

Macroeconomic Stabilization and the Magnitude of Financial Crises

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Very preliminary and incomplete

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Abstract

The recent financial crisis revealed a large exposure to systemic risk of the financial sector after a relatively long period of high aggregate stability. This period of low macroeconomic fluctuations, also called the Great Moderation, is often attributed to a successful policy of stabilization, including improvements in the conduct of monetary policy. This paper argues, using a standard banking model with inefficient borrowing, that such stabilization policies during moderate times can increase the magnitude of a financial crisis due to higher optimal risk exposure by financial intermediaries. Taking into account amplification effects during a crisis, a stabilization policy may also result in higher aggregate volatility of output and lower aggregate welfare. Using historical data, this paper also provides empirical support for a link between macroeconomic stability and the severity of financial crises.

JEL classification:

Keywords:

1 Introduction

Since the mid-1980s, the western world has experienced a significant reduction in the volatility of the business cycle, a phenomenon often referred to as the Great Moderation. Among others, this reduction in volatility is attributed to improvements in government stabilization policies, mainly monetary policy. This episode seems to have come to an end in 2007, when the financial crisis hit the economy leading to large losses in output.

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This paper investigates how an environment of low aggregate fluctuations in normal times, possibly resulting from a successful stabilization policy, may affect risk taking of the financial sector and therefore the magnitude of a financial crisis that occurs with low probability. I first use historical time series provided by Schularick and Taylor (2012) to establish that after a period of low aggregate fluctuations, financial crises are more likely to occur and, if they occur, have a more severe impact on the real economy. Using an extended version of the bank risk taking model of Stein (2011), I then show that a policy that successfully stabilizes fluctuations in normal times may induce rational financial intermediaries to expose themselves to larger liquidity risk. In case of a severe adverse shock to the system, the high risk exposure will increase the output losses during the crisis. Due to a crisis amplification mechanism in the form of a fire sales spiral, overall volatility may rise in response to the stabilization policy, reducing aggregate welfare.

In this model, banks may raise funds to invest in a modern sector by issuing short term or long term debt. Riskless short term debt is cheaper, since it serves households as privately created money, but exposes banks to liquidity risk in case of low returns in an intermediate period. If an adverse shock lowers intermediate returns, banks need to liquidate projects and sell capital to a traditional sector in order to finance the repayment of short term debt. Due to the aggregate nature of this shock and hence the need for liquidity throughout the financial sector, the large supply of capital will put pressure on its price, triggering more liquidation of investments and resulting in large output losses. Since asset prices enter the borrowing constraint of banks, this pecuniary externality can lead to inefficient high levels of short term borrowing and exposure to liquidity risk.

I consider a version of this model with three possible aggregate states, which affect the intermediate returns of the investment project. The economy may be in a good or a bad state, representing the regular fluctuations of booms and recession, or in a low probability state with a liquidity crunch. While the event of a liquidity crunch is exogenous, its consequences and the size of an eventual fire sale crisis are endogenously determined by the risk taking of the banks. The considered stabilization policy can reduce the size of fluctuations between good and bad times, but is ineffective when a crisis hits the economy. As a first order effect, this reduces aggregate fluctuations, but may also affect the risk taking decision of the financial sector. To avoid costly asset liquidation in bad times, banks limit the amount of short term debt issued. A policy that mitigates normal times fluctuations reduces the containing effect of the bad state, leading to higher levels of short term borrowing and liquidity risk exposure. If hit by a crisis shock, the economy will suffer larger output losses, and due to amplification effects, the policy can lead to an increase in volatility of aggregate output.

(Literature review)

The rest of this paper is organized as follows. Chapter 2 provides empirical support for the effect of macroeconomic stability on the likeliness and the severity of a financial crises event. A simple model of financial sector risk exposure is presented in chapter 3, effects of a stabilization policy are analyzed in chapter 4. Finally, chapter 5 concludes.

2 Empirical evidence

To investigate an empirical relation between macroeconomic stability and financial crises, I use the dataset provided by Schularick and Taylor (2012), containing annual series for economic and financial data covering 14 countries. The data set also provides country specific identifiers for financial crises events ¹. To establish a correlation between the impact of a financial crises and the volatility of the macroeconomic environment, I estimate equations of the form

$$dgdp_{c,t} = \delta_0 + \gamma * vol8_{c,t} + \delta_1 * dgdp8_{c,t} + \delta_1 * y_t + \sum_{c \in C} \beta_c * I_c \quad (1)$$

where $dgdp$ is the growth rate of real gdp during a financial crises event, $vol8$ is the variance of real gdp growth in the 8 years before the crises², $dgdp8$ us the mean growth rate of real gdp in the 8 years bofre the crises, y_t is a time trend and I_c are country fixed effects. Results from OLS estimations of variations of this specification are reported in columns 1-4 of table 1.

In all specifications, the estimate of the coefficient γ is positive and significant, indicating that financial crises following a period of high macroeconomic fluctuations tend to have a less severe impact on gdp growth. Or vice versa, financial crises that follow after years of stable gdp growth tend to have a more severe impact on the real economy. This result is also robust controlling for a time trend, country fixed effects, and the level of gdp growth in the years before the crises. The latter confirms that we are not capturing a boom-bust cycle of gdp growth, but indeed an effect of the volatility of gdp growth beyond what is captured by its level.

Column 5 reports results of a regression using all observations and additionally a dummy variable indicating a financial crises event, plus interaction terms. The results show that the measure for macroeconomic volatility has

¹All results that follow are robust to changes in the definition of a financial crises event

²changing size of the window to 10 or 12 years does not affect the results significantly

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	OLS	OLS	OLS	OLS	OLS	Probit	Probit
Volatility	16.83*** (4.013)	17.89*** (3.920)	17.88*** (3.997)	18.48*** (4.633)	0.477 (0.498)	-15.95* (8.354)	-13.70** (6.925)
GDP growth			0.00504 (0.0393)	0.00149 (0.0514)	-0.000466 (0.0110)	0.0105 (0.133)	0.127 (0.183)
Crisis					-0.0228*** (0.00803)		
Volatility*Crisis					5.506** (2.777)		
Time trend	N	Y	Y	Y	Y	N	Y
Country fixed effects	N	N	N	Y	Y	N	Y
Observations	33	33	33	33	1703	1716	1716
R-squared	0.369	0.380	0.380	0.508	0.213		

Table 1: Dependent variable is real gdp growth during a financial crisis event in columns 1-4, real gdp growth in column 5, incident of a financial crisis in columns 5-6. Robust standard errors reported in brackets.

no significant effect on gdp growth during normal times, but only in a financial crises event. While a financial crisis event by itself leads to lower gdp growth, as indicated by the negative coefficient on the crisis dummy, the drop in gdp is more pronounced if the years before the crisis were characterized by high aggregate stability. This indicates that macroeconomic stability may have a non-linear effect on the size of a financial crisis event.

Finally, Column 6-7 estimate the effect of macroeconomic stability on the likelihood of the incident of a financial crises event, using a probit specification. The negative and significant coefficient on volatility indicates that financial crises are less likely to occur after a period of high aggregate volatility. Though not all specifications are reported, this result is again robust to controlling for time trends, country fixed effects, gdp growth, and different definitions of both financial crises events and aggregate volatility.

3 Model

The baseline model presented in this chapter is an extended version of the one presented by Stein (2011). The model is very stylized, but captures all key mechanisms that also carry through more involving alternative specifications. This version highlights in a very simple setting how a reduction in aggregate volatility can lead to an increase in financial sector risk exposure, which in turn can lead to more frequent and more severe financial crises. Overall, this reduction in volatility may also lead to losses in aggregate welfare.

3.1 Households

The economy is populated with a continuum of identical households of mass one. Each household has a linear utility function of the form

$$U_0 = c_0 + \beta E(c_2) + \gamma M$$

where M denotes holdings of privately created risk less money in period 0. This pins down short term and expected long term gross interest rates

$$R_B = \frac{1}{\beta}$$

$$R_M = \frac{1}{\beta + \gamma}$$

I assume that β and γ are greater than zero and that $\beta + \gamma < 1$. All households hold a large initial endowment A of the consumption good. I assume that households have access to a costless storage device for the consumption good between all periods, which ensures that households are indifferent between income in period 1 and 2.

3.2 Banks

There is a continuum of identical banks of mass one, which are owned by the households. Each bank has zero initial endowment. Banks have access to a technology that turns one unit of the consumption good into one unit of capital investment in a modern sector of the economy. At $t = 0$, each bank faces an investment possibility of size I in the modern sector. Banks finance this investment by borrowing short term or long term from households. The fraction of the investment financed by short term borrowing is denoted by μ .

At the beginning of $t = 1$, the aggregate state of the world S is revealed, where $S \in \{G, B, C\}$ with probabilities $\{p, q, 1 - p - q\}$. Banks receive a first stream of return from their investment of size $L_S I$, where $L_G \geq L_B > L_C = 0$. Banks may also liquidate part of their investment and sell capital to a traditional sector at price π_S . Liquidating a fraction d_S of the original investment generates a revenue of $d_S \pi_S I$. At the end of period 1, maturing short term debt is repaid to the households.

The second return of the project in $t = 2$ depends again on the aggregate state. If $S = G$, the project returns $FI > I$. If $S \in \{B, C\}$, the second period return of the project is $\lambda I / \alpha$ with probability α and 0 with probability $(1 - \alpha)$, so the expected return is λI with $\lambda < 1$. This rules out that long term debt can be made risk free, and that any short term debt can be rolled over at $t = 1$.³

³Note that neither bank holding of liquidity nor state-contingent debt is ruled out by assumption, but it will never occur in equilibrium. State-contingent debt is never risk free

3.3 Traditional sector

In a less productive traditional sector, investing K in $t = 1$ returns an output of $G(K)$ in $t = 2$, where $G(\cdot)$ is a concave function with $G(0) \leq \lambda$. Assuming that there is no initial capital in the economy, investment in the traditional sector will be equal to capital liquidation in the modern sector, and hence $\pi_S = G'(K_S) = G'(d_S I)$. I also assume that $KG''(K) + G'(K) > 0$ for all relevant values of K , which rules out multiplicity of equilibria on the market for capital.

3.4 Short term debt and asset sales

Given these assumptions, banks will only liquidate projects in $t = 1$ if the current stream of income is not sufficient to repay the maturing short term debt. Hence we have

$$d_S I k_S = \max\{\mu I R_M - I L_S, 0\}$$

$$d_S = \max\left\{\frac{\mu R_M - L_S}{\pi_S}, 0\right\}$$

Assuming $L_G > \mu^{max} R_M$, there will be no liquidation in state G . In state B , banks will liquidate a share of the investment only if current stream of income is insufficient, so

$$d_B = \begin{cases} 0 & \text{if } L_B \geq \mu R_M \\ \frac{\mu R_M - L_B}{\pi_B} & \text{else} \end{cases}$$

Since $L_C = 0$, banks will always need to liquidate part of the project in state C if $\mu > 0$. Further, since $\max(d_S) = 1$, the maximum fraction of investment than can be financed by risk less money is given by

$$\mu^{max} = \frac{\pi_C}{R_M}$$

3.5 Banks' maximization problem

Bank revenues ex-post are given by

$$\Pi = \begin{cases} L_G I + F I & \text{if } S = G \\ L_B I + d_B \pi_B I + (1 - d_B) \lambda I & \text{if } S = B \\ d_C \pi_C I + (1 - d_C) \lambda I & \text{if } S = C \end{cases}$$

and is in this model equivalent to long term debt. Also, instead of holding one unit of liquidity at costs $R_B - 1$, a bank may always undertake an identical reduction of liquidity risk by borrowing one unit less in short term and one more in long term at costs $R_B - R_M$, which is thus always the preferred option.

In $t = 0$, the bank solves

$$\begin{aligned} & \max_{\mu} p(F + L_G) + q((1 - d_B)\lambda + L_B + d_B\pi_B) \\ & \quad + (1 - p - q)((1 - d_C)\lambda + d_C\pi_C) - \mu R_M - (1 - \mu)R_B \\ & \text{subject to} \\ & d_B = \max\left\{\frac{\mu R_M - L_B}{\pi_B}, 0\right\} \\ & d_C = \frac{\mu R_M}{\pi_C} \\ & \mu \leq \frac{\pi_C}{R_M} \end{aligned}$$

taking prices as given. To ensure participation, I assume that the project is profitable even if financed exclusively through long term debt, i.e. $p(L_G + F) + q(L_B + \lambda) + (1 - p - q)\lambda \geq R_B$. Note that the maximization problem is entirely linear, except for a kink at $\mu = L_B/R_M$, after which banks will need to liquidate part of their investment in state B . As long as $\mu < L_B/R_M$, increasing μ reduces financing costs by $(R_B - R_M)I$, but increases costs from liquidation in state C by $\frac{R^M}{\pi_C}(\lambda - \pi_C)I$. Thus banks will borrow short term up to $\mu = L_B/R_M$ if

$$R^B - R^M \geq R^M(1 - p - q) \left(\frac{\lambda}{\pi_C} - 1 \right) \equiv Sp^1$$

For $\mu \geq L_B/R_M$, increasing μ also increases liquidation costs in the intermediate state B by $I\frac{R^M}{\pi_B}(\lambda - \pi_B)$, so banks will exhaust their capacity of short term borrowing $\mu^{max} = \frac{\pi_C}{R_M}$ if

$$R^B - R^M \geq R^M \left((1 - p - q) \left(\frac{\lambda}{\pi_C} - 1 \right) + q \left(\frac{\lambda}{\pi_B} - 1 \right) \right) \equiv Sp^2$$

The optimal fraction of short term borrowing for given prices is then, as long as $L_B \leq \pi_C$, given by

$$\mu^* = \begin{cases} 0 & \text{if } R^B - R^M < Sp^1 \\ \in [0, L_B/R^M] & \text{if } R^B - R^M = Sp^1 \\ L_B/R^M & \text{if } Sp^2 > R^B - R^M > Sp^1 \\ \in [L_B/R^M, \pi_C/R^M] & \text{if } R^B - R^M = Sp^2 \\ \pi_C/R^M & \text{if } R^B - R^M > Sp^2 \end{cases}$$

If instead the return L_B is larger than the price of capital in state C , banks will never need to liquidate assets in state B . So the optimal choice of short

term borrowing is

$$\mu^* = \begin{cases} 0 & \text{if } R^B - R^M < Sp^1 \\ \in [0, k_C/R^M] & \text{if } R^B - R^M = Sp^1 \\ k_C/R^M & \text{if } R^B - R^M > Sp^1 \end{cases}$$

Note that for an intermediate range of the interest rate spread $Sp^1 < R^B - R^M < Sp^2$, banks avoid liquidation in state B by limiting short term borrowing to $\mu = L_B/R_M$.

3.6 Equilibrium

In equilibrium capital prices π_B and π_C , and hence also the thresholds levels for the spread SP_1 and SP_2 , depend on the aggregate level of short term borrowing. Denoting with $Sp(\mu)$ the value of the threshold level evaluated at μ , equilibrium levels of short term borrowing are given by

$$\mu^* = \begin{cases} 0 & \text{if } R^B - R^M \leq Sp_1(0) \\ \mu^1 \in [0, \frac{L_B}{R^M}] & \text{if } Sp_1(0) < R^B - R^M < Sp_1\left(\frac{L_B}{R^M}\right) \\ \frac{L_B}{R^M} & \text{if } Sp_1\left(\frac{L_B}{R^M}\right) \leq R^B - R^M \leq Sp_2\left(\frac{L_B}{R^M}\right) \\ \mu^2 \in [\frac{L_B}{R^M}, \bar{\mu}] & \text{if } Sp_2\left(\frac{L_B}{R^M}\right) < R^B - R^M < Sp_2(\bar{\mu}) \\ \bar{\mu} & \text{if } R^B - R^M \geq Sp_2(\bar{\mu}) \end{cases}$$

for $L_B \leq \pi_C(\bar{\mu})$, where $\bar{\mu}$ solves $\bar{\mu} = \frac{\pi_C(\bar{\mu})}{R^M}$, μ^1 solves $R^B - R^M = Sp_1(\mu^1)$, μ^2 solves $R^B - R^M = Sp_2(\mu^2)$, and $\pi_C(\mu)$ is defined by

$$\pi_C(\mu) = G' \left(\frac{\mu R_M}{\pi_C(\mu)} I \right)$$

so $\pi_C(\mu)$ is a decreasing function. Note that both Sp_1 and Sp_2 are decreasing functions of μ , and hence there is no multiplicity of equilibria. Similarly for

values of L_B exceeding $\pi_C(\bar{\mu})$, equilibrium short term borrowing is

$$\mu^* = \begin{cases} 0 & \text{if } R^B - R^M \leq Sp_1(0) \\ \mu_1 \in [0, \bar{\mu}] & \text{if } Sp_1(0) < R^B - R^M < Sp_1(\bar{\mu}) \\ \bar{\mu} & \text{if } R^B - R^M \geq Sp_1(\bar{\mu}) \end{cases}$$

where μ_1 solves $R^B - R^M = Sp_1(\mu_1)$.

4 Stabilization policy

I will now analyze the effects of a policy that stabilizes aggregate activity in normal times, but that is ineffective in crisis times. The economy is considered to be in normal times whenever it is not in a crisis, i.e. when $S \in \{G, B\}$. A possible rationale for this is successful conventional monetary policy that stabilizes aggregate fluctuations during normal times, but may hit the zero lower bound in crisis times. The policy stabilizes the return to banks L_S in period 1. Denoting $L_G = \bar{L} + \sigma_L$ and $L_B = \bar{L} - \sigma_L$, the policy can be interpreted as reducing the value of σ_L .⁴

To see how short term borrowing and hence exposure to liquidity risk is affected by this policy, consider first a low initial value of L_B , smaller than the price of capital in crisis under maximum short term borrowing $\pi_C(\bar{\mu})$. The equilibrium level of short term borrowing μ^* is unaffected by changes in L_B if either the spread is very low, i.e. $R_B - R_M < Sp_1\left(\frac{L_B}{R^M}\right)$ and hence short term borrowing is not constrained by the bad state, or if the spread is very high, $R^B - R^M > Sp_2(\bar{\mu})$, so that banks already borrow the maximum amount in short term. For all intermediate values of the spread, banks want to contain the amount of assets they need to sell in the bad state, so improving returns in the bad state will relax this constraint and induce higher levels of μ^* .

Proposition 1 *Equilibrium short term borrowing μ^* is non-increasing in σ_L . It is strictly decreasing in the intermediate range of the spread $Sp_1\left(\frac{L_B}{R^M}\right) < R^B - R^M < Sp_2\left(\frac{L_B}{R^M}\right)$ if $L_B < \pi_C(\bar{\mu})$, and in $Sp_2\left(\frac{L_B}{R^M}\right) \leq R^B - R^M < Sp_2(\bar{\mu})$ if G is strictly concave. μ^* is constant in σ_L otherwise.*

Proof See appendix.

⁴From now on, I will assume equal probability of good and bad times, i.e. $p=q$, such that the policy does not directly affect expected returns.

Consequently, a stabilization policy that reduces σ_L will lead to higher levels of short term borrowing for an intermediate range of the spread. For the remaining of this paper, I assume that the spread is in the intermediate range $Sp_1\left(\frac{L_B}{R^M}\right) < R^B - R^M < Sp_2\left(\frac{L_B}{R^M}\right)$ and that first period revenues in the bad state are low enough to affect the short term borrowing decision, i.e. $L_B < \pi_C(\bar{\mu})$. Reducing σ_L then always leads to higher equilibrium μ^* , as stated in Proposition 1, and higher short term borrowing also translate directly in a more severe crisis. Larger liquidity needs in $t = 1$ leads to more asset sales in a crisis state, pushing down the price of capital and leading to the liquidation of a large fraction of investment in the modern sector.

Proposition 2 *Aggregate output in the crisis state, given by $\lambda(1 - d_C)I + G(d_C I)$ is strictly increasing in σ_L .*

Stabilization in normal times can increase the severity of a crisis, because banks will rely more on short term borrowing and hence are more exposed to liquidity risk.

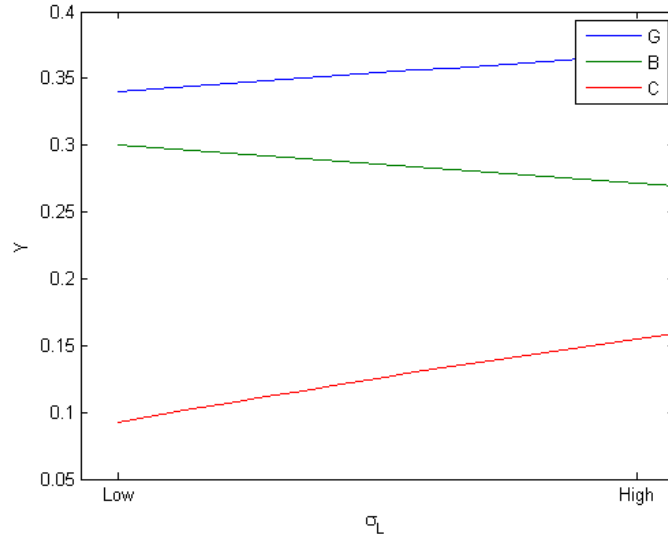


Figure 1: Aggregate output in each state for increasing values of σ_L

Aggregate output in crisis times is given by

$$Y_C = G(d_C I) + (1 - d_C)\lambda I$$

where d_C solves $d_C = \frac{\mu R^M}{G'(d_C I)}$. Any increase in equilibrium short term borrowing will reduce crisis output since $G' < \lambda$. Due to the concavity of G , a higher μ also reduces the price of capital in case of a crisis, triggering more

liquidation and hence amplifying the adverse effect of a crisis shock.

Expected aggregate output of the economy is given by

$$E(Y) = p(L_G + F)I + q((L_B + (1 - d_B)\lambda)I + G(d_B I)) + (1 - p - q)(G(d_C I) + (1 - d_C)\lambda I)$$

so that an increase in short term borrowing always reduces expected output. It follows that under the assumption of $p = q$, a stabilization policy that reduces σ_L lowers expected output whenever banks react with a higher equilibrium μ . More interestingly, a stabilization policy that reduces the fluctuations between good and bad times may increase overall volatility of output, due to higher exposure to liquidity risk and the amplification effects during the crisis.

Proposition 3 *A marginal reduction of σ_L increases volatility of aggregate output if*

$$p(Y_G - E(Y)) - q(Y_B - E(Y)) < (1 - p - q)(Y_C - E(Y))(\lambda - G'(d_C I)) \frac{\partial d_C}{\partial \sigma_L} \quad (2)$$

where

$$\begin{aligned} Y_G &= (L_G + F)I \\ Y_B &= (L_B + \lambda)I \\ Y_C &= G(d_C I) + (1 - d_C)\lambda I \\ E(Y) &= pY_G + qY_B + (1 - p - q)Y_C \\ \frac{\partial d_C}{\partial \sigma_L} &= \frac{-1}{G'(d_C I) + d_C I G''(d_C I)} \end{aligned}$$

Proof See appendix.

Note that the LHS of condition (2) refers to the reduction of volatility achieved by reducing the distance of Y_G and Y_B , while the RHS constitutes the impact of a more severe crisis. The magnitude of the later depends on the output loss due to liquidation ($\lambda - G'(d_C I)$) and the size of the amplification effect $\frac{\partial d_C}{\partial \sigma_L}$. Note also that as σ_L becomes smaller and normal times more similar, the LHS of condition (2) becomes smaller while the RHS increases due to the concavity of G' . This results in a generally U-shaped pattern of the reaction of total volatility to σ_L .

As I show next, the increased risk taking by banks may also lower aggregate welfare in the economy. Since households' utility function is $c_o + \beta E(c_2) + \gamma M$, resulting aggregate welfare is given by

$$U = (A - I) + \beta E(Y) + \gamma \mu I$$

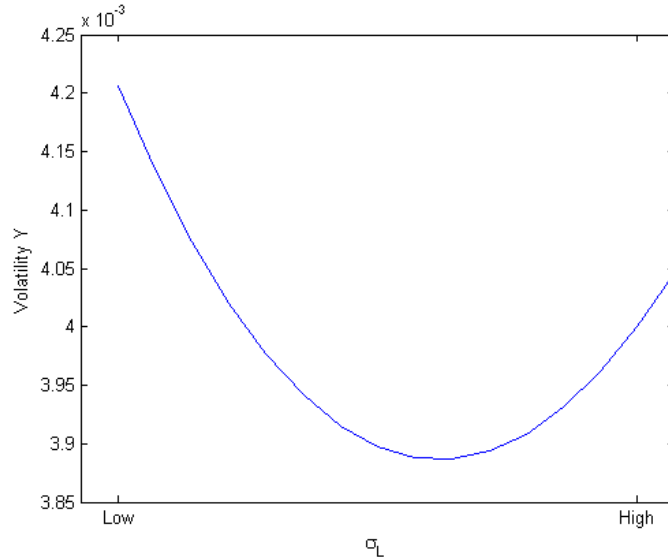


Figure 2: Volatility of expected output for increasing values of σ_L

Assuming equal probability of good and bad times, i.e. $p = q$, the stabilization policy affects aggregate welfare through the level of short term borrowing in two ways. Larger levels of short term borrowing reduces expected output but increases the creation of private money, which enters directly the utility function of households. Which effect dominates depends again on the parameter specification, as shown in Proposition 4.

Proposition 4 *A marginal reduction of σ_L reduces aggregate welfare if*

$$(1 - p - q)(\lambda - G'(d_C I)) \frac{R_M}{G'(d_C I) + d_C I G''(d_C I)} > \gamma \quad (3)$$

Proof See appendix.

Since the LHS of condition (3) is again increasing in the severity of the crisis, aggregate welfare is a U-shaped function of the stability parameter σ_L .

5 Conclusion

In this model, banks decide on the financing of an investment through short term or long term debt. Short term debt is cheaper, but exposes the bank to liquidity risk in case of an adverse aggregate shock. For an intermediate range of the interest rate spread, banks will limit their reliance on short term financing to avoid liquidity problems during regular bad times. A

stabilization policy that limits fluctuations during normal times also reduces the moderating effect of bad periods, leading to a larger exposure of banks to liquidity risk. As a result, crisis times will be more severe and lead to larger output losses. Due to amplification effects of fire sales, stabilization in normal times may result in larger total fluctuation of aggregate output and also reduce aggregate welfare.

References

- [1] Acharya⁵, Viral V., Hyun Song Shin and Tanju Yorulmazer (2011), 'Crisis Resolution and Bank Liquidity', *Review of Financial Studies*, vol. 24(6), pages 2166-2205.
- [2] Benigno, Gianluca, Huigang Chen, Christopher Otrok, Alessandro Rebucci and Eric R. Young (2011), 'Monetary and Macro-Prudential Policies: An Integrated Analysis', mimeo.
- [3] Bolton, Patrick, and Xavier Freixas (2006), 'Corporate Finance and the Monetary Transmission Mechanism', *Review of Financial Studies*, 19,: 829-870.
- [4] Bianchi, Javier and Enrique G. Mendoza (2010), 'Overborrowing, Financial Crises and 'Macro-prudential Taxes'', NBER Working Papers 16091.
- [5] Brunnermeier, Markus K., and Yuliy Sannikov (2012), 'A Macroeconomic Model with a Financial Sector', mimeo.
- [6] Diamond, Douglas W., and Raghuram G. Rajan (2009), 'Illiquidity and Interest Rate Policy', NBER Working Papers 15197.
- [7] Farhi, Emmanuel and Jean Tirole (2012), 'Collective Moral Hazard, Maturity Mismatch, and Systemic Bailouts', *American Economic Review*, vol. 102(1), pages 60-93, February.
- [8] Fernández-Villaverde, Jesús, Pablo A. Guerrón-Quintana and Juan Rubio-Ramírez (2011), 'Supply-Side Policies and the Zero Lower Bound', NBER Working Papers 17543.
- [9] Gai, Prasanna, Sujit Kapadia, Stephen Millard and Ander Perez (2008), 'Financial Innovation, Macroeconomic Stability and Systemic Crises', *Economic Journal*, vol. 118, issue 527, pages 401-426.
- [10] Gennaioli, Nicola, Andrei Shleifer and Robert Vishny (2012), 'Neglected risks, financial innovation, and financial fragility', *Journal of Financial Economics*, 104: 452-468.
- [11] Gertler, Mark and Nobuhiro Kiyotaki (2010), 'Financial Intermediation and Credit Policy in Business Cycle Analysis', in: Benjamin M. Friedman and Michael Woodford (ed.), *Handbook of Monetary Economics*, edition 1, volume 3, chapter 11, pages 547-599.

⁵Note that most entries in this bibliography are not yet referenced in this version of the main text.

- [12] Gertler, Mark, Nobuhiro Kiyotaki and Albert Queralto (2011), 'Financial Crises, Bank Risk Exposure and Government Financial Policy', mimeo.
- [13] He, Zhiguo and Arvind Krishnamurthy (2012), 'Intermediary Asset Pricing', *American Economic Review*, forthcoming.
- [14] Holling, Crawford S. (1973), 'Resilience and stability of ecological systems' *Annual Review of Ecology and Systematics*, 4, 1-24.
- [15] Holling, Crawford S. and Gary K. Meffe (1996), 'Command and Control and the Pathology of Natural Resource Management', *Conservation Biology*, 10(2): 328-337.
- [16] Jiménez, Gabriel, Steven Ongena, José-Luis Peydró and Jesús Saurina (2011), 'Hazardous Times for Monetary Policy: What Do Twenty-Three Million Bank Loans Say about the Effects of Monetary Policy on Credit Risk-Taking', mimeo.
- [17] Loayza, Norman V. and Romain Ranciere (2006), 'Financial Development, Financial Fragility, and Growth', *Journal of Money, Credit and Banking*, vol. 38(4), pages 1051-1076, June.
- [18] Lorenzoni, Guido (2008), 'Inefficient Credit Booms', *Review of Economic Studies*, 75 (3), July: 809-833.
- [19] Mankiw, N. Gregory and Matthew Weinzierl (2011), 'An Exploration of Optimal Stabilization Policy', *Brookings Papers on Economic Activity*, Spring.
- [20] Rajan, Raghuram G. (2005), 'Has financial development made the world riskier?', *Proceedings, Federal Reserve Bank of Kansas City*, issue Aug, pages 313-369.
- [21] Schularick, Moritz and Alan M. Taylor (2012), 'Credit Booms Gone Bust: Monetary Policy, Leverage Cycles, and Financial Crises, 1870-2008', *American Economic Review*, 102(2): 1029-1061.
- [22] Stein, Jeremy C. (2012), 'Monetary Policy as Financial Stability Regulation', *The Quarterly Journal of Economics*, 127(1): 57-95.

A Proofs

Proof of Proposition 1 If $L_B \geq \pi_C(\bar{\mu})$, equilibrium short term borrowing does not depend on L_B (nor L_G), hence $\frac{\partial \mu^*}{\partial \sigma_L} = 0$.

If $L_B < \pi_C(\bar{\mu})$ and $R^B - R^M < Sp_1\left(\frac{L_B}{R^M}\right)$ or $R^B - R^M > Sp_2(\bar{\mu})$, equilibrium short term borrowing does not depend on L_B and $\frac{\partial \mu^*}{\partial \sigma_L} = 0$.

If $L_B < \pi_C(\bar{\mu})$ and $Sp_1\left(\frac{L_B}{R^M}\right) \leq R^B - R^M \leq Sp_2\left(\frac{L_B}{R^M}\right)$, $\mu^* = \frac{L_B}{R^M}$, so $\frac{\partial \mu^*}{\partial \sigma_L} = -\frac{1}{R^M} < 0$.

If $L_B < \pi_C(\bar{\mu})$ and $Sp_2\left(\frac{L_B}{R^M}\right) < R^B - R^M < Sp_2(\bar{\mu})$, μ^* is implicitly defined by

$$\begin{aligned} R_B - R_M &= \left((1-p-q) \left(\frac{\lambda}{\pi_C} - 1 \right) + q \left(\frac{\lambda}{\pi_B} - 1 \right) \right) \\ \pi_C &= G' \left(\frac{\mu^* R_M I}{\pi_C} \right) \\ \pi_B &= G' \left(\frac{\mu^* R_M - L_B I}{\pi_B} \right) \end{aligned}$$

So $\frac{\partial \mu^*}{\partial \sigma_L} = 0$ if $G''(\cdot) = 0$. For $G''(\cdot) < 0$, applying the implicit function theorem, we get

$$\frac{d\mu^*}{d\sigma_L} = \frac{(1-p-q)\pi_B^2 \frac{\partial \pi_C}{\partial \mu} + q\pi_C^2 \frac{\partial \pi_B}{\partial \mu}}{(1-p-q)\pi_B^2 \frac{\partial \pi_C}{\partial \sigma_L} + q\pi_C^2 \frac{\partial \pi_B}{\partial \sigma_L}}$$

with

$$\begin{aligned} \frac{\partial \pi_S}{\partial \mu} &= \frac{G''(X_S)\pi_S X_S}{\mu(G'(X_S) + X_S G''(X_S))} < 0 \\ \frac{\partial \pi_C}{\partial \sigma_L} &= 0 \\ \frac{\partial \pi_B}{\partial \sigma_L} &= -\frac{G''(X_B)R_M I}{G'(X_B) + X_B G''(X_B)} > 0 \end{aligned}$$

where $X_S = d_S I = \frac{\mu R_M - L_S}{\pi_S} I$. Hence $\frac{\partial \mu^*}{\partial \sigma_L} < 0$.

Proof of Proposition 3 From

$$\frac{\partial Var(Y)}{\partial \sigma_L} = 2E \left[(Y - E(Y)) \frac{\partial Y}{\partial \sigma_L} \right]$$

and

$$\begin{aligned}\frac{\partial Y_G}{\sigma_L} &= I \\ \frac{\partial Y_B}{\sigma_L} &= -I \\ \frac{\partial Y_C}{\sigma_L} &= (G'(d_C I)I - \lambda I) \frac{d_C}{\sigma_L}\end{aligned}$$

we get directly that

$$\begin{aligned}\frac{\partial Var(Y)}{\partial \sigma_L} &< 0 \\ \Leftrightarrow \\ p(Y_G - E(Y))I - q(Y_B - E(Y))I &< -(1 - p - q)(Y_C - E(Y))(G'(d_C I)I - \lambda I) \frac{d_C}{\sigma_L} \\ \Leftrightarrow \\ p(Y_G - E(Y)) - q(Y_B - E(Y)) &< (1 - p - q)(Y_C - E(Y))(\lambda - G'(d_C I)) \frac{d_C}{\sigma_L}\end{aligned}$$

Further we have

$$d_C(\sigma_L) - \frac{\mu(\sigma_L)R_M}{G'(d_C(\sigma_L)I)} = 0$$

and hence

$$\begin{aligned}\frac{\partial d_C}{\partial \sigma_L} &= \frac{\mu'(\sigma_L) \frac{R_M}{G'(\cdot)}}{1 + \frac{\mu(\sigma_L)R_M}{(G'(\cdot))^2} G''(d_C I)I} \\ &= \frac{\mu'(\sigma_L)R_M}{G'(\cdot) + d_C G''(\cdot)}\end{aligned}$$

and from $\mu(\sigma_L) = \frac{L_B}{R_M}$ we have $\mu'(\sigma_L) = -\frac{1}{R_M}$ and so

$$\frac{\partial d_C}{\partial \sigma_L} = \frac{-1}{G'(\cdot) + d_C G''(\cdot)} < 0$$

Proof of Proposition 4 to be done, easy