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The Macroprudential Toolkit

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Abstract

Most treatments of financial regulation worry about threats to the banking system and the economy from defaults or credit crunches. This paper argues that the recent crisis points to fire sales through capital markets as another source of financial and economic instability. Accounting for fire sales implies several changes to the standard approach. First, if there are three channels of instability, then three regulatory tools are needed to deliver stability. Second, if only a single capital tool and a single liquidity tool are available, then there is a risk that using them pushes activity into the shadow banking system. Third, liquidity requirements on the asset side of bank balance sheets are conceptually different than liquidity requirements on the liability side.

The paper starts with a review of the recent theoretical work on fire sales that form the building blocks for a next generation of models of the financial system. A summary of some evidence suggesting that fire sales were present in the crisis is offered. Next a general equilibrium model of the financial system in which default, credit crunches and fire sales are all possible is presented. The paper concludes with a discussion of the regulatory options and speculation on how the model could be extended.

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1. Introduction

This paper asks a series of questions about how a systemic regulator might operate to avoid a replay of 2007 to 2009. The ultimate causes of the crisis are still being debated, as are the full set of costs, but there seems to be broad agreement that during the credit boom, excessive leverage contributed to the extent of the crisis, and that starting in late 2007 deleveraging became a serious problem. We argue that a central lesson from the crisis is that fire sales are a likely, and damaging, consequence of deleveraging, because they magnify the effects of the resulting credit crunch on economic performance. Therefore, besides acting to mitigate the leverage cycle, a successful systemic regulator will need a way to combat fire sales and, more fundamentally, build incentives into the system that limit the factors that cause and propagate them.

While many observers of the crisis assign a prominent role to fire sales in the crisis, there has been little work on how this should impact regulation. For example, the only change implemented so far as part of the so-called "Basel 3" reforms of bank regulation, apply to capital levels at banks. Eventually, banks will also be required to change their funding structure to rely on less short-term financing, and perhaps also to hold more assets that are liquid (i.e. can be sold even in times of stress without moving prices much). Should we expect this package of policies to be enough to head off another deleveraging event?

The answer surely depends on whether stabilizing the banking sector is enough to stabilize the whole financial system. Hanson, Kashyap and Stein (2010) argue that one risk with the current thrust of regulation is that it will create powerful incentives to move financing from the banking system to unregulated financial institutions and securitization, or what is loosely termed the "shadow banking system". The crisis also showed that market financing arrangements and non-bank financial institutions (NBFIs) can be fragile and can cause systemic problems. In particular, the failure of some NBFIs such as Lehman Brothers caused some of the biggest problems in the crisis. Likewise, the breakdown of securitization led to reductions in credit availability. Hence, the full set of problems faced by regulators potentially includes defaults, credit crunches and fire sales that occur not just across institutions but also across securities and assets. A satisfactory regulatory toolkit must account for all three of these channels.

In the remainder of this paper we explore implications of this view. We compare various tools for mitigating defaults, credit crunches and fire-sales and investigate what happens if the regulator has only two tools to combat these three problems. To do this we describe some comparisons of different outcomes for a general equilibrium model proposed by Goodhart, Kashyap, Osorio and Tsomocos (2010) (GKOT) that allows for each of the three channels. The main conclusion from this investigation is financial stability cannot be delivered with only two tools when there are three sources of instability.

The outline of the paper is as follows. Because there is a well-established literature on defaults and credit crunches, we begin with a brief review of the theory and evidence regarding our third source of instability: fire sales. Most macro models simply do not allow for fire sales; this analysis suggests several ingredients that should be part of an adequate model of the financial system to capture these phenomena.

The next section of the paper describes the GKOT model that embodies these ingredients. The model is decidedly reduced-form, in that it does not micro-found the individual pieces of the model. Instead it is designed to explore the general equilibrium consequences of different regulatory restrictions. While the set up is necessarily somewhat complicated, most of the critical linkages are quite intuitive. We describe the interesting interactions between different regulatory constraints.

The concluding section of the paper focuses on the gaps identified by the model in the current regulatory toolkit and asks how they might be filled and what we might expect if they are not. We also step outside of the model and identify some of the real world challenges and responses to gaps in the regulatory toolkit.

2. Deleveraging and Fire Sales

Many accounts of the crisis, especially after the failure of Lehman Brothers in September 2008, point to fire sales as having occurred. For instance, Federal Reserve Chairman Ben Bernanke, in summarizing his lessons from the crisis for economic research said “a vicious circle sometimes developed in which investor concerns about the solvency of financial firms led to runs: To obtain critically needed liquidity, firms were forced to sell assets quickly, but these "fire sales" drove down asset prices and reinforced investor concerns about the solvency of the firms.” While this view is widely shared, research documenting the role of fire sales in the crisis and modeling its causes and consequences are just emerging.[1] Because we argue that this dynamic was so central to the crisis, we begin with a summary of three recent models that highlight different aspects of fire sales. These ingredients will be built into the model that is sketched in Section 3. We then briefly summarize some empirical evidence regarding fire sales during the crisis.

2.1 The Theory of Fire Sales

An excellent starting point for anyone interested in understanding fire sales is the recent survey of Shleifer and Vishny (2010b). They sketch the historical development of the literature, propose a unifying definition of and framework for characterizing fire sales, and review some of

[1] Similar assessments are offered by French et al (2010) and the US Treasury (2009).

the most important empirical evidence showing the existence of fire sales. Rather than rehashing all of this, we focus our summary on the variants of the theory that are most relevant for the crisis and motivate the model that we describe in the next section.

We adopt the Shleifer-Vishny (2010b) definition whereby a fire sale is "essentially a forced sale of an asset at a dislocated price. A sale is forced in the sense that the seller cannot wait to raise cash, usually because he owes that cash to someone else. The price is dislocated because the highest potential bidders are typically involved in a similar activity as the seller, and are therefore themselves in a similar financial position. Rather than bidding for the asset, they might be selling similar assets themselves."

There are two recent papers, Shleifer and Vishny (2010a) and Diamond and Rajan (2010), that are particularly helpful in thinking about the role of banks in contributing to fire sales for financial assets (as opposed say to operating assets, such as airplanes). By their nature, banks are exposed to the possibility of rapid customer withdrawals. Hence, regardless of whether the reason for such withdrawals is be due to fundamental liquidity needs or panic, banks can certainly find themselves being forced to sell assets to service redemptions. Put differently, the forced sale condition is an obvious possibility for banks.

Diamond and Rajan (2010) presume that banks hold some assets that have a limited set of natural buyers, and other very liquid assets. So they effectively assume that if the banks are forced to sell an unexpectedly large amount of the illiquid asset it is possible that there will be insufficient buyers and prices will fall below the value that an unconstrained informed buyer would pay. The focus of their model is the precautionary steps the banks will take to when there is an elevated probability of having to sell into a fire sale.

The interesting case occurs when a large enough deposit outflow happens so that when the bank has to sell assets it becomes insolvent. In that case, they ask whether the banks will want to sell some illiquid assets ahead of time to eliminate their risk of failing? Their analysis of this question delivers a sharp result: the bank will always want to gamble and risk failure, rather than taking available pre-cautions to prevent failure.

The basis for this result is quite intuitive and rests on three observations. First, if the shock will render a bank insolvent then it must be the case that the likely resultant fire sale is extreme with asset prices dropping substantially. But in that case, the rate of return given the fire sale will be extraordinary. Second, if a fire sale is possible, then prices ahead of time must reflect that as well to produce willing buyers. So the fear of the fire sale in the future partially depresses today's prices. Selling today is like buying actuarially fair insurance against the fire sale. Hence the choice of selling the illiquid asset ahead of time amounts to extinguishing the option to profit from the bounce-back in prices if no fire sale occurs. Finally, the equity holders' profits are all derived from scenarios where the firm remains solvent, and thus they do not care that their actions make the extent of the fire sale more severe than necessary.

Together these three considerations lead the bank owners to view pre-cautionary asset sales unfavorably. Essentially the equity holders put little weight on prevention because so much their returns disappear when they shed liquidity risk. Banks would prefer to take even more of these liquidity risks at market prices (making the future fire sale worse), instead of reducing these risks.

Shleifer and Vishny (2010a) have a closely related result. In their set up, banks are subject to swings in investor sentiment that can push prices away from fundamental valuations. Their banks face the choice between holding loans directly or securitizing them. If a bubble develops banks must decide whether to ride it by expanding the balance sheet as far as possible using securitization. In making this choice, the banks understand that a change in sentiment and crash in prices is possible, but as in Diamond and Rajan (2010), the incentive to take precautions against the crash are overwhelmed by the drive to maximize profits. This occurs because securitization profits depend on the willingness of investors to buy securitized loans at high prices. Moreover, in the case emphasized by Shleifer and Vishny returns from securitization in the boom are much higher than returns from direct lending or from buying distressed assets after a price drop. Hence, banks leverage themselves fully in the boom to securitize more while they can, even if a price drop is likely and they are likely to experience some losses on their loan inventories.[2]

When prices do crash, the banks will be seriously under-capitalized and will have to cut back lending (which by assumption in their model generates a credit crunch and less investment for the overall economy). This effect is more powerful if banks have been able to take on leverage to engage in additional securitization. If they are levered, the crash forces the banks to sell assets to cover losses, so that the initial price decline is amplified.

In the model described in the next section we incorporate many of these ideas. In particular, the banks will be levered and will profit from securitizing loans. There will not be any natural force in the model that creates incentives for a bank to preserve dry powder (i.e. liquid assets) that can be deployed in a fire sale. We will explore how regulation might change this outcome.

The second set of theoretical models, which we draw upon, presumes that disagreements about valuations can be an important factor in influencing market dynamics. Well before the crisis, Geanakoplos (1997, 2003) had argued that if investors have different beliefs about future prices and borrowing is possible, then optimists will borrow to buy securities and this leverage will

[2] As they point out, if there is uncertainty about how long the bubble persists, the incentives to securitize become even more powerful because then the option to securitize at even higher prices comes into play.

make the financial system fragile. Geanakoplos (2009) presents a model of this type and shows that if bad news arrives, the news will cause prices to fall for three separate reasons. First, the bad news directly lowers expectations about the fundamental value of assets and hence lowers prices. Second, some optimists lever up to reflect their optimism and hence will be wiped out when the bad news comes. They are will be replaced by less optimistic buyers which also leads to lower prices. Finally, the new buyers may again want to borrow to finance some of their purchases. But, their willingness to use leverage is always lower than the initial optimists, and this endogenous decline in desired leverage will further reduce prices.

These effects can be particularly important when assets are being financed by secured borrowing, as in a repurchase agreement. In that case, if prices decline, then the value of the assets when they are offered as collateral falls too. This creates a funding problem for the borrowers who must come up with additional resources to fill in for the lost collateral value. If the borrowers decide simply to cut back on their purchases, this can reduce prices further, and create a further price drop and another hit to collateral values – see Gromb and Vayanos (2002) for an early model of this sort. This problem gets worse still if the lenders change the "haircuts", the amount of equity that must be added for a given amount of collateral, as the collateral values fall.

Many observers have argued that this dynamic was central to the crisis. Brunnermeier and Pederson (2009) offer a model where security prices and haircuts are jointly determined. This mechanism gives rise to fire sales as an initial price decline combined with an increase in haircuts creates a spiral of further declines in prices and increases in haircuts. Adrian and Shin (2010a and 2010b) show how monetary policy can interact with these incentives to exacerbate leverage cycles and how the use of value-at-risk models by banks can lead to similar dynamics.

The model we describe embeds some of these elements as well. In particular, in the model non-bank financial institutions (NBFIs) buy securitized assets from banks and finance their portfolio with repurchase agreements. The NBFIs are more willing to take on risk than the banks, and will stretch their balance sheets as much as they can given the limits on their financing. If prices drop then the NBFIs will be wiped out and return collateral to the banks. The banks suffer losses and may have to sell additional assets to honor their short term promises. The additional sales can be thought of as a fire sale. We do not have endogenous haircut dynamics in the model but can study how minimum haircut regulation can change price dynamics.

2.2 Evidence on fire sales

Proving the existence of a fire sale is challenging since we can never be confident about the exact fundamental value of a security. Indeed, there is usually some news that is associated with any sale, so proving that subsequent prices are dislocated is difficult.

As mentioned above, a necessary condition for the existence of fire sales is absence of informed buyers who stand willing to bid for assets that are offered. One piece of indirect evidence for fire sales is the breakdown of arbitrage trades. One remarkable thing about the last few months of 2008 was the failure of a number of relative prices to adhere to their normal patterns. Perhaps the most striking example is the breakdown of covered interest parity (CIP). As explained by Griffoli and Ranaldo (2010) “basic CIP arbitrage entails borrowing in one currency and lending in another to take advantage of the interest rate differential while avoiding exchange rate risk.”

Griffoli and Ranaldo show that the excess returns associated with CIP are normally tiny and fleeting. Following the failure of Lehman Brothers, however, the returns on trades that involve short positions in dollars skyrocket: rising to over 3 percentage points (on an annualized basis) immediately after the failure, but staying above 1 percent for several months. Importantly, CIP continued to hold for other currency pairs that did not involve dollars. So the evidence points strongly towards frictions that prevented the hedge funds and proprietary trading desks that normally dominate trading in these markets from shorting the dollar.

Over the same period Campbell, Shiller and Viceira (2009) show that the prices of U.S. inflation protected treasury securities (commonly called TIPS) and conventional US government bond prices moved in unusual ways. Yields on TIPS surged shortly after Lehman failed, while conventional yields dropped. The difference, that market participants usually refer to as the implied break even rate for inflation, dropped precipitously and was negative for the last two months of 2008.

Campbell et al point out several reasons why these developments were surprising. First, there was an emerging consensus that TIPS yields and conventional yields were beginning to move in lock step. Indeed, Brière and Signori, whose paper appeared in print in March 2009, conclude that inflation linked bonds since 2003 no longer provided diversification benefits relative to conventional bonds.

Second, while one can argue whether an abrupt swing in inflation expectations with implied forecasts suddenly moving towards zero for many years is plausible, this hypothesis is actually testable. Jonathan Wright (2009), in his published comment on the paper, offers one such test. He compares yields on five year nominal bonds and TIPS that were both issued in the spring of 2008. TIPS bring compensation for inflation and are protected from deflation, so TIPS prices should be strictly higher than similar maturity conventional bonds. Yet starting right after Lehman failed until early 2009 this ceased to be true.

Finally, Campbell et al. cite various reports from market observers that argue the pricing anomaly occurred because Lehman had many TIPS that it was using as collateral and after the bankruptcy this collateral was turned over to counterparties that were owed money by Lehman. In this situation the counterparty has no incentive to worry about the price impact of selling the asset; as long the proceeds from the sale exceed the amount the counterparty is due, the counterparty is protected. The only cost of selling quickly (if doing so reduced prices) is that the amount returned to Lehman's estate would be reduced. On the other hand, hanging on to the TIPS would risk that prices could fall and eliminate the cushion, so the counterparty might lost money. This asymmetry creates a powerful incentive to sell quickly. Federal Reserve data on broker dealer transactions for TIPS shows a huge spike in trading activity the week that Lehman failed. Many hedge funds which normally step in to buy were suffering losses on other asset classes, so when the TIPS were sold, prices moved noticeably.

There many other trades that others have discussed that show similar patterns. For example, Duffie (2010) describes anomalies involving bond yield spreads and credit default swaps. Normally the combined return of buying both a risky corporate bond and the protection against default on the bond tracks the return on a government security without any default risk. This relationship broke down in late 2008 before returning to normal in 2009.

Similarly, Mitchell and Pulvino (2010) describe convergence trades related to convertible bonds. They construct a theoretical benchmark price for these bonds over the 1990s and 2000s and show that on average, for their sample of over 3000 bonds, prices are within 0.5% of the benchmark. But between September and November 2008, the normal pricing rules broke. According to Mitchell and Pulvino inability to obtain funding led to transactions occurring far below the theoretical benchmark: discounts of above 10% prevailed for weeks after the Lehman failure. Relative to data from 1990 until August 2008 these observations were more than 8 standard deviations away from the mean pricing error.

Taken together these observations suggest that some investors appear to have been definitely constrained in ways that are unusual. The dislocations were not confined to a single market or type of trade. Hence, it seems reasonable to conclude that in times of stress many natural buyers, for whatever reason, are not active.

Suggestive evidence in favor of the margin spiral mechanism is provided by Gorton and Metrick (2010). Their basic story is that losses on subprime mortgages led to deterioration in bank health that then led to credit availability problems for borrowers that were not directly connected to subprime markets. Data limitations make this difficult to substantiate, so to tell the story they bring together a couple pieces of evidence.

First, they note that many financial institutions are heavily dependent on the financing that they raise through repurchase agreements. For repo transactions, the haircuts reflect the confidence that suppliers of funds have in the financial institutions. If haircuts rise then the financial institutions need to find alternative financing.

Next, they show that the steady deterioration in the credit quality of subprime loans was not continuously mirrored in the interbank markets. Rather interbank lending rates jump after August of 2007 and then deteriorated again sharply after Lehman failed in September 2008; in contrast, estimates of subprime credit quality trended down steadily. But during the crisis it appears that were distinct shifts in banks' confidence in each other's creditworthiness.

Third, they show that when banks became reluctant to each other, banks other lenders became hesitant to accept collateral at the usual prices, even for collateral that was not housing related. The haircuts on student loans, auto loans and credit cards all jump after the interbank market becomes acutely stressed. We know also that prices of these securities began to fall at the same time. As interbank lending rates came down, haircuts also dropped.

Ideally one would like to show that the haircut changes begat price declines, which brought further increases in haircuts and another round of price declines. Unfortunately, consistent, reliable high frequency data of this type are not available. So all Gorton and Metrick can show is a remarkable coincidence in the timing of price changes and haircut movements.

3. A General Equilibrium Model for Studying Macroprudential Tools

To explore the implications of fire sales we need a model. This is challenging since there is not a workhorse model that rationalizes the standard regulatory tools of capital and liquidity requirements, let alone one that includes also the possibility of fire sales. Fortunately work by Goodhart, Tsomocos and Vardoulakis (2010) and Goodhart, Osorio and Tsomocos (2010) contain the building blocks that are needed to analyze these questions. Goodhart, Kashyap, Osorio, and Tsomocos (2010) assemble these building blocks to create a model that is suitable for analyzing these issues. Not surprisingly given all the ingredients the resulting model is complicated, so we summarize its main components and implications for macroprudential regulation.

3.1 Assumptions

The Goodhart, Kashyap, Osorio, and Tsomocos (GKOT) model has 6 main actors, three types of households, two financial institutions and a passive central bank. The heterogeneity is necessary to generate motives for and gains from trade and risk-sharing. GKOT consider two types of assets that provide utility: "housing" (which is durable) and "potatoes" (which are not durable). There is an initial time period during which trade occurs and then a second period for which there is uncertainty.

One household (R) is very well endowed with "housing" and it operates in both periods. A second household (P) is less well endowed with "potatoes" and operates in both periods. The third household (F) enters the market only in the second period and is endowed only with potatoes; the necessity of allowing for this first time home buyer will be clear shortly.

The differences in endowment motivate trade. The R household will be selling homes to finance its consumption of potatoes, while the P household will need to borrow to buy housing. In the initial period P and R trade to correct for their different endowments.

The second period has a minimal amount of uncertainty, with one "good" outcome in which house prices rise modestly and a second, "bad", state of nature in which house prices collapse. The collapse state is presumably rare but provides a simple way to study a crisis.

The new household, F, appears in the second period because if the set of actors was unchanged, then defaults on housing loans would not matter because the defaulting borrowers would wind up owning the houses again. So absent another set of buyers the model would not be very interesting.

The financial system is made up a bank (β) and a non-bank financial institution (N), both of which are risk-averse. The bank has higher capital and more risk aversion than the other institution. The risk aversion is meant as a stand in for other frictions that make defaults sufficiently unpleasant that the financial institutions have a motive for avoiding them.[3]

The bank does all the lending and deposit-taking as far as the households are concerned. The bank makes two types of loans. Some are long term loans to the poor households that need to borrow to finance house purchases. Others are short-term bridge loans to finance consumption of the rich households who have a timing mismatch between their need to purchase goods and receipts from selling houses. The bank makes an active choice about whether to hang onto the long term loans or to securitize them. The bank faces capital requirements on the loans that remain on its balance sheet, with the risk weights depending on the expected risk of the loans. The bank can also invest in cash, which pays no interest but provides diversification benefits in the event of a house price crash.

The banks fund themselves with long term deposits from the rich households and borrowing from the central bank. The central bank provides banks with short term debt that is impossible to default upon. This is a shortcut that captures the idea that suppliers of this funding will shorten the maturity of loans to guarantee repayment when risks are looming.

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[3] If one takes the standard approach of making the financial institutions risk neutral, then one is led to corner solution allocations if bankruptcy costs are linear.

N buys housing loans that are securitized by the banking sector and funds them through repurchase agreements with the banks; we call these transactions securitized interbank loans. Figure 1 summarizes the flows between the different actors in the economy.

3.2 Equilibrium

The bank and the other financial institution compete to supply housing finance. Because N is willing to tolerate more risk and the bank can borrow at low rates from the central bank, there will be a tendency for the bank to use short term financing to extend housing loans which are then securitized and sold to N. An important consideration that limits this tendency is the default risk on the interbank loans. The banks also trade off making short-term safe bridge loans against riskier long-term housing loans.

Hence the bank is equating three margins on loans: the profits from holding loans directly on the balance sheet that must be financed by a mix of deposits plus capital (where less capital is needed for bridge loans than housing loans) and the return on securitized loans that involve extending credit via interbank loans.

There are two possible states of nature in the second period. The model's parameters and endowments are set so that in the more likely scenario house prices rise modestly and there are no defaults. In the other less likely case, house prices crash and all the potential sources of financial instability come into play.

In the crisis state, homeowners default on their mortgages. When that happens, the value of the securities that are tied to the houses falls and the cash flows to the N drop. This leads the N to default on the repo agreement, and it returns the collateral to the bank.

Following the interbank default, there are potentially three sources of spillovers. First, the losses born by the bank can cause it to reduce lending to the households. This can happen because the banks will have to use some of their equity to make up for the losses on the mortgages. So households who are seeking normal financing (and whose own credit risk has not changed) will find that nonetheless that their borrowing costs have changed. This contraction in loan supply can be called a credit crunch.

GKOT rule out the possibility of the bank simply raising enough capital to replace the capital lost as a result of the default. It is possible to complicate the model to allow this, but the structure of the model implies that as long as there are some rising marginal costs of raising outside equity, such as adverse selection, then banks will not immediately want to make up all the losses. So the extreme assumption in GKOT does not change anything important.[4]

Second, the default in the interbank market leaves the banks with mortgages that are in default. The associated losses can also lead the bank to default partially on its long term deposit contracts. The bank suffers a reputational cost from this default but the depositors have to cut consumption. This means that some households who have not defaulted on any obligations suffer losses because of the problems in the banking system.

In addition, when the bank resells the houses it has repossessed, the houses will be priced based on the amount of potatoes that the potential buyers will have to trade for them. (Had there not been a default, then essentially the total supply of potatoes in both periods would be relevant for pricing the houses.) This will mean that price of potatoes will rise and the rich household will be able to buy fewer potatoes. But this general shift in relative prices seems like a robust, inevitable consequence of a house price collapse that would hold in any sensible model.

Third, after the interbank default the banks might have to sell other assets to pay off deposits. If they do this by selling housing loans, then the relative price of potatoes will rise further. This second round reduction in house prices reduces the value of house prices as collateral which is another spillover. This second round sale can be interpreted as fire sale in the sense of Shleifer and Vishny (2010b): the sale is forced in that the banks must do it to honor their deposit contract, and the non bank financial institutions are broke which depresses the level of house prices.

3.3 Regulatory implications

There are no Pareto improvements that can be made through regulation in this model. So regulations that make the crash in house prices less devastating come at the expense of making households worse off in the good state. But this strikes us as the realistic case where regulation has both costs and benefits. Indeed, regulation is only necessary and interesting if it constrains firms from making choices that they would prefer. Unfortunately, this suggests that quantitative analysis of regulation requires knowledge of these costs and benefits and this knowledge is relatively limited.

Nonetheless, the model yields some interesting observations about the regulatory toolkit. First and most importantly, given that there are three potential inefficiencies associated with the house price collapse, intuitively we would expect it to take three tools to mitigate the problems. This

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[4] Tsomocos (2003), working with a variant of this model, goes a step in this direction by allowing secondary market trading in equity after losses are realized. With rational expectations the secondary market prices are anticipated by the bank so it understands there is a risk of undercapitalization.

suggests that we would not expect a combination of only a requirement on capital and a single liquidity requirement to be the most efficient way to limit the damage from the house price decline. Instead, the model provides some insights about the efficacy of different tools. Besides restrictions on capital and liquidity, the GKOT set up can be used to study rules that constrain the non-bank financial institution by forcing it to post higher margins (i.e. face larger haircuts from the banks) in its repo transactions.

In the final version of this paper we will review some specific experiments in the GKOT model from varying capital, liquidity and haircut rules. At this point we describe the structural features of how the regulations operate in the model.

Capital requirements have two effects. First, holding everything else constant, a bank with more capital will have a bigger buffer to guard against losses that follow from the house price drop. The buffer will better insulate the long term depositors from the house price drop and also permit more lending by the bank. Second, there is an endogenous response whereby the amount of lending done by the bank in the initial period when capital requirements are raised. Because housing loans carry a higher capital charge, the bank will want to make fewer of those loans.

Haircuts alter the way that the interbank loans would operate. When N is forced to post more of its own capital to take on the securitized home loans, it will do less of this activity. This means that when the housing collapse comes, the size of the interbank default is reduced and the spillover effects are lowered.

There are two types of potential liquidity requirements. One operates on the asset side of bank's balance sheet, which we call Liquidity A, and forces the bank to keep less housing loans on its balance sheet than it would otherwise. Holding all else equal, when the interbank default occurs the Liquidity A regulation will mean that bank has a larger pool of cash that can be used to pay off depositors. This reduces potential fire-sale spillovers.[5]

Liquidity requirements can also be started as restrictions on the liability-side of the bank's balance sheet, which we dub Liquidity-L rules. In this case the regulation will limit the amount of short-term funding that bank use. A Liquidity-L regulation will reduce the amount of securitization and hence the size of an interbank default, making the consequences of the default less of a problem. In this sense it operates like a capital requirement – both have the effect of pushing the bank toward longer term funding that can absorb losses when loans are not fully paid.

There are many interesting questions that can be asked with the model. For example, we can look at how the substitutability of different regulations. One particularly interesting case is how

[5] There is a possible indirect effect whereby the bank holds more liquid assets but also securitizes more loans than it would otherwise, but in GKOT's numerical analysis this effect is inconsequential.

far the absence of haircut regulation can be compensated by other rules. We will report some of these comparisons in the final version of the paper.

4. Conclusions and Open Questions

The GKOT model is helpful for formalizing intuition and yields some observations about regulatory choices that we believe are relatively general. For example, in the presence of these sources of instability regulators need three tools to deliver stability. Likewise, the model suggests that clamping down on banks will move activity to the shadow banking system.. A third generic observation is that the Liquidity-L and Liquidity-A regulations solve different problems and should not be thought of as being inter-changeable.

Indeed, the logic behind imposing a Liquidity-A regulation is somewhat subtle. As we saw in this current crisis, a determined central bank can provide support to many markets so that dysfunctional markets can be made liquid. But for this to work consistently requirements many things to fall into line. Once a market has broken down, buying assets puts the government at risk for overpaying which may bring political resistance. So part of what one buys with Liquidity-A requirements is time for the government to consider other options. But in some countries restrictions on what central banks can buy may be a constraint. In this case, a Liquidity-A regulation brings some direct protection against fire sales that might not otherwise be possible.

The model at this stage is still incomplete in several important respects. One simplification is the structure of the financial system, where there is only one type of non-bank institution which derives all its funding from the banking system. This is a useful starting point but some of its implications should be taken with caution.

For example, this setup suggests that once the regulator has three tools to deal with credit crunches, fire sales and defaults, the regulator can substantially reduce the threats posed by each of these channels. Thus, the Liquidity-L regulations and haircuts in this model operate in very similar ways by limiting a fire sale after an inter-bank default. But near equivalence seems unlikely to carry over to more general models.

Regulations on haircuts that are asset specific and apply regardless of who owns the asset will create buffers that liquidity-L rules would not. So if new financing structures develop to facilitate leveraged financing haircut rules would naturally limit these strategies. Liquidity-L rules only operate by potentially preventing the institutions to which the liquidity rules apply from contributing to a fire sale. So a market meltdown involving institutions not subject to the Liquidity-L regulations would still be possible.

As mentioned earlier, the benefits of regulation are not well developed. Without having spelled out the specific externalities that follow from the defaults, it is not possible to discuss bailout policies. Hence, as of now we cannot address some of the most controversial regulatory choices.

A more specific variant of this problem in the model's implicit assumption of no knock-on costs from the damage done to households when they default; the defaulting households are assumed to suffer a reputational cost from defaulting, but the model has no aggregate effects associated with a large number of defaults. We believe that if household balance sheets are impaired that the economy functions poorly even if financial institutions are healthy. If this assumption is correct, then tools which are equivalent in their ability to insulate the financial system are not necessarily the same. If one tool limits household exposure to risk more than another, then that tool should be preferred.

Finally the model does not provide much guidance on the key issues regarding the "optimal" level of capital and liquidity requirements. Eventually a full multi-period version of the model can be developed where the parameters are calibrated realistically. But in the meantime, the model's implications about the levels of regulatory tools and how they might change over the business and credit cycle are not very informative. The financial system is inherently pro-cyclical. The model, and common sense, tells us that delivering financial stability requires constraining financing during a boom. But deciding how far to go in this quest will be one of the most challenging issues for regulators.

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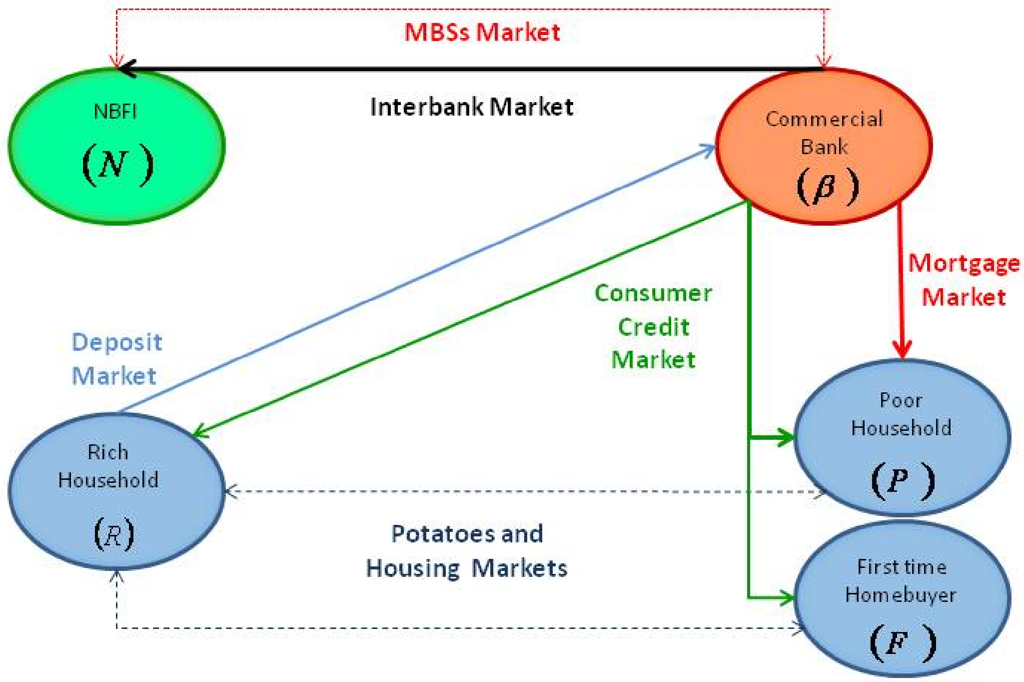
Figure 1 Nominal Flows in the Goodhart, Kashyap, Osorio, Tsomocos (2010) model



The straight lines and their direction represent lending flows. The dashed lines indicate trade.