21

Leverage and Macroprudential Policy

John Geanakoplos

1 Introduction

At the World Econometric Society Congress of 2000, I proposed a theory of booms and crashes: the leverage cycle, caused by a buildup of too much leverage and then a faster deleveraging.[1] I argued that leverage is an endogenous variable that can vary widely. Rising leverage leads to rising asset prices and increasing economic activity. But this rise parodoxically makes the economy more vulnerable, so that eventually, a little bit of "scary bad news" can cause leverage to plummet and trigger a great crash.

Between 2000 and the 2007–2009 crisis, leverage did indeed rise in the balance sheets of banks and households, and so did prices for housing and mortgage-backed securities. Then leverage and asset prices collapsed. After 2010, leverage and asset prices eventually recovered.

Changes in leverage are often caused by changes in the perceived downside risk of assets serving as collateral for loans. There is a feedback between lessened down risk, caused, for example, by more optimism or lower asset volatility, increased leverage, and a rise in asset prices. This feedback loop becomes dangerous when more perceived down risk leads to lower leverage and falling asset prices. The culmination can be an economy-wide margin call leading to a crash.

Traditionally, macroeconomic cycles have been attributed to insufficient or excessive aggregate demand for investments and assets, that is, to fluctuations in demand caused by the "animal spirits," irrational exuberance, risk appetite, or precautionary savings of investors. The leverage cycle begins with the observation that much of demand is facilitated by borrowing. When uncertainty rises, investors see more downside risk but also more upside potential. Lenders, on the other hand, don't share in the upside; they see bigger downside losses. Lenders therefore have a bigger incentive than borrowers to change the terms of the contract. They ask for more collateral.

In Section 2, I lay out the logic of my original leverage-cycle story. One crucial element is the heterogeneity of agents. In my original work, this stemmed from different priors. It could be due to different risk tolerance or to many other differences between agents. But it implies that different agents have different marginal propensities to buy the asset when their wealth changes. Leveraging the purchase of an asset is a bet on the price of the asset. Good news makes everyone value the asset more, but the resulting rise in its price also shifts wealth toward the agents who had been leveraging the asset. These beneficiaries of

[1] See Geanakoplos (2003). See also Geanakoplos (1997, 2010a).

the price rise likely are the agents with the higher marginal propensity to buy it, increasing demand still more. The wealth redistribution from news thus reinforces the news, creating more asset-price volatility than would occur with homogeneous agents.[2]

On top of that, if the news itself also changes the forward view on the asset volatility, this will change leverage. For example, calming good news will lead lenders to worry less about collateral values and thus to lend more easily. The same buyers with a high propensity to spend will then be able to leverage more (gaining access to more of their future wealth), and this will drive the asset prices still higher, greatly amplifying the fundamental news.

The crash in the leverage cycle occurs when scary (volatility-increasing) and bad (expectation-reducing) news come together *while* the economy is already leveraged. The bad news lowers the price because of the direct effect of bad news on asset value. The prevailing high leverage then lowers the price more by magnifying the wealth redistribution stemming from the falling price. The scary news then lowers the price still more because old holders are forced to deleverage by selling the asset, and new buyers cannot leverage as much as the old buyers had previously because of tightened lending standards.

In Section 3, I point out that leverage is a special kind of asset tranching that has been extended by all sorts of financial innovations, which themselves in effect create even more leverage. One can thus speak of a financial innovation cycle. In Section 4, I point out that there can be multiple leverage cycles, where each one triggers the next one until they all come crashing down together. In Section 5, I argue that leverage or collateral is just one of many credit terms, albeit the most important, that the lenders require of borrowers, all of which vary over the cycle. When one of them, say, FICO gets looser, even if leverage stays the same, effectively they have all gotten looser, ceteris peribus. The multiplicity of credit terms is captured by the credit surface.

The leverage cycle and leverage-cycle crash are effectively a risk scenario. The leverage-cycle story thus lends itself perfectly to stress testing, either by a regulator or by a risk manager. The leverage-cycle apparatus of the credit surface also leads to a more sophisticated kind of monetary policy, in which the interest rate is no longer regarded as the only lever to manage credit. In Section 6, I briefly describe the leverage-cycle implications for monetary policy and macroprudential policy, including stress tests.[3]

2 The Leverage Cycle

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 demand-centric and interest rate-centric view of macroeconomics is that it ignores the lenders. It leaves unanswered what we mean by "tight credit," if not just a high interest rate. When businesspeople talk about tight credit, they don't mean that the riskless interest rate set by the Federal Reserve is too high. They mean that at the going riskless

[2] This wealth redistribution is proportional to the change in the total value of the purchased assets. If each agent is spending a small fraction of his or her wealth on the asset, the amplification will be small. But if the asset is, say, housing, then the wealth redistribution is much more important.

[3] This essay is adapted from part of Geanakoplos (2019).

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 ratio of 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 (or enables the purchase of a $100 asset that serves as collateral), then we say that the collateral rate is 125 percent, the loan to value (LTV) is 80 percent, the margin or downpayment is 20 percent, and the leverage is 5 because $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 the original $20. A 1 percent fall in the collateral price leads to a 5 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 Minsky (1977) and the economic historian Kindleberger (1978). Neither of these authors used a mathematical model to express his 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.[4]

There are three mechanisms that drive the leverage cycle and three more mechanisms that create the leverage-cycle crash. The first driver is that leverage can be made endogenous via the credit surface. The second is that leverage increases when perceived down risk decreases, either because of greater optimimism or reduced volatility. The third is that higher leverage makes for higher asset prices, all else being equal. All three mechanisms can be described by precise mathematical theorems in the binomial uncertainty world. The leverage cycle typically moves from good news that reduces volatility to higher leverage, then to higher asset prices. Eventually, the news worsens and uncertainty rises, which leads to lower leverage and falling asset prices.

The downward trajectory of the leverage cycle is sometimes much more violent than the slower upward trajectory. 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 three leverage-cycle-crash mechanisms, which all sometimes come together in a margin call.

The scary news leverage-crash mechanism occurs when scary news abruptly increases uncertainty, which in turn abruptly reduces leverage, leading to margin calls. This mechanism is the same as the volatility-leverage mechanism. It just moves much faster in the downward direction.

The bad news liquid wealth crash mechanism occurs when bad news reduces a collateral price, leading to a margin call even when leverage is unchanged. The margin call reduces

[4] Collateral appears in formal macroeconomic models first in Bernanke and Gertler (1986) and then simultaneously in Kiyotaki and Moore (1997), Holmstrom and Tirole (1997), and Geanakoplos (1997). One difference between my approach to leverage and the rest is that I emphasized the endogeneity of leverage and changes in leverage, whereas they did not.

the liquid wealth of the asset's leveraged owner, potentially forcing him or her to sell even though there is no conventional wealth effect, just when the lower price might have incentivized him or her to buy. Finally, when debts are high, and large sales are necessary to repay the debts, as in a margin call, the economy can be very fragile because of a wealth-redistribution effect if the marginal propensity to spend on the collateral is higher for its leveraged owners than for the new buyers. I call this last mechanism the *debt-fragility crash mechanism*.

Each mechanism again corresponds to a precise mathematical theorem. Panic plays no necessary role in the mechanisms. Of course, panic might exacerbate the mechanisms. But they are powerful even without the added froth of panic. 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*.

2.1 The Three Mechanisms of the Slow Leverage Cycle

2.1.1 Endogenous Leverage: The Credit Surface

As a graduate student, I had 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 I was immediately struck by a puzzle. How can one 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 different 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*.[5] See Figure 21.1. 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 with any combination of those three characteristics.[6] I shall be content to mostly stick with the collateral credit surface in this chapter, although I return to the more general case in Section 5.

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

[5] See Geanakoplos (1997).

[6] See Geanakoplos (2016). One could also imagine different axes corresponding to different kinds of collateral, depending on the precise legal rights for the confiscation of the collateral.

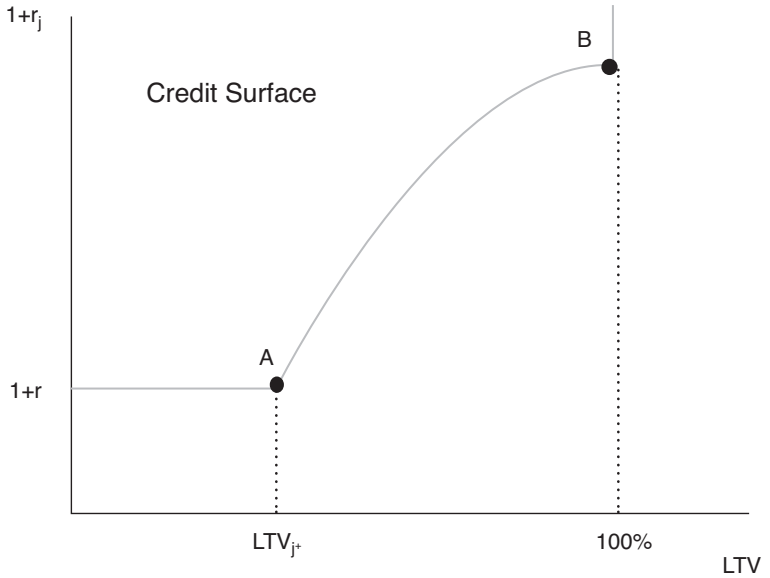


Figure 21.1 Credit surface.

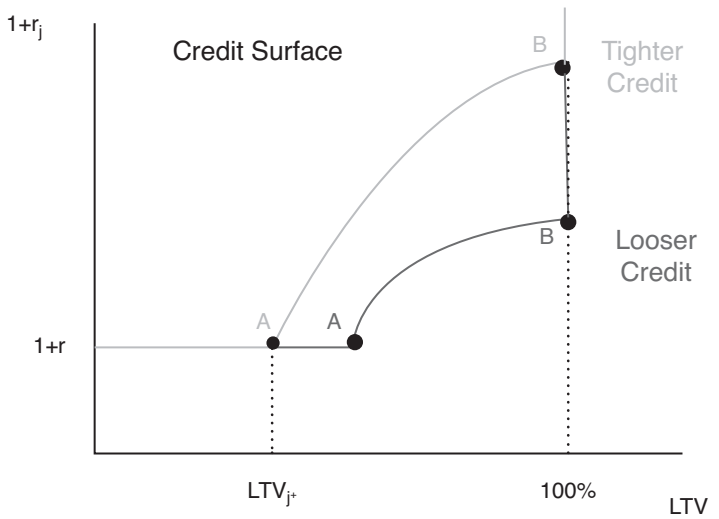


Figure 21.2 Credit surfaces, with tight and loose credit.

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 21.2, 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 21.1.[7] 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.[8] (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, or whether lenders' probabilities differ from borrowers' probabilities.[9, 10]

2.1.2 Leverage and Down Risk or Volatility

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:

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

I emphasize that leverage rises when the down risk abates, that is, when the world gets safer. One way this can happen is if expectations become so optimistic that returns on the collateral are anticipated to be higher in every future state.

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 or just higher probabilities of the best state, leverage will not rise.[11]

When risks are symmetric, the worst case is worse if volatility is higher. This shifts the credit surface to the left and up, as indicated in Figure 21.2. The theory then predicts that leverage will go down for assets whose expected volatility goes up. The great advantage of expected volatility as a marker of safety is that it is observable, either through the implied volatility of option prices or through recent volatility, which is highly predictive of expected volatility. And indeed, margins (in, say, the commodities markets) almost always go up when

[7] See Fostel and Geanakoplos (2015). 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 houses or paintings, or for financial assets with trinomial states, 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.

[8] Everybody has to know that only two things can happen and agree on which two things can happen, although not necessarily on their probabilities.

[9] In Geanakoplos (2003), I had proved the same theorem but only under the additional hypothesis that agents are risk neutral.

[10] The question of what expectations lead to more leverage in cases where there are more than two states is quite complicated. The biggest advance was made by Simsek (2013). See also Phelan (2017).

[11] If the probability of the good state rises, the price of collateral will likely rise. By the binomial no-default theorem, the equilibrium promise will remain the same. So leverage will fall.

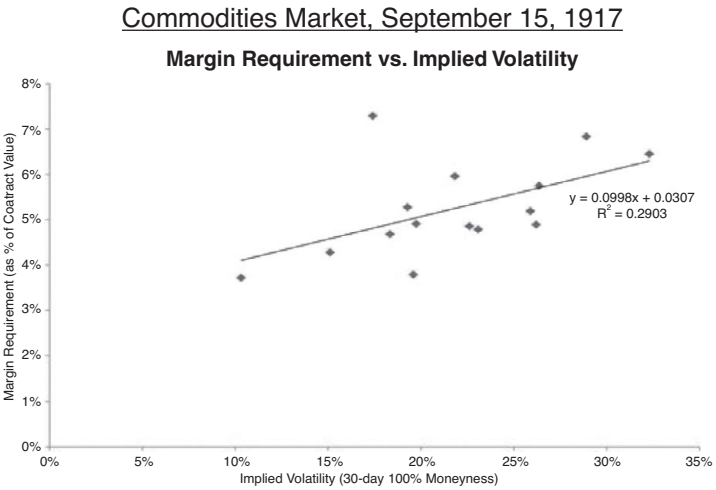


Figure 21.3 Volatility and leverage.

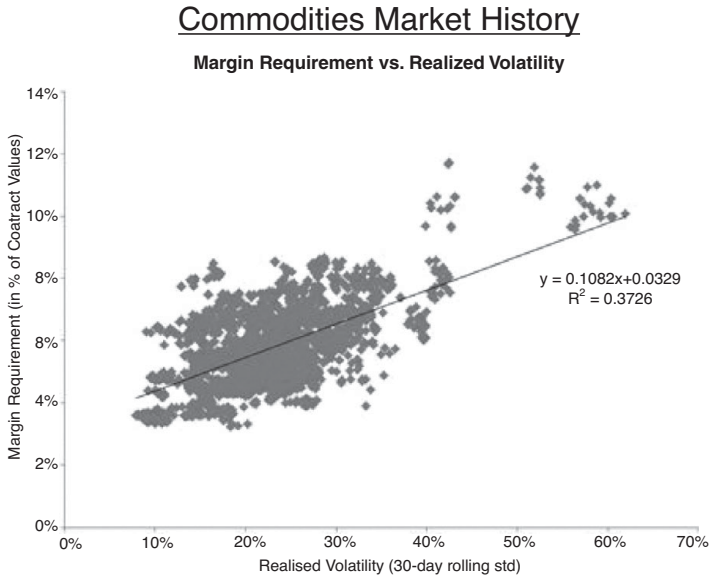


Figure 21.4 Historical volatility and leverage.

either kind of volatility goes up. By contrast, it is notoriously difficult to quantify optimism about the mean of tomorrow's price; in stock prices, yesterday's direction does not predict today's direction.

Figure 21.3 shows the connection between margins in the commodities futures markets and the implied volatility of the underlying prices.

Similarly, Figure 21.4 shows the connection between margins in the commodities futures markets and the recent volatility of the underlying prices.

2.1.3 Leverage and Asset Prices with Agent Heterogeneity

The third key mathematical idea is that all else 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 downpayment, more buyers can express their demand for the collateral (houses or mortgage-backed securities, etc.), 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.[12] Fostel and Geanakoplos (2014) proved that in any binomial model with financial assets, constraining leverage below the equilibrium maxmin value, for example, by prohibiting leverage altogether, always lowers the value of an asset, assuming that the risk-free interest rate does not change.[13] The magnitude of the price effect brought on by the change in leverage depends on the heterogeneity of agent valuations. The more the heterogeneity, the bigger the leverage–price effect.

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, to be sure, might be thought of as collateral for its bond issuances. But they overlooked that their argument depends on the reliability of nonfirm debt as well. Their argument, as clarified by Stiglitz (1969), is essentially the following. Suppose a firm issues a debt promise of D and raises the rest of its money by 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 $D' < D$, then it would have to issue more equity E'. The bondholders who had previously purchased the promises $D - D'$ 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 $D'' = D - D'$, thereby giving the market the same debt it had before and at the same time releveraging the equity E' so that it becomes just like E. In essence, the reduced leverage at the firm level is compensated by increased leverage at the investor level.

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 reliable as the original firm, so D'' 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.

[12] 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 buyers get access to more borrowing, a fewer number of them can buy all the assets, creating a higher marginal buyer and thus a higher price. This is essentially the demonstration given in Geanakoplos (2003) that higher leverage leads to higher collateral prices.

[13] 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 party offset their gain in purchasing power, leaving the final collateral price ambiguous.

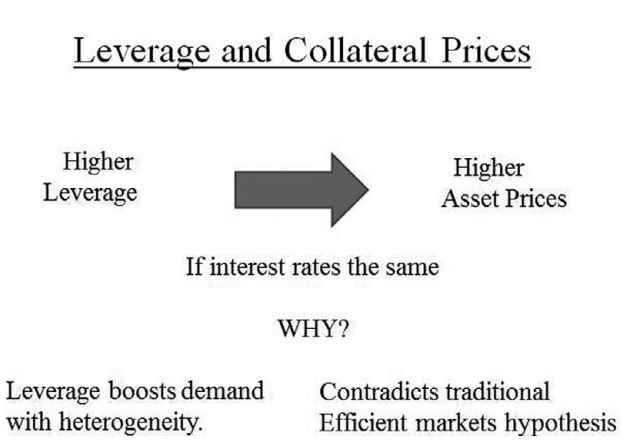


Figure 21.5 Leverage and asset prices.

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 a smaller LTV. The homeowner would simply have to come up with a bigger down payment because 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 the homeowner's increased equity to increase his or her 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 increased firm down risk reduces firm debt, the equity may increase in size, but it will not support a compensating increase in debt, so total leverage will go down, and the firm price will fall. See Figure 21.5.

The lead-up to the 2007–2009 financial crisis, the crisis itself, and also its aftermath give some evidence for the leverage-cycle connection between collateral prices and leverage. In Figure 21.6, we see the connection between the price of a portfolio of AAA subprime bonds and the LTV lenders offered to the hedge fund Ellington Capital on similar bonds. As the figure indicates, leverage and prices fell together during the crisis and eventually rose together in the recovery.[14]

In Figure 21.7, we see the connection between the Case–Shiller housing index and the leverage on nongovernment mortgages from 2000 to 2009. Again, leverage and the asset

[14] This graph first appeared in Geanakoplos (2010) and is updated here. For a graph of margins on repo just after 2007, see Gorton and Metrick (2012).

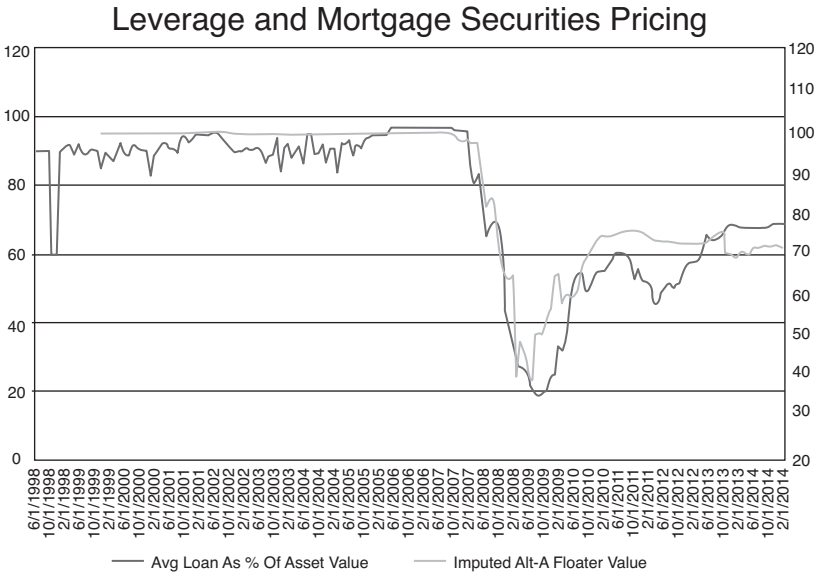
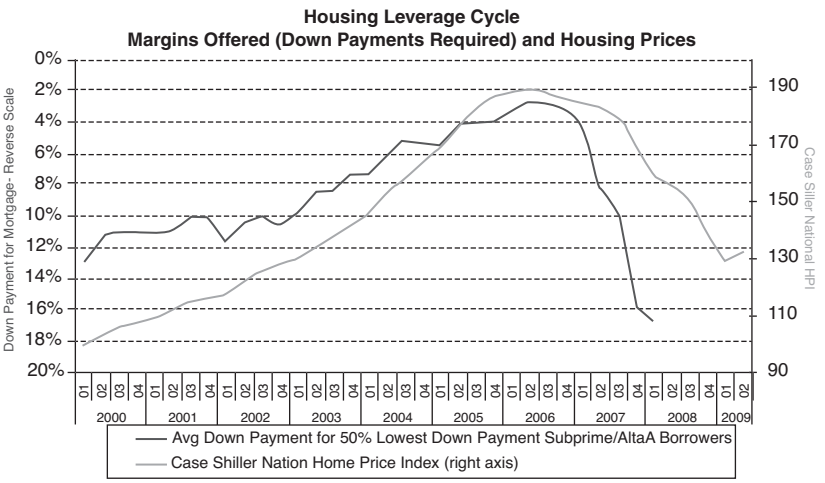


Figure 21.6 Leverage and mortgage securities pricing. Source: Geanakoplos (2009), updated to 2014.



Observe that the Down Payment axis has been in reversed, because lower payment requirements are correlated with higher home prices.

Note: For every AltA or Subprime firstloan originated from Q12000 to Q1 2008, down payment precentage was calculated as appraised value (or sclae price if available) minus total mortagage debt, divided by appraised value. For each quarter, the down payment percentages were ranked from highest to lowest, and the average of the bottom half of the list is shown in the diagram. This number is an indicator of down payment required: clearly many home owner put down in more than they had to, and that is why the top half is dropped from the average. A 13% down payment in Q1 2000 cores ponds to leverage of a about 7.7, and 2.7% down payment in Q2 2008 corresponds to leverage of about 37.

Figure 21.7 Leverage and housing prices.

price move together.[15] The great crisis of 2007–2009 was the culmination of a double leverage cycle, in mortgages and in mortgage securities.

2.1.4 The Slow Leverage Cycle

The leverage cycle typically moves from good news that reduces volatility and flattens the credit surface, which leads to higher leverage, and then to higher asset prices. Eventually, the news worsens and uncertainty rises, which leads to a steeper credit surface, lower leverage, and falling asset prices. This is shown in Figure 21.8, which puts together the three leverage cycle mechanisms. I call this the slow leverage cycle because it does not yet explain why the downward trajectory might be faster than the upward trajectory.

Needless to say, a steady alternation between good news and bad news will create a cycle in asset prices. The novel contribution of the leverage cycle is that an alternation between low uncertainty and high uncertainty will also create a cycle in prices because leverage will rise and fall. This latter price oscillation can occur even if every individual's expectation of the mean of future payoffs remains constant. The amplitude of the price cycle is magnified when both kinds of news occur together because good news and calming

[15] Adelino et al. (2018) argue 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 et al., acknowledge that DTI rose dramatically leading up to the crisis, as emphasized by Greenwald (2018). So credit terms manifestly became looser. The credit surface is multidimensional, as I mentioned at the outset and as I shall emphasize more in Section 5. LTV is not a standalone variable. By 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 (e.g., a mortgage) as opposed to a short-term loan (e.g., a repo). With a more appropriate measure of LTV, they would have found a big rise during the mid-2000s. Goodman (2019) 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 2 or 3 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 et al., 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 et al., 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 21.6. Adelino et al., 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, which 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.

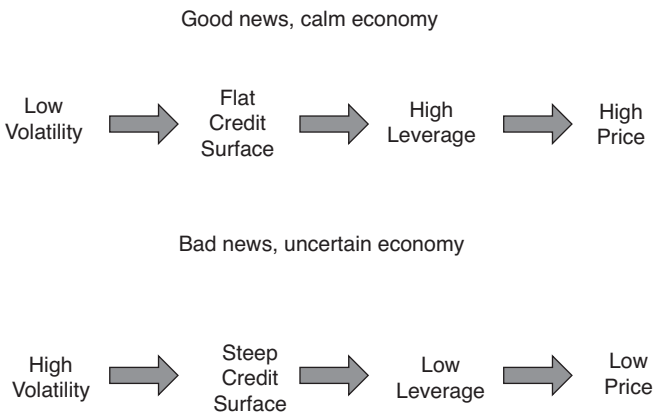


Figure 21.8 The leverage cycle.

Figure 21.9 Bad news and high volatility.

news raise asset prices for different reasons, the first directly and the second through higher leverage. In particular, an increase in expected outcomes that also reduces the maximum percentage shortfall below the expectation will increase prices by much more than the increased expectation.

The coincidence between good news and reduced uncertainty, or bad news and increased uncertainty, is not rare. As Figure 21.9 shows, volatility usually does go up (as measured by the Volatility Index [VIX]) when news is bad (as measured by a fall in the Standard & Poor's [S&P] 500).

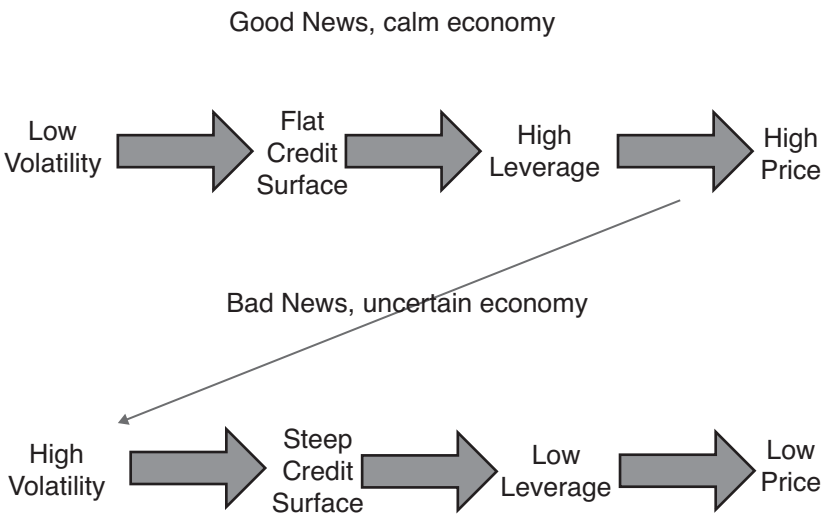


Figure 21.10 Dynamic leverage cycle.

2.2 The Three Mechanisms of the Leverage Cycle Crash

Sometimes in the leverage cycle, prices can go down much faster than they go up. The slow leverage cycle is just a comparative statics exercise. It does not take into account that the economy is more vulnerable *while* it is highly leveraged. Bad news then transfers wealth away from the leveraged owner, who has effectively made a bet on the asset price rising by leveraging. The key idea of the leverage cycle crash is that with agent heterogeneity, this transfer of wealth causes a further price decline. The transfer of wealth can be even more consequential because it is liquid wealth; some agents with high future wealth may nonetheless be forced to respond to the disappearance of their liquid wealth. The down cycle is thus more severe when following the up cycle than it would be on its own. This dynamic aspect of the leverage cycle is emphasized by the amendment to Figure 21.8 shown in Figure 21.10.

Paying closer attention to the leveraged starting point of the downward stage, we uncover three more mechanisms that can combine to cause a crash. All three come into play in a margin call: a situation in which a leveraged holder of an asset has to repay his or her debt and would like to reborrow it (i.e., to "roll it over") but finds that he or she can reborrow less than he or she must repay. The first two precipitate the margin call, and the third accelerates the downward price spiral once it starts. The first and third rely on an added hypothesis, that the leveraged buyer has a higher marginal propensity to spend on the collateral asset than the lenders do.

2.2.1 Bad News–Liquid Wealth Mechanism

The first 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 did 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

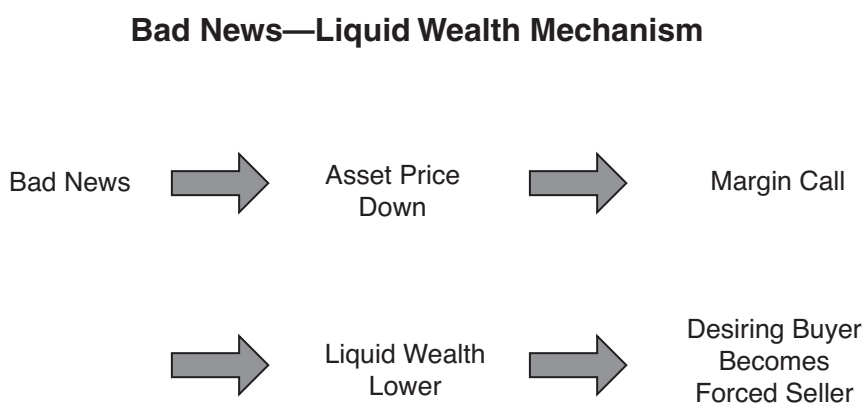


Figure 21.11 Bad news—liquid wealth crash mechanism.

who is not planning to sell or buy it faces no loss of purchasing power. In conventional microeconomic theory, where there is no issue of default, there would be no wealth effect.[16] The situation is different for a leveraged owner of an asset. A leveraged owner whose debt is coming due and who plans to roll over the debt at the same LTV without trading the asset faces a margin call of LTV $\times$ 1 if the asset price drops \$1. This loss in liquid wealth gives the owner an incentive to sell the asset, despite its drop in price, in order to restore his or her liquid wealth. Of course, the lender who receives the margin payment now has more wealth to buy the asset herself. But typically, the lender has a much smaller marginal propensity to spend on the asset out of wealth than the owner.

In fact, the owner has a liquid-wealth-effect incentive to sell a great deal of the asset. If the owner's marginal propensity to spend on the (downpayment for the) asset out of each liquid dollar is m, and if he or she is leveraging the asset λ times, then the owner will want to sell LTV $\times\, m \times \lambda = m \times (\lambda - 1)$ dollars worth of the asset on account of the liquid wealth loss of LTV $\times$ 1 dollars.[17] If the owner has no buffer of liquid wealth and no other assets to sell or borrow against, then $m = 1$. If $m = 1$ and $\lambda = 4$, the owner will sell \$3 worth of each asset he or she owns for every \$1 fall in the asset price. By contrast, the unleveraged owner of the asset, who has $\lambda = 1$, has no liquid wealth incentive to sell.

The substitution effect normally stabilizes the price by propping it up when it falls by inducing bigger demand. Had the asset been owned free and clear ($\lambda = 1$), the owner might have wanted to increase his or her holdings at the lower price. By contrast, the liquid 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. See Figure 21.11.

2.2.2 Scary News—Leverage Mechanism

The second mechanism involves an abrupt change in the anticipation of down risk, which I call *scary news*. It will prevent holders of collateral whose debts are coming due from rolling

[16] The conventional wealth effect is the product of the intended net trade and the change in price. When the intended net trade is zero, there is no conventional wealth effect.

[17] Recall that LTV $= (\lambda - 1)/\lambda$.

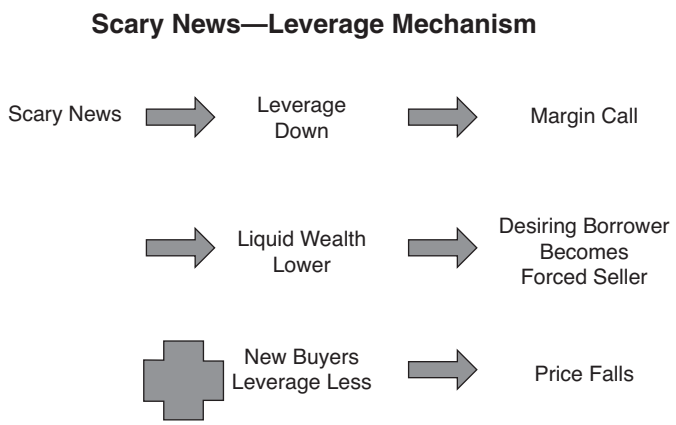


Figure 21.12 Scary news—leverage crash mechanism.

over all the debt, creating a similar liquid wealth reason to sell as in the first mechanism, causing a fall in price even if there had been none before. In addition, the new buyers will not be able to borrow as much, which will cause the asset price to fall more. The scary part of the news is potentially more powerful than the bad part of the news. See Figure 21.12.

2.2.3 Debt-Fragility Mechanism

Debt crises have always been linked to fragile economies. Historically, in times of debt troubles, politicians often make speeches about restoring confidence. President Roosevelt said you have nothing to fear but fear itself. Bernanke and Geithner said similar things about restoring confidence, as did Prime Minister 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 third mechanism arises from high levels of debt in periods when the debt needs to be paid off. Paying off the debt requires the sale of commodities or assets. Large sales themselves are not necessarily a sign of fragility because they are matched by large purchases. But the fragility arises if the marginal propensity to spend on the traded asset, out of the last dollar of wealth, is higher for the sellers than the buyers. I call this a *propensity-to-spend reversal*, because the agent with the higher propensity to spend is the seller. This propensity-to-spend reversal is not the norm, except when selling leveraged assets to pay off debt. The agents with a high marginal propensity to spend leveraged to buy the assets. A margin call forces them to sell the asset, thus causing the propensity-to-spend reversal.

The propensity-to-spend reversal causes fragility through the 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 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 he or she might want less of everything, including Y. In more dramatic words, the further the price goes down, the more he or she 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

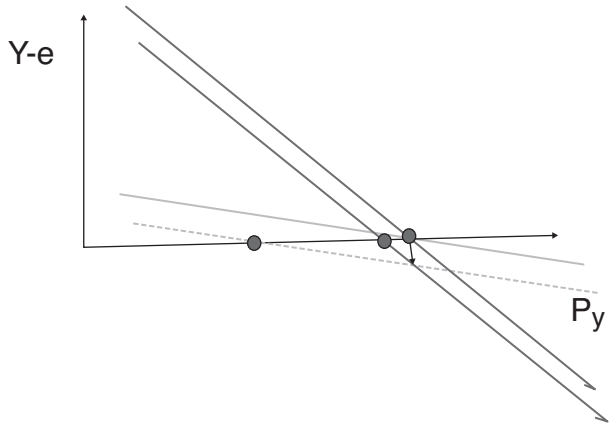


Figure 21.13 Equilibrium with flatter excess demand gives rise to fragile equilibrium.

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.[18] A drop in the price of Y effectively redistributes income from the sellers to the buyers, in proportion to how much is sold. If the marginal propensity to spend on Y out of income is higher for the sellers, then their income-induced drop in the 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.[19] 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 large sales of some good.[20]

See Figure 21.13, which illustrates how the same vertical downward shock 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)

[18] The famous Slutsky equation says that the income effect is the product of the marginal propensity to consume and excess demand. Because 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.

[19] With still bigger sales, the income effect will reverse the substitution effect, and demand will be increasing. But that means there are multiple equilibria.

[20] This is worked out in Ben Ami and Geanakoplos (2017).

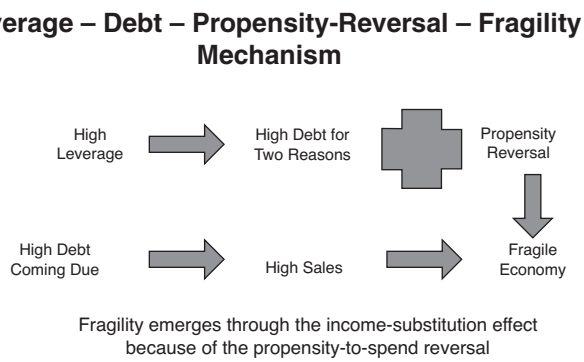


Figure 21.14 Debt—fragility crash mechanism.

When leverage rises, asset prices rise, so borrowers are borrowing a higher percentage of a higher number. Thus, with higher leverage, borrowing goes up for a squared reason, so debt can skyrocket. 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. If collateral is scarce, and if leverage becomes low, then there is a hard cap on the sales of new promises, and so there must be sales of some good or asset. The borrowers who accumulated the large stock of that asset presumably did so because they had a high marginal propensity to spend on it. When a margin call forces them to sell, we get a propensity-to-spend reversal. If the marginal propensities to spend are markedly higher for sellers than buyers, then the economy is fragile. Economies that have large short-term debts therefore are perpetually in a vulnerable situation because they perpetually have enormous sales.

Putting all this together, the debt-fragility mechanism is really a leverage–debt–propensity-reversal–wealth-redistribution–fragility mechanism. See Figure 21.14.

2.2.4 The Leverage-Cycle Crash

Putting the volatility–leverage mechanism together with the debt–fragility–income-redistribution mechanism, we see that a little bit of scary bad news can have a huge effect on asset prices. The leverage cycle I described in 2003 combines all six mechanisms and goes like this: A long period of low volatility leads to a flatter credit surface and thus increased leverage, as well as 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'

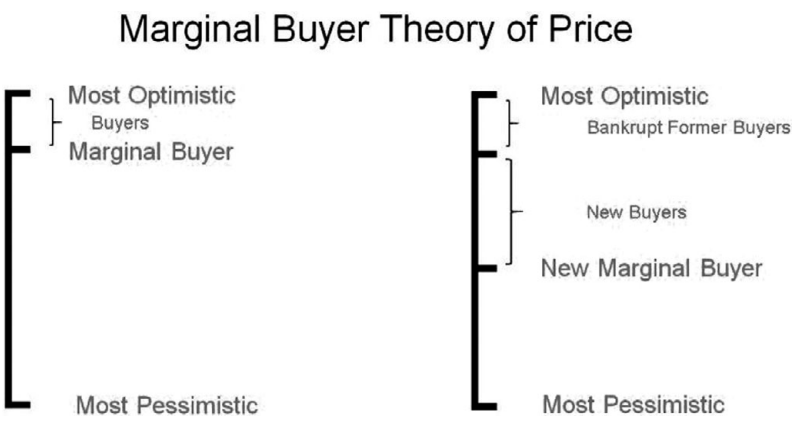


Figure 21.15 Leverage cycle and crash.

demand for assets.[21] Asset prices and activity will stay low as long 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 and crash can be described in a simple special case that illustrates all six mechanisms and gives rise to another diagram that uses the idea of a 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 or she 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, from which this example is taken, I assumed differences in optimism. See Figure 21.15.

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 and set by the down risk (mechanisms 1 and 2). Few agents will be needed to buy the asset because each one can buy a lot using borrowed funds. With few buyers, the marginal buyer will be high up the line and because his or her valuation is equal to the price, the price will be high, as indicated on the left side of Figure 21.15 (mechanism 3).

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 (mechanism 4). The initial fall in the asset price

[21] Another driver of the crash is the sudden emergence of the credit default swap (CDS). A 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 CDSs in 2003 but added them to the story in 2010. See Section 3 on the financial innovation cycle.

causes them to lose more wealth, especially because they are so leveraged. On the right-hand side of Figure 21.15, we consider 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 (mechanism 6).

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 (mechanism 5). 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. The price will then reflect the valuation of a much more pessimistic buyer. The fall in price is more attributable 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.

The leverage-cycle crash is related to so-called "fire sales." For a good account of the important literature on fire sales, see Shleifer and Vishny (2011). 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 overvaluation and buildup of debt due to the soaring leverage and the sudden transition from high leverage to low leverage, which plays 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 language like *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.[22]

2.3 Expectations and the Leverage Cycle

The leverage cycle, as I told it, does not rely on extrapolative or irrational expectations. It can perfectly well occur with rational expectations. The story does depend on heterogeneity in asset valuations and marginal propensities to buy out of income. I motivated this heterogeneity by different priors, meaning my agents were all completely rational Bayesians, aware of all the possible states of nature, but always put different prior probabilities on the down state. There could have been other ways to explain the heterogeneity, including differences in risk aversion or differences in utility for the assets, as I have demonstrated in later work. My early leverage-cycle work had rational updating; the cycle would have gotten even more dramatic with extrapolative expectations.[23]

I do not discount the importance of irrational expectations but merely note that they are not needed for the story. Different beliefs are not indispensable for the story either, but they can play an important role, as they did in my model of 2000–2003, dating from before the 2007–2009 crisis. What characterizes the run-up in the model is that the risk of falling prices is low and is recognized as low by everyone. Indeed, Bernanke dubbed the era as the "great moderation." With little perceived down risk, even the pessimistic agents can

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

[23] This is explored in Thurner et al. (2012).

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 prices fall to reflect the views of a different and more pessimistic class of agents.

After the crisis, a number of authors sought to explain the 2000–2006 price surge as a bubble stemming from bubbly expectations. According to this view, in 2000, everybody began to think that the future demand for housing was going to be high, and this persisted until 2007, when everybody mysteriously began to think the future demand would be low.[24] Anabtwawi and Schwarcz (2011) pointed out that optimistic expectations would lead lenders to give out loans with more leverage, which would push prices up. In that sense, the (irrational) exuberance story and the leverage cycle are similar. Indeed, Robert Shiller, who famously recognized the housing bubble as it was beginning, advised me to interpret the leverage cycle as irrational exuberance by the lenders. I am grateful to him for saying so simply what he took to be the innovation of the leverage cycle, that asset prices could be pushed up by the changing beliefs of lenders, even with no changes in the beliefs by buyers. But I find the great-moderation (i.e., reduced-volatility) explanation for increased leveraged lending more aesthetically pleasing than the story of irrational exuberance (about price trends), although, as I said, both could be right.[25]

[24] See, for example, Kaplan et al. (2017).

[25] Kaplan et al. (2017) take a more extreme view, that changing expectations from 2000–2007 about future housing demand caused the boom and the crash, and yet that the changing lending standards (that they acknowledge) 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 very interesting, I find the Kaplan et al. (2017) story far-fetched. First, it takes an unprecedented shift in expectations alone to justify a 90 percent increase in housing prices in the 6.5 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 the Kaplan et al. model, so those don't explain the change. At the same time, Kaplan et al. must assume a simultaneous and completely exogenous shift in credit standards. How convenient 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 early 2000s got housing prices going up, and that extrapolative expectations kept pushing them further. That could also happen in a more sophisticated model of dynamic expectation revision, as in Bordalo et al. (2018). But they recognize the importance of expectations on credit conditions as a channel for affecting asset prices.

Second, although Kaplan et al. (2017) 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, the 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 very much will depend on credit conditions.

3 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 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 it is now on the rise again.

In Fostel and Geanakoplos (2014), we argued that there is a financial innovation cycle that follows and boosts the leverage cycle. The financial innovation cycle made the crash of 2007–2008 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 well 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 accomodating 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, which 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.

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, called *subprime loans*, began to be initiated by the private sector. These in turn were collected into pools, which were then tranched. The subprime market grew from almost nothing in 1990 to over $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 that they could bet against the subprime mortgages. 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.[26]

[26] 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, because the capital requirements for sovereign debt were so low. As the ratio of debt to Greek gross domestic product (GDP) rose, investors became more jittery. When the Greek crisis started just after the revision of Greek deficit numbers, Prime Minister Papandreou blamed it all on the CDS market.

Krishnamurthy et al. (2018) similarly describe the exponential rise of Bitcoin price and the subsequent crash as the result of financial innovation.

4 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 it also explains some commonly observed cross-sectional differences and linkages between cycles in different asset classes, such as flight to collateral and contagion.[27]

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, with low volatility, turn out to be the assets that can be leveraged more.[28]

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 connected to crossover investors. As we saw in Section 1, the leverage cycle in one asset amplifies the bad news and creates wealth redistribution 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.

Two examples of this kind of spillover into seemingly unrelated markets involve the mortgage market and emerging markets bonds in 1997–1998 and in 2007–1908. In 1997, a crisis started in Asian and Russian emerging markets and was followed within 6 months or a year by a sudden downturn in mortgages. (See the leverage graph in Figure 21.6.) In 2007, a crisis in mortgages then seemed to migrate to emerging markets.

As I mentioned earlier, the great crisis of 2007–2009 was the culmination of a double leverage cycle, in two separate but interrelated markets, mortgages and mortgage securities. Declining cash flows in one asset induce lenders to tilt the credit surface in the other. George Soros's (2009) principle of reflexivity includes the proposition that historical crashes invariably involve disasters in two separate but interrelated markets. Although he 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.

5 The Credit-Terms Cycle and Central Bank Policy

As I mentioned at the outset, leverage is just one of many terms that come with loans, besides 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

[27] In this section, I follow Fostel and Geanakoplos (2008).

[28] In the language of Fostel and Geanakoplos (2008), they have more collateral value.

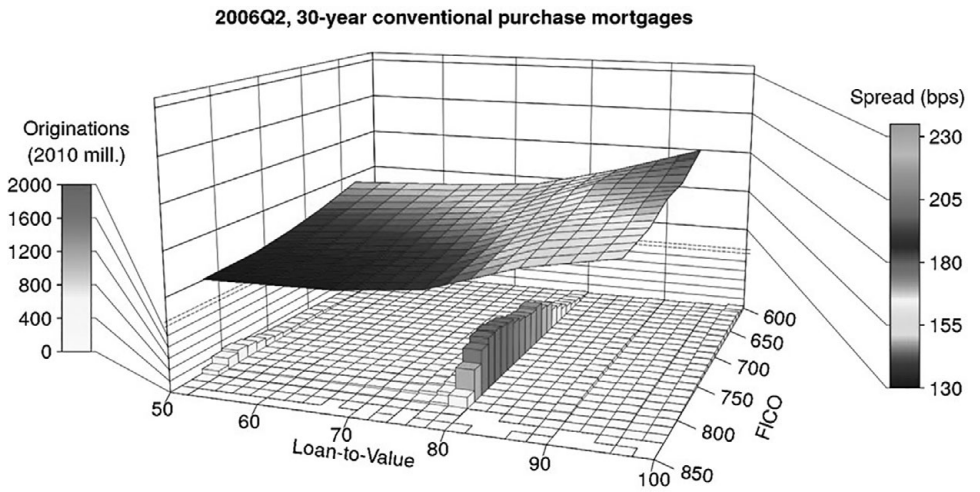


Figure 21.16 Q2 2006 mortgage credit surface.
Source: Geanakoplos and Rappoport (2019) using Black Knight Financial Services and BLS.

a function of 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 like that shown in Figure 21.16.[29]

Figure 21.16 shows the average interest rate charged on all fixed-rate Federal National Mortgage Association (FNMA) and Freddie Mac mortgage loans in the second quarter of 2006 as a function of LTV and FICO. Loans with the highest FICO and lowest LTV, in the southwest corner, are the safest loans. Loans with the highest LTV and lowest FICO, in the northeast corner, are the riskiest loans. Even for the conforming group of households that passed many hurdles to get into the government programs, there is a difference in interest rate depending on credit characteristics. But the curve is generally quite flat, indicating a loose credit surface. The rectangular blocks below the surface give the volume of loans at the point on the surface just above. One can see that the bulk of the loans had less than 80 percent LTV. But there is a significant number with LTVs close to 100 percent and FICOs around 650.

Consider next 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 less. See Figure 21.17.

In Figure 21.18, we see the corporate bond credit surface for 2007.[30] As it was for mortgages in 2006, the corporate bond credit surface is very flat.

[29] See Geanakoplos and Rappoport (2019).

[30] 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 and Rappoport (2019).

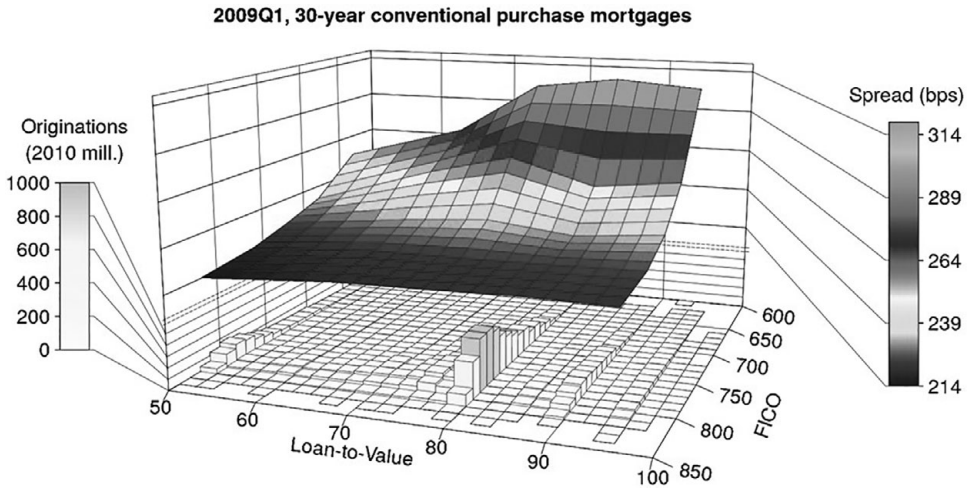


Figure 21.17 Q4 2008 mortgage credit surface.
Source: Author's elaboration using Black Night Financial Services and BLS.

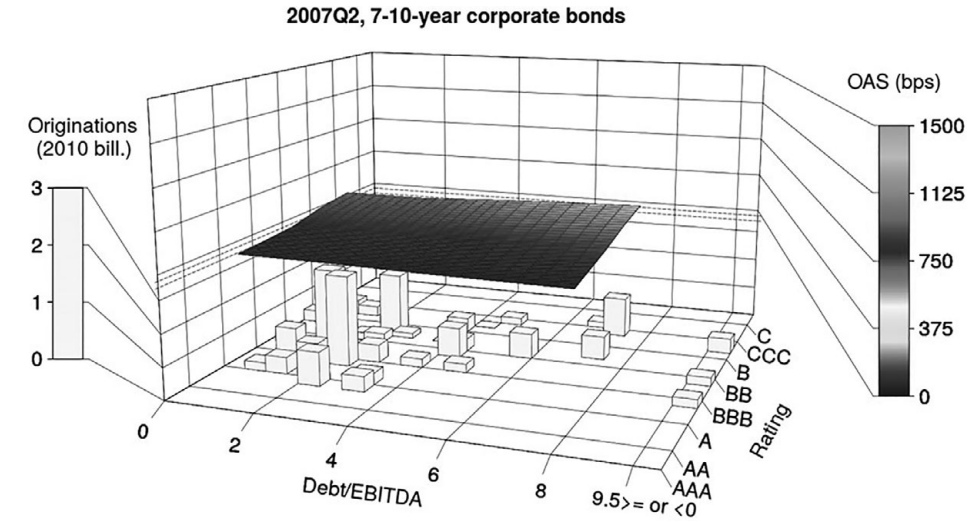


Figure 21.18 Q2 2007 corporate bond credit surface.
Source: Geanakoplos and Rappoport (2019) using ICE, Bond Indices, Mergent FISD, CRSP/Compustat, Compustat, and BLS.

In the fourth quarter of 2008, the credit surface became remarkably steeper, making it much more difficult to borrow. The reader should be aware that the credit surfaces do not always move in tandem. Today (in late 2019), 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. See Figure 21.19.

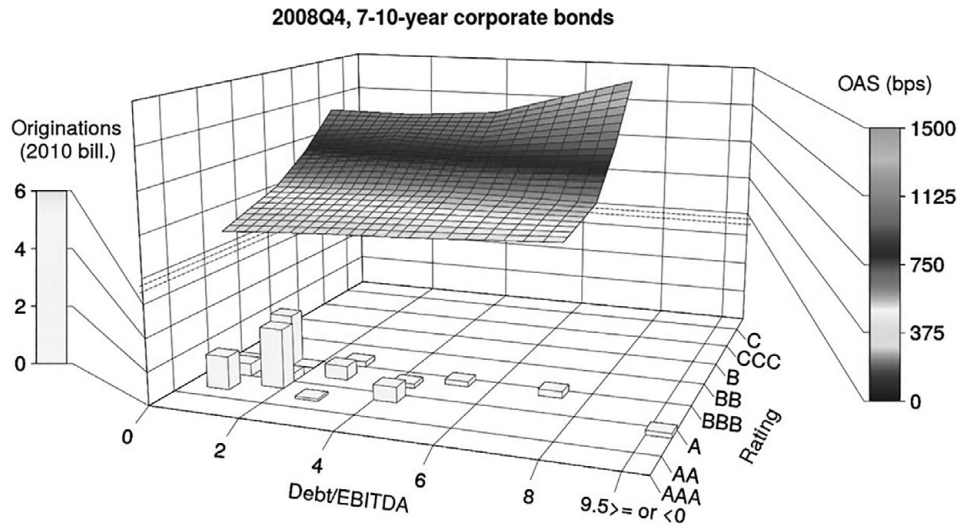


Figure 21.19 Q4 2008 corporate bond credit surface.
Source: Author's elaboration using Bank of America, bond indices, Mergent FISD, CRSP/Compustat, and BLS.

6 Monetary Policy and Macroprudential Policy

The policy implications of the leverage cycle are that central banks should smooth the cycle, restraining leverage in booms and propping up leverage in the acute stage of the crisis.[31] How to do so involves monetary policy and macroprudential policy. Indeed, an implication of the leverage cycle is that it is hard to separate the two. See Figure 21.20.

One crucial question is always, Where in the leverage cycle are we? This question can be addressed by monitoring and by stress tests. Stress tests are most important when we get closer to the top of the leverage cycle. Of course, by then, it is difficult to stave off a crash, even if we know it is coming. The interesting thing is that knowing that we are approaching the precipice, we should reverse the monetary policy that we had been using to keep us from getting too far up the mountain.

A second crucial question is whether the upswing in the leverage cycle is due to an unusual investment opportunity or to a market in which borrowers and especially lenders are taking bigger risks. Here again, monitoring and especially stress tests can give valuable information.

6.1 Monitoring the Leverage Cycle

In my opinion, the Federal Reserve should produce credit-surface pictures for the general public each quarter. Not only that, but they should be produced for the unsecured consumer

[31] I have also argued that if in the aftermath of a leverage-cycle crash, depressed asset prices are too low relative to debts, debt must be partially forgiven. See Geanakoplos and Koniak (2008, 2009) and Geanakoplos (2010b, 2019).

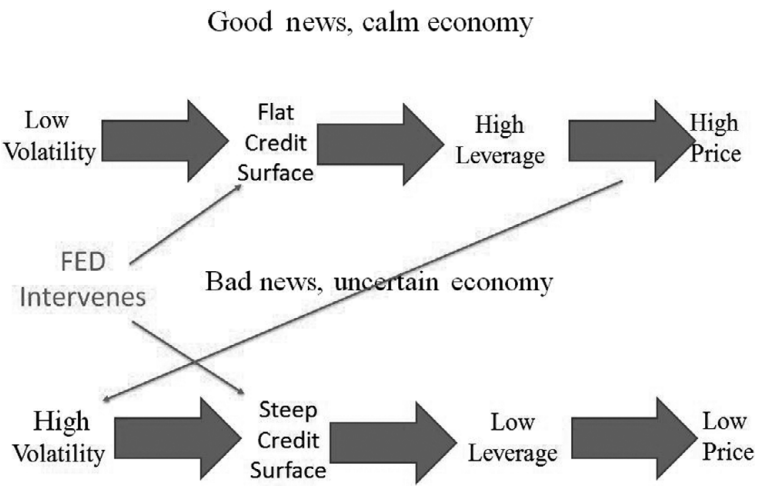


Figure 21.20 Monetary policy and macroprudential policy.

loan credit surface and other surfaces, as well as for the mortgage credit surface and the corporate bond credit surface. This will give economists, businesspeople, macroprudential regulators, and the Fed itself a much better picture of credit conditions in the economy.

The credit surface also includes the number of loans made at each point of the surface. The Fed can keep track, for example, of the percentage of new loans made at over 90 percent LTV, or the median LTV of the 50 percent of loans with the highest LTV, as in Figure 21.7. Similar numbers can be recorded for FICOs, DTIs, and so forth.

The Fed should also be keeping track of the evolution of asset prices. Each credit surface that corresponds to a collateral type should be associated with the price of the collateral (or the index of the collateral type). At the same time, the trailing volatility of the collateral price should be recorded. (Better still would be a trailing down volatility.) The Fed might also keep track of activity such as production in the sectors associated with each loan type.

The Fed should carefully note when there is a financial innovation in the loan market corresponding to a collateral type.

The hallmark of the upswing of a leverage cycle is a flattening credit surface, increasing leverage (as given by the volume data), increasing numbers of low-FICO loans, increasing asset prices, and low down volatility. Once the cycle has progressed unusually far, the Fed should intervene with monetary policy to slow things down. How to tell when things have gone too far will require some more dedicated historical research. The situation is analogous to the traditional Fed role in monitoring the Phillips curve (connecting output or employment to inflation), except that asset prices replace commodity prices. Indeed, in my opinion, traditional monetary policy could be substantially improved by incorporating leverage-cycle concepts.

In conducting monetary policy, the Fed should be aware of how the changes it makes in the riskless rate (in the southwest corner) affect the whole credit surface of each type. Perhaps the changes 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.[32] Do Federal Reserve risky asset purchases (called *quantitative easing*) have similar effects, or are they better at tilting the credit surfaces? In my opinion, the Fed should use the language of the various credit surfaces to explain its policy aspirations. Is the hope to shift or steepen the mortgage credit surface or the corporate credit surface?

Finally, if there are parts of some credit surface the Fed or macroprudential regulators wish to target, then they should use unconventional tools to specifically affect those areas alone. For example, at the current time, the mortgage credit surface is still very unkind to low to medium-FICO borrowers. 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.[33]

6.2 Stress Tests

Stress tests are designed to judge whether crucial intermediaries could survive a severe downturn and to warn of increasing risk of a severe downturn. Monitoring the leverage cycle displays the preconditions for a crash. Stress tests are indispensable to uncovering whether the preconditions are creating genuine risk.

The leverage cycle is an archetypal scenario, which recurs in crisis after crisis, that in broad strokes lays out the critical stress test scenarios. The defining signature of the leverage-cycle crash is bad news and simultaneously much tighter credit and higher volatility. Looking at the portfolio of loans a bank or other intermediary faces, what happens if the loans start to default (say, because unemployment rises or activity and profits decline), and at the same time the loans cease to prepay because borrowers' access to credit has been curtailed? And at the same time, the banks themselves lose access to their credit? And at the same time, what if the prices of the securitized loans they own also fall further than the reduction in their underlying loan cash flows warrant because leverage on the securities declines? Do the intermediaries have enough capital to maintain their positions, or will they be forced to sell? Will they default?

Of course, if we assume enough simultaneous bad shocks, every bank will collapse. The point of the leverage cycle is that it describes plausible simultaneous shocks. The scary scenario described in the last paragraph is plausible according to leverage-cycle principles, and it happened in the crisis of 2007–2009. The simultaneity of shocks emerged because leverage tightened for both securities and loans at the same time.

Turning to the economy as a whole, the leverage cycle becomes systemic when the assets that function as collateral are similar across the whole economy or because the same group of borrowers owns several asset classes that together are large. Prices declining in two unrelated industries, such as mortgages and emerging markets, can happen because crucial leveraged buyers are crossover investors in both industries. The macroprudential regulators therefore

[32] I analyze just this question in Geanakoplos and Rappoport (2019).

[33] There is some doubt about whether the US Federal Reserve has such powers because it has not exercised them. It certainly does have the power to regulate margins on stocks.

need to keep track of the portfolio composition of all highly leveraged crossover investors in order to see which assets are linked through common ownership.

Stress tests should not only examine the effects on bank capital from changes in cash flows but also from price declines. And the price declines should not simply be taken as exogenous but themselves be generated from stress tests with data-driven inputs. For example, a crucial determinant of the size of plausible price declines is the heterogeneity of the valuations of different potential buyers. When some assets are propped up in value by a small class of investors who are highly leveraged and who (at that leverage) value the assets much more than anybody else, there is risk of steep price declines.[34] In order to judge the resilience of the system, the macroprudential regulators must know which big players (who themselves have high valuations) have enough free capital to absorb assets that might be disgorged by leveraged holders facing margin calls.

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[34] The leveraged buyers are often the banks, which, because of their access to sticky deposits and sophisticated valuation models, can find extra value in assets, so long as they don't cause large regulatory capital charges. In fact, these assets might be so valuable to the banks because they are not assessed for high capital charges while most other assets are.

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