Leverage, Securitization and Shadow Banking: Theory and Policy

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Abstract

Leverage and securitization are at the core of the shadow banking system. We provide a non-technical review of the theory of leverage developed in collateral general equilibrium models with incomplete markets. We explain how leverage can be endogenously determined in equilibrium, and its relation with tail risk, volatility and asset prices. We provide a description of the Leverage Cycle and how it differs from a Credit Cycle. We also describe some cross-sectional implications of multiple leverage cycles, including contagion, flight to collateral, and swings in the issuance volume of the highest quality debt. Finally, we review some ideas on how to measure and manage leverage.

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Introduction

Most of the recent post-crisis regulatory reforms concentrate on bank leverage and bank capital requirements. However, leverage and securitization also occur in the shadow banking system, outside traditional banks. Short term lending (repos) and securitization are indeed at the core of shadow banking activities.

Shadow banks are similar to traditional banks to the extend that they engage into maturity transformation activities. But shadow banks are crucially different from traditional banks since they are subject to a very different regulatory framework and safety nets.

Financial innovation in the form of securitization (like pooling and tranching) increased dramatically in the decade before the financial crisis. There are many forces behind securitization that have been widely analyzed before such as the potential for regulatory arbitrage and increased risk sharing. However collateral is also key to understand securitization. Collateral and securitization are devices to make lending more attractive. In fact, securitization, and financial innovation in general, is a way of stretching the scarce collateral in the economy.

This paper wants to put forward the idea that collateral and leverage are crucial to understand the shadow banking system and its fragility. The goal is to provide a non-technical review of the collateral general equilibrium theory of endogenous leverage and discuss a few policy ideas on how to properly measure and manage leverage.[1]

In classical macroeconomic models with financial frictions like like Bernanke-Gertler (89), Kiyotaki-Moore (97), Holmstrom-Tirole (97), the strategy to endogenize leverage is through theoretical foundations coming from the corporate finance tradition. Borrowing limits are set using "skin in the game" type of arguments. On the con-

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[1]For a technical review see Fostel-Geanakoplos (forthcoming)

trary, the theoretical foundations for endogenous leverage in the collateral general equilibrium models starting with Geanakoplos (97), are based on the idea that default happens when collateral is worth less than the promise. This situation applies to most of shadow banking where borrowers have no control over the future payoff of the asset.

The main lessons from the collateral general equilibrium theory are the following. First, leverage is endogenous and fluctuates with the fear of default. Second, leverage is therefore related to the degree of uncertainty, volatility or low tail risk of asset markets. Third, increasing leverage on a broad scale can increase asset prices. Fourth, the scarcity of collateral creates a collateral value that can lead to bubbles in which some asset prices are far above their efficient levels, creating leverage cycle. Finally, multiple leverage cycles can explain important phenomena like flight to collateral, contagion and violent swings in volume of trade in high quality assets.

The main policy implication is that managing leverage may be far more important and efficient than managing interest rates. We briefly discuss a few ideas on how to properly measure and manage the leverage cycle.

Theory of Leverage and Collateral

Default and Endogenous Leverage

Collateral general equilibrium theory not only models the role of leverage on asset prices and economic activity, but it also provides a theory of endogenous determination of collateral requirements. This seems to be a difficult problem, since in standard general equilibrium theory one clearing market condition for the credit market endogenously determines the interest rate. So how can one supply-equals-demand

equation for loans determine two variables, interest rate and leverage?

In collateral equilibrium models developed by Geanakoplos (1997) and Geanakoplos-Zame (1997), the problem is solved by considering a whole menu of contracts, each characterized by a collateral level and a promise of repayment. In equilibrium all contracts are priced and hence each contract has a corresponding LTV. However because the collateral backing promises is scarce, only a few contracts will be actively traded in equilibrium. In this sense, collateral requirements and leverage are determined endogenously in equilibrium.

But which contracts are traded in equilibrium? Geanakoplos (2003) and Fostel-Geanakoplos (2012a) provide an example in which all agents choose the same contract from the menu. Fostel-Geanakoplos (2013a) provide a complete characterization. They proved that in binomial economies with financial assets serving as collateral, every equilibrium is equivalent (in real allocations and prices) to another equilibrium in which there is no default.[2] Thus in binomial economies with financial assets, actual default is not observable. But potential default has a dramatic effect on equilibrium: it sets a hard limit on borrowing. Agents can promise at most the worst payoff of the asset in the future. This result shows that agents would like to borrow more at going riskless interest rates but cannot, even when their future endowments are more than enough to cover their debts. The limit on borrowing is caused by the potential of default, despite the absence of default in equilibrium.[3]

Binomial economies and their Brownian motion limit are special cases. But they are extensively used in finance. They are the simplest economies in which one can begin

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[2]An asset is financial when it does not provide direct utility to its holder and when its payoffs do not depend on ownership. For example, houses and land are not financial assets.

[3]Fostel and Geanakoplos (2013a) provide refinements of the result. They show that under default costs or costs associated to the use of collateral, in every equilibrium only the max min contract is traded. The max min contract is the contract that promises to pay the worst payoff of the asset in the future. It is the maximum promise that avoids default.

to see the effect of uncertainty on credit markets.[4]

Notice that this strategy of making leverage endogenous is different from the corporate finance approach used in the macro literature such as Kiyotaki-Moore (97) and Bernanke-Gertler (89) or more recently in Acharya-Viswanathan(2011) and Adrian-Shin (2010) . The corporate finance view relies on "skin on the game" type of arguments. These moral hazard or agency problems are indeed at the core of the corporate world. However, these were not the type of problems that were at the center of the recent crisis and shadow banking: sellers of MBS (mortgage backed securities) did not have any type of control over the MBS future cash flows.

Once we know which contract is traded in equilibrium, we have a well-defined formula for the leverage associated to each asset used as collateral. Loan to value, LTV, is defined as the ratio between what can be borrowed using the asset as collateral and the price of the asset. In binomial economies an asset LTV is given by tail risk as shown by the following:[5]

$$LTV = \frac{worst\ case\ rate\ of\ return}{riskless\ rate\ of\ interest}.$$

This formula is simple and easy to calculate. Moreover, it provides interesting insights. First, the formula explains which assets are easier to leverage: those assets with low tail risk. Second, it explains why changes in the bad tail can have such a big effect on equilibrium even if they hardly change expected asset payoffs: they change leverage. Finally, the formula also explains why, even with rational agents who do not chase yield, high leverage historically correlates with low interest rates.

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[4]With multiple states or non financial assets like houses, default would emerge in equilibrium, but still leverage would be endogenous. For examples see Fostel-Geanakoplos (2012a), Araujo et al (2011), Simsek (2013), Geanakoplos-Kubler (2013).

[5]See Fostel-Geanakoplos (2013a).

Leverage and Volatility

Many papers have assumed a link between leverage and volatility: low volatility is usually associated with high levels of leverage. It turns out that this is the case in binomial economies with only one financial asset. In this special case the above LTV formula expressed in terms of tail risk can be equivalently expressed as:[6]

$$margin = 1 - LTV = k \times Volatility\ of\ collateral\ payoffs.$$

The formula says that the equilibrium margin on an asset is proportional to the volatility of a dollar's worth of the asset. The trouble with this formula is that the risk neutral pricing probabilities used to calculate volatility depend on the asset. If there were two different assets co-existing in the same economy, we might need different risk neutral probabilities to price each of them. In a few words, ranking the leverage of assets by the volatility of their payoffs would fail if we tried to measure the various volatilities with respect to the same probabilities.

This suggests that the link between volatility and leverage is not as robust and that what really matters in general is tail risk.

Leverage and Asset Prices

Collateral general equilibrium models provide a theory that links collateral and liquidity with asset prices.

When assets can be used as collateral, they are priced above their marginal utility of their payoffs. This pricing premium for collateral is called collateral value, because it stems from the added benefit of enabling borrowing. Fostel-Geanakoplos (2008)

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[6]See Fostel-Geanakoplos (2013a).

showed that the price of an asset that can be used as collateral is given by:

$$p = PV + CV.$$

The price of any asset has two components. The Payoff Value, PV, which reflects the usual discounted marginal utility of future payoffs. The second component, the Collateral Value, CV, reflects the value of the asset due to its collateral role. Interestingly, the existence of collateral values create deviations from the efficient markets hypothesis, which in one of its forms asserts that there are risk-adjusted state probabilities that can be used to price all assets.

The collateral value is also related to liquidity. When borrowing is limited by the need to post collateral, some agents would be willing to pay a higher interest for the loan than the market requires, if they did not have to put up the collateral. This extra interest is called the liquidity wedge. Fostel-Geanakoplos (2008) showed that when borrowing constraints are binding, agents discount all the cash flows by the liquidity wedge. As a result, as agents become more liquidity constrained, when liquidity wedge is high, their asset valuation will decline.

On the other hand, the surplus a borrower can gain by taking out a particular loan backed by a particular collateral is called the liquidity value of the loan (or contract). Since one collateral cannot back many competing loans, the borrower will always select the loan that gives the highest liquidity value among all loans with the same collateral. This leads to a theory of endogenous contracts in collateral equilibrium, and in particular, to a theory of endogenous leverage as described above. The liquidity value of a contract depends on the payoff of that contract and on the agents' liquidity need as expressed by the liquidity wedge. Fostel-Geanakoplos (2008) proved that in fact, the collateral value of an asset equals the liquidity value of a contract that uses the asset as collateral. In this way the knot is completely tight:

this theory explains the relationship between asset prices, collateral and liquidity.

Finally, as shown in Fostel-Geanakoplos (2012b), collateral values can create bubbles. Harrison-Kreps (1978) defined a bubble as a situation in which an asset trades for a price which is above every agent's payoff value. They showed a bubble could emerge in equilibrium if there were at least three periods, because the buyer in the first period could sell it in the second period to somebody who valued it more than he did from that point on. In collateral equilibrium bubbles can emerge even in a static model due to the presence of collateral values.

The Leverage Cycle

The theoretical results described in previous sections have interesting time series implications when studied in a dynamic framework. As explained in Geanakoplos (2003), leverage cycles arise in equilibrium. Leverage cycles are characterized by a dynamic feedback between leverage, asset prices and volatility (or tail risk).

First, leverage and asset prices tend to move hand in hand: there is a two-way feedback between leverage and collateral prices. Figures 1 and 2 show leverage cycles in the housing and repo markets respectively. Both markets were at the epicenter of the recent financial crisis. The figures clearly show how previous to the crisis, both leverage and collateral prices, went up and how they both eventually collapse after the crisis in the housing and repo markets.
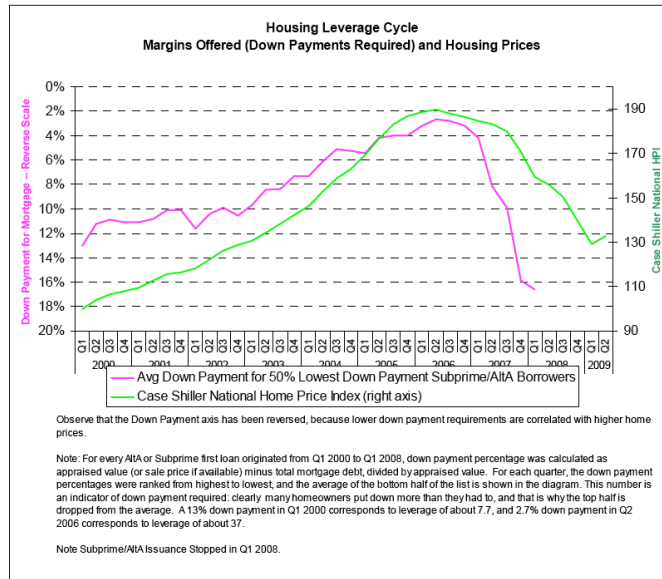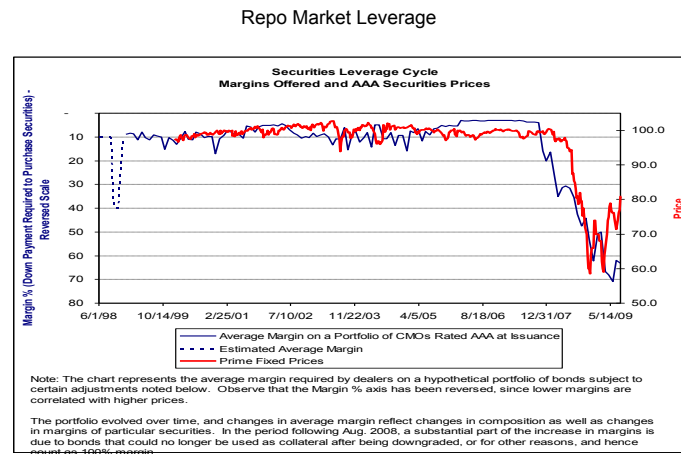
Housing Leverage Cycle
Margins Offered (Down Payments Required) and Housing Prices

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

Note: For every AltA or Subprime first loan originated from Q1 2000 to Q1 2008, down payment percentage was calculated as appraised value (or sale price if available) minus total mortgage 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 homeowners put down more than they had to, and that is why the top half is dropped from the average. A 13% down payment in Q1 2000 corresponds to leverage of about 7.7, and 2.7% down payment in Q2 2006 corresponds to leverage of about 37.

Note Subprime/AltA Issuance Stopped in Q1 2008.

Figure 1: Housing Leverage Cycle. From Geanakoplos 2010.

Repo Market Leverage

Securities Leverage Cycle
Margins Offered and AAA Securities Prices

Note: The chart represents the average margin required by dealers on a hypothetical portfolio of bonds subject to certain adjustments noted below. Observe that the Margin % axis has been reversed, since lower margins are correlated with higher prices.

The portfolio evolved over time, and changes in average margin reflect changes in composition as well as changes in margins of particular securities. In the period following Aug. 2008, a substantial part of the increase in margins is due to bonds that could no longer be used as collateral after being downgraded, or for other reasons, and hence count as 100% margin.

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Figure 2: Security Leverage Cycle. From Geanakoplos 2010.

Second, the leverage cycle predicts a two-way feedback between leverage and asset prices with volatility (or more generally with tail risk): when volatility or tail risk

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is low, leverage and asset prices are high. Figure 3 shows the VIX index, which is considered the "fear factor" in financial markets and widely used as a measure for market volatility. The index is at low levels before the crisis, precisely when leverage and asset prices are at record high levels, and it skyrockets just before the crisis at the moment when leverage and asset prices collapse as seen in Figures 1 and 2.

As we saw in the previous section, collateral is usually scarce and hence borrowing is usually constrained. But when volatility (or tail risk) is low and stable, the existing scarce collateral can support massive amounts of borrowing, provided there is sufficient agent heterogeneity to generate a need for trading the collateral. In such times a bubble can emerge in which the prices of the assets that can be used as collateral rise to astronomical levels, far above their "Arrow-Debreu" Pareto efficient levels. During this ebullient time, the combination of high prices and low volatility creates an illusion of prosperity. But in fact the seeds of collapse are growing as the assets get more and more concentrated in the hands of the most enthusiastic and leveraged buyers.
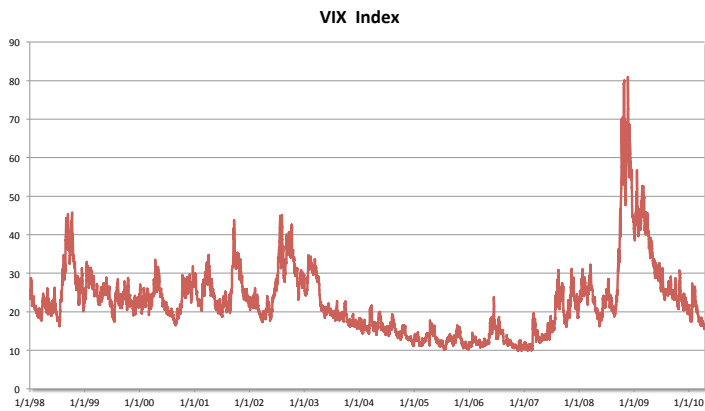

Figure 3: Volatility. From Fostel-Geanakoplos 2012a.

When bad news that creates more uncertainty (or that comes with very high low tail risk) occurs, the bubble can burst. The bad news itself lowers the prices. But it also drastically reduces the wealth of the leveraged buyers, forcing them to sell. And most importantly, credit markets tighten and potential new investors cannot find funding. Is the interaction of all these three factors that can reduce the price by much more than the bad news itself.

This evolution from low volatility and rising leverage and asset prices, to high volatility and declining leverage and asset prices is called the leverage cycle.

It is very important to distinguish between a leverage cycle and a credit cycle. They are not the same: leverage cycle is a feedback between asset prices and leverage, whereas a credit cycle is a feedback between asset prices and borrowing. If leverage is constant, then borrowing and asset prices rise and fall together, but leverage is unchanged. Of course a leverage cycle always produces a credit cycle. But the opposite is not true. Macroeconomic models with financial frictions such as Kiyotaki-Moore (1997) produce credit cycles but not leverage cycles. At odds with the empirical evidence, in these models a credit cycles co-exists in equilibrium with counter-cyclical leverage.

Not every model with financial frictions and collateral constraints can generate a leverage cycle. For leverage cycles to appear in equilibrium uncertainty is needed, and a particular type of uncertainty: one in which bad news is associated with an increase in future volatility or tail risk. The literature on credit cycles has traditionally not been concerned with volatility. In a leverage cycle, leverage is the most important quantitative driver of the change in asset prices over the cycle. If LTV were held to a constant, or even worse, if it is counter-cyclical, the cycle would be considerably dampened.

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Multiple Leverage Cycles

Many kinds of collateral exist at the same time, and therefore there can be many simultaneous leverage cycles. Collateral equilibrium theory not only explains time series properties like the leverage cycle described above, but it also explains some commonly observed cross sectional differences and linkages between leverage cycles in different asset classes. In particular, multiple co-existing leverage cycles can explain phenomena such as flight to collateral, contagion and drastic swings in the volume of trade of high quality assets.[7]

Flight to Collateral

When similar bad news hits different asset classes, some asset classes often preserve their value better than others. This empirical observation is traditionally given the name flight to quality, since it is interpreted as a shift toward safer assets that have less volatile payoff values. Fostel-Geanakoplos (2008) called attention to a new channel which they called flight to collateral: after volatile bad news, collateral values widen more than payoff values.

More precisely, each asset experiences its own leverage cycle and hence prices for all assets go down after bad news by more than their expected values decline. However, the gap between asset prices widens after bad news by more than the gap in expected payoffs. After bad news, the payoff values of all assets go down. But their collateral values move in different directions: while the collateral value of some assets go down, amplifying their leverage cycle, the collateral value of other assets increase, smoothing their leverage cycle. Hence, the widening spread in prices is almost entirely explained by the widening of collateral values.

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[7]For technical details see Fostel-Geanakoplos (2008) and Fostel-Geanakoplos (forthcoming).

Flight to collateral occurs when the liquidity wedge is high (so marginal buyers are liquidity constrained) and the dispersion of LTVs is high. During a flight to collateral, investors prefer to buy those assets that enable them to borrow money more easily (higher LTVs). The other side of the coin is that investors in need of liquidity get more cash by selling those assets on which they borrowed less money because the sales revenues net of loan repayments are higher.

Flight to collateral is related to what other papers have called flight to liquidity. Flight to liquidity was discussed by Vayanos (2004) in a model where an asset's liquidity is defined by its exogenously given transaction cost. In Brunnermeier-Pedersen (2009), market liquidity is the gap between fundamental value and the transaction price. They show how this market liquidity interacts with funding liquidity (given by trader's capital and margin requirements) generating flight to liquidity. In our model an asset's liquidity is given by its capacity as collateral to raise cash. Hence, our flight to collateral arises from different leverage cycles in equilibrium and their interaction with the liquidity wedge cycle.

Contagion

When bad news hits one asset class, the resulting fall in its price can migrate to other assets classes, even if their payoffs are statistically independent from the original crashing assets.

Fostel-Geanakoplos (2008) showed that a leverage cycle in one asset class can migrate to a different asset class through movements in the liquidity wedge. A leverage cycle in one asset class alone can move the liquidity wedge. As explained above, the liquidity wedge is a universal factor in valuing all assets. So an increase in the liquidity wedge of marginal buyers after bad news reduces their valuation of all assets. Crucially, contagion does not only happen during extreme episodes through

dramatic sell offs. Contagion can occur also during less extreme stages called the anxious phase due to the presence of a portfolio effect: marginal buyers end up buying more after bad news, amplifying the movements of the liquidity wedge.

There is a vast literature on contagion. Despite the range of different approaches, there are mainly three different kinds of models. The first blends financial theories with macroeconomic techniques, and seeks international transmission channels associated with macroeconomic variables. Examples of this approach are Corsetti, Pesenti, and Roubini (1999), and Pavlova-Rigobon (2008). The second kind models contagion as information transmission. In this case the fundamentals of assets are assumed to be correlated. When one asset declines in price because of noise trading, rational traders reduce the prices of all assets since they are unable to distinguish declines due to fundamentals from declines due to noise trading. Examples of this approach are King-Wadhwani (1990), Calvo-Mendoza (2000) and Kodres-Pritsker (2002). Finally, there are theories that model contagion through wealth effects, as in Kyle-Xiong (2001). When some key financial actors suffer losses, they liquidate positions in several markets, and this sell-off generates price comovement. Our model shares with the last two approaches a focus exclusively on contagion as a financial market phenomenon. But our model further shows how leverage cycles can produce contagion in less extreme but more frequent market conditions: the anxious economy, where there is no sell-off. The leverage cycle causes contagion even when trade patterns differ from those observed during acute crises.

Swings in High Quality Trade Volume

When collateral general equilibrium models are extended to include asymmetric information, we can also explain extreme volatility in trade volumes. Importantly, owners of the assets can observe their asset quality, but investors cannot. Following

the techniques in Fostel-Geanakoplos (2008) and Dubey-Geanakoplos we can allow for signaling as well as adverse selection in collateral equilibrium without destroying market anonymity.

Co-existing leverage cycles generate flight to collateral as before. But a new effect comes from the supply side. In order to signal that their assets are high quality (so that investors will pay more for them and be able to borrow more using them as collateral), the owners of the good quality asset always sell less than they would if their types were common knowledge. However, after bad news, the drop in volume of their sales is huge.

Flight to collateral and informational asymmetries generate such a big drop in good issuance, even though the news is almost equally bad for all assets assets. The explanation is that the bigger price spread between types caused by the flight to collateral requires a smaller good type issuance for a separating equilibrium to exist. Unless the good issuance level becomes onerously low, bad types would be more tempted by the bigger price spread to mimic good types and sell at the high price. The good types are able to separate themselves by choosing low enough quantities since it is more costly for the bad type to rely on the payoff of its own asset for final consumption than it is for the good type.

There is a growing literature that tries to model asymmetric information within general equilibrium, like Gale (1992), Bisin-Gottardi (2006), and Rustichini-Siconolfi (2008). Our model combines asymmetric information in a general equilibrium model with a model of endogenous credit constraints and leverage.

Policy: Measuring and Managing Leverage

As we saw in the previous sections, leverage is a crucial variable that affects asset pricing and can generate cycles and cross-market dynamics like contagion and flight to collateral. Asset prices are too high ex-ante, compared to Arrow Debreu first best prices, and eventually they crash after bad news, rising and falling in tandem with leverage. If we were to add investment and production of the asset into the model, we would find that there is over-production ex-ante as well, and a dramatic drop in production and investment levels during crisis times.[8]

Macroeconomic stability policy has concentrated almost entirely on regulating interest rates. But the interest rate is not the key variable in the leverage cycle, and most of the time, as shown by the theoretical models, they barely move. Hence, collateral equilibrium models and the leverage cycle theory suggest that it might be more effective to stabilize leverage than to stabilize interest rates. This point has be made in several papers such as Geanakoplos (2010), Garleanu-Pedersen (2012), Geanakoplos-Pedersen (2011) and Fostel-Geanakoplos (forthcoming).

Fostel-Geanakoplos (forthcoming) and Geanakoplos-Kubler (2013) show that restricting asset leverage ex-ante can be a Pareto improving policy. The main intuitive reason why restricting leverage can lead to pareto improvements is that curtailing credit will lead to relative price changes in the future, which will have redistributive consequences that may be overall beneficial. In particular, restricting leverage ex-ante may cause an increase in asset prices in the future and hence can cause a reduction in the number of defaults.

Access to this type of public data of leverage at the institution and security level (properly aggregated) can be very very valuable for crisis prevention, detection and

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[8]For the effect of collateral on investment and production see Fostel-Geanakoplos (2013b).

post-management. Moreover, leverage has the advantage of being a model-free measure of systemic risk. In what follows we discuss two important ideas regarding measuring and monitoring leverage.[9]

Asset-based leverage vs Investor-based leverage

In order to properly monitor leverage it is important to distinguish between investor-based leverage and asset-based leverage.

The balance sheet approach to leverage is an important one. Investor-based leverage data is ultimately a clear indicator of a financial institution's ability to repay the loan. For example, even in the case a bank holds in its balance sheet highly leverage assets, this may not necessarily create default risk if it also holds large liquidity reserves.

Recent policy responses to deal with financial regulation, including Basil III, have focused on imposing leverage caps at the institution level in the form of debt/equity limits. However, as discussed in Geanakoplos (2010) and Geanakoplos-Pedersen (2011), this approach has several problems. First, leverage will migrate from regulated institutions to un-regulated ones in the shadow banking system due to regulatory arbitrage. Second, an institution-based cap on leverage will incentivize each institution to shift towards more risky securities. Banks can leverage a lot against say Treasury Bills and much less against risky securities, so a cap on total leverage, without regard to asset type, will induce a balance sheet re-composition towards less leverage and riskier securities. Third, balance sheet leverage poses the question of how to treat some crucial securities such as CDS; should we consider them as debt or equity? Basel III proposes to treat them as debt, in the amount equal to their total payment in case of 100% default; this clearly grossly overstates leverage. Finally, measuring

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[9]For a more detailed treatment see Geanakoplos (2010) and Geanakoplos-Pedersen (2011).

leverage by balance sheet debt to equity ratios could pose measurement problems, since balance sheet data only includes old loans (more of this below).

For these reasons, it is crucial that financial regulation focuses on regulating leverage at the security level (irrespective of borrower or lender) as well. Leverage across all asset classes should be systematically gathered and properly aggregated. Moreover, leverage should be recorded also for those asset classes with 100% margin (those assets that cannot be used as collateral) in order to avoid bias. Tracking leverage is not only about margin levels but also about keeping track of which assets classes are being used as collateral. This also provides relevant information about credit conditions.

Finally, asset-based leverage has the advantage that is agent-independent. Hence, measuring and managing leverage at the security level may be easier to implement and politically more feasible.

Old Leverage vs New Leverage

Another crucial distinction when measuring and monitoring leverage is that of old loans vs new loans. One of the problems mentioned before with the balance-sheet approach to leverage is that it does not distinguish the leverage of old loans from new loans and thus may not be a timely indicator of increase risk of a crisis.

Leverage of old loans and new loans go in opposite directions: when market conditions deteriorate leverage on old loans goes up whereas on new loans collapses. The old leverage in the balance sheet is backward looking and changes only gradually over time by construction. On the other hand, leverage of new loans provides timely information on the current credit environment. Hence, the average leverage on old loans evolves slowly and reflects the credit environment over the past time period

while leverage on new debt can abruptly change.

Incidentally, the lack of measurement on new loans is what drives one of the most important results in Reinhart-Rogoff (2009): de-leveraging on average begins two years after a crisis. It is important to understand that de-leveraging is a key element of a crisis as we discussed before in the theory section, and not a lagged consequence of it.

In short, it is crucial for proper crisis management to keep track not only of leverage on old loans but also of leverage (i.e., down payments or margin requirements) on new loans. Leverage and margins should be recorded every time an asset is used as collateral.

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