was further developed by the 18th century economist Jean Baptiste Say in his work "A Treatise on Political Economy".

The systematic and quantitative accounting view of economies was not developed until 1920s and 1930s pioneered by Colin Clark [10] and Simon Kuznets [11]. During the World War II, Richard Stone, who was a student of Colin Clark, worked with James Meade under the supervision of John Keynes [10] to create an accounting framework of how to pay for the war effort of the UK. The first national account for the UK was published 1941. After the War II, the national accounts for many countries were created. The first national account for the US was published in 1947. Today, the national accounting system is the bedrock of modern economics, and more or less reflects the reality of the world economics in a scientific way that is independent of value systems and political ideologies. The open challenge for economists is how to extend these empirical measurements into the forecast of the future in a scientific manner, and how to improve the empirical measurements to make them even more relevant, accurate, and scientific.

Naturally, the nation accounting system becomes the starting point of virtually all macroeconomic forecasting models with the noticeable exception of the IS-LM model. Combining with time series analysis, empirical forecasting models like traditional structural econometric model (SEM) were created [12-14]; marrying empirical analysis with neoclassical economic theories, Real Business Cycle Theory [15-17], and new Keynesian [18-23], DSGE models were built; taking advantage of the power of computer simulation, agent-based computational economic (ACE) models were developed [24-25].

Stock-flow Consistent (SFC) macroeconomic models pays close attention of flow of funds. Morris A. Coperland was credited to develop in 1949 [26] the quadruple-entry system to trace flow of funds of sectors of US economy. However, the work of Coperland did not lead to a macroeconomic forecasting model many years later until James Tobin [27], Wynne Godley [28-31], and their colleagues [32-40] in 1980s. Over years, Stock-flow Consistent (SFC) models have become a creditable alternative to general equilibrium macroeconomic models. However, equilibrium models like DSGE remain dominant in textbooks, academics, central banks, investment banks, and government agencies with strong institutional supports, because equilibrium models fit comfortably with mainstream neoclassical theories of economics. SFC models are

distinctly non-neoclassical as Wynne Godley called them "macroeconomics without equilibrium and disequilibrium" [29]. For years, SFC models largely remain on fringes of academic economics with only a small group of followers [41-42].

The situation started to change after the great recession of 2008. It was very difficult for mainstream economists and DSGE modelers to find excuses for failure to forecast and model such a monumental economic event like the great recession of 2008. Surprisingly, despite a relatively small group of modelers, Bezemer pointed out [41-42] that several SFC modelers Godley from 1999 to 2006 [31,33-35], Godley and Lavoie in 2007 [36-38], Keen in 2006 [43], and Hudson in 2006 [44-45] have successfully forecasted the great recession of 2008 to different degrees of accuracy and scope. In contrast, almost no one among hundreds and thousands of neoclassical economists and DSGE modelers foresaw the worst recession since the great depression [41, 42]. Even among few mainstream economists like Shiller [46-47] and Roubini [48] did forecast the recession, their reasoning was based the consequence of housing bubble bursts and had nothing to do with neoclassical economic theories or DSGE modeling.

From the above short description of the history of accounting models, it is crystal clear that accounting models should be the truly orthodox of economics. In past decades, economics made an unfortunately wrong turn [49-53] by combining the scientific national accounting system with the unscientific neoclassical economic theories to produce equilibrium models like IS-LM and DSGE models. This paper proposes that the right approach to macroeconomics is to combine the scientific national accounting system with the FEOE to build scientific IBS+ macroeconomic models.

In the historic prospective, IBS+ models share many common grounds with non-neoclassical models like SEM and SFC models. The sharp difference is that IBS+ models emphasize the FEOE framework, indeterminacy, and the balance sheet views of the economy, while SEM and SFC models are deterministic in nature.

4.4 Accounting as a Field of Science

Although accounting is as ancient as the numbers, and the numbers has grown into one of the humanity proudest intellectually achievement: mathematics, accounting remains remain largely the same through ages with the exception of the invention bookkeeping system. So is accounting a field of science? The world largest accountant organization does not think so. American Institute of Certified Public Accountants defines accounting as "the art of recording, classifying, and summarizing in a significant manner and in terms of money, transactions and events which are, in part at least, of financial character, and interpreting the results thereof."

Accounting serves many purposes like taxation, financial reporting, and forecasting. This paper asserts that if accounting is used for forecasting purposes under the framework of physics laws of social science and fundamental equation of economics, then accounting is a field of science because forecasting the future in any field is physics. This might explain why accounting is such a universal language for business. To define accounting as a science is important because it sets an interesting new value-free standard of accounting which requires accounting to describe truthfully the economic reality in the same way that rulers measure the spacing and clocks measure the time in physics.

National accounting system is a good example of scientific accounting. A good scientific forecasting model should provide valuable feedbacks to new measurement, more precise measurement, and measurement provides new data for better theories and the foundation of better forecasting. The scientific process of the positive feedback between forecasting and measurement, which has been working wonderfully in physics since Galileo's Leaning Tower of Pisa experiment in 1589, should also work well in accounting and economic forecasting.

4.5 The Fundamental Question of Macroeconomics

In next few sections, we compare an IBS+ model and a DSGE model side-by-side.

Before building any macroeconomic model, one question must be confronted first: what is predictable and what is not predictable in macroeconomics? The question is so important logically that this paper calls it the fundamental question of macroeconomics, because the answer to this question largely defines the basic structure and methodology of a macroeconomic model.

Is recession predictable? For DSGE models, the answer is no. DSGE models regard recessions as exogenous shocks. In other words, by design, DSGE models are blind to developing high-tech bubbles, credit bubbles, stock market bubbles, housing bubbles, excessive government debt, and other dangerous economic imbalances. Therefore, to use DSGE models to guide the government monetary policies is like to ask a blind to drive a school bus.

Are key macroeconomic indicators predictable? Most existing macroeconomic models including DSGE, SEM, and SFC models believe that key macroeconomic indicators like unemployment rate and inflation rate are predictable deterministically. For standard DSGE models, the stochastic behavior comes only from the exogenous shocks.

In an IBS+ model, the probabilities of future recessions are predictable. The joint probability distribution function of the key macroeconomic indicators is precisely predictable according to FEOE while the precise values of key macroeconomic indicators are not predictable.

If a model tries to predict the unpredictable and ignore the predictable, the model is doomed to failure. The indeterminacy embedded in the macroeconomic dynamics is the fundamental reason that explains why it has been so hard to forecast precise values of key macroeconomic indictors.

4.6 A Model Universally Applicable

One remarkable feature of a IBS+ model is that the model are universally applicable to any kind of economy from Robinson Crusoe economy to City of Detroit, State of New York, North Korean, Cuban, Chinese, Japanese, European, and US economy. The reason of universality is simply because the balance sheet analysis is fundamental to any economic entity.

By comparison, it has found very difficult [54] to extend DSGE models for economies like North Korea, China, and other emerging economies because of the idiosyncratic economic structures and poorly developed market economy in these

countries. By design, assumptions of DSGE models are very restrictive because the general equilibrium and AD/AS framework limit the applicability to mature market-based economies. And the poor performance during the great recession of 2008 has proven that DSGE models also did not work well for these mature economies either.

4.7 A Model with Falsifiable Predictions

Whether an economic model is falsifiable and how to falsify an economic model are fundamental questions in economics. Yet these questions are very controversial. Do the poor performance of DSGE models during the great recession of 2008 really mean these models are falsified and economists should abandon these models? Because Federal Reserve has to disclose their economic forecasting publically, their forecasts were often found far off the acceptable marks. For example, in an addendum to Fed minutes of October 2007, just a few months before the start of one of the worst recession in history, Fed forecasters were expecting the economy to grow 1.8 to 2.5% in 2008. Should Federal Reserve throw out their forecast models? In reality, Federal Reserve is still using more or less the same models today and will use them in the foreseeable future.

Physics Laws of Social Science and Fundamental Equations of Economy shine some lights on these difficult and controversial questions. An IBS+ model is falsifiable. However, because the forecast by an IBS+ model is the probability density of an economic variable, the falsifying process is more complicated and requires many repeated observations.

Take the rock-paper-scissor game as a simple example. Let's say the forecast by FEOE is one-third probability for each three outcome. A different deterministic model would forecast a pre-determined sequence of moves with 100% confidence. These two forecasting model are falsifiable with the relative entropy measures from the information theory with sufficient repeated observations.

4.8 A Model Forecasting both Tail Risks and Statistical Averages

One most important feature of an IBS+ model is its ability to forecast both tail risks and the statistical averages. The tail risk is simply the tail portion of the probability density distribution and the statistical average is the mean of the probability distribution in an IBS+ model. In macroeconomics, the tail risks and statistical averages often have very different dynamics. Therefore, it is critically important to forecast both of them accurately.

For example, when the congress failed to reach an agreement to raise debt ceiling limit in early November 2013, the tail risk of a severe recession in 2014 rose significantly. The financial markets started to react with selling off the treasury bills at risks of default, and the financial market volatility shot higher. However, the risk of a severe recession in 2014 is very small because most likely the congress would act before pushing the country to default its debt obligation. Therefore, the forecasts of statistical averages of key economic growth indicators should be barely impacted by the temporary failure of the congress to reach an agreement to raise the debt ceiling.

Take another example. At the end of 2006, the US economy was doing fine with few signs of imbalances. It is perfectly natural for a macro model to forecast rosy

averages of economic growth indicators for both 2007 and 2008. It was very difficult to foresee a severe recession was coming in 2008 at the end of 2006 from the statistical averages. However, it was not difficult to see the tail risks of a recession rising rapidly at the end of 2006 because the US housing market peaked in early 2006, and much more importantly the early-payment-defaults of subprime mortgages rose alarmingly in the second half of 2006.

Most economists are familiar with Paul Samuelson's comment on the ability of the stock market to predict the recessions. In 1966, Paul Samuelson famously said, "The stock market has forecast nine of the last five recessions." While many economists took this Samuelson's quote as a way to dismiss the forecasting power of the equity market, from the tail risks point of view, Samuelson's observation makes perfect sense because by the tail risk is not about 100% certainty of recession going to happen by the definition, the macroeconomic events are indeterministic in nature, and financial markets are sensitive to both tail risks and statistical averages of economic forecasts is fundamentally important for a macro model to have both endogenous and exogenous uncertainties. The cores of DSGE models are deterministic and uncertainties are exogenous. Comparing with IBS+ models, Lack of endogenous uncertainties and instability is a major weakness of DSGE models.

4.9 A Model Based on Initial Reality

Like any forecasting model in physics, the initial condition plays a key role in an IBS+ model. Because there are usually significant amount of uncertainties in the economic forecasting and any historic relationships except laws of physics are not certain to hold in the future, the initial reality becomes only thing we can be 100% certain in any economic forecasting. In an IBS+ model, the initial reality is the initial balance sheet of the economy.

DSGE models are also able to start with the empirical data from the initial accounting data of balance sheets of key sectors. That is a key advantage and strength of DSGE models comparing to static equilibrium models. However, the choice of sectors in DSGE models is very limited. By design, DSGE models could not take advantage of more detailed information of the initial reality. For example, financial sectors were often ignored in many DSGE models. Without financial sectors, it is impossible to forecast many financial crises.

4.10 A Model Capturing Economic Dynamics Accurately

One remarkable feature of an IBS+ model is its flexibility to select key sectors and assets to be modeled. In a different economic environment or different economy, key sectors could be very different. In the 2001 recession, the key sectors are high-tech and telecommunication. In the great recession of 2008, the key sectors are housing, mortgage finance, auto, and financial services. For Chinese economy of 2013, the key sectors are housing, shadow banking system, banking, and regional governments. Without detail information of key sectors, it is impossible to model economic dynamics accurately.

A fatal flaw of DSGE models is their inability to include arbitrary economic key sectors. When we use the AS-AD framework and micro-foundation with one consumer

and one firm, most sector-level details must be ignored. Without accurately capturing dominating economic dynamics of key economic sectors, a macro forecasting model cannot be taken seriously. For example, it is impossible to model Chinese economy realistically without capturing the dynamics of housing and the key shadow banking system. However, there is no natural place for the shadow banking system in DSGE models. For the US economy, with a framework of one consumer and one firm in DSGE models, there would be no room for subprime mortgage borrowers and lenders. Yet during the great recession of 2008, it was the early payment defaults of subprime mortgages in late 2006 that led to the collapse of the subprime lenders like New Century and Option One Mortgage in early 2007, which started the chain reaction of a vicious cycle of downturn.

DSGE models ignore relevant sector details, and UK economist Charles Goodhart noted in an interview in 2009 that "Everything that a central bank ought to be interested in was excluded from the model."

4.11 A Model Emphasizing Realistic Decision Making Not Artificial Microfoundation

One of central tenets of any DSGE model is its microfoundation. However, the assumption that the maximization of utility by consumers and the maximization of profits by firms is over-simplification and unrealistic.

Since IBS+ models deal with the balance sheets of real economic sectors, the behavior of decision making is founded on the average behavior of the real economic agents.

For example, one hallmark feature during the financial panics like the Great Recession of 2008 is that the leaders of firms are rushing to deleverage approximately at the same time. This kind of self-preservation behavior of firms cannot be described by the profit maximization.

4.12 A Model Avoiding Fallacy of Division and Composition

During the great recession of 2008, the balance sheets of financial giants AIG, Bear Sterns, Lehman Brothers, Fannie Mae, and Freddie Mac became major sources of macroeconomic instability for the US and world economy. However, the aggregated balance sheet of all US insurance companies including AIG looked fairly healthy while the default of AIG alone was sufficient to push the US recession to a whole new level of severity. Therefore, in order to capture the downturn risks of US economy accurately, the balance sheet of AIG must be separated from other healthier insurance companies. The fallacy of division is to use the healthiness of whole insurance industry to conclude that insurance companies would not have caused economic instability. The fallacy of composition is to use the troubles of AIG to conclude that whole insurance industry were bankrupt. It is very easy to commit logic fallacies when making conclusions by combining assets and balance sheets.

When taking the balance sheet views of an economy in an IBS+ model, on one hand we have to choose as fewest sectors and fewest assets as possible in order to keep the model simple, and on the other hand we have to make sure that we would not commit

the fallacy of division and composition when grouping assets, companies, and industries into aggregation.

DSGE models with a framework of one consumer and one firm is nearly impossible to avoid the fallacy of division and composition. Therefore, standard DSGE models cannot properly handle endogenous instabilities caused by consumers and firms.

4.13 A Model Emphasizing Institutional Economics

Since a standard DSGE model has a framework of one consumer and one firm, it is impossible to include important insights from institutional economics. However, the legal and ownership structures of key economic institutions often play critical roles in the evolution of the macroeconomics.

For an economy like China where the central and local governments play the central roles in every aspect of economy, the institutional economics becomes the key tool to understand the dynamics of macroeconomics. For example, all major banks and key industries are directly controlled and supervised by the central government in China.

Even in a mature economy like US, the government still plays critical roles in macroeconomics. For example, after the great recession of 2008, most new mortgages are originated by a few government controlled entities like FHA, Fannie Mae and Freddie Mac. Almost all student loans are originated by the US government. Gave rapidly growing of the student loan debts, there are many discussions whether the massive defaults of the student loan could create a new financial crisis. Because the student loans are largely owned the US government, massive defaults of the student loans could only add more to budget deficits for the federal government rather than a new financial crisis. If the student loans were privately owned, it would be a completely different discussion.

Since an IBS+ model deals with the balance sheets, the ownership and legal structure are naturally built into the dynamics of the balance sheets.

4.14 A Model Based on Sound Theoretical Foundation

An IBS+ model is built on physics laws of social science and fundamental equation of economics. Since physics laws of social science are universal laws of physics, modelers don't have worry about the theoretical foundation of an IBS+ model.

The biggest problem of DSGE models is their shaky theoretical foundation. (1) DSGE models are built on neoclassical economics, which is not compatible with FEOE. (2) Much of modern economics is built on laws of supply and demand. Unfortunately, laws of supply and demand are not compatible with FEOE, they are statistical relationships in a sense that they work sometimes and do not work in other time, and they are not laws of physics. To analyze any market, indeterministic supply demand pricing (ISDP) model derived from FEOE works much better [5]. The framework of AS-AD and price stickiness is a wrong framework to study how the macroeconomics works. (3) The central assumption of DSGE models is that markets always return to a deterministic steady state or the equilibrium state. In DSGE models, by design the economy would never go from the equilibrium state into the disequilibrium state without external shocks. Therefore, by design, DSGE models cannot forecast recessions caused by endogenous instabilities. (4) The micro-foundation of DSGE models imposes idealized behavior on a

few agents. A model should model the important decision making processes in the real economy not imposing unrealistic behavior on agents. DSGE models assume that firms will always maximizing profits. In the real world, for a firm to manage the balance sheet properly, managers must balance profits and risks. It was exactly poor risk management that drove Lehman Brothers into bankruptcy while the similar financial firms like Goldman Sach with better risk management survived.

The important thing is that the success of macroeconomic models like SEM and SFC has already proved that one does not need neoclassical, laws of supply and demand, the framework AS-AD and price stickiness, general equilibrium, and micro-foundation to model macroeconomics. These shaky and unscientific concepts not only provide no useful insight to modeling but also restrict models so much so that models are no longer universally applicable and no longer capable of capturing the true dynamics of the macroeconomic reality.

Balance sheet modeling and forecasting used by an IBS+ model is not new to economics. On Wall Street, analysts have analyzed and modeled balance sheets on the daily basis for well over a hundred years. Therefore, there are vast literatures and intellectual heritages exiting in forecasting the future performance of balance sheets and default risks of individuals, companies, and governments. It is interesting to note that few popular macroeconomic theories are used by wall-street analysts. While macroeconomics is different from businesses in some ways, national accounting system makes crystal clear that fundamentally the behavior of macroeconomics is just the behavior of the aggregated balance sheet.

4.15 A Model with Indeterministic Mean Reversion

The important question in macroeconomic modeling is how to design long-term behavior of models and the terminal state of modeling. DSGE models assume that the economy always returns to the equilibrium steady state of growth. Deterministic SFC models [55] either end with a steady state of same flow of funds rates, or deterministic chaos defined by a set of ordinary differential equations.

These steady states in DSGE and SFC models look artificial and unrealistic. Historic experience of US is that the economy tends to oscillate in repeated cycles of boom and bust with the indeterministic timing. In order to be consistent with FEOE, an IBS+ model ends with a stable probability distribution of many possible states with mainly positive and some negative growth rates. The mean of probability distribution corresponds to the steady state of long-term average growth rate. The probability distribution reflects the possible range and uncertainty to pin point the economic states in the future.

4.16 A Model Emphasizing Inventory Dynamics

So far we have focused on the balance sheet view of macroeconomics. However, the analysis of macroeconomics is not complete without analyzing market dynamics of key markets like labor and money. In this section, we are taking a market-centric view of macroeconomics with indeterministic supply demand pricing (ISDP) models with emphasizing inventory dynamics.

Inventory is one of most outstanding features of any market-based economy because most markets such as labor, money, housing, auto, other manufactured goods, and commodities carry inventories. For any market, the existence of inventory means supply is always greater than demand. Therefore, supply curve would never intersect with demand curve. And there is no such thing as marshallian cross or market equilibrium defined as supply equals demand. The existence of inventory undermines the entire framework of laws of supply and demand and market equilibrium and the general equilibrium theory. For these reasons, despite the fundamental importance of inventory for any economy, most standard textbooks in microeconomics and macroeconomics prefer to ignore such an awkward topics.

FEOE rejects the general equilibrium theory. Without the framework of laws of supply and demand and market equilibrium, the importance of inventories determining the growth potential and short-term fluctuations of macroeconomics starts to emerge.

There are many kinds of inventories in a market-based economy. In the goods producing part of economy, inventories include both the physical inventories and the spare capacities of production. In USA, the business inventory is part of national accounting system and a key component of GDP. Analyzing the business inventory is incomplete without examining the available spare capacity which is monitored by Federal Reserve. In the service part of economy, the unemployed labor force is one of good proxies of the spare capacity. Some service industries like hotels and airlines, the vacancy rates are available for analysis. The unemployment rate is a direct measure of inventory of the labor supply. In the money market, the existence of cash can be viewed as a form of inventory of money for potential investments. When demand exceeds supply, the waiting lists are created. In a market-based economy, the waiting lists do exist but not very common. Interestingly, in a centrally planned economy, the waiting lists are everywhere.

The central tenet of traditional macroeconomic models is the general equilibrium defined as aggregate supply equals to aggregate demand and saving equals investment. However, in a real market-based economy, because the existence of inventories, the aggregate supply is always greater than aggregate demand, labor supply is always greater than labor demand, and saving is always greater than investment, many macroeconomic models based on the concept of the market equilibrium become out of touch with the economic reality.

Inventory dynamics turns out to be the key to understand the many dynamics of macroeconomics. For example, there is a strong causality relationship between the inflation rates and the inventory, spare capacity, and unemployment rates. The recession of 2001 was largely due to too much inventory and spare capacity built up in high-tech and telecom industries. The housing inventory and especially the distressed housing inventory played key roles in the dynamics of US macroeconomics during the great recession of 2008.

One of most important empirical observations in macroeconomics is the Philips Curve, which represents the relationship between the inflation rate and the unemployment rate. The Philips Curve is the direct result of the inventory dynamics in the economy. Therefore, ignoring the important inventory dynamics would make any macroeconomic model superficial.

In an IBS+ model, the inventory is the bridge between the primary balance sheet view and the secondary market-centric view of macroeconomics, because inventories, spare capacity, and cash are important parts of balance sheets and carefully managed by owners the balance sheets.

In conclusion, when applying FEOE to macroeconomics, inventory becomes one of the most important concepts of macroeconomics. A good macroeconomic model must be built upon the analyzing inventory dynamics of labor, money, physical inventories of finished products, and spare capacity under the framework of indeterministic future aggregate balance sheets.

4.17 How to Fix DSGE and ACE Models

DSGE models have their own strength and weakness. To fix DSGE models is to expend or preserve their strength and eliminate their weakness.

The strength of DSGE models includes the following: (1) the accounting view of the initial state of the economy, which allows DSGE models to start out with empirical data. This is a big improvement over other equilibrium models; (2) the successful marketing strategy, which enables DSGE models to dominate the macroeconomic landscape. These models assume that economy always returns to stable steady growth states with policy actions might accelerate or delay the process. This feature has great appeals to politicians and central bankers who would like to "test" their policy ideas. This marketing strategy is essentially the same as the magic snake oil, which promises its usage would return any sick patient to the steady health state. As a marketing tool, snake oil has worked wonder for thousands of years around the world. Also DSGE models combines many different schools of thoughts like classical, neoclassical, new classical, Keynesian, new Keynesian, monetarism, mnand new neo-Keynesian. By making so many friends in high places, and dressing up models in fancy mathematics, these models have become the state of arts of macroeconomics.

The weakness of DSGE models is their macroeconomic theories. With heavy burden of many poor theoretical ideas and limited empirical sector data, in essence, DSGE models are just over-parameterized extrapolation models. Like any over-parameterized model, it fits empirical data wonderfully but forecasts the future poorly. That is what exactly has happened in recent years. With almost no support from macroeconomic theories, SEM and SFC models performed much better than DSGE models.

In science, theories are only as good as their forecasts. We have to abandon those macro theories that are incompatible with FEOE. However, after replacing these macro theories with FEOE, DSGE models became essentially IBS+ models.

Agent-based computational economic (ACE) models have been often promoted [25] as creditable alternatives to DSGE models. There is no doubt that computer simulation is a proven tool in statistical physics and chemistry. However, in statistical physics and chemistry, computer simulation has been successfully used in systems with homogenous agents and simple weak interactions. From the balance sheet point of view, macroeconomics consists of heterogeneous agents with strong and complicated business interactions. For example, during the great recession of 2008, tiny subprime mortgages borrowers brought down small subprime lenders first. Then the shutdown of subprime

refinancing led to massive new defaults of subprime mortgages, and subprime CDO AAA-rated tranches became worthless. Financial giants like AIG who provided financial guaranteed of CDO tranches asked government's help to stay alive. The sizes of balance sheets of AIG, subprime lenders, and subprime borrowers cannot be more different. The interactions among them were so complicated that only few most careful financial experts would have noticed that AIG actually guaranteed billions of subprime CDO tranches because at any moment AIG had millions of other insurance policies for individuals and businesses all over the world. Therefore, despite their successes in statistical physics and chemistry, ACE models are not very useful when dealing with in-homogenous agents with strong and complicated business interactions in macroeconomics. However, the computer numerical techniques will be certainly used in most macroeconomic forecasting models including IBS+ models. In essence, ACE models take an agent-centric view of the macroeconomics, if those agents are the owners of balance sheets, ACE models could become similar to IBS+ models superficially at least.

4.18 Summary

We have presented the structure and features of an IBS+ model. With side-by-side comparison with DSGE models, we have proved that an IBS+ model is superior in many ways. However, the IBS+ model is so new that it remains to see whether an IBS+ model is able to achieve what have achieved by a DSGE model.

Attempting to model short-term macroeconomic fluctuations by ignoring inventory, debt, financial derivatives, asset bubbles, over-investments, and risk management, macro models like DSGE are taking a wrong path to look for fish on trees.

In the general framework of FEOE, people are the least predictable because they have free wills, the economic reality captured by the balance sheets are the most predictable because physical assets like factories and houses change slow and relatively predictably, and the markets are somewhat predictable because markets combines the people with free wills and market economic reality independent of human free wills. Therefore, from the experience of modeling the behavior of corporations over last hundred years, the primary focus is always on the dynamics of the corporate balance sheets with additional analysis on the market forces and corporation managements. In macroeconomics, it should be no different. The primary view of the macroeconomics should always be the dynamics of the aggregate balance sheets. The market-centric view is secondary, and the agent-centric view is even more marginal.

The balance sheets of many modern global corporations like Apple, Toyota, JP Morgan, Samsung, and Exxon are bigger than the aggregate balance sheets of many small countries. Therefore, there is no reason why balance sheets analysis, which has been applies to corporations so successfully over a century, could not be applies to macroeconomics.

5 A Classification of Causes of Economic Crises

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In this section, we will build an IBS+ model to analyze the causes of economic crises as one of applications of an IBS+ model. Every economic crisis is unique. However, the IBS+ model is universally applicable.

Economic crises [56-57] have plagued humanity since the dawn of capitalism. Despite intense studies over last several hundred years, the questions about causes, forecasting, and prevention of economic crises remains unsolved. Despite almost every professional economist has just lived through and witnessed every detail of the Great Recession of 2008, yet causes of this most recent recession has become very controversial. The reason of failure for economists to reach a consensus about causes of the great recession of 2008 is that current mainstream economics does not provide a reliable, value free, and universal framework to analyze and explain past economic events. For example, DSGE models treat the great recession as an external shock to otherwise the equilibrium economy. Thus by definition, DSGE models could not offer any insight about causes and forecast of the great recession.

We start with the debates on the causes of the great recession of 2008. Then we reformat the question what causes economic crises into a value free and scientific forecasting question. Then we will build an IBS+ model and formulate a classification of causes of economic crises.

5.1 Debates on Causes of the Great Recession of 2008

The causes of the great recession of 2008 have been in the front pages of newspapers, magzines, and research reports ever since the start of the recession. It is remarkable that given more or less the same set of facts, people drew all kinds of conclusions. Even the official Financial Crisis Inquiry Commission could not reach a unanimous conclusion.

The reason for so many different opinions is that the research on what caused the great recession depends on the purpose of your research, the way you analyze the economy, the data set you use, the economic theories and analytical tools you use, and the time frame you focus on. The historic facts are events happened in 4-dimensional time and space. In social science, these historic events are chained in an indeterministic way. In order to make sense of the complicated historic reality, we are forced to make simplified mental models to focus on just things we are interested in. Therefore, although historic data are the same, our simplified mental models are very different. For example, if one would like to learn a monetary policy lesson, one could conclude that Federal Reserve kept the low interest rates too long between 2002 and 2004, which fueled the housing bubbles. If one would like to learn a mortgage underwriting lesson, one could conclude that the poor mortgage underwriting was a major cause of the recession.

Since economics is fundamentally a forecasting science like physics, this paper is focused on learn a lesson on how to forecast a recession in advance. By focusing on forecasting a recession by an econometric model, it is a science and becomes a value-free approach, which is theoretically independent of personal opinions. Also this paper took a balance-sheet-centric view of the economy. We further limit causes mainly to quantifiable balance sheet data from historic national accounting and corporate financial filings. Since macroeconomic events are indeterministic, we limit the time period 2 to 4 quarters before the official start date of the recession. In order to organize all these relevant information together in a coherent way, we need to build an IBS+ forecasting model.

5.2 Build an IBS+ Recession Forecasting Model and a Universal Leading Economic Indicator

To build an IBS+ model for the recession forecasting is straight forwards. For defined a recession simply as an economic event with the negative GDP growth for two or more consecutive quarters. The model only forecasts the probability of a recession in 2 to 4 quarters into the future, which is the essentially tail risk of the future GDP growth rate while ignoring all other probability distributions.

In terms of sector choices, we scan all sectors of the economy to identify possible trouble sectors, evaluate their potential impacts on the future GDP growth, and quantified their contributions to the probability of recession.

To put in a mathematical equation, we use the logistic regression formulation to ensure that the summation of probabilities do not excess 100%.

$$\log(\frac{P}{1-P}) = \sum_{i=0}^{n} C_i S_i$$

Where P is the probability of a recession, n the total number of trouble sectors we identified, C_i the contribution from the sector i measured by the natural logarithm of the odds, and S_i the relative sector size of contributing to GDP for the sector i.

The holy grail of the business cycle research is to develop reliable leading indicators that could forecast the coming recessions. In essence, the tail risk P is the abstract universal leading indicator that forecasts the recession from an IBS+ model. The tail risk P is a purely economic indicator, and closely related with financial indicators like the stock market index and the slope of yield curve. One problem of existing leading indicators is the false positives. The tail risk P solving the false positive problem by using probability, which is required by physics laws of social science and reflects the indeterministic nature of macroeconomics.

5.3 An Classification of Causes of Economic Crises

Because the IBS+ model for recession forecasting is universally applicable to any economy through history, we can use this model to classify causes of all historic recessions in a consistent way. The hypothesis is that recessions belonging to the same class have the same causes, the similar economic dynamics, and the similar of potential policy prescription. In medicine, the classification of diseases is central for diagnose and treatment. From the physics point of view, the balance sheets in economy and the human bodies are very similar because both of them are dissipative structures requiring the careful management to stay healthy.

The proper management of the balance sheet can be very challenging. Every year in US, there are millions of household and thousands of companies filing for bankruptcy. During the great recession of 2008, although financial giants like Lehman Brothers and AIG had employed thousands of risk management professionals with the best talents available in the world, these firms still managed to get into big troubles.

There are 5 types of potential problems for a balance sheet: asset devaluation, rising debt, drop of income, rising costs, and short-term liquidity crisis. Asset devaluation and rising debt will result in insolvency. The drop of income and rising cost

will deplete the savings. The sudden changes of flow of funds in an economy like government expenses cutting after a major war are captured by the changes of income and expenses flows. The short-term liquidity crisis is the inability to pay bills in cash even though the balance sheet could be solvent. The mismanagement of asset, debt, income, expenses, and liquidity will cause economic troubles. The proper management of a balance sheet also must include the proper risk management for unexpected shocks and surprises.

In essence, the management of a balance sheet requires the financial disciplines, which often are found missing for many individuals, businesses, and governments. Normally the mismanagement of balance sheets by households, businesses, and governments has no severe macroeconomic consequence. The market economy like US is so big that it is very resilient to small shocks because losses more than 1% of GDP in a quarter are very rare. However, occasionally the mismanagement of balance sheets does get out of control and starts the vicious cycles of recession.

Because a recession by definition is an accounting event, it could always be traced troubles back to mismanagement of balance sheets and sudden changes of flow of funds. However, sometimes causes of recessions are better assigned to the exogenous natural and man-made shocks. For example, the recent US congressional failure to raise debt ceiling could create a recession. It makes more senses to classify the cause as a political decision instead of calling the mismanagement of government debt. Whenever in doubt, we simple assign the blame on mismanagement of balance sheets. For example, many people believe that repeal of Glass-Steagall Act caused the recent financial crisis. Although the repeal of Glass-Steagall certainly made financial firms more complex, we still assign the mismanagement of financial firms as causes of recession for the simplicity of the classification. In theory at least, a recession could happen without obvious mismanagement of balance sheets especially in countries like Japan where the economic growth is very weak and the population is aging rapidly or shrinking.

The simple classification is summarized in the following:

- Exogenous Shocks:
  - Natural Causes
    - Earthquake
    - Epidemic diseases
  - Man-made Causes
    - Wars
    - Monetary policy
    - Fiscal policy
    - Currency policy
    - Other political decisions
- Endogenous Balance Sheet Mismanagement
  - Households/Financials/Other Firms/Governments
    - Asset devaluation
    - Burden of debt and obligations
    - Reduction of income
    - Rise of expenses
    - Liquidity Crisis

Many recessions in history are caused by endogenous factors, which are the factors captured by the national account system and flow of funds. The recession 2001 recession was mainly caused by mismanagement of inventories and over-investment by high-tech and telecomm companies. The saving and the loan banking crisis and the sharp oil price rise before the first gulf war mainly caused the 1990 recession. Between 1836 recession and the great depression of 1929, the economic crises were often associated with banking panics. Bank and other financial firms were often highly leveraged institutions with concentrated financial assets like marketable securities, mortgages, loans, credit lines, and Guarantees. It was only after the creation of FDIC in 1933, the panic bank runs were replaced by the orderly bank took over by FDIC.

Some recessions in US were caused by exogenous factors like wars. Post war spending cuts often forced the economy to adjust structurally in terms of labor forces and production. For example, World War I recession in 1918, recession of 1945 after World War II, and recession of 1953 after the Korean War. Post war spending cuts also played roles in 1973 recession after the Vietnam War.

It will be interesting to apply the classification presented above to study systematically the historic economic crises worldwide. It will be followed up by the future researches.

5.4 Causes of the Great Recession of 2008

In this section, we will apply the IBS+ model to build a qualitative forecasting model at the end of 2006 to estimate the recession probability one year ahead.

The choice of sectors is mainly based on the sector sensitivity to the housing market because the US housing market was peaked in the early 2006, and the early payment default was rising at an alarming rate during 2006. The selection of sectors is listed as the following:

- Household
  - Prime
  - Near Prime
  - Subprime
- Financial Firms
  - Subprime Mortgage Lenders
  - Other Mortgage Lenders
  - Banks
  - Bond Insurer (AIG, MBIA, AMBAC, etc)
  - Quasi-Government Mortgage Agency
  - Other Financial Firms
- Non-Financial Firms
  - Home Builders
  - Auto makers
  - Other Firms
- Government

The choice of asset and liability is also based on the sensitivity to the downturn of housing market. Most of information listed in the following was public information and can be found in company financial filings, industry publication, and government national accounting statistical data.

- Households
  - Asset
    - Inflated Housing Price
    - Equity Depleted by Home Equity Extraction
  - Liability
    - Personal Debt to GDP Record High
    - Not-Affordable Mortgages
- Financial Firms
  - Asset
    - Structured Products
      - CDO, CBO, ABS, CBMS, CLO
    - Non-Agency Mortgages
  - Liability
    - Extremely high leverages for Wall Street Investment Banks
    - Bond Insurance with extremely high leverages
      - AIG, MBIA, AMBAC
    - Mortgage Buyback Guarantee
      - Subprime Mortgage Lenders
      - Banks
    - Agency Mortgage Default Guarantee
      - Fannie Mae, Freddie Mac
- Non-Financial Firms
  - Liability
    - Pension Liability
      - GM/FORD/Chysler
  - Asset
    - Over-investment in Residential Structures
      - Home Builders

At the end of 2006, the private household debt to GDP ratio was at an alarmingly high level. The household debt was dominated by the mortgage debt. The sharp rise of household debt was fueled by the expansion of the home ownership rates and the extraction of home equity through cash-out refinancing by treating the house as an "ATM machine". The cash-out refinance was very common for subprime and near prime borrowers because mortgage lenders favored the payment-tested borrowers over the first-time home buyers. Because the epidemic poor underwriting standard, the early payment default rates of subprime and near prime mortgages had been rising very rapidly through 2006. At the end 2006, it was clear to financial markets that if the housing price failed to rise in the next few years, many subprime and near prime mortgages were going to default. The credit default swap, which is the insurance costs against default, for BBB – rated subprime bonds reached record high at the end of 2006. Therefore, just based on information from the household sectors alone, the recession risk was rising rapidly in

2006 after the peak of the US housing market because the consumer spending was partially supported by the home equity extraction.

The financial firms were extremely highly leveraged at the end of 2006. For example, the asset to equity ratio for Lehman Brothers was about 30 to 1 according to its annual report. The high leveraged was very troublesome if the housing price was going to fall sharply because these financial firms owned trillions dollars of mortgages, mortgage bonds, and CDOs. The financial firms were also liable for massive mortgage related guarantees. Fannie Mae and Freddie Mac owned or guaranteed nearly $5 trillion mortgages. Bond insurers including AIG, MBIA and AMBAC were insuring hundreds of billions of mortgage bonds and CDO tranches with extremely thin capitals. The mortgage lenders usually offer to buy back a mortgage if the mortgage defaults in the first six month. The sharp rise of the early payment defaults of subprime mortgages in the end of 2006 push the subprime lenders like New Century into financial crises. If these subprime lenders were going to scale back or give up mortgage lending, the subprime mortgage default would rise dramatically because many borrowers were paying artificially low initial teasing mortgage rates by choosing so-called hybrid mortgage products. Therefore, the financial firms were like a ticking time bomb at the end of 2006.

Among non-financial firms, home builders and the housing market related industries were very vulnerable to a housing market downturn. Over-investment during the housing market boom was apparent. The auto industry was financially sick because the heavy burden of the pension liability. Otherwise, the corporate sectors were fairly healthy at the end of 2006. The stock markets were at reasonably valuation relative to earnings. In Government sectors, many local governments were also burden by the pension liability. The finance of local governments heavily depended on the real estate taxes, which was vulnerable to a housing market downturn.

To summarize, causes of great recession of 2008 were mainly mismanagement of balance sheets by households and financial firms. Based on public available balance sheet information, the tail risk of a recession was rising sharply after the peak of the US housing markets in early 2006.

5.5 Generalization of Austrian Schools' Work on Credit, Fisher's debt deflation theory, and Minsky's Financial Instability Hypothesis

The framework of FEOE emphasizes all factors impact on the health of a balance sheet including credit, other liability like insurance, derivatives, and guarantees, inventory, asset valuation, income, expense, and liquidity. Therefore, the framework of FEOE of mismanagement of balance sheets can be viewed as the generalization of the Austrian credit cycle theories [58], Irving Fisher's debt deflation theory [59], and Minsky's financial instability theory [60-62].

The credit cycle is the expansion and contraction for household and firms to access to credit in an economy. The Austrian business cycle theory [58] emphasizes credit extensions by financial firms and mal-investment by firms as the fundamental causes of short-term economic fluctuations. Irving Fisher's debt deflation theory focuses on the role of deleveraging in creating busts, recessions, and depressions. Hyman Minsky went a step further by proposing financial instability hypothesis and emphasizing the endogenous instability of financial firms, which swing between robustness and fragility.

The credit cycle theory is criticized by mainstream economists. In the AD-AS framework, the credits are close to zero sum games between lenders and borrowers. Thus credits are irrelevant and should have no macro impacts on aggregates. Therefore, in many DSGE models, credits, leverage, deleverage, defaults, and financial firms are not even modeled. During the great recession, instead of a macroeconomic nonevent, the bankruptcy of Lehman Brothers proves to be a macroeconomic disaster. Given their sizes, the bankruptcy of AIG, Fannie, Freddie, or Citigroup would be even much worse without government financial supports. In the FEOE framework, the bankruptcy of balance sheets would have ripple effects on many related players because the interconnection of balance sheets between lenders and borrowers and flow of funds.

Another line of criticism of the credit cycle theory is that the theory is logically inconsistent with the rational choice theory because it implies that financial firms act irrationally: during the boom period, they extend too much credit; and during the bust, they withdraw too much credit. The traditional rational choice theory might not able to capture the scope of complexity of managing the balance sheet of financial firms. To manage the balance sheets properly is to maximize net value of the firms, to control properly the risks and liquidity, and to balance the short gains and long-term objectives. In the FEOE framework, because the future economy is indeterministic, the low visibility of the future limits the financial firms' ability to turn on and off the credits at the exact timing.

5.6 Summary

Because IBS+ models are universally applicable, we could apply these models to analyze the historic economic crises. The IBS+ approach allows the value-free forecasting method to analyze historic events. The tail risk of a coming recession can be used as the abstract universal leading indicators of a recession.

This paper proposes a classification of causes of economic crises using IBS+ models to analyze balance sheets of key economic sectors. Applying this classification to examine recent economic crises, we conclude that most economic crises are caused by mismanagement of balance sheets by key economic players. This paper suggests that economic crises are largely caused by inevitable misbehavior of humanity and not caused by any fundamental flaw of capitalism. Historically, treating mismanagement of balance sheets as main causes of economic crises is a generalization of Austrian business cycle theory, Fisher's debt deflation theory, and Minsky's financial instability hypothesis.

From the tail risk point of view, almost all recessions can be forecasted. In contrast, one key assumption of all DSGE models is that economic crises are exogenous shocks and cannot be forecasted within the models.

6 Concluding Remarks

We have applied FEOE to build an IBS+ model for macroeconomics in this paper and an ISDP model in an earlier paper [5] for describing the market supply, demand, and pricing dynamics. These two examples prove that FEOE are useful and easy to use for solving important economic problems.

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