

*Stochastic Optimal Control and the U.S. Financial Debt Crisis.* By J.L. Stein, Springer Science. April 2012, ISBN 978-1-4614-3078-0, 157 pages

Since the 1980s, economic and financial crisis have multiplied. This trend has affected not only emerging countries but also the major developed countries, such as Japan, the United States, and nations in Europe. Some have internal causes, but they also result from international transmissions of shocks; the United States has been particularly affected by such crises. As recent events show, with few exceptions, each crisis also has taken policymakers, central bankers, finance professionals, and economists by surprise. Although literature on crises is abundant, it focuses mostly on explaining crises *ex post*, rather than proposing *ex ante* indicators. A recent paper by Reinhart and Rogoff (2011) is an excellent example.

Work by Jerome L. Stein stands out from this body of literature, in that it not only looks retrospectively at the causes of crises but goes beyond that effort to show that it is possible to construct early warning signals (EWS) of excessive debt, which can be essential for risk management. The point of the book is to show that from an analysis of debt—or rather, the debt-to-net worth ratio of private agents—we can compute optimal debt ratios to deduce an EWS, which represents the difference between the actual and an optimal debt ratio. The probability of a debt crisis rises with greater excess debt. Stein uses mathematical methods, such as stochastic optimal control (SOC), to determine the optimal debt, in combination with an economic approach to debt crises. With real-world examples, Stein applies his method of analysis systematically to earlier crises in the United States (agricultural, S&L), as well as more recent events, such as the U.S. subprime crisis, the failure of AIG, and the crisis affecting the euro. In eight chapters, Stein also offers a three-step approach: (1) highlight errors causing the crisis, (2) determine the optimal debt ratio using the SOC method, and (3) verify the theory empirically by calculating the EWS for each crisis.

#### **Mistakes at the origin of financial crises**

Reading Stein's book brings to mind the notion that financial crises are not inevitable but rather result from an error or series of mistakes that economists realize only after it is too late. Responsibility for the crisis might be left to states (as in the Euro area, Chapter 8), to financial institutions (the Fed, IMF; Chapter 2), or to market operators and/or Quants (Chapter 3).

In Chapter 8 for example, Stein analyzes four countries in the Euro area that currently are experiencing the greatest difficulties financing their debt: Greece, Portugal, Ireland, and Spain. The governments of Greece and Portugal are mainly responsible for their debt crises, to the extent that they have failed to control their deficits. Stein discusses the Maastricht criteria, which require that the public debt-to-gross domestic product (GDP) ratio not exceed 60%, and shows why this ratio is not optimal. It follows from the relationship  $(\text{deficit}/\text{GDP}) = g (\text{debt}/\text{GDP})$ , where  $g$  is the growth rate of nominal GDP that results from a simple assumption of stability in the debt/GDP ratio over the long run. In Spain and Ireland, another error allowed housing bubbles to develop, without regard to the growth of private debt. Stein insists that the debt ratio of private agents (e.g., households) has increased dramatically; the capital gains associated with price increases in this sector exceeded the rate of interest. Without EWS—that is, without calculating the optimal debt ratio of households—it was impossible to intervene in time. The subsequent bursting of the bubble increased public debt so much that governments had no choice but to implement bank rescue plans. Finally, in accordance with Standard & Poor's downgrade of the Euro area countries, Stein asserts that European leaders focused on the wrong indicator. The public debt ratio is important, but the countries suffering the worst difficulties are those with the highest external debt ratios. Therefore, Stein suggests the NATURAL Real EXchange rate model (NATREX) of the real equilibrium exchange rate, which attempts to analyze the relationship between the dynamics of the real exchange rate and external debt. With NATREX, the author can show how demand for nontradable goods/real estate in Spain and Ireland, as well as the rise in public expenditures in Portugal and Greece, both led to sharp appreciation and overvaluation in their currencies, preventing them from generating sufficient trade balance surpluses to guarantee the service of external debt and its stability over the long term. Many European economists (e.g., the Ifo Institute) and even some governments thus are talking about debt problems and competitiveness. For Stein, without a sharp depreciation of the Euro, and perhaps without the abandonment of the Euro by countries such as Greece, austerity plans are doomed to fail.

In Chapter 2, Stein turns to a severe criticism of the U.S. Federal Reserve's policy and its previous chair Alan Greenspan. He criticizes the Fed's adherence to the "Jackson Hole Consensus," which ignores asset prices and focuses solely on changes to the money supply. Issing (2011, p. 5) offers a similar argument: "restricting the role of the central bank to be totally passive in the period of the build-up of a bubble and practically pre-announcing the bank's function as a 'savior' once a bubble burst represents an asymmetric approach, one that might create moral hazard and over time contribute to, if not trigger, a sequence of ever larger bubbles and following collapses." Stein further shows that during 2004–2006, "money growth and inflation (CPI) were moderate, but the inflation of house prices was high" (table 2.1), which signaled the development of a bubble. He explains Greenspan's position according to a belief in the generality of First Theorem of Welfare Economics, which states that the market regulates itself. Stein shows this theorem cannot be applied to financial markets.

Chapter 3 is devoted to an analysis of the role of Quants in the financial crisis, including their responsibility for creating structured products related to the securitization of mortgages. This securitization by ad hoc special investment vehicles (SIV) financed the acquisition of assets/mortgages through the issuance of securities. But to the extent that not all claims were of equal quality, "the Quants devised a method to sell the derivatives of dubious value as AAA securities," namely, dividing collateralized debt obligations (CDOs) into "tranches"—senior (top), mezzanine (medium), and equity (lowest). The SIVs' incomes were primarily allocated to the senior tranche, which obtained an AAA rating, then to the mezzanine, and so forth. This strategy suffered from the serious mistakes made by its developers. Stein lists three: First, following the efficiency market hypothesis (EMH), they considered property prices equal to anticipated prices, when the trend (drift) was zero. Second, they assumed the stability of the distribution of capital gains on the U.S. housing market, even though the facts contradicted this prediction. Therefore, the risk calculation, using the value-at-risk (VaR), was inherently wrong. Third, they ignored the correlations between returns on different tranches, as well as the systemic risk of a general crisis in the system. In this case, Stein recognizes that the conditional probability that the assets of the senior tranche will fail when assets of inferior tranche fail is close to unity. These same errors have led rating agencies to assign subprime erroneous notes to CDO tranches.

Certainly, there is widespread criticism in current literature of financial markets (e.g., Crouhy et al., 2007), but Stein's analysis is richer, in that it offers a critical review of several reference models, including the CAPM (capital asset pricing model) and EMH, showing that they are not suitable in the context of securitization and tranching. Finally, following Stein's criticisms, we can express our surprise at the "enthusiastic" reception these products received in financial circles, given their opacity.

### **SOC method, optimal debt, and EWS**

In the future, we cannot effectively protect against financial crises if we don't make the effort to calculate EWS and therefore the optimal debt of private agents. Optimal debt can be calculated using the SOC method, whose foundations (and the underlying philosophy) are presented in Chapter 4. The applications available for analysis include the U.S. financial crisis (Chapter 5), AIG's failure (Chapter 6), and the agricultural and S&L crises in the 1980s (Chapter 7).

In Chapter 4, Stein explains the need to define the optimal debt-to-net worth ratio of households that borrow to purchase real estate, as well as the optimal insurance liabilities-to-net worth ratio of an insurer such as AIG. Considering that there is uncertainty in future capital gains for real estate and the future interest rates faced by households, as well as capital gains and claims against insurers, the SOC method is necessary. In each case, the optimizer selects the ratio that maximizes its anticipated net worth (assets minus liabilities) for a future date. Stein discusses different criteria functions (HARA, exponential, logarithmic) and outlines methods for solving the SOC problem. In the case of insurance, he complements the presentation with a critical analysis of the Cramér/Lundberg model.

Then using the results from Chapter 4, Stein applies the SOC method (Chapter 5) to explain the U.S. financial crisis. From a specification of the dynamics of asset prices, according to the uncertainty arising from asset prices and interest rates (Model I) or capital gains (rate of growth in asset prices) and interest rates (Model II), it is possible to obtain an optimal debt that relates positively to the NET RETURN, defined as either the difference between capital productivity and the real interest rate or capital productivity plus the drift of capital gains less the mean rate of interest. In both

cases, the optimal debt is reduced by the risk. Many models of stochastic variables (asset prices, interest rates) are possible, which makes it difficult to choose the “right” one. Stein proposes calculating an EWS from the upper optimal debt (denoted  $f^{**}$ ), compatible with various stochastic processes. To obtain  $f^{**}$ , assume that the long-term real interest rate will tend to zero (i.e., the growth rate of the price will converge to the nominal interest rate). Then, to take into account differences in measurement units, Stein proposes normalizing  $f^{**}$  by subtracting the mean and dividing by the standard deviation. The EWS, or excessive debt indicator, is the difference between the debt ratio (debt service/disposable income) normalized and the upper optimal debt ratio (rental income/index house price) normalized. He thus could predict that in the United States, excess debt would increase sharply and continuously starting in the early 2000s, which should have been a warning signal, both to authorities and for the markets.

The failure of AIG is inseparable from the crisis of the 2000s, but Stein devotes Chapter 6 solely to this unique situation. The first insurance group in the world, AIG invested heavily in the early 2000s in the market for credit default swaps (CDS), designed to insure against the defaults of bond issuers. With more \$440 billion of CDS in its accounts, AIG was a leader in this market. But in 2007, the downturn in the U.S. housing market, and the margin calls that followed, led to losses of \$11.5 billion. In hindsight, it seems clear that AIG’s liabilities were disproportionate to its assets (excessive leverage of 11:1). After a brief critical review of actuarial theory, Stein again uses the SOC method to determine the optimal liabilities-to-net worth ratio and the optimal leverage (assets-to-net worth) ratio. However, a lack of data prevents the calculation of the optimal liabilities ratio, so Stein suggests an indirect approach to set a warning indicator that compares the excessive debt of mortgagors against the leverage. If excessive debt and leverage increase simultaneously, the probability of borrowers’ default and the fall in the value of the CDOs guaranteed by AIG would be high, increasing the risk of a liquidity crisis for AIG (i.e., negative correlation between CDO and CDS). In reality, the margin calls to AIG required its rescue by the U.S. federal government in 2008 to avoid the systemic risk associated with AIG’s bankruptcy.

Following the same principles, Chapter 7 covers the U.S. crises of the 1980s. Stein starts with the agriculture crisis; he calculates a EWS for this sector, retaining for the actual debt the debt-to-net income ratio and for the optimal debt the difference between the productivity of capital (gross value/assets) and the interest rate. Excess debt in the agricultural sector is clearly demonstrated for the first half of the 1980s. Then Stein presents the S&L crisis, whose primary cause was the excess of debt in real estate, especially in the states of Texas and Florida.

Stein’s book thus offers a key means to understand the financial crises: They are always the result of excessive debt or excessive liabilities of agents (mortgagors/insurers), accompanied in most cases by a speculative bubble. Certainly this result is not new, but it helps explain the myopia of agents. Transcripts from Fed meeting published by *The New York Times* (Appelbaum, 2012) show that the U.S. authorities had not taken sufficient measure of the seriousness of the situation. This myopia also appears in the market when we consider the interest rate spreads, between Germany on one side and Ireland, Greece, and Portugal on the other (see Chapter 8, figure 8.1). Another example arises in the abuses of financial engineering, according to the belief that mathematics allowed for ignorance of economic mechanisms. The strong message of Stein’s book is that it is possible to construct a EWS that can provide essential information about the risk of a crisis, as long as we calculate optimal debt-to-liability ratios. Stein also details the SOC method and proposes several convincing applications to various crises.

Even non-specialists with less familiarity with stochastic calculus can read the chapters of this book easily, leaving aside the purely mathematical parts. In his previous works Stein has stressed the need to explore the dynamics of real exchange rates and external debt together. The increasing use of NATREX to calculate the real exchange rate equilibrium shows that economists and international institutions may have received the message. One can only hope that the advocated approach for determining optimal debt using the SOC method to derive EWS will become widespread and result in further subsequent developments. The stakes are high: to prevent financial crises and their ruinous economic, social, and political consequences.

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