Greenspan, Dodd-Frank and Stochastic Optimal Control

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Dodd-Frank financial reform bill

The Dodd-Frank (D-F) bill establishes the Financial Services Oversight Council. The bill authorizes the Federal Reserve Board to act as agent for the Council to monitor the financial services marketplace to identify potential threats to the stability of the US financial system and to identify global trends and developments that could pose systemic risks to the stability of the US economy and to other economies.

Is the Fed capable of fulfilling these requirements? Shojai and Feiger (2010), in their article *Economists' Hubris – The Case for Risk Management* – write that the tools that are currently at the disposal of the world's major global financial institutions are not adequate to help them prevent such crises in the future and that the current structure of these institutions makes it literally impossible to avoid the kind of failures that we have witnessed. I evaluate what Greenspan has learned and develop the Stochastic Optimal Control approach that should be used to implement the D-F bill.

Greenspan's retrospective

Greenspan's paper (2010) presents his retrospective view of the crisis. His theme has several parts. First, the decline and convergence of world real long-term interest rates – not Federal Reserve monetary policy – led to significant housing price appreciation, a housing price bubble. Second, this bubble was leveraged by debt. There was a heavy securitization of subprime mortgages. In the years leading to the current crisis, financial intermediation tried to function on too thin layer of capital – high leverage – owing to a misreading of the degree of risk embodied in ever more complex financial products and markets. Third, when the bubble unraveled, the leveraging set off a series of defaults. Fourth, the breakdown of the bubble was unpredictable and inevitable, given the 'excessive' leverage – or unduly low capital – of the financial intermediaries.

Prior to the subprime crisis of 2007, there was a false sense of safety in financial markets. Alan Greenspan said in 2004 that "the surge in mortgage re-financings likely improved rather than worsened the financial condition of the average homeowner". Moreover "overall, the household sector seems to be in good shape, and much of the apparent increase in the household sector's debt ratios in the past decade reflects factors that do not suggest increasing household financial stress" (Greenspan 2004a and 2004b). The market and the Fed did not consider these mortgages to be very risky. By 2007 a measure of risk, the yield spread (CCC bonds – 10 year US Treasury), fell to a record low.

When the crisis came in 2008, Greenspan said: "those of us who have looked to the self-interest of lending institutions to protect stockholders' equity, myself included, are in a state of disbelief". The lesson for the future that he has learned is that it is imperative that there must be an increase in regulatory capital and liquidity requirements by banks (Greenspan 2010).

My basic questions are: what is an optimal leverage or capital requirement that balances the expected growth against risk? What are theoretically founded – not *ad hoc* empirical – early warning signals of a crisis? I explain why the application of stochastic optimal control (SOC) is the effective approach to determine the optimal degree of leverage, the optimum and excessive risk and the probability of a debt crisis.

I show that the theoretically derived early warning signal (EWS) of a crisis is the excess debt ratio, equal to the difference between the actual and optimal ratio. The excess debt of households starting from 2004–2005 indicated that a housing crisis was most

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likely. This SOC analysis should be used by those charged with surveillance of financial markets. It is hoped that the Fed will not be like the *ancien régime: "Ils n'ont rien appris, ni rien oublié"*.

Stochastic optimal control (SOC)/dynamic risk management

The financial crisis was precipitated by the mortgage crisis and spread through the financial sector due to high leverage. I focus upon the housing sector, which was has been at the origin of the crisis. At the beginning of the financial chain are the mortgagors/debtors who borrow from financial intermediaries – banks, hedge funds, government sponsored enterprises. The latter are creditors of the mortgagors, but ultimately are debtors to banks or to institutional investors at the other end. For example, the Federal National Mortgage Association (FNMA) borrows in the world bond market and uses the funds to purchase or later resell packages of mortgages. If the mortgagors fail to meet their debt payments, the effects are felt all along the line. The stability of the financial intermediaries and the value of the traded derivatives – CDO and CDS – ultimately depend upon the ability of the mortgagors to service their debts. When the mortgagors default, the whole leveraged financial structure collapses.

SOC is dynamic optimization where key variables are stochastic. A sketch of the SOC approach will facilitate understanding the analysis below. Technical mathematical details are in my recent papers (Stein 2010 and 2011). The criterion/object is to maximize the expected logarithm of household net worth at a future date. This is a risk-averse strategy because the logarithm is a concave function. Declines in net worth are weighted more heavily than increases in net worth. In fact very severe penalties are placed upon bankruptcy – a zero net worth. This criterion is the growth variable that will optimally balance expected growth and risk.

The growth of net worth is affected by leverage. An increase in debt to finance the purchase of assets increases net worth by the return on investment, but decreases the growth of net worth by the associated interest payments. The return on investment has two components. The first is the *productivity of assets* and the second is the *capital gain* on the assets. An increase in leverage will increase expected growth if the return on investment exceeds the interest rate. The productivity of assets is observed, but the future capital gain and the interest rates are unknown when the investment decision is made. The true stochastic process is unknown. One must specify the stochastic process on the capital gain and interest rate if one wants to select the optimal leverage – to maximize the expected logarithm of future net worth.

The SOC approach derives an optimal debt ratio conditional upon the stochastic processes. Alternative stochastic processes imply different optimal debt ratios. My standard of optimality is based upon sustainable stochastic processes concerning the capital gain and interest rate. By contrast, the market optimized on the basis of unsustainable stochastic processes, which led to the bubble and its subsequent collapse.

A *sustainable* stochastic process is as follows. Call this the Prototype Model. Reasonable variations imply similar qualitative but not quantitative results. The capital gain is the sum of two terms: a constant drift and a Brownian motion term. The interest rate has a similar structure: a constant drift plus a Brownian motion term. The capital gain and interest rate are negatively correlated. The drift of the capital gain is constrained not to exceed the drift of the interest rate, to preclude the 'free lunch' described below.

Given the stochastic process, an optimal leverage or capital requirement is derived as follows. The expected growth of net worth is a concave function of the leverage. It is maximal when the optimal leverage is chosen. As the leverage exceeds the derived optimal, the expected growth declines and the variance/risk rises. If the debt ratio is less than the optimal, expected growth is unduly sacrificed to reduce risk. Leverage is equal to one plus the debt ratio; and the capital requirement is the inverse of the leverage. I focus upon the debt ratio, and the other ratios follow.

The main theoretical results are as follows. (1) The optimal debt ratio is not a number, but a function. It is proportional to: the drift of the capital gain less the drift of the rate of interest plus the current productivity of capital less a risk premium. The factor of proportionality is the reciprocal of risk elements. Therefore the optimal debt ratio or capital requirement will vary among sectors and over time. One size does not fit all. (2) Define the excess debt as the actual debt ratio less the optimal ratio. For a sufficiently high excess debt, the expected growth is zero or negative and the variance is high. The probability of a decline in net worth or a debt crisis is directly related to the excess debt ratio.

The market selected a debt ratio based upon an illusion of a 'free lunch' – an *unsustainable* stochastic process. The market estimated the drift of capital gains on the basis of recent price changes. The recent capital gains exceeded the interest rate so that the mortgagors thought that they were getting a free lunch. The rises in housing prices and in owner equity induced a demand for mortgages by banks and funds. The mortgagors borrowed at an interest rate below the capital gain. In about 45-55 percent of the cases, the purpose of the subprime mortgage taken out in 2006 was to extract cash by refinancing an existing mortgage loan into a larger mortgage loan. They expected to repay the loan plus interest from the higher value of the home, due to the capital gain. The quality of loans declined. The share of loans with full documentation substantially decreased from 69 percent in 2001 to 45 percent in 2006 (see Demyanyk and Van Hemert 2007). The ratio of debt/income rose drastically. The only way to service or refinance the debt was for the capital gain to exceed the interest rate. This is an unsustainable situation since it implies that there is a 'free lunch' or that the present value of the asset diverges to infinity.

Is the Fed capable of implementing the D-F bill? The Fed, IMF, Treasury and the 'Quants'/market lacked the appropriate tools of analysis to answer the following questions: what is an optimal leverage or capital requirement that balances the expected growth against risk? On the basis of the SOC analysis, I derive the Early Warning Signals of the crisis. The excess debt starting from 2004–2005 indicated that a crisis was most likely. This SOC analysis should be used by those charged with surveillance of financial markets.

The basic equations: Prototype Model

The formal structure of the Prototype Model is the subject of this part. The reader is referred to Stein (2010 and 2011) and to Fleming and Stein (2004) for the mathematical details. The empirical implications for an EWS are in the later sections.

Criterion function

As my criterion of performance, I consider maximizing the expected logarithm of net worth of the mortgagors. I focus upon the net worth of the mortgagors for two reasons. First, the entire structure of the derivatives rested upon the ability of the mortgagors to repay their debts. Hence I ask what the optimal debt ratio of the mortgagors is. Second, I derive an Early Warning Signal (EWS) that a bubble, the housing price bubble, is likely to collapse.

Let W(X,T) be the expected logarithm of net worth X(T) at time T relative to its initial value X(0). The stochastic optimal control problem is to select debt ratios f(t) = L(t)/X(t) during the period (0,T) that will maximize W(T) in equation (1). The maximum value is W*(X,T). The optimal debt/net worth ratio f*(t) plus one is the optimal leverage, and will vary over time. The solution of the stochastic optimal control/dynamic risk management problem tells us what an optimal and what an 'excessive' leverage is.

(1) $W^*(X,T) = \max_f E \ln [X(T)/X(0)]$,
$f = L/X$ = debt/net worth; leverage = assets/net worth = $1 + f$

The logarithm ln(X) is a concave function of X(T). As the expectation E[X(T)] goes to zero, the logarithm ln [E(X(T)] goes to minus infinity. Therefore the expectation E[ln X(T)] would go to minus infinity as E[X(T)] goes to zero. Low values of net worth close to zero may not be likely, but they have large negative utility weights. Hence the criterion function reflects strong risk aversion. Bankruptcy X = 0 is severely penalized.

Dynamics of net worth

The mortgagors have a net worth X(t) equal to the value of assets A(t) less debt L(t), see equation (2). The value of assets A(t) = P(t)Q(t) is the product of a *deterministic* physical quantity Q(t), for example an index of the 'quantity' of housing, times the *stochastic* price P(t) of the capital asset which is the housing price index.

(2) $X(t) = A(t) – L(t) = P(t)Q(t) – L(t)$, while
$A(t) = P(t)Q(t)$.

The control variable is the debt ratio. The next steps are to explain the stochastic differential equation for net worth, relate it to the debt ratio, and specify what are the sources and characteristics of the risk and uncertainty.

In view of equations (1) and (2), focus upon the change in net worth dX(t) of the mortgagors. It is the equal to the change in the value of assets dA(t) less the change in debt dL(t). The change in the value of assets dA(t) = d(P(t)Q(t)) shown in equation (3) has two components. The first is the change due to the change in price of capital asset, which is the capital gain or loss term, A(t)(dP(t)/P(t)). The second is investment in housing I(t) = P(t) dQ(t), the change in the quantity times the price.

(3) $dA(t) = d(P(t)Q(t)) = Q(t)dP(t) + P(t)dQ(t) = A(t)dP(t)/P(t) + I(t)$

The change in debt dL(t), equation (4), is the sum of expenditures less income. Expenditures are the debt service i(t)L(t) at interest rate i(t), plus investment I(t) = P(t) dQ(t) plus C(t) the sum of consumption, dividends and distributed profits. Income Y(t) = ß(t)A(t) is the product of assets A(t) times its productivity. Variable ß(t) corresponds to the imputed rental income from housing divided by the value of housing. This equation can be expressed as (4a) where saving S(t) = ß(t)A(t) – C(t) and investment is I(t). Thus the change in debt is the sum of interest payments plus investment less saving.

(4) $dL(t) = i(t)L(t) + P(t)dQ(t) + C(t) - ß(t)A(t).$
(4a) $dL(t) = i(t)L(t) + I(t) - S(t).$

Combining these effects, the change in net worth dX(t) = dA(t) – dL(t) can be shown

(5) $dX(t) = dA(t) - dL(t) = A(t)[dP(t)/ P(t) + ß(t)\, dt] - i(t)L(t) - C(t)\, dt.$

Since net worth is the value of assets less debt, equation (6) describes the dynamics of net worth equation (5) in terms of the ratio f(t) = L(t)/X(t) of debt/ net worth and an arbitrary consumption ratio c(t) = C(t)/X(t) ≥ 0. Since leverage A(t)/X(t) = (1+f(t)), the control variable could be either f(t) the debt ratio or the leverage.

(6) $dX(t) = X(t)\ \{(1 + f(t))\ [dP(t)/P(t) + ß(t)\ dt] - i(t)\ f(t) - c(t)\ dt\}.$

The mortgagors borrow at interest rate i(t) and benefit from the capital gain dP(t)/P(t). Both variables are stochastic/unpredictable. What is the optimum debt ratio, leverage or capital requirement?

The optimization of equation (1) subject to equation (6) depends upon the stochastic processes underlying the capital gain dP(t)/P(t), productivity of capital ß(t) and interest rate i(t) variables. The productivity of capital ß(t) is deterministic and observable but changes over time. However the change in price dP(t) from t to t+dt and future interest rates are unpredictable, given all the information through present time t. The derived optimal debt ratio, leverage or capital requirement will depend upon the specification of the stochastic processes of the capital gain and interest rate.

Optimization in the Prototype Model

The Prototype Model that I use for optimization describes the stochastic process of the capital gain as equation (7) and the interest rate as equation (8). The capital gain dP(t)/P(t) has a constant drift or mean π dt and a diffusion or stochastic term $\sigma_p dw_p$. The expectation of the stochastic term is zero and its variance is $\sigma_p^2 dt$. Similarly the interest rate has a mean or expectation of i dt and a variance of $\sigma_i^2 dt$. The correlation between the capital gain and interest rate is $E(dw_p dw_i) = \rho\, dt$, $1 \geq \rho \geq -1$.

(7) $dP(t)/P(t) = \pi\, dt + \sigma_p\, dw_p.$

(8) $i(t) = i\, dt + \sigma_i dw_i$
$E\, dw_p = E\, dw_i = 0,\ E(dw_i^2) = dt,\ E\,(dw_p^2) = dt,\ E(dw_i dw_p) = \rho\, dt.$

The maximization of expected net worth, equation (1), subject to the stochastic processes, equations (6)–(8), implies equation (9) for f*(t) the optimal ratio of debt/net worth. Since leverage is equal to one plus the debt ratio and capital requirement is the reciprocal of leverage, equation (9) is the key theoretical result:

(9) $f^*(t) = [[(\pi + ß(t) - i) - (\sigma_p^2 - \rho\sigma_i\sigma_p)]/[\sigma_p^2 + \sigma_i^2 - 2\,\rho\sigma_i\sigma_p] \geq 0.$

The economic meaning and implications of f*(t) are explained in the next part. An empirically useful *upper bound* on the optimal debt ratio in the prototype model f**(t) occurs when the two disturbances are independent and the drift of the capital gain is equal to that of the interest rate, equations (9a) and (9b):

(9a) $f^*(t) < [(ß(t) - \sigma_p^2]/[\sigma_p^2 + \sigma_i^2] \geq 0.$

(9b) $f^{**}(t) = [(ß(t) – \sigma_p^2]/[\sigma_p^2 + \sigma_i^2]$

The ‘fundamentals’ that determine the optimal debt ratio f*, leverage (1+f*) or capital requirements 1/(1+f*) are in the right hand side of equation (9).

Economic implications of the optimum debt ratio/leverage/capital requirements in the Prototype Model

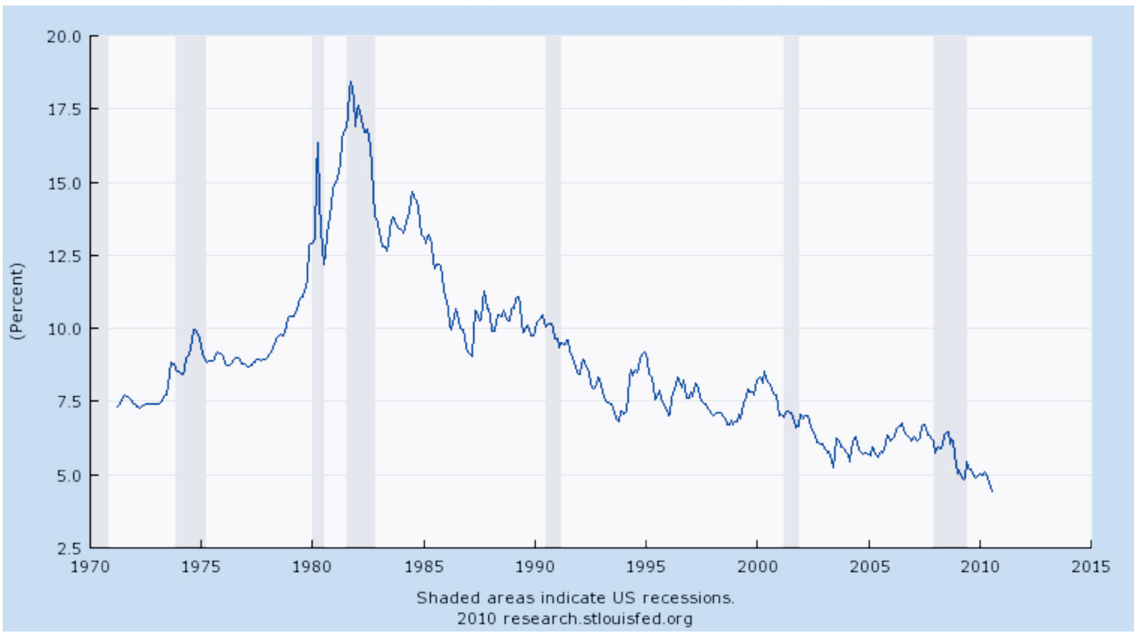
There are several important implications of equation (9). First, the optimum debt ratio f*(t) is proportional to the expected return (π + ß(t) – i) less a risk premium ($\sigma_p^2 – \rho\sigma_i\sigma_p$), where the factor of proportionality is $1/[\sigma_p^2 + \sigma_i^2 – 2\,\rho\sigma_i\sigma_p]$, the risk elements. Optimal leverage and capital requirements follow. Second, debt will only be optimal if the expected return exceeds the risk premium. Third, define excess debt Ψ(t) = f(t) – f*(t) as the difference between the actual debt ratio f(t) and the optimal f*(t). As the debt ratio exceeds the optimum f*(t) there is an ‘excess debt’ and the expected growth declines. For sufficiently high debt ratio *f-max,* the expected growth is zero. A *warning signal* that too much risk has been undertaken is that the excess debt Ψ(t) = f(t) – f*(t) is large. Alternatively, leverage is excessive when the debt ratio exceeds f*(t). The probability of a crash increases with the excess debt, and is very likely when f(t) > f-max. The capital requirement A/X = 1/[1+f(t)] is optimal when f(t) = f*(t) and is too low for debt ratios above f*(t). This is general formulation that can be applied to any sector. Equations (9) or (10) imply the optimal capital requirement X*(t)/A(t).

Application to housing sector: estimates of excess debt as an early warning signal of a crisis

The financial crisis was precipitated by the mortgage crisis. First, from 1995–2005 the decline in the 30-year fixed rate mortgage interest rates (Figure 1) led to capital gains CAPGAIN (Figure 2). Second, the mortgagors and the financial intermediaries deluded themselves in thinking that the mean of the capital gain – based upon the recent price experience – could continue to exceed the mean of the interest rate. Hence the market thought that the ‘optimum’ debt ratio, based upon π – i > 0, exceeded f**(t) in equation (9b). They thought that the ‘free lunch’ could continue. Third, a whole structure of financial derivatives was based upon the ultimate debtors – the mortgagors. Fourth, the financial intermediaries, whose assets and liabilities were based upon the value of derivatives, were very highly leveraged. Percentage changes in the values of their net worth were large multiples of percentage changes in asset values. Fifth, the financial intermediaries were closely linked – the assets of one group were liabilities of another. The whole structure of derivatives rested upon the mortgagors being able

Figure 1

THIRTY-YEAR CONVENTIONAL MORTGAGE RATE IN THE US

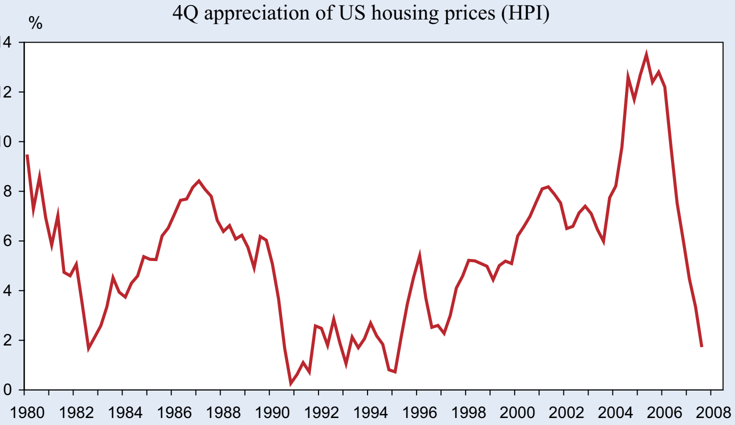


Source: Board of Governors of the Federal Reserve System.

Figure 2

APPRECIATION OF SINGLE-FAMILY HOUSING PRICES CAPGAIN

4Q appreciation of US housing prices (HPI)



Source: Office of Federal Housing Enterprise Oversight (OFHEO).

to service their debts. Sixth, the collapse occurred when the capital gain fell below the rate of interest: the 'free lunch' was over. Defaults and bankruptcies occurred. A cascade was precipitated by the mortgage defaults.

The application of the Prototype Model/SOC analysis is done in several steps. First, on the basis of the analysis, I derive estimates of the excess debt $\Psi(t) = f(t) - f^*(t)$ that lowered the expected return and raised risk. Early warning signals (EWS) are thereby derived. An Early Warning Signal of a debt crisis is a series of excessive debts $\Psi(t) = f(t) - f^*(t) > 0$. When the debt ratio f(t) exceeds f-max, the expected growth is negative and the risk is high. The next question is: what are the appropriate measures of the actual and the optimal debt ratio to evaluate excess debt $\Psi(t)$?

The debt ratio that I use in empirical work is the ratio of household debt as a percent of disposable income, since I do not have estimates of household net worth. In order to make alterative measures of the debt ratio and key economic variables comparable, I use normalized variables where the normalization (N) of a variable Z(t) called N(Z) = [Z(t) – mean Z]/standard deviation. The mean of N(Z) is zero and its standard deviation is unity. The normalized debt ratio is equation (10) and is graphed in Figure 3:

(10) DEBTRATIO = N[f(t)] = [debt/disposable income – mean]/standard deviation.

One cannot be sure what the correct stochastic processes on the capital gain and interest rate are. Therefore there is ambiguity concerning the exact value of the optimal debt ratio $f^*(t)$. For this reason I work with $f^{**}(t)$ which is an *upper bound* of the *optimum debt ratio* based upon equation (9b). A justification is as follows. In the case of the housing sector, historically the mean capital gain 1980–2007 was $\pi = 5.4$ percent, with a standard deviation of 2.9 percent. The 30-year conventional mortgage rate of interest from 1998 to 2007 ranged between 7.5 percent and 6 percent. If we assume that the difference $(\pi - i)$ between the mean interest rate and the mean capital gain is not significant, and the correlation $\rho = 0$, then an *upper bound* of the optimal debt ratio f^{**} for the housing sector is (9b). This formulation is qualitatively, but not quantitatively, consistent with alternative theoretical measures of the optimum debt ratio implied by alternative stochastic processes.

(9b) $f^{**} = L^*/X = [ß(t) - \sigma_p^2]/[\sigma_p^2 + \sigma_i^2] \geq 0.$

The term $[ß(t) - \sigma_p^2]/[\sigma_p^2 + \sigma_i^2]$ represents the *'fundamental' determinants of the optimal debt ratio.* We must estimate ß(t), the productivity of assets. The productivity of housing assets is the (implicit net rental income/value of the home) plus a convenience yield in owning one's home. Assume that the convenience yield in owning a home has been relatively constant. The productivity of assets ß(t) is rental income/value assets = Y(t)/A(t) = Y(t)/Q(t)P(t), where Y(t) is rental income, P(t) is an index of housing prices and Q(t) is an index of the physical quantity of housing. Therefore ß(t) is proportional to a ratio of rental income to an index of housing prices.

(11) ß(t) ~ Y(t)/P(t)

An empirical proxy for $f^{**}(t)$ an upper bound of the optimal debt ratio is RENTPRICE defined in equation (12). Since the units of numerator and denominator differ, it makes sense to use normalized variables to estimate ß(t) the productivity of assets. The term [(ß(t) – ß)] is the deviation of the *current* return on assets from its *mean* value ß over the entire period.

In Figure 3 and equation (12) variable RENTPRICE is the normalized return, measured in units of standard deviation from the mean ß. It is equal to the ratio of (rental income/index of housing prices – mean)/standard deviation.

(12) N(f**(t)) = [Y(t)/P(t) – mean]/st. dev. ~ [(ß(t) – ß)] / σ(ß) = RENTPRICE

Variable N(f**(t)) in equation (12) is proportional to an upper bound of the optimal debt ratio in equation (9b). Both the actual (DEBTRATIO) and optimal (RENTPRICE) are graphed in normalized form in Figure 3.

The next question is how to estimate the excess debt Ψ(t). I estimate excess debt Ψ(t) = (f(t) – f**(t)) by using the difference between two normalized variables N(f(t)) – N(f*(t)), see equation (13). This difference is *measured in standard deviations.*

(13) Excess Debt Ψ(t) = N[f(t)] – N[f*(t)] = DEBTRATIO – RENTPRICE.

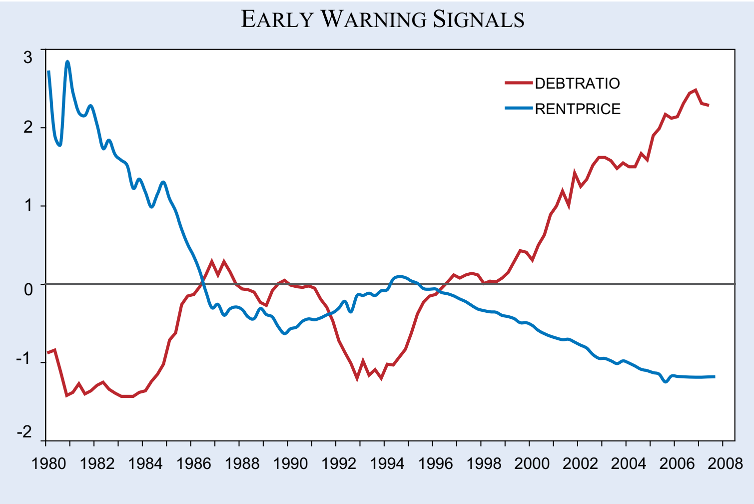
Excess Debt Ψ(t) corresponds to the difference between the two curves DEBTRATIO and RENTPRICE in Figure 3. The probability of a decline in net worth is positively related to Ψ(t) the excess debt because, as the excess debt rises, the expected growth declines.

In the most general way, Figure 3 should be viewed as follows. Assume that over the entire period 1980–2007 the debt ratio was not excessive. Both variables are normalized to make them comparable. When the DEBTRATIO is above (below) its mean, the RENTPRICE should be above (below) its mean. When the debt ratio rose significantly above a proxy for an upper bound of the optimal debt ratio, the RENTPRICE declined below the mean. From 1996 and by 2007 it was 1.5 standard deviations below the mean. The actual debt ratio DEBTRATIO grew steadily above the mean from 1998, and by 2007 was 2 standard deviations above the mean. Thus the excess debt grew to 3 standard deviations above the mean from1998 to 2007.

The normalized actual debt ratio got out of line with the normalized proxy for an upper bound of the optimal debt ratio. The latter reflects the 'fundamentals'. The sequence of excess debts Ψ(t) is a clear measure of a bubble. The actual debt was induced by capital gains in excess of the interest rate. The debt could only be serviced from capital gains. This situation is unsustainable. When the capital gains fell below the interest rate, the debts could not be serviced from income. A crisis was inevitable.

The advantages of using excess debt Ψ(t) in Figure 3 as an Early Warning Signal compared to just the ratio of housing price/disposable income are that Ψ(t) focuses upon the fundamental determinants of the optimal debt ratio as well as upon the actual ratio. The probability of declines in net worth, the inability of the mortgagors to service their debts and the financial collapse and a crisis due to leverage, are directly related to the excess debt.

Figure 3



Notes: Excess debt Ψ(t) = N[f(t)] – N[f*(t)]; N[f(t)] = DEBTRATIO = (household debt as percent of disposable income – mean)/standard deviation; N[f**t)] = RENTPRICE = (rental income/housing price index – mean)/standard deviation.
Sources: FRED, Federal Reserve Bank St. Louis; Office of Federal Housing Enterprise Oversight (OFHEO).

Conclusions

The Jackson Hole Consensus (JHC) has been the prevailing regulatory approach taken by the Fed. It is based upon three principles. Central banks (i) should not target asset prices; (ii) should not try to prick an asset price bubble; and (iii) should follow a 'mopping up' strategy after the bubble bursts by injecting enough liquidity to avoid serious effects upon the real economy. A justification for this policy was seen in the period 2000–2002 with the collapse of the dot.com bubble.

Issing (2010) objects to the JHC because it constitutes an asymmetric approach. When asset prices rise without inflationary effects measured by the CPI, this is deemed irrelevant for monetary policy. But when the bubble bursts, central banks must come to the rescue. This, he argues, produces a moral hazard. He wrote: "did we really need a crisis that brought the world to the brink of a financial meltdown to learn that the philosophy which was at the time seen as state of the art was in fact dangerously flawed? We must conduct a thorough discussion as to appropriate strategy of central banks with respect to asset prices".

Greenspan argues that the crisis was unpredictable. It is ironic that the Fed claims that it can use the Federal Funds rate to target inflation or to stabilize the economy but asserts that the financial crisis was unpredictable and inevitable. On the other hand, on the basis of the SOC analysis in this paper, the sequence excess debts $\Psi(t)$ from 2003 in Figure 3 was an early warning signal of a crisis.

The Dodd-Frank bill authorizes the Fed to perform market surveillance. I explain why the application of stochastic optimal control (SOC) is an effective approach to determine the optimal degree of leverage, the optimum and excessive risk, the optimum risk/expected return trade-off and EWS of the probability of a debt crisis. A similar analysis was applied to the Asian crisis in Stein (2006). This SOC analysis should be used by those charged with surveillance of financial markets.

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