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Leverage Caused the 2007–2009 Crisis

JOHN GEANAKOPLIS

The Leverage Cycle

There are two standard explanations of the cause of the 2007–2009 crisis. The first is greed, greed that overtook the banks, then the mortgage brokers, then the rating agencies, then the bondholders and then the borrowers. One can see these forces at work in the movie *The Big Short*.

A second explanation is that a panic exploded in 2008 and 2009, causing a run on banks, on money markets and on collateral. According to the second theory, the only way to stem the panic was to restore confidence, as former Federal Reserve Chairman Ben Bernanke explained in his book *The Courage to Act*, and as Treasury Secretary Timothy Geithner argued in his book *Stress Test*.

Greed and panic cannot be legislated away, or prevented by macroprudential policy.

At the World Econometric Society Congress of 2000, long before the crisis of 2007–2009, I proposed another theory of booms and crashes: the leverage cycle, caused by a buildup of too much leverage and then a faster de-leveraging.¹ Rising leverage leads to rising asset prices, making the economy progressively more vulnerable, so that eventually a little bit of “scary bad news” can trigger a great crash. If the asset prices end up far enough below the debts, then a failure to partially forgive underwater debtors can create more losses.²

Between 2000 and the 2007–2009 crisis, leverage did indeed rise in the banks and in households, and so did housing and mortgage-backed securities prices. Then leverage and asset prices collapsed. Eventually leverage and asset prices recovered. The failure to forgive a non-negligible amount of mortgage debt did, in my opinion, delay the recovery, and stirred resentment that lingers today. Unlike greed and panic, the leverage cycle crash can be prevented by wise public policy.

The conventional view in macroeconomics had long been that cycles are caused by fluctuations in aggregate demand. These can be smoothed over by raising the interest rate when demand is too high, and lowering the interest rate when demand is too low. The trouble with this interest rate-centric view of macroeconomics is that it leaves unanswered what we mean by tight credit, if not just a high interest rate. When business people talk about tight credit, they don't mean that the riskless interest rate set by the Fed is too high. They mean that at the going riskless interest rate, or anything close to it, they cannot get a loan, because lenders are afraid they might default. Default is what is missing in the traditional macroeconomics theory.

Once default is recognized as a possibility, we should expect lenders to require additional terms for a loan, such as a maximum debt to income (DTI), or a minimum credit score (FICO). The most important requirement is usually collateral, and I concentrate on collateral here.

If an \$80 loan requires collateral of \$100, then we say that the collateral rate is 125 percent, the loan to value (LTV) is 80 percent, the margin or down payment is 20 percent, and the leverage is five, since \$20 cash can allow for the purchase of an asset worth \$100. All of these amount to the same thing. It has been known for centuries that more leverage leads to more risk. If the collateral falls in value to \$99, and the \$80 loan is paid off, the borrower is left with \$19 out of his original \$20. A one percent fall in the collateral price leads to a five percent fall in investor capital, which are in the same ratio as the leverage.

The new idea in the leverage cycle is that more leverage causes higher collateral prices. The only precedents for this seem to be in the work of Hyman Minsky³ and the economic historian Charles Kindleberger.⁴ Neither of these authors used a mathematical model to express his

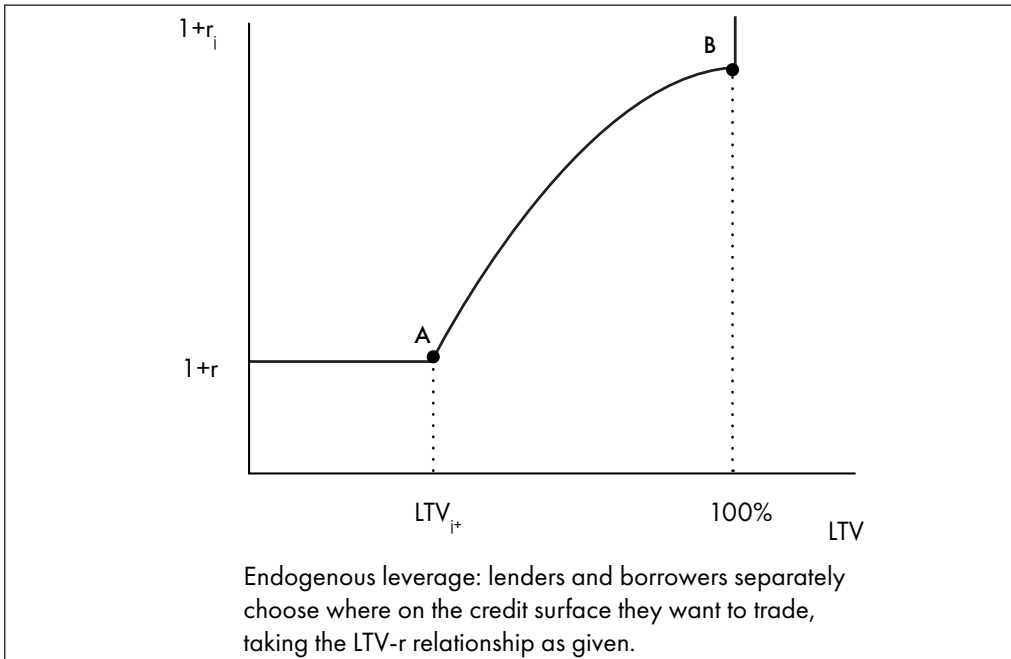
1 John Geanakoplos, “Liquidity, Default and Crashes: Endogenous Contracts in General Equilibrium” in Mathias Dewatripont, Lars Peter Hansen & Stephen J Turnovsky, eds, *Advances in Economics and Econometrics: Theory and Applications, Eighth World Congress*, vol 2 (Cambridge, UK: Cambridge University Press, 2003) 170 [Geanakoplos, “Liquidity, Default and Crashes”]. See also John Geanakoplos, “The Leverage Cycle” in Daron Acemoglu, Kenneth Rogoff & Michael Woodford, eds, *NBER Macroeconomics Annual 2009*, vol 24 (Chicago: University of Chicago Press, 2010) 1:65 [Geanakoplos, “The Leverage Cycle”].

2 I added the forgiveness dimension to the leverage cycle in 2008. See John Geanakoplos & Susan Koniak, “Mortgage Justice is Blind”, *The New York Times* (20 October 2008); John Geanakoplos & Susan Koniak, “Matters of Principal”, *The New York Times* (4 March 2009).

3 Hyman Minsky, “A Theory of Systemic Fragility” in Edward Altman & Arnold W Sametz, eds, *Financial Crises: Institutions and Markets in a Fragile Environment* (New York: John Wiley and Sons, 1977) 138.

4 Charles P Kindleberger, *Manias, Panics, and Crashes: A History of Financial Crises* (New York: Basic Books, 1978).

Figure 1: Credit Surface



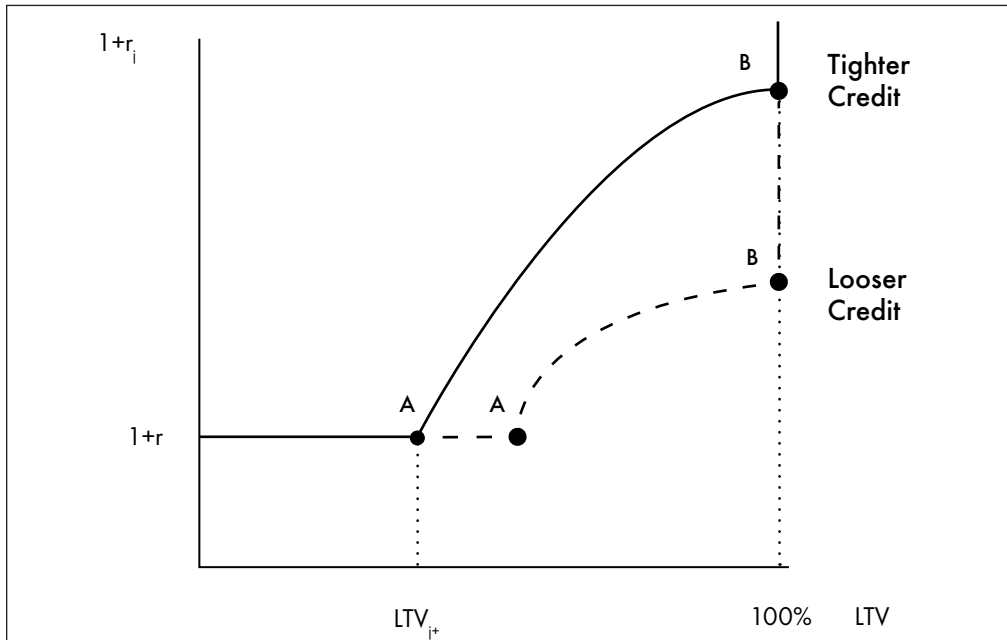
Source: Author.

ideas, and neither had collateral explicitly in mind (Minsky was talking about a firm borrowing money, and by leverage he meant a ratio of debt payments to income). Both of them made the extrapolative (irrational) expectations of borrowers the linchpin of their theories.⁵

There are four mathematical concepts behind the leverage cycle. The first is that leverage can be made endogenous via the credit surface. Second, that leverage increases when volatility, or more precisely, down risk, decreases. The third is that higher leverage makes for higher asset prices, all else being equal. Fourth, a highly leveraged economy is vulnerable to crashes stemming from small shocks that create more uncertainty, which I call “scary bad news.” A little bit of scary bad news can topple a highly indebted economy through two kinds of margin calls: one caused by the bad news reducing collateral prices, and the other caused by the scary part of the news reducing leverage. Each concept corresponds to a precise mathematical theorem in the case of binomial economies. If the leverage cycle theory of crashes had to be stated in one or two words, it would not be panic; it would be margin call.

5 Collateral appears in formal macroeconomic models first in Ben Bernanke & Mark Gertler, “Agency costs, collateral, and business fluctuations” (1986) Proceedings, Federal Reserve Bank of San Francisco, and then simultaneously in 1997 in Nobuhiro Kiyotaki & John Moore, “Credit Cycles” (1997) 105:2 J Political Economy 211; Bengt Holmstrom & Jean Tirole, “Financial Intermediation, Loanable Funds, and the Real Sector” (1997) QJ Economics 112, and my own work, John Geanakoplos, “Promises, Promises” in W Brian Arthur, Steven N Durlauf & David A Lane, eds, *The Economy as an Evolving Complex System*, vol 2 (Reading, MA: Addison-Wesley, 1997) 285 [Geanakoplos, “Promises”]. One difference between my approach to leverage and the rest is that I emphasized the endogeneity of leverage and changes in leverage, while they did not.

Figure 2: Looser and Tighter Credit Surfaces



Source: Author.

As a graduate student, I never heard the word “collateral” mentioned in any course I took, even in macroeconomics and finance. But when I worked in the fixed income department at Kidder Peabody in the late 1980s and early 1990s, collateral came up in almost every conversation. I began to think about collateral as a theorist, and was immediately struck by a puzzle. How can a single supply-equals-demand equation for a loan determine the price (or interest rate) on the loan and also the collateral rate or leverage or LTV on the loan? It seemed impossible that one equation could determine two variables. This same problem becomes even worse when one considers all the other terms of a loan, such as FICO and DTI.

I resolved this puzzle for collateral when I realized that I should be thinking about a different price for each level of leverage. A loan should be defined by a pair (promise, collateral), not just by the promise, and each pair must have its own separate price. Fixing the collateral, bigger and bigger promises give rise to higher and higher leverage. At first the loans are so small that the collateral fully protects the lender. But after a certain point, the loans are not fully protected and might default. They get riskier and riskier and the interest rises. The surface generated by the interest rate corresponding to each level of leverage is what I called the credit surface.⁶ See Figure 1. More generally, one could imagine a credit surface with independent axes including LTV, DTI and FICO, and a vertical axis giving the corresponding interest rate charged to a loan

⁶ See Geanakoplos, “Promises”, *supra* note 5.

with any combination of those three characteristics.⁷ I discuss only the collateral credit surface in this chapter, although I return to the more general case in the last section.

Borrowers and lenders each choose where they want to be on the credit surface. In equilibrium, for each level of leverage there is a separate supply-equals-demand equation and a separate price. At many leverage levels there may be zero supply and zero demand. The most interesting borrowers are not the ones on the flat part of the credit surface, who are able to borrow unconstrained quantities at the riskless interest rate as in the old style of macroeconomics. The agents who are at point A and beyond are often the pivotal drivers of fluctuations in economic activity, and they are constrained, because each time they try to borrow more (on the same collateral), they face a higher interest rate.

The credit surface also clarifies the meaning of tight credit. It is not the height of the riskless rate per se, but also the steepness of the credit surface that renders credit tight. Thus, in Figure 2, the bottom credit surface line is looser than the top credit surface line, even though the riskless interest rate is the same.

For binomial economies with financial assets, Ana Fostel and I proved that the only leverage level that would be positively traded in equilibrium is the maxmin loan, which promises the maximum without any risk of default. This is point A in Figure 1.⁸ The theorem guarantees that, in equilibrium, the credit surface rises sufficiently fast beyond point A that nobody will choose to trade there. Leverage is completely endogenous, chosen freely by borrowers and lenders at any point, but the theory predicts exactly where it will end up. Of course the binomial assumption, that only two things can happen, is very unrealistic. (It approximates reality best with very short-term loans, such as repurchase agreements [repos].) But the conclusion does not depend on the preferences of the agents or their endowments, or their probability assessments of the future states.⁹

The binomial no-default theorem has an immediate consequence for leverage, which Fostel and I called the binomial leverage theorem. Geometrically, it is clear that point A is defined by the worst-case scenario. With a little bit of algebra, we showed that in binomial models with financial assets, equilibrium LTV is equal to the worst-case gross return, divided by the gross riskless rate of interest:

$$\text{LTV} = \frac{1}{1+r} \frac{\text{worst collateral payoff}}{\text{price of collateral}}$$

7 See John Geanakoplos, “The Credit Surface and Monetary Policy” in Olivier J Blanchard et al, eds, *Progress and Confusion: The State of Macroeconomic Policy* (Cambridge, MA: MIT Press, 2016) 143 [Geanakoplos, “The Credit Surface”]. One could also imagine different axes corresponding to different kinds of collateral, depending on the precise legal rights for the confiscation of the collateral.

8 See Ana Fostel & John Geanakoplos, “Leverage and Default in Binomial Economies: A Complete Characterization” (2015) 83:6 *Econometrica* 2191. Financial assets give no direct utility for holding them (like a painting would), and their future dividends do not depend on who holds them. Think of a share of GE stock, or of a mortgage-backed security. Thus, in binomial economies with financial assets, leverage to the right of point A will never be observed. This is not true for trinomial economies, where the most interesting borrowers might indeed be to the right of point A. Loans to the left of point A are overcollateralized. If we ignore the irrelevant extra collateral, we could say those loans are maxmin loans on a smaller collateral base.

9 In Geanakoplos, “Liquidity, Default and Crashes”, *supra* note 1, I proved the same theorem, but only under the additional hypothesis that agents are risk neutral.

We emphasize that leverage rises when the down risk abates, that is, when the world gets safer. Of course, if expectations become so optimistic that returns on the collateral (relative to the riskless rate) are anticipated to be higher in every future state, then leverage will rise.

Feeling optimistic and feeling safe often go hand in hand. But sometimes they can be quite different. If agents think there is more upside in just the best state, leverage will not rise.

When risks are symmetric, the worst case is worse if volatility is higher. Expected volatility is easy to measure via options markets, whereas expected returns are hard to measure. It has been known among Wall Street traders that margins (in, say, the commodities markets) go up when volatility goes up. There is no comparable empirical correlation between expected returns and leverage. The binomial leverage theorem asserts that leverage is determined by volatility, or more generally, down risk, and it does not depend on utilities, endowments, the number of traders or the type of financial asset.

The third key mathematical idea is that all else being equal, more leverage increases asset prices. The reason is almost self-evident, yet it had not really been examined in the literature. With a smaller required down payment, more buyers can express their demand for the collateral (houses or mortgage-backed securities, for example), and the same buyers can buy more units, leading to greater demand and a higher price, provided there is heterogeneity in the valuations agents place on the asset.¹⁰ We proved that in any binomial model with financial assets, constraining leverage below the equilibrium maxmin value always lowers the value of an asset, assuming that the risk-free interest rate does not change.¹¹

The link between leverage and asset prices contradicts the famous Modigliani-Miller (M-M) Theorem, which asserts that prices should be unaffected by leverage. One difference is that Modigliani and Miller did not explicitly discuss collateral. They did have in mind a firm, which certainly might be thought of as collateral for its bond issuances. But they overlooked that their argument depends on the reliability of non-firm debt as well. Their argument, as clarified by Joseph Stiglitz,¹² is essentially the following. Suppose a firm issues a debt promise of D and raises the rest of its money-issuing equity of value E . Suppose it does not default on D in any state of nature. If the firm were restricted to sell a promise $D^1 < D$, then it would have to issue more equity E^1 . The bondholders who had previously purchased the promises $(D - D^1)$ would be disappointed at losing access to riskless debt, and the equity holders would be forced to absorb more equity, and tamer (less leveraged) equity, possibly reducing their expected returns. The M-M Theorem is proved by noting that the equity holders could themselves issue the missing debt $D^1 = D - D^1$, thereby giving the market the same debt it had before, and at the same time releveraging the equity E^1 so it becomes just like E . In essence, the reduced leverage at the firm level is compensated by increased leverage at the investor level.

10 Imagine all the buyers arrayed on a vertical corresponding to their valuation of the asset. The marginal buyer is the agent whose valuation is equal to the price. The higher valuation agents will be buyers, and the lower valuation agents will sell the asset. As the natural buyers get access to more borrowing, a smaller number of them can buy all the assets, creating a higher marginal buyer, and thus a higher price.

11 If the interest rate rose as agents leveraged more, agents would discount the cash flows from the asset more harshly, and so their lower valuations would partly offset their gain in purchasing power, leaving the final collateral price ambiguous.

12 Joseph Stiglitz, "A Re-Examination of the Modigliani-Miller Theorem" (1969) 59 *American Economic Rev* 784.

One flaw in this M-M proof is that collateral is not generally transferable: just because the firm can be used as collateral does not necessarily mean the equity can be used as collateral. The equity holder might have a different propensity to repay, perhaps not as reliably as the original firm, so D^H would not be treated by the market as a perfect substitute for D . When leverage goes down for the economy as a whole, there are real consequences.

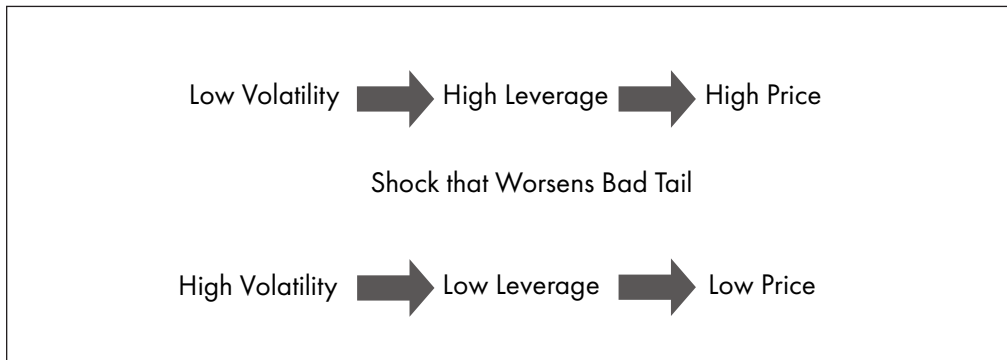
For example, consider a new homeowner who is limited (say, by regulation or by a worse down risk in housing prices) to taking out a mortgage at smaller LTV. They would simply have to come up with a bigger down payment, since taking out a second loan would not be permitted by the regulation, or by the worse down risk. There is no outside agent who could use her increased equity to increase his leverage. The drop in debt will necessarily have real consequences for the economy and for the price of the houses. This same argument applies word for word to the purchaser of any asset, such as a mortgage-backed security. The only situation in which the M-M logic partially applies is the one they had in mind. The buyer of firm equity could indeed use the equity as collateral for a further loan, thus compensating for the lower debt-to-equity ratio at the firm level. But the flaw emerges here as well if we go one step deeper. If a regulation limits the leverage that can be used by agents using firm equity as collateral, or if the equity returns from firms have greater down risk, then leverage will go down at the agent level as well as at the firm level, and collateral prices will fall.

The fourth mathematical concept consists of three mechanisms that can combine to cause a crash. The first two involve a margin call: a situation in which a leveraged holder of an asset has to repay her debt and would like to reborrow it (i.e., to “roll it over”) but finds that she can reborrow less than she must repay.

The first mechanism involves abrupt changes in anticipations of down risk. An awareness that the down risk is worse, even if unlikely, may cause expected cash flows to decline. But more importantly, it causes leverage to go down, which will also cause asset prices to go down. We express this in Figure 3, where we illustrate the effect of scary news (news that increases uncertainty, or more precisely, down risk).

The second margin call mechanism arises from high leverage, and the debt coming due, even if there is no change in leverage, and even if the leveraged buyer does not intend to sell the collateral. This kicks in when bad news leads to a fall in the asset price and a loss of equity for the leveraged holder. Normally, if a commodity declines in price by \$1, an owner who is not planning to sell or buy it faces no loss of purchasing power. A leveraged owner whose debt is coming due and who plans to roll over the debt at the same LTV without trading the asset, on the other hand, faces a margin call of $LTV \cdot 1$. This loss in liquid wealth gives them a countervailing incentive to sell the asset, despite its drop in price.

In fact, they have a wealth effect incentive to sell a great deal of the asset. If their marginal propensity to spend on the (downpayment for the) asset out of each liquid dollar is m , and if they are leveraging the asset at λ , then they will want to sell $LTV \cdot m \cdot \lambda = m \cdot (\lambda - 1)$ dollars worth of the asset on account of the liquid wealth loss of $LTV \cdot 1$ dollars. If $m = 1$ and $\lambda = 4$, the wealth effect is for her to sell \$3 worth of each asset she owns for every \$1 fall in the asset price. By contrast, the unleveraged owner of the asset, who has $\lambda = 1$, has no wealth incentive to sell.

Figure 3: Volatility-Leverage-Price Mechanism

Source: Author.

The substitution effect stabilizes the price by propping it up when it falls by inducing bigger demand. By contrast, the wealth effect for the leveraged owner of the asset is to sell after the price falls, causing the price to fall further. This destabilizing effect makes for a more fragile economy.

The third mechanism arises from high levels of debt. I call it the income redistribution effect. Debt crises have always been linked to fragile economies. Historically, in times of debt troubles, politicians often make speeches about restoring confidence. Franklin Delano Roosevelt said you have nothing to fear but fear itself. Bernanke and Geithner said similar things about restoring confidence, as did Prime Minister Alexis Tsipras of Greece. All of them seemed to believe that by changing expectations, they could move the outcome a long way. In other words, they thought the economy was fragile: a small push could cause a big shift. So why does high debt make for fragile economies?

The answer comes from an old microeconomic dichotomy called the income and substitution effect. When the price of a good (Y) goes down, the substitution effect is that agents will try to buy more of it, because, all else being equal, it is more attractive by virtue of being cheaper. This tends to stabilize prices. But if an agent is already selling Y , then all else is not equal. There is an additional income effect. The lower price makes the seller poorer, which means they might want less of everything, including Y . In more dramatic terms, the further the price goes down, the more they might have to sell. The usual stabilizing effect of lower prices raising demand can be reversed for sellers. In the language of demand theory, the income effect counteracts the substitution effect for the sellers. On the other hand, the income effect reinforces the substitution effect for the buyers. As the price goes down, they effectively get richer and for that reason they want to buy more, beyond their pure substitution effect. The crucial observation is that if the marginal propensity to buy Y (out of an additional dollar of wealth) is higher for the sellers than for the buyers, then the sellers' income effect will be stronger.¹³ A drop in the price of Y effectively redistributes income from the sellers to the buyers, in proportion to how much is

¹³ The famous Slutsky equation says that the income effect is the product of the marginal propensity to consume and excess demand. Since in equilibrium the excess demand of the sellers of Y must be the negative of the excess demand of the buyers, the aggregate income effect on Y is the product of the difference between the sellers' and the buyers' marginal propensities to consume Y and the excess demand of the sellers for Y .

sold. If the marginal propensity to spend on Y out of income is higher for the sellers, then their income-induced drop in consumption of Y will be greater than the buyers' income-induced increase in consumption. In aggregate, the income effect will tend to reverse the substitution effect. Unlike the income effect, the substitution effect is invariant to the quantity sold. Hence for bigger sales, the aggregate income effect diminishes the stabilizing aggregate substitution effects more. With big enough sales, the aggregate demand curve for Y will be close to flat.¹⁴ But a flat demand curve means that equilibrium prices will have to move dramatically to restore equilibrium after a small shock. The economy is fragile. Thus, a little bit of bad news can have a big effect on prices in an economy with high sales of some good.¹⁵

See Figure 4, which illustrates how the same vertical shock down will produce a small change in the equilibrium price of an economy with steep demand (i.e., with a dominant substitution effect), but produce a large change in the equilibrium price of an economy with flat demand (i.e., with a dominant income effect).

When there is a large debt that is coming due, then there must be a large sale, either of some good or of more promises, to pay the debt. Economies that have large short-term debts are perpetually in a vulnerable situation, because they perpetually have enormous sales. The borrowers who accumulated the large stock of that asset presumably did so because they had a high marginal propensity to hold it. If the marginal propensities to consume are markedly higher for sellers than buyers, then the economy is fragile.

When leverage rises, asset prices rise, so borrowers are borrowing a higher percentage of a higher number. With higher leverage, borrowing is doubly boosted, so debt can skyrocket. Thus, by increasing debt, leverage can also make the economy fragile through the income redistribution mechanism. See Figure 5.

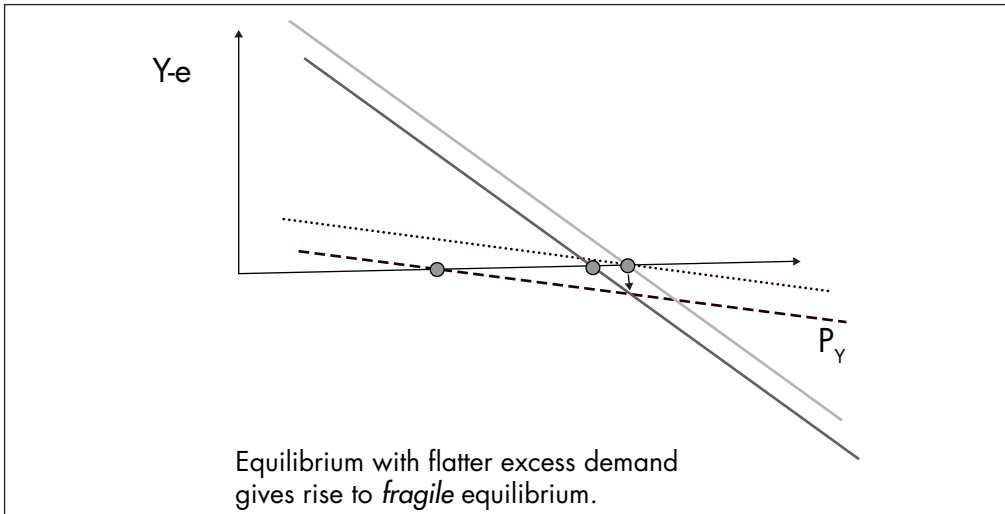
Thus, the leverage cycle I described in 2003 is shown in Figure 6 and goes like this. A long period of low volatility leads to a flatter credit surface and thus increased leverage, and laxer credit standards generally (for the same reasons). That raises asset prices and increases activity. But it also makes the economy more vulnerable, because of the double boost to new debt of higher asset prices and higher leverage. A little bit of bad news decreases everybody's valuations, and lowers prices a little. But as we saw at the outset, the most leveraged buyers will lose the highest fraction of their wealth from the price drop. They are likely to be the highest valuation/highest marginal propensity to spend buyers, and their disappearance (or reduced purchasing power) further reduces asset prices, from the income effect discussed earlier. If the news is scary, as well as bad, the increased uncertainty steepens the credit surface and lowers leverage. Thus, asset prices drop for three reasons: the bad news; the wealth transfer away from high leverage/high valuation/high marginal propensity to spend agents; and the final drop in leverage reducing old and new buyers' demand for assets.¹⁶ Asset prices and activity will stay low as long

14 With still greater sales, the income effect will reverse the substitution effect, and demand will be increasing. But that means there are multiple equilibria.

15 This is worked out in Yaniv Ben-Ami & John Geanakoplos, "Debt, Fragility, and Multiplicity: Thinking Outside the Edgeworth Box" (2017) Yale Working Paper.

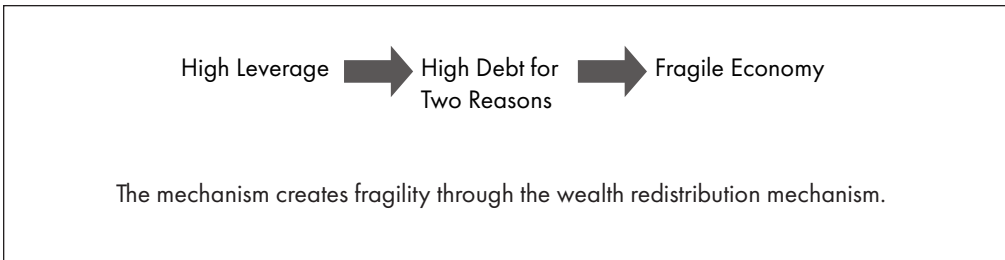
16 Another driver of the crash is the sudden emergence of the credit default swap (CDS). CDS is a way for pessimists to leverage their short selling of the asset. For the same reason that leverage increases asset prices when buyers can leverage more, so too does increased access to leverage by the short sellers of the asset lower its price. I had not anticipated CDS in 2003, but added them to the story in 2010. See the third section of this chapter entitled "The Financial Innovation Cycle."

Figure 4: Fragile Equilibrium



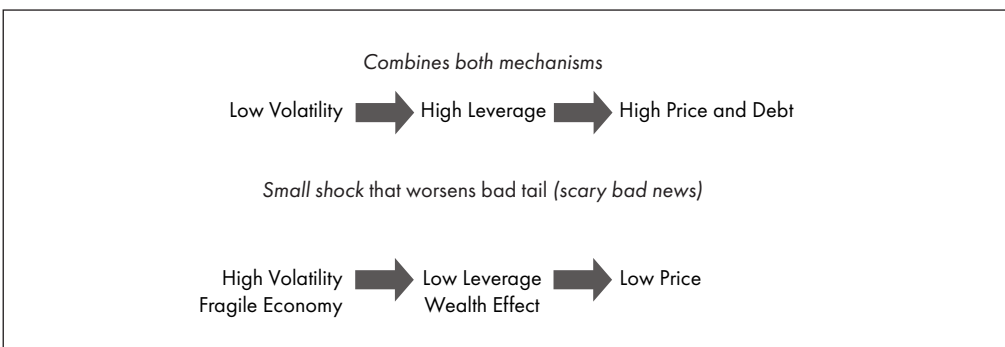
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Figure 5: Leverage-Debt-Fragility Mechanism

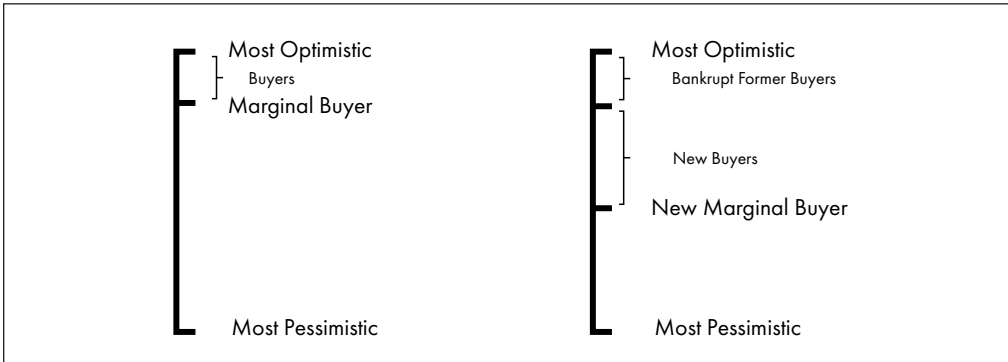


Source: Author.

Figure 6: Leverage Cycle



Source: Author.

Figure 7: Marginal Buyer Theory of Price

Source: Author.

as uncertainty remains high and the credit surface remains steep. And as I added in 2008, if the debt is too high relative to the lower asset prices, full repayment may become impossible. With a big enough disparity, partial forgiveness may be the only way out of the recession.

The leverage cycle can be described in another diagram that uses the idea of the marginal buyer. Suppose that we array all the agents in the economy in a vertical line according to their valuations of an asset, with the highest valuation at the top and the lowest valuation at the bottom. (For simplicity, think of a continuum of agents, each valuing the asset at a level independent of how much he buys.) The valuation heterogeneity could have many causes. Some agents might be more risk tolerant. Some might get higher utility out of holding the asset, or could use it more productively. Some might be more optimistic about the future value of the asset. The heterogeneity is important, not the source. In my 2003 paper, I assumed differences in optimism.

Whatever the asset price, some agent, whom I call the marginal buyer, will think it is fair. More optimistic agents will buy the asset and less optimistic agents will sell it. In the expansionary part of the leverage cycle, when volatility is low, leverage will be high. Fewer agents will be needed to buy the asset, since each one can buy more using borrowed funds. With fewer buyers, the marginal buyer will therefore be higher up the line, and since their valuation is equal to the price, the price will be high, as indicated in the left side of Figure 7.

When bad news comes, every agent, including the marginal buyer, will value the asset less, so the asset must fall at least a little in price. But the old buyers will be forced to sell the asset in order to pay back their loans. The initial fall in the asset price causes them to lose more wealth, especially because they are so leveraged. On the right side of Figure 7, we take an extreme case where the old buyers lose so much wealth that they can no longer buy any assets. The new marginal buyer is necessarily further down the line and more pessimistic. So the asset price falls for a second reason, caused by the loss in wealth of the original buyers.

If the news is scary, anticipated volatility will be high and leverage will drop. The new buyers will not have access to as much borrowed funds. Thus, even at a lower price, there will need to be many more buyers than previously, and the gap down from the original marginal buyer to

the new marginal buyer will be very large, and bigger than the gap from the top to the original marginal buyer. The price will then reflect the valuation of a much more pessimistic buyer. The fall in price is due more to the change in marginal buyer, occasioned by the wealth losses of the optimists and the curtailment of leverage, than it is to the bad news itself.

Heterogeneity in asset valuations plays a crucial role in the leverage cycle. That is why some people leverage, and others lend, and why the price falls so much when the leveraged buyers are forced to sell.

The leverage cycle also relies critically on expectations. At the beginning, agents do not fear down risk in the near future, and so lenders extend loose collateral terms on short-term loans. Later, agents become much more worried about short-term down risk, and the collateral terms dramatically tighten.

In my 2003 and 2010 papers,¹⁷ the heterogeneity is represented by different priors, thus infusing expectations throughout the leverage cycle. What characterizes the run-up in the model is that the risk of falling prices is low, and recognized as low by everyone, so that even the pessimistic agents can participate in the bubble stage by lending so much, while the more optimistic agents exercise disproportionate influence over prices by borrowing so much. When bad news hits and down risk increases in everyone's reckoning at the same time (scary bad news), leverage falls and after the ensuing forced sales, prices fall to reflect the views of a different and more pessimistic class of agents.

Although expectations drive the model, they need not be irrational expectations. Indeed, all the agents in my papers¹⁸ are completely rational Bayesians, always aware of all the possible states of nature, always Bayesian updating, although they begin with different priors. There are other ways besides different priors to explain the heterogeneity, including differences in risk aversion or differences in utility for the assets, as has been demonstrated in later work.¹⁹ Those models preserve the leverage cycle with completely rational expectations. In those models, expectations are also playing a driving role because, at the beginning, everyone rationally thinks the world is pretty safe, and then in the middle of the crisis, they think the world is very dangerous.

The leverage cycle model gets even more dramatic with extrapolative expectations.²⁰ Because the mathematics is simpler without the rationality hypothesis (a fixed point is replaced by a dynamical system), dropping rationality allows one to analyze a far richer environment, getting endogenous clustered volatility and so on. The essence of the leverage cycle is not rationality, but a focus on lending terms. It is the idea that in the upswing, lending terms get easier, and at the peak, and during the crisis, lending terms get more difficult. Irrational or extrapolative expectations do not contradict the leverage cycle; they can reinforce it. But they are not indispensable.

17 Geanakoplos, "Liquidity, Default and Crashes", *supra* note 1; Geanakoplos, "The Leverage Cycle", *supra* note 1.

18 *Ibid.*

19 See e.g. John Geanakoplos & Felix Kubler, "Why is Too Much Leverage Bad for the Economy?" [forthcoming Yale Working Paper].

20 See Stefan Thurner, J Dooyne Farmer & John Geanakoplos, "Leverage Causes Fat Tails and Clustered Volatility" (2012) 12:5 *Quantitative Finance* 695.

After the crisis, a number of authors sought to explain the 2000–2006 price surge as a bubble stemming from optimistic expectations, which were then followed by pessimistic expectations. According to this view, in 2000, everybody began to think that future demand for housing was going to be high, and this persisted until 2007, when everybody began to think future demand would be low.²¹ Iman Anabtawi and Steven L. Schwarcz, and Christopher L. Foote, Lara Loewenstein and Paul S. Willen pointed out that optimistic expectations would not only lead buyers to push up prices, but would also lead lenders to give out loans with more leverage, which would push prices further up.²² By connecting (irrational) exuberance to lending, the irrational exuberance story and the leverage cycle become similar. Robert Shiller, who famously recognized the housing bubble as it was beginning,²³ advised me to interpret the leverage cycle as irrational exuberance by lenders. I am grateful to him for saying so simply what he took to be the innovation of the leverage cycle, that cycles can be driven by the changing beliefs of lenders, in addition to the animal spirits of investors.

The leverage cycle is, in spirit, the same as the irrational exuberance of lenders. But I find the leverage cycle story, with its reliance on changing expectations about volatility or uncertainty, more convincing and more aesthetically pleasing, than the irrational exuberance story about directional change (even if it includes lenders), although both could be right. There is a lot of evidence on expectations about volatility, from the volatility index and from past volatility, which is a good predictor of future volatility. There is very little evidence about directional expectations. It is just too easy to say, after the fact, that prices went up from 2000–2006 because expectations were optimistic, and went down from 2007–2010 because expectations turned pessimistic. That applies in particular to those who think lending standards had nothing to do with either the boom or bust.²⁴

21 See e.g. Greg Kaplan, Kurt Mitman & Giovanni L. Violante, “The Housing Boom and Bust: Model Meets Evidence” (2017) National Bureau of Economic Research Working Paper No 23694.

22 Iman Anabtawi & Steven L. Schwarcz, “Regulating Systemic Risk: Towards an Analytical Framework” (2011) 86:4 *Notre Dame L Rev*; Christopher L. Foote, Lara Loewenstein & Paul S. Willen, “Cross-Sectional Patterns of Mortgage Debt during the Housing Boom: Evidence and Implications” (2016) Federal Reserve Bank of Boston Working Paper No 16-12.

23 Robert Shiller, *Irrational Exuberance* (Princeton, NJ: Princeton University Press, 2000).

24 Kaplan, Mitman & Violante, *supra* note 21, take a more extreme view that changing expectations from 2000 to 2007 about future housing demand caused the boom and the crash, and yet that changing lending standards played absolutely no role in moving housing prices. The reason they give for the latter is that homeowners could always rent instead. In their view, borrowing constraints do not affect the total demand for housing, but merely redirect it from owning, which requires borrowing, to renting, which does not. Although Kaplan, Mitman and Violante’s story is very interesting, I find it far-fetched. First, it takes an unprecedented shift in expectations alone to justify a 90 percent increase in housing prices in six and a half years from 2000 to 2006, as measured in the CoreLogic Case-Shiller housing index. From where did this change in outlook come? Interest rates are fixed in Kaplan, Mitman and Violante’s model, so those don’t explain the change. At the same time, they must assume a simultaneous and completely exogenous shift in credit standards. How convenient that these two happened at exactly the right time, and together. By contrast, there had been years of stability leading up to the 2000s — which not even a foreign attack on American soil could shake — that led people to call it the Great Moderation. There is no mystery as to why people might have rationally believed in the 2000s that down risk was lower (without thinking that things were going to rapidly improve). In the leverage cycle, the volatility assumption endogenously leads to laxer credit conditions, which in turn endogenously produce price appreciation. Shiller might argue that the Greenspan–Fed drop in interest rates in the early 2000s caused housing prices to go up, and that extrapolative expectations kept pushing them further. That could also happen in a more sophisticated model of dynamic expectation revision, as in Pedro Bordalo, Nicola Gennaioli & Andrei Shleifer, “Diagnostic Expectations and Credit Cycles” (2018) 73:1 *J Finance* 199. But they recognize the importance of expectations on credit conditions as a channel for affecting asset prices. Second, although Kaplan, Mitman and Violante incorporate changing credit conditions into their model, their “proof” that credit terms do not influence housing prices depends on the ability of entrepreneurs to convert owner-occupied housing to rental housing at low cost. It also requires the use value of home ownership to be not much greater than the use value of home rentals. Finally, and most importantly, their paper ignores, by assumption, the obvious heterogeneity in the population. If some agents are more optimistic than others, they will prefer to buy rather than rent, and as credit conditions ease, they will want to spend still more on buying. Their total demand for housing will depend very much on credit conditions.

The leverage cycle crash is related to so-called fire sales. For a good account of the important literature on fire sales, see Andrei Shleifer and Robert Vishny.²⁵ There are, however, several differences. The most important is that the leverage cycle injects the critical element of varying and endogenous leverage. The fire sale literature misses the over-valuation and buildup of debt due to the soaring leverage, and the sudden transition from high leverage to low leverage, which play a vital role in all crashes. It also misses the aftermath, during which the credit surface is still steep and new borrowing remains low. The fire sales literature addresses part of the middle game, without discussing the opening or the endgame. The more recent fire sales literature uses terms such as “deleveraging,” without actually endogenizing asset leverage. It does, however, include the idea of heterogeneous buyers and the loss in price when high-valuation buyers are forced to sell to low-valuation buyers.²⁶

The 2007–2009 Crisis

The crisis of 2007–2009 did not happen out of the blue. There was a long period of increasing leverage and rising asset prices. Moreover, the crisis itself was not an overnight panic, like one sees in bank runs.²⁷ It lasted for at least three years,²⁸ and the aftermath carried on for many years after that, despite the most extraordinary central bank interventions in history.

Figure 8 illustrates the rise and fall in LTV over time on a portfolio of AAA floating rate MBS that Ellington Capital Management has followed since 1998, superimposed on an index of prices for similar securities kept by Morgan Stanley. As can be seen, LTV was around 90 percent in the late 1990s, then jumped down to 60 percent for a few months in the 1998 crisis, then returned to its previous level for seven years. Around 2005, it went up to 95 percent. But as scary bad news came out about subprime securities in 2007, leverage came down and the asset prices came down. And then they both went up together. This diagram first appeared in my 2010 paper, with data through 2009.²⁹

At the end of 2007 and all through 2008, mortgage securities holders were going bankrupt every month. A website called *ml-implode.com* posted the names of the casualties as they happened. The biggest names were Countrywide, Bear Stearns, Merrill and Lehman Brothers, who were each leveraged more than 30 to one, but the list includes dozens of other names. As these companies failed, the mortgage securities inevitably ended up in the hands of agents who had not valued them as highly, consistent with the marginal buyer version of the leverage cycle.

A similar leverage story can be seen in the housing market. Figure 9 shows the Case-Shiller housing index, which rises by 90 percent from 2000 to the third quarter of 2006, then drops 30 percent after the crisis begins. Superimposed is the graph of average LTV for the top half

25 Andrei Shleifer & Robert W Vishny, “Fire Sales in Finance and Microeconomics” (2011) 25:1 *J Economic Perspectives* 29.

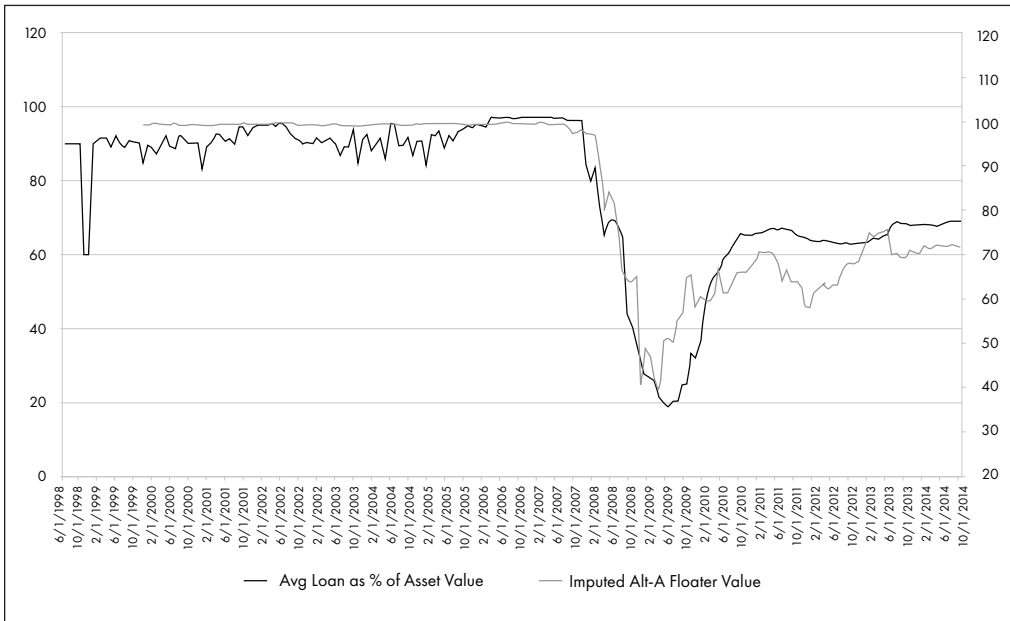
26 More subtly, the fire sales literature conflates valuation with marginal propensity to spend out of income, although to be sure the two often go hand in hand, as when there are linear utilities.

27 To be sure, the collapse of Lehman Brothers almost a year and a half into the crisis, in September 2008, made things a lot worse. But the crisis was vastly more than the Lehman story. And even the Lehman collapse itself was not obviously a panic rather than a margin call. Ben Bernanke excused himself from not bailing out Lehman by testifying that Lehman was insolvent, and not in a bank run.

28 The stock market was 33 percent lower in June 2010 than it had been in May 2005, and unemployment was up to 9.4 percent in June 2010 compared to 4.4 percent in May 2007.

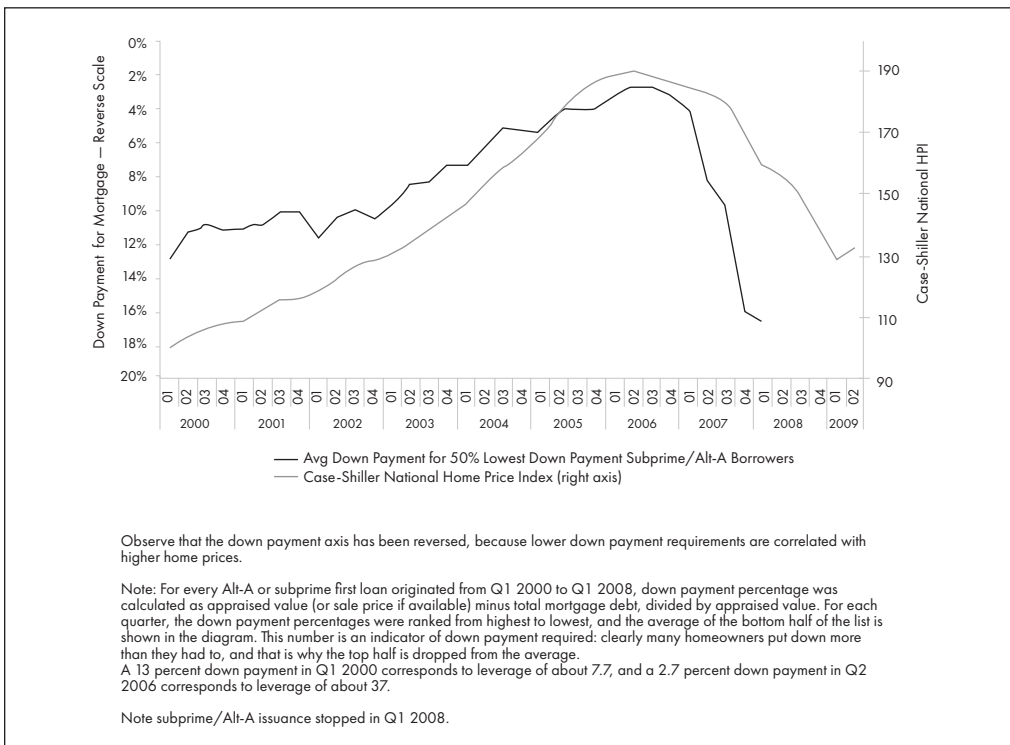
29 Gary Gorton & Andrew Metrick, “Securitized Banking and the Run on Repo” (2012) 104:3 *J Financial Economics* 425 also documented the rise in repo margins during the crisis; Geanakoplos, “The Leverage Cycle”, *supra* note 1.

Figure 8: Leverage and Mortgage Securities Pricing



Source: Ellington Management Group.

Figure 9: Housing Leverage Cycle



Source: Ellington Management Group.

(ranked in order of leverage) of all Alt-A and subprime non-government loans. It starts with margins at 14 percent in 2000, and goes to margins of 2.7 percent in the same quarter as housing markets hit their peak. Afterward, housing and leverage fall together.³⁰

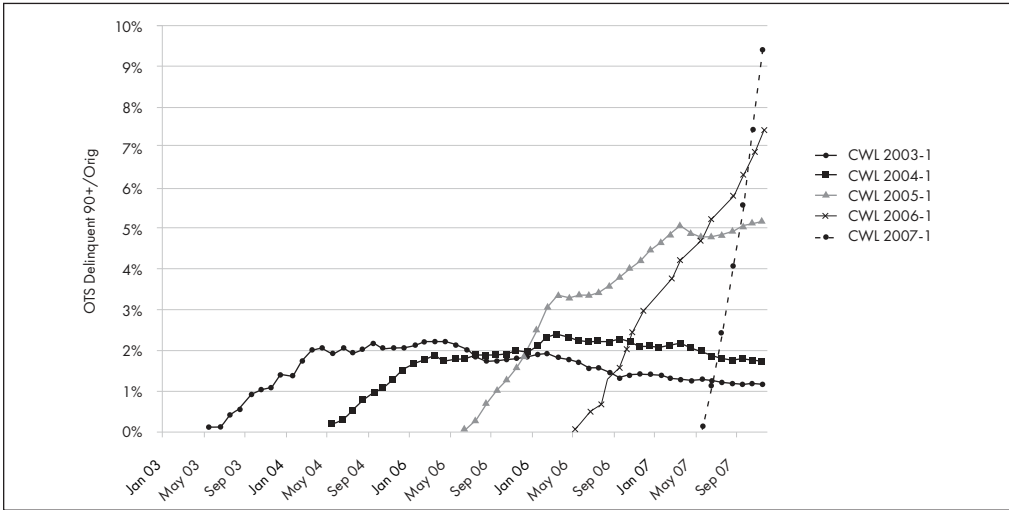
By any measure, volatility was low in the period preceding the crisis of 2007–2009. Indeed, Ben Bernanke dubbed the period “The Great Moderation.”³¹ Volatility soared during the crisis, and then eventually subsided, all in parallel to the changes in leverage and asset prices. All that remains is to describe the scary bad news that triggered the crisis.

Many people suggest the drop in housing prices caused the crisis. But that raises the question of what caused the drop in housing prices. It is easy to see why housing prices might have stopped going up in 2006. Leverage stopped going up because it could not go higher. LTV has a natural upper bound at 100 percent if there is little penalty for default. (Subprime borrowers have low ratings, and so the credit score loss of defaulting is not as high.) By 2006, the average LTV for the top half was already 97.3 percent, meaning that a lot of them were close to 100 percent. And many of these were negative amortizing loans that really should be counted as higher LTVs. But even if housing prices couldn’t go higher, that still leaves the question: why did they fall?

In my opinion, the trigger to the crisis was the increase in subprime delinquencies. For many consecutive vintages of Countrywide loans, the percentage of original balance that were currently delinquent would slowly rise from zero percent at origination to about two percent and stay there. But in Figure 10 we see that by the beginning of 2007 the delinquency rate for

30 In Manuel Adelino, Antoinette Schoar & Felipe Severino, “The Role of Housing and Mortgage Markets in the Financial Crisis” (2018) 10 Annual Rev Economics 25, the authors argued that housing mortgage leverage did not rise leading up to the crisis, or fall afterward. They announce the surprising nature of their findings as “contrary to popular beliefs,” including of most of Wall Street. Let me mention several ways in which their interpretation of the data strikes me as wrong. First, Adelino, Schoar and Severino acknowledge that DTI rose dramatically leading up to the crisis, as emphasized by Daniel Greenwald, “The Mortgage Credit Channel of Macroeconomic Transmission” (2018) MIT Sloan Working Paper No 5184-16. So credit terms manifestly became looser. The credit surface is multidimensional, as I mentioned at the outset, and as I shall emphasize more in the next section. LTV is not a standalone variable. Inverting the credit surface and writing LTV as a function of interest rate and other credit terms, such as DTI and FICO, the LTV surface got looser according to their own analysis. Second, LTV is a subtler measure when talking about a long-term loan (such as a mortgage) as opposed to a short-term loan (such as a repo). With a more appropriate measure of LTV, they would have found a big rise during the mid-2000s. Laurie Goodman, “Housing Credit Availability Index” (2019) Urban Institute, online: <www.urban.org/policy-centers/housing-finance-policy-center/projects/housing-credit-availability-index> constructs a risk index of mortgages and finds that it rose substantially in the mid 2000s. The mid-2000s were famous for introducing riskier mortgages, such as interest-only mortgages, negative amortizing mortgages and floating rate mortgages (whose initial interest is lower, especially with teaser rates for the first two or three years). These became 30 to 40 percent of all the originations in that time period. They defaulted much more frequently in the crisis than conventional mortgages with comparable borrowers. The reason these mortgages are regarded as riskier is that the borrowers pay less over the early years of the mortgage. Mortgage default is much more likely on a day in the third year than on the very first day. The mortgage payments through the third year are a smaller fraction of the original debt with the riskier mortgage. A measure of LTV that corresponds to the scheduled LTV in the third year (assuming stable housing prices) would have risen in the mid-2000s. Third, Adelino, Schoar and Severino focus their attention on new mortgages. But of course mortgage refinancing, especially cash-out refinancing, was notorious for higher LTVs during the mid-2000s, in part because the appraisal value used in the LTV calculation was widely viewed, even at the time, as inflated. It is simply not true that LTV on refinanced loans does not affect housing prices. Homeowners in need of cash can sell their homes, but if they can borrow more without selling, then the homes do not go on the market. An important reason housing prices fell rapidly during the crisis is that homeowners could not refinance their loans and were forced to sell. Fourth, and most importantly, by their own measures, Adelino, Schoar and Severino show that private lending standards, including LTV, did indeed get looser in the run-up to the crisis of 2007–2009, consistent with the diagram in Figure 9 (“Housing Leverage Cycle”). Adelino, Schoar and Severino say that the looser private standards were compensated by stricter government lending during the same time. (By “government,” they do not mean Fannie and Freddie, who themselves were delving for the first time into subprime-like loans, but rather Federal Housing Administration loans.) They lose track of this distinction when later they emphatically declare that lenders did not change their LTV standards. The economy is much more vulnerable when the private sector is holding high LTV loans and the government is holding low LTV loans than it is in the reverse situation.

31 Ben Bernanke, “The Great Moderation” (Speech delivered at the meetings of the Eastern Economic Association, Washington, DC, 20 February 2004), online: <www.federalreserve.gov/boarddocs/speeches/2004/20040220/>.

Figure 10: Scary Bad News

Source: Ellington Management Group.

2005 vintage loans had already reached four percent, and the delinquency rate for 2006 vintage loans had already reached three percent.

These are tiny numbers, but the fact they had broken through the old two percent threshold caused investors to worry that the number might go much higher. The down risk was much greater. Traditional macroeconomists would expect the prices of these loans to go down, and indeed the BBB subprime bond index collapsed in early 2007. I identified that, at the time, as the beginning of the down phase of the leverage cycle.³²

But more importantly, lenders did not just increase the interest rate they charged on new subprime loans. They increased the margins, as can be seen in Figure 9. These higher down payments closed a large number of potential buyers out of the housing market, and (in my opinion) that led to the fall in housing prices.

The global financial crisis of 2007–2009 was the culmination of a double leverage cycle, in mortgages and in mortgage securities. George Soros's principle of reflexivity includes the proposition that historical crashes invariably involve disasters in two separate but interrelated markets.³³ Although Soros didn't apply this insight to housing and mortgage securities, the mortgage crisis fits. Leverage rose in housing and in mortgage securities together. Trouble with mortgage delinquencies depressed mortgage securities prices, which led to cutbacks in housing leverage, which depressed housing prices, which indicated future default losses, which reduced mortgage security prices.

³² See video of Geanakoplos talk on the Leverage Cycle at Santa Fe Institute, March 2007.

³³ George Soros, *The Crash of 2008 and What it Means: The New Paradigm for Financial Markets* (New York: Public Affairs, 2009).

The Financial Innovation Cycle

Half a century ago, more and more goods became usable as collateral for leveraging. Thirty years ago, securitization and tranching, especially of mortgage-backed securities, emerged and grew dramatically. Finally, over the last 10 to 15 years, the credit default swap (CDS) mortgage market suddenly blossomed at the end of the securitization boom. After the crisis of 2007–2009, the complexity of these instruments declined, but is now on the rise again.

In Fostel-Geanakoplos,³⁴ we argued that there is a financial innovation cycle that follows and boosts the leverage cycle. The financial innovation cycle made the crash of 2007–2009 bigger than it would have been otherwise.

In periods of quiet, financiers innovate to stretch the available collateral. When a single asset can be used to collateralize multiple loans, it is stretched. When collateral backs promises that are in turn used as collateral to back further promises, which I call pyramiding, the original collateral is effectively reused and thus stretched. Leverage can be thought of as buying an asset while simultaneously borrowing. But it can equally be thought of as a way of cutting the collateral into two pieces: a bond and a risky junior piece. Cutting the bond into still more pieces, which involves pyramiding and tranching, is a more advanced financial innovation, requiring more complex record keeping, a more sophisticated court system and accommodating tax laws. By skillfully cutting the collateral into appropriate pieces, entrepreneurs can sell the pieces for more than the original collateral. Competition then bids the whole collateral price up to the sum of its parts. The search for profits from scarce collateral through financial innovation makes collateral more valuable, over and above its payoff value. Leverage raises the prices of assets, and tranching raises their prices still more. And they rise higher because the financial innovation comes in stages, not all at once. Once the prices get high enough — which, unfortunately, is the moment when the indebted economy is becoming especially vulnerable — another financial innovation, the CDS, is introduced. It enables the pessimists to bet against the asset. This tends to lower asset prices. A little bit of bad news can then lead to a great crash.

CDSs tend to lower asset prices because they lure optimists, who would have bought the assets on leverage, into selling the CDS insurance instead, where they are making a similar bet that assets can only go up in price. They make the crash just as bad because when prices do fall, the optimists must pay out on the insurance and the wealth effect kicks in, just as they would have lost money as forced sellers of the assets had they bought them on leverage.

The run-up to the crisis of 2007–2009 fits the pattern of the financial innovation cycle perfectly. Throughout the later 1990s and 2000s, higher LTV loans, known as subprime loans, began to be initiated by the private sector. These, in turn, were collected into pools, which were then tranching. The subprime market grew from almost nothing in 1990 to more than \$1 trillion in 2006. Housing prices skyrocketed from 2000 to 2006. At the end of 2005, a small group of investors who thought housing prices and mortgages were overvalued pushed to get the indexed subprime mortgage CDS market established so they could bet against the subprime mortgages. The CDS/collateralized debt obligation market got even bigger than the subprime

³⁴ Ana Fostel & John Geanakoplos, “Endogenous Collateral Constraints and the Leverage Cycle” (2014) 6:1 Annual Rev Economics 771.

market (although they were betting on subprime loans). The indices stayed high for about 11 months, but then cracked at the end of 2006 on the release of delinquency reports for subprime mortgages. The housing market tumbled soon afterward. Had the CDS been trading robustly from the beginning, prices might not have gotten so high.³⁵

Multiple Leverage Cycles

Many kinds of collateral exist at the same time, hence there can be many simultaneous leverage cycles. Each one has its own credit surface. Collateral equilibrium theory not only explains how one leverage cycle might evolve over time, but also explains some commonly observed cross-sectional differences and linkages between cycles in different asset classes, like flight to collateral and contagion.³⁶

It is commonly observed that in times of crisis some assets retain their value (or even rise in value) while the others lose value. This situation is often called a flight to safety. Another way to describe the situation is a flight to collateral. The safe assets, those with low volatility, turn out to be the assets that can be leveraged more.³⁷

A second commonly observed phenomenon is that when bad news hits one asset class, the resulting fall in its price seems to migrate to other assets, even if their payoffs are statistically independent from the original crashing asset. There are two reasons for this contagion. As we saw in the first section of this chapter, the leverage cycle in one asset amplifies the bad news and creates wealth distribution away from the most optimistic buyers of the asset. If these buyers are also crossover holders of a second asset, their losses in the first asset might force them to raise money by selling the second asset. Moreover, the leverage cycle price decline in the first asset will make these buyers feel there is a special opportunity there, leading them to withdraw even more money from the second asset to take advantage. These two reasons to withdraw demand for the second asset lead to price declines there.

The Credit Terms Cycle and Central Bank Policy

The policy implications of the leverage cycle are that central banks should smooth the cycle, restraining leverage in booms, and in the acute stage of the crisis, propping up leverage. If, in the aftermath, depressed asset prices are too low relative to debts, debt must be partially forgiven.

As I mentioned at the outset, leverage is just one of many terms that come with loans, beside the interest rate. In boom times, many credit terms get relaxed, not just leverage. It is important to keep track of all of them. The general credit surface is the loan interest rate as a function of

35 A similar story unfolded with Greek sovereign debt. After Greece gained entry into the European Monetary Union in 2000, it was able to borrow more money. Eventually Greek banks were buying Greek sovereign bonds, at very high LTV, since the capital requirements for sovereign debt were so low. As the ratio of debt to Greek GDP rose, investors became more jittery. When the Greek crisis started just after the revision of Greek deficit numbers, Prime Minister George Papandreou blamed it all on the CDS market. In Galina Hale et al, "How Futures Trading Changed Bitcoin Prices" (2018) FRBSF Economic Letter, Federal Reserve Bank of San Francisco, the authors similarly describe the exponential rise of bitcoin prices and the subsequent crash as a result of financial innovation.

36 In this section, I follow Ana Fostel & John Geanakoplos, "Leverage Cycles and the Anxious Economy" (2008) 98:4 American Economics Rev 1211.

37 In the language of Fostel and Geanakoplos (*ibid*), they have more collateral value.

its various terms, including LTV, DTI, FICO (or credit score), and, of course, maturity. Not all of these terms can be displayed easily in the same picture. By picking any two credit terms, such as LTV and FICO, the Washington Federal Reserve has worked with me to produce credit surfaces such as the following.³⁸

Figure 11 shows the average interest rate charged on all fixed rate mortgage loans from the Federal National Mortgage Association (Fannie Mae) and the Federal Home Loan Mortgage Corporation (Freddie Mac) in the second quarter of 2006 as a function of LTV and FICO. Loans with the highest FICO and lowest LTV, in the bottom left corner, are the safest loans. Loans with the highest LTV and lowest FICO, in the upper right corner, are the riskiest loans. Even for the conforming group of households who passed many hurdles to get into the government programs, there is a difference in interest rate depending on credit standards. But the curve is generally quite flat, indicating a loose credit surface.

Consider in Figure 12 the mortgage credit surface in the last quarter of 2008, after the crisis had started. It is much steeper, and the number of low FICO, high LTV loans is much lower.

In Figure 13 we see the corporate bond credit surface for 2007.³⁹ As it was for mortgages in 2006, the corporate bond credit surface is very flat.

As shown in Figure 14, in the fourth quarter of 2008, the credit surface became markedly steeper, making it much more difficult to borrow. The reader should be aware that the credit surfaces do not always move in tandem. Today, for example, the corporate credit surface has again become very flat, but the mortgage credit surface has not. These differences should be taken into account by the Fed in its deliberations.

In my opinion, the Fed should produce these credit surface images for the general public each quarter. They should also be produced for the unsecured consumer loan credit surface and other surfaces, including the mortgage credit surface and the corporate bond credit surface. This will give economists and business people a much better picture of credit conditions in the economy.

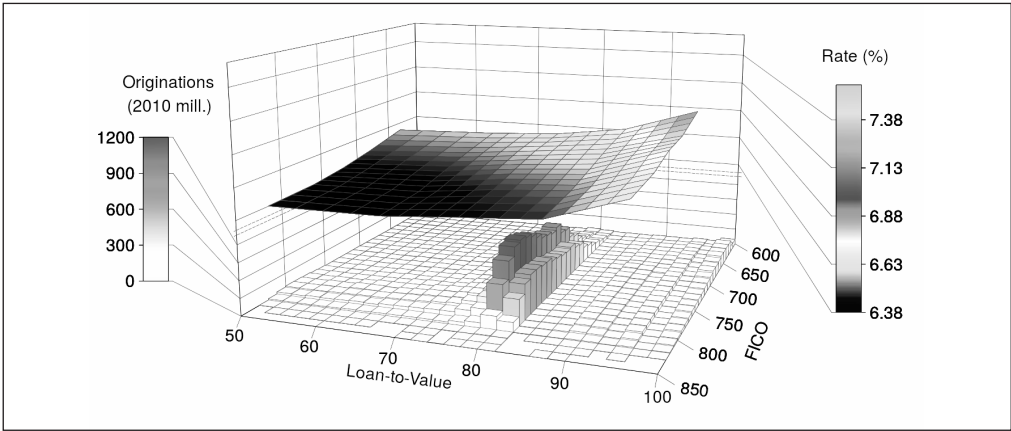
The Fed should also be aware of how its changes in the riskless rate (in the bottom left corner) affect the whole credit surface of each type. Perhaps they move every credit surface rigidly upward or downward, or perhaps the risky end of the credit surface moves less than the safer end, blunting much of the power of conventional monetary policy.⁴⁰ Do risky asset purchases (called quantitative easing) by the Federal Reserve have similar effects or are they better at tilting the credit surfaces? In my opinion, the Federal Reserve should use the language of the various credit surfaces to explain their policy aspirations. Do they hope to shift or steepen the mortgage credit surface or the corporate credit surface?

38 See Geanakoplos, "The Credit Surface", *supra* note 7. See also John Geanakoplos & David E Rappoport W, "Credit Surfaces, Economic Activity, and Monetary Policy" (2019) SSRN, online: <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3428729>.

39 There are complications in presenting simple interest rates for different bonds at different times if, for example, some of the bonds are callable and others are not. For corporate bonds, we replace the interest rate with something called the option adjusted spread, which adjusts for the option value of the bonds. I do not have space to go into these details here, but I refer the reader to Geanakoplos & Rappoport (*ibid*).

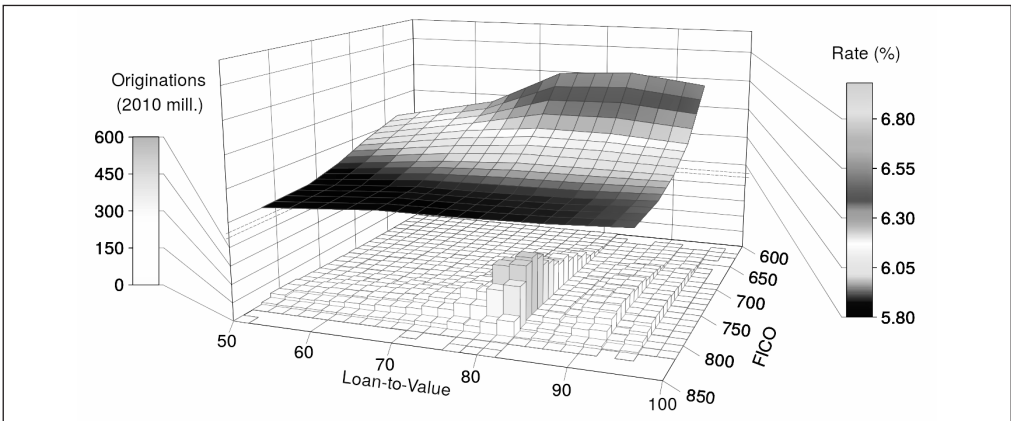
40 We analyze this question in Geanakoplos & Rappoport, *supra* note 38.

Figure 11: 2006Q2, 30-year Conventional Purchase Mortgages



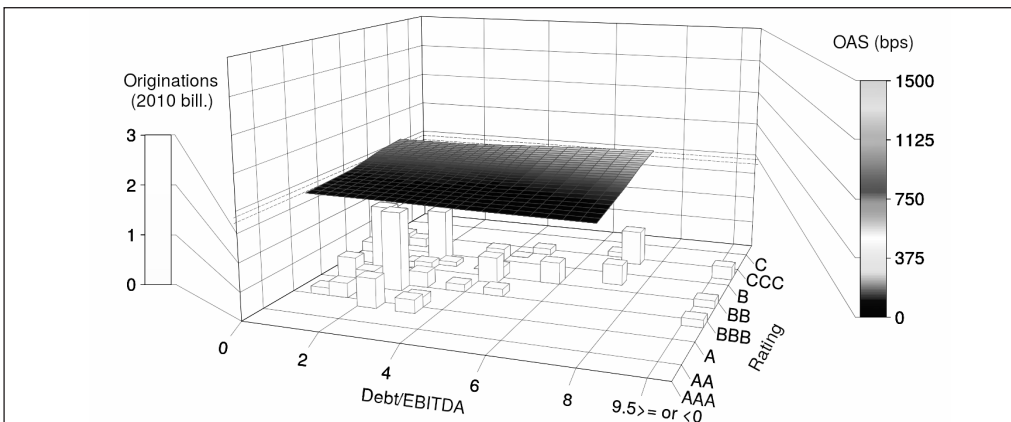
Source: Geanakoplos & Rappoport, *supra* note 38.

Figure 12: 2008Q4, 30-year Conventional Purchase Mortgages

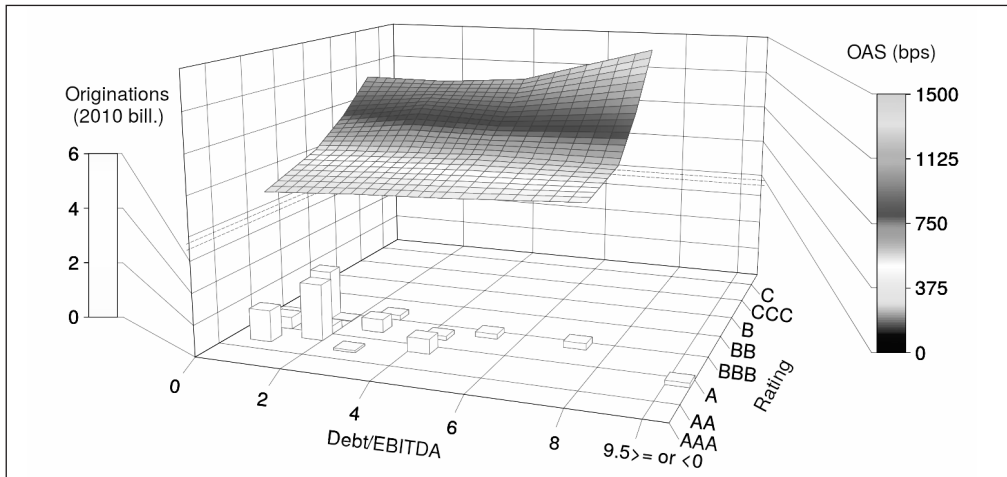


Source: Geanakoplos & Rappoport, *supra* note 38.

Figure 13: 2007Q2, 7- to 10-year Corporate Bonds



Source: Geanakoplos & Rappoport, *supra* note 38.

Figure 14: 2008Q4, 7- to 10-year Corporate Bonds

Source: Geanakoplos & Rappoport, *supra* note 38.

Finally, if there are parts of some credit surface they wish to affect, then they should use unconventional tools to target those areas. For example, at the current time, the mortgage credit surface is still very unkind to borrowers with a low to medium FICO. If the Fed wanted, it could purchase loans of that type, which would bring down their rates. If the Fed thought that housing prices were rising too rapidly, it might declare, as Stanley Fischer did in 2010 as head of the Bank of Israel, that no mortgage loans could be issued with more than 60 percent LTV.⁴¹

Forgiveness

In 2008 and 2009, Susan Koniak and I wrote two op-eds in *The New York Times* advocating partial forgiveness for subprime loans.⁴² We argued that once homeowners with bad credit ratings fell far enough under water, they were likely to default on their loans, and that lenders who insisted on receiving full satisfaction would wind up with less money in the end than if they forgave some of the debt. We went on to predict that subprime debt would not be forgiven because the loans were all securitized in pools controlled by servicers who had no incentive to write down principal during a crisis. The bondholders, who ultimately receive all the cash flows and might have an incentive to forgive, did not know the names of the homeowners or the identities of the other bondholders, and did not have the legal right to modify the loans anyway. I testified two times in Congress about these matters, and 17 hedge funds also testified that they would like to partially forgive the subprime debt that paid their bonds.

The example Susan Koniak and I gave in favour of forgiveness was of a \$160,000 subprime loan, backed by a house that had fallen in value to \$100,000. Why should a homeowner, who did not

⁴¹ There is some doubt about whether the Federal Reserve has such powers, since it has not exercised them. It certainly does have the power to regulate margins on stocks.

⁴² Geanakoplos & Koniak, *supra* note 2. A fuller discussion appears in John Geanakoplos, “Solving the Present Crisis and Managing the Leverage Cycle” (2010) Federal Reserve Bank of New York Economic Policy Rev 101 [Geanakoplos, “Solving the Present Crisis”].

have a good credit rating to protect, pay 60 percent more than the house was worth, when he could walk away with no penalty? Foreclosing when the homeowner stopped paying turned out to be even worse than we predicted. The average subprime mortgage foreclosure recovered about 25 percent of the principal, which in our example would have been \$40,000. The reason, as we argued, is that it can take two or three years to get the foreclosed homeowner out of his house, during which time he does not pay his mortgage, or pay his house taxes, or fix his house. And on the way out he might take all the copper. By partially forgiving the loan down to \$90,000, the lender likely would have gotten the whole \$90,000, either because the homeowner would keep paying his coupon (lowered by the principal reduction), or because he would sell the house for the profit of \$10,000 and pay off the whole loan. On top of that, we added a clause that if housing values miraculously turned around and the homeowner sold the house for more than \$100,000, then half the appreciation would be owed to the lenders, up to the point where the original loan was made whole.

Our recommendation was that all the significantly underwater loans in non-agency pools should be sent to community bankers hired by the government (so the New Haven loans would go to a New Haven banker, the Boston loans to a Boston banker, and so on). The banker's job would be to modify the loans they made in the way that would make the most money for the lender. We predicted that the community bankers, acting in the interest of the lender, would often choose principal reduction in cases like our example. The original servicer would continue to pass the modified homeowner payments on to the bondholders and continue to receive its fees. Of course the plan would have required an act of Congress to negate the original (failing) contracts that set up the pools. The plan was meant to solve the coordination problem of the bond holders who under the circumstances could not possibly negotiate their way into a Pareto improvement. Congress did not act.

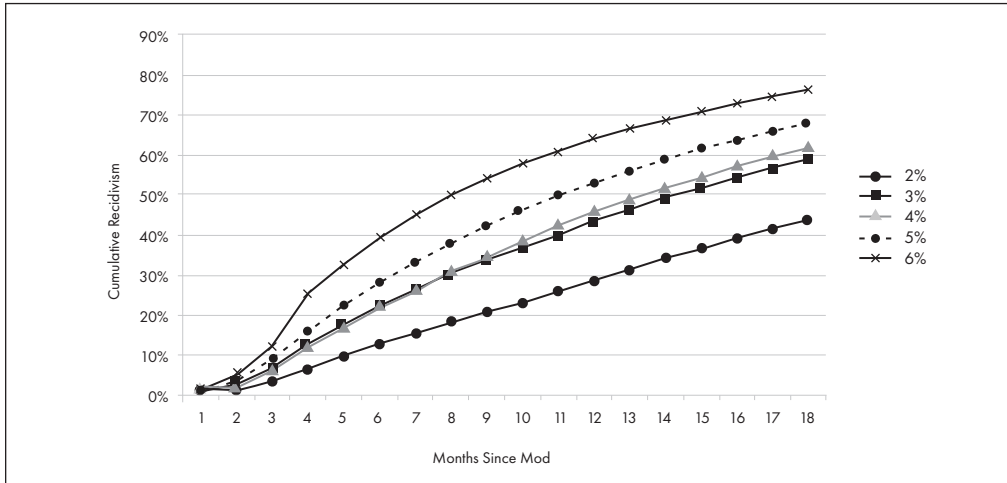
There were many reasons given by the Obama administration and Treasury Secretary Geithner for not creating some kind of forgiveness plan for underwater homeowners. One argument was that it was too complicated. Another was a political concern that the prudent folks who didn't take large loans would resent a plan that "rewarded" reckless homeowners who took high LTV loans and subsequently found themselves under water. Finally there was a vague sense that principal forgiveness creates a moral hazard.

I have attempted elsewhere⁴³ to rebut each of these arguments, and there is not room here to repeat those rebuttals in detail. Let me mention simply that the burden of forgiveness was to be borne entirely by the (hedge fund) lenders who owned the loans, not by the government or taxpayers. It would have been up to the administration to explain that although your neighbour would receive a principal reduction and you would not, you would not personally lose anything. And the house next door would have stayed occupied and tended, rather than becoming a blight on your neighbourhood.

As for the moral hazard, the administration instead implemented coupon reductions for homeowners who stopped paying, once they proved that they had suffered some hardship, such as losing their jobs. The government coupon reduction plan created a direct moral hazard, since one had to stop payment in order to become eligible. The results of government programs to

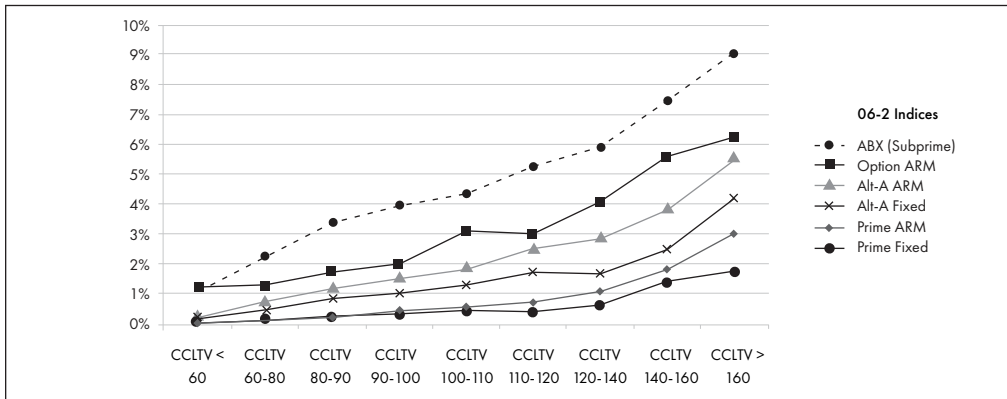
43 Geanakoplos, "Solving the Present Crisis", *supra* note 42.

Figure 15: Subprime Cumulative Recidivism by Coupon and Months Since Modification



Source: Ellington Management Group.

Figure 16: Net Monthly Flow (Excluding Mods) from <60 Days to >60 Days DQ



Source: Ellington Management Group.

reduce coupon rates were not good for subprime mortgages. Recidivism was high, as shown in Figure 15.

By contrast, we proposed principal forgiveness for subprime borrowers based on being far enough under water, especially if they were current, on the grounds that they would eventually default. At the time of the op-eds, it certainly seemed likely that most would eventually default. Figure 16 gives the monthly rates of new delinquencies. Subprime loans with combined current LTV of 140 to 160 percent were defaulting at six percent per *month*.

Reducing principal for seriously underwater homeowners, independent of whether they are delinquent, creates no moral hazard incentive to stop coupon payments.⁴⁴ Our plan was

⁴⁴ It might create an incentive to take out bigger loans. To the extent that higher leverage raises home prices and makes the economy more vulnerable, the practice of writing down principal makes leverage constraints more important.

analogous to Robert Shiller's proposal that mortgage principal be written down automatically, as a matter of contract, depending on how far the local housing index falls. Since no homeowner can control the housing index, there is no moral hazard. The biggest difference is that we targeted the forgiveness to subprime borrowers and others who had bad credit ratings.

The most serious objection to principal writedowns was articulated by Lawrence Summers, former Secretary of the Treasury, at the time, and repeated often since the crisis. He felt that by writing down grossly underwater mortgages before they defaulted, the lenders might lose money on borrowers who would have paid back the entire principal in the end, even though they were underwater. Of course, such a concern could be raised at any time, not just in the middle of a crisis when the servicers are confronted with unusual incentives not to write down loans. If lenders were often willing to write down principal before and after the crisis, but not during the crisis, it suggests that principal reduction is, after all, an important tool, and that a great opportunity might have been missed during the crisis because of the perverse incentives of servicers in the crisis.⁴⁵ Figure 17 shows that principal reductions were indeed a much smaller portion of modifications during the crisis than they were before and after.⁴⁶

Ten years later, scholars are trying to assess whether forgiveness might have worked. A consensus is emerging that, because of the enormous costs to foreclosures during a crisis, timely interventions starting in 2008 could have helped homeowners and lenders, but too little was done, too late.

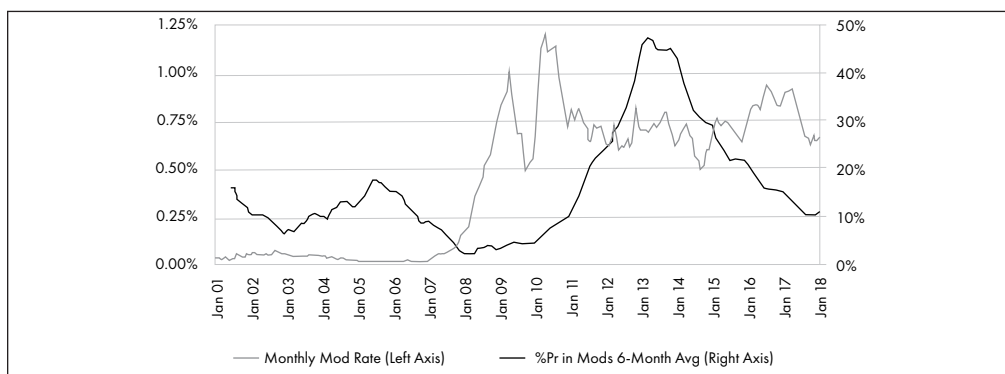
On the more specific question of whether payment reductions or principal reductions would have been better, the preliminary assessments appear to be coming down on the side of Summers against principal forgiveness.⁴⁷ But I am skeptical. The forgiveness plans contemplated in these studies are not targeted. They casually suggest that because only eight percent of homeowners ultimately stopped paying, while a lot more were delinquent or underwater, principal forgiveness would have lost too much money from those who were ultimately going to pay. None of these scholars makes a loan-by-loan analysis of all the affected loans. None asks: what if we just targeted deeply underwater loans, or deeply underwater loans of people who have poor credit ratings, as Susan Koniak and I suggested in 2008.

Table 1 bears out what was suggested in Figure 16, that most deeply underwater subprime borrowers went into foreclosure. So losses from forgiving subprime borrowers who would

⁴⁵ The crisis saw a flood of underwater homeowners, and the servicer staffs were too small to look into all of them at once. Hiring new staff would have been an enormous expense that would bring no return to the servicer (although it might have helped the bondholders). Second, after many bankruptcies, the servicers nearly all became owned by the biggest banks. These banks owned large amounts of second loans. If they reduced principal on large amounts of first loans (loans that they did not own), pressure would have built to start writing down second loans to zero, which would have represented a huge loss. Third, by doing nothing, the servicers ran less legal risk than they would have by taking radical steps. There is also a crucial reason why banks that directly owned loans virtually stopped writing down principal during the crisis. Writing down a loan requires taking an immediate loss. If the bank does not write down the principal, it may be able to hold the loan on its books at par (for example, if it has not yet defaulted), even though it knows that eventually the loan will default with some probability, at a higher expected loss than the forgiveness loss. In a crisis, banks near bankruptcy themselves are eager to avoid taking losses.

⁴⁶ Some of the principal modifications after the crisis were forced on the banks by government penalties for the banks' handling of mortgages leading up to the crisis. The penalties were paid in principal forgiveness to underwater homeowners.

⁴⁷ See e.g. Peter Ganong & Pascal Noel, "Liquidity vs. Wealth in Household Debt Obligations: Evidence from Housing Policy in the Great Recession" (2018) National Bureau of Economic Research Working Paper No 24964. For a summary of many of these studies, see Christopher L Foote & Paul S Willen, "Mortgage-Default Research and the Recent Foreclosure Crisis" (2018) 10:59-100 Annual Rev Financial Economics.

Figure 17: Non-Agency Modification Rates

Source: Ellington analysis using data from Loan Performance and CoreLogic. Data as of August 2018.

Table 1: Defaults and Losses from Securitized Subprime Loans Active on January 1, 2008

Subprime	LTV				Defaults as % of	
	Vintage	Bucket	# of Loans	Originated UPB	UPB	Losses
	2005	Total	1,279,159	193,851,423,927	60.11%	43.89%
	2005	<100%	431,239	48,801,419,674	41.08%	29.81%
	2005	100-120%	403,819	59,415,146,407	55.83%	40.69%
	2005	120-140%	214,185	39,502,695,654	68.13%	49.84%
	2005	140-160%	118,376	22,909,685,144	75.56%	55.23%
	2005	>160%	111,540	23,222,477,048	82.15%	60.38%
	2006	Total	1,974,792	297,597,342,221	67.93%	50.12%
	2006	<100%	332,379	32,860,245,805	44.49%	32.50%
	2006	100-120%	774,534	107,165,017,069	58.97%	43.17%
	2006	120-140%	305,899	53,614,399,261	72.12%	53.35%
	2006	140-160%	294,598	54,029,393,474	79.57%	58.82%
	2006	>160%	267,382	49,928,286,612	85.51%	63.74%
	2007	Total	439,628	75,977,800,805	66.94%	48.16%
	2007	<100%	41,552	4,487,639,121	45.26%	32.40%
	2007	100-120%	218,195	34,442,860,192	59.17%	42.30%
	2007	120-140%	69,664	14,292,865,051	71.00%	51.06%
	2007	140-160%	64,363	13,120,081,080	78.28%	56.59%
	2007	>160%	45,854	9,634,355,361	83.37%	60.62%
	Total	Total	3,693,579	567,426,566,953	65.13%	47.73%

Source: Ellington Management Group.

have eventually paid would not have been high.⁴⁸ For loans that reached 120 percent LTV or more, about 75 percent went into foreclosure, with losses on average of about 75 percent per foreclosure (giving total losses of about 56 percent of the unpaid balance of all active loans in 2008 that reached LTV above 120 percent). Many of these loans defaulted even though they got coupon payment reductions. By contrast, a policy that wrote down principal to just below 100 percent LTV would have cost about 35 percent of the unpaid principal balance, and might have eliminated almost all the foreclosure losses.⁴⁹ And some of the 35 percent would have been recouped from the borrowers who never defaulted, when their houses regained their value.

The recent debate on forgiveness versus temporary payment reduction revolves too much around a false classification of homeowners into one of two extremes. Either homeowners default because they run out of money (by losing their jobs, for instance), in which case reducing their coupon payments will keep them afloat until they can resume paying fully, or homeowners default strategically before they run out of money because they realize their house is never going to be worth as much as the loan, in which case principal reduction of the right size can be the inoculation against default. In fact, nobody ever waits to default on their mortgage until they are completely penniless. Everybody is strategic to some extent. And everybody has to worry about their future income when paying their mortgage. A correct analysis of the optimal mortgage modification policy must quantify, person by person, their willingness to default — that is, their sensitivity to how bad a deal their mortgage is.⁵⁰ One thing is clear: subprime borrowers will be, on average, more willing to default than prime borrowers, hence principal forgiveness will be, on average, more useful for them.⁵¹ Another critical issue is to quantify the effect on housing prices on stopping the wave of foreclosures, and the feedback of higher prices on reducing defaults and increasing recoveries.⁵² These topics need further work. Among the issues to be investigated is how the results might depend on the timing of the policy.

I close by noting that it is uncontroversial that more could have been done to help keep homeowners in their homes during the crisis, whether by forgiveness or payment extension — or, better, some combination of the two, tailored to individual circumstances. It is ironic that the government was hesitant to act for fear of enraging the population that did not get helped. By helping banks instead of homeowners, even if those homeowners were subprime homeowners, the government caused much more trauma to the psyche of the nation.

48 The statistics on so-called Alt-A loans are similar, although not quite so bad.

49 Writing down a 150 percent LTV loan by 35 percent would give a new LTV of 97.5 percent.

50 Another problem with some of the empirical studies is that they are based on a very small selection of loans. The authors do not quantify how important the selection bias might be. For example, Ganong and Pascal, *supra* note 47, study the Home Affordable Modifications Program (HAMP), which was a small, non-representative sample of loans, and then look at a tiny experimental subgroup of those that got principal reductions. They conclude that principal reductions lose money for the lender. To be eligible for HAMP, homeowners had to certify that they had suffered some special income hardship. The program was therefore biased toward agents who were going to default for income reasons. Second, the HAMP principal reductions were ill-advisedly set to 115 percent of LTV, large enough to lose money from the homeowners who would have paid anyway, but too small to convince a defaulter to change his mind. The principal reductions were biased toward failure. Third, the principal reductions were given very late, to people who had managed to stay more or less current on their loans despite being underwater for a long time. Again, a biased sample. Fourth, the program did not target subprime or Alt A homeowners. The vast majority of HAMP homeowners paid in the end, so of course principal reductions to all of them would have lost money.

51 Philip Kalikman is conducting a comprehensive person-by-person analysis of the income loss-strategic default calculation as part of his dissertation research at Yale.

52 Ahyan Panjawani is conducting a careful loan-by-loan analysis in the context of an agent-based housing model as part of his dissertation research at Yale.

