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A Dynamic Model Approach of Securitization and the Financial Crisis

Mubanga Mpundu*

Faculty of Education and Training, North-West University, Mafikeng Campus, Mmabatho 2735, South Africa.
*Email: mubangampundu@gmail.com

ABSTRACT

Securitization involves the transformation of illiquid assets into liquid and easy to sell ones. The paper focuses on the effect of unexpected negative shocks on low quality (LQ)-asset price and input, collateralized debt obligation price and output as well as profit through the use of numerical analysis. In this regard, two kinds of multiplier processes are considered with the first being the within-period or static multiplier process where the shock such as a ratings downgrade was found to cause a fall in net value of the LQ-entity and compels it to reduce its asset demand. In this case, by keeping the future constant, the transaction fees decrease to clear the market and the asset price falls by the same amount. In turn, this lowers the value of the LQ-entity's existing assets and reduces their net value even more. Since the future is not constant, this multiplier misses the intuition which was given by the more realistic inter-temporal dynamic multiplier. In this case, the decrease in asset prices results from the cumulative decrease in present and future opportunity costs, stemming from the persistent reductions in the constrained LQ-entity's net value and asset demand, which are in turn propelled by a decrease in asset price. The article in addition gives a simulation results for the full nonlinear model taking into consideration the role of uncollateralized asset backed securities. It's clear in the paper that most banks securitize assets without having sufficient capital and liquidity.

Keywords: Assets, Credit, Derivatives, Dynamic, Static, Credit Risk
JEL Classifications: G1, E44, C6

1. INTRODUCTION

According to Mulaudzi et al. (2014), the period before the occurrence of the 2007-2009 financial crisis was hit by financial product developments that were intended to achieve objectives such as offsetting a particular risk exposure (such as asset default) or obtain financing. Some practices that were major drivers of the financial crisis included the pooling together and bundling of low quality-assets (LQA) into asset backed securities (ABS) and collateralized debt obligations (CDOs) through a financial process called securitization. (Demyanyk and Van Hermert., 2008: Elliehausen and Hwang., 2010). The process of securitization enables the transformation of illiquid assets into liquid ones which can then be sold in the market easily to investors according to their preference Fabozzi et al.,2007: Fender and Scheicher., 2009). CDOs are separated into tranches involving high quality (HQ), mezzanine or medium quality and equity or LQ (Petersen et al., 2009: Petersen et al., 2012). Investors choose what type of tranche suits them and purchase them accordingly by insuring them through credit default swaps (CDS). (Mukuddem-Petersen et al, 2011; Viral and Richardson., 2009; Wilson., 2009). According to (Mulaudzi et al. 2014; Wilson et al., 2010)), CDO issuance grew from an estimated $20 billion in Q104 to its peak of over $180 billion by Q107, then decreased to under $20 billion by Q108. Further, the credit quality of CDOs declined from 2000 to 2007, as the level of LQ and other non-HQ asset debt increased from 5% to 36% of CDO assets. LQAs were financed by securitizing assets into structured asset products (SAPs) such as ABSs and CDOs (U.S Federal Reserve Bank., 2010: Kendra, 2007). The lower-rated tranches of LQ ABSs formed 50-60% of the collateral for derivatives (Housing Derivatives., 2008; FDIC Quartely Banking Profile, First Quarter., 2008; FDIC Quartely Banking Profile (Pre-Adjustment), Fourth Quarter., 2007). These were extremely sensitive to a deterioration in asset credit quality. For example, housing went through a classic inventory cycle with the worsening of the inventory-to-sales cycle being evident in the midst of the LQA crisis. When this inventory situation worsened, the risk that price would fall more rapidly deepened (Petersen et al., 2012). According to (BCBS December 2012; BCBS, April 2009), banks that securitize assets are able to achieve targets which include but are not limited to reducing their regulatory capital requirements, obtaining additional sources of funding at low cost, enhancing financial ratios and managing their portfolio risk in turn diversifying their portfolios by acquiring different asset types from different areas.

The Bank for International Settlements (BIS) introduced several drafts to analyze and respond to the LQ-asset crisis and in 2009 the New Capital Accord, referred to as Basel III, was proposed[1] and in November 2010, the G20 leaders officially endorsed the Basel III framework which was implemented in January 2013 and will eventually be fully implemented by 2019 through the BCBS[2] reviews and recommendations from the financial sector and general public (BCBS, September 2012; BCBS, December 2010 and Bernd, 2011). According to Hannoun (2010), the aim of Basel III is to prepare the banking industry for future economic downturns by improving the banking sectors ability to absorb shocks arising from financial and economic stress, improving risk management and governance, and strengthening banks transparency and disclosures. The framework also aims to enhance firm-specific measures, such as macro-prudential regulations to help create a more stable banking sector, by reducing the pro-cyclical amplification risks across the banking sector over time (BCBS, December 2010). Basel III can further be defined as a firm-specific, risk based framework and a system wide, systemic risk-based framework according to Bernd (2011).

The public response to Basel III framework was different as is expected in every new regulatory reform. According to some, Basel III was unable to change the framework but instead only makes it more complex (BCBS, 2009). Therefore, it cannot solve the problem caused by Basel II, especially the pro-cyclical effects while other people regarded Basel III as a great improvement in implementation (TingTing, 2011). In this article, LQ and HQ assets and entities will be referred to as LQ and HQ-assets or entities respectively.

1.1. Literature Review

During the 2007-2009 financial crisis outburst, the notion of funding liquidity frequently was pointed out in relation to asset prices (Attila, 2012: BCBS, June 2011). The funding or balance sheet liquidity can be explained as the ability of a financial institution to settle obligations with as immediate as possible (Drehmann and Nikolaou, 2010). This notion fundamentally supposes that funding conditions should be an essential part of asset and financial stability valuation process (Attila, 2012). In the core of rapidly evolving financial theory, it is inherently not unexpected that there are difficulties with the identification of liquidity and as a consequence with its measurement (Attila, 2012; BCBS, September 2011). Discovering an appealing relationship between asset prices and monetary or credit aggregates seems interesting but only after the 2007-2009 financial crisis was a suitable answer arrived at (Drehmann et al., 2010). According to Borio et al. (2001), continuous rapid credit growth coupled with enormous increases in asset prices seems to increase the possibility of an occurrence of financial instability. On the other hand, rapid credit growth, on its own, creates uncertain risk to the stability of the financial system and the same can be said to be true for quick growths in asset prices or investments (Attila, 2012; BCBS, June 2011). The combination of events, such as the coordinated occurrence of fast credit growth and rapid increases in asset prices that increases the likelihood of financial risk, rather than any one of these events alone (Borio et al., 2001; Iacoviello.., 2005). The key feature of the development of financial systems since the 1970s has according to (Koijen, 2009; Thakor, 1996: Taksar and Zhou., 1998), been the rapid expansion of financial markets. The importance of liquidity has been acknowledged by central banks in respect to both monetary and financial stability (Attila, 2013; Borio et al., 2001). According to (Petersen et al. 2011; BCBS, July 2009), the credit risk transfer through the derivatives market resulted in the origination of inferior quality assets by originators. It is believed that asset standards became slack because securitization gave rise to moral hazard, since each link in the asset chain made a profit while transferring associated credit risk to the next link (Mukuddem-Petersen et al., 2008; Mpundu et al., 2013). The increased distance between originators and the ultimate bearers of risk potentially reduced originators' incentives to screen and monitor assets (Deng et al., 2011). The increased complexity of residential asset-backed securities (RABSs) and markets also reduces the investor's ability to value them correctly (Mukkuddem-Petersen et al., 2008: Petersen et al., 2009).

CDS are financial instruments that are used as a hedge and protection for debt holders, in particular LQ-CDOs protect investors, from the risk of default (Kau et al., 2011). Like all swaps and other credit derivatives, CDSs may either be used to hedge risks (specifically, to insure investors against default) or to profit from speculation (Petersen et al., 2012). In the FC, as the nett payoff to the investors decreased because of LQ-CDOs losses, the probability increased that protection sellers would have to compensate their counterparties (Sundaresan and Wang, 2007). This in turn created uncertainty across the system, as the investors wondered which agents would be required to pay to cover their losses.

A destabilizing element of the 2007-2009 financial crises was the pro-cyclical amplification of financial shocks throughout the banking system, financial markets and the broader economy (Ting Ting, 2011; Wilson and Wu., 2010). The tendency of market participants to behave in a pro-cyclical manner was amplified through a variety of channels (Kendra, 2007). These include through accounting standards for both mark-to-market assets

1 In July 2009, the revised securitization and trading book rules was issued, and in December 2009, Basel III consultative document was issued.

2 The Basel Committee on Banking Supervision consists of senior representatives of bank supervisory authorities and central banks from Argentina, Australia, Belgium, Brazil, Canada, China, France, Germany, Hong Kong SAR, India, Indonesia, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, Russia, Saudi Arabia, Singapore, South Africa, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. It usually meets at the Bank for International Settlements BIS in Basel, Switzerland, where its permanent Secretariat is located.

and held-to-maturity loans, margining practices, and through the build-up and release of leverage among financial institutions, firms, and consumers (BCBS, May 2010; BCBS, September 2012). The Basel Committee introduced a number of measures to make banks more resilient to such pro-cyclical dynamics. These measures will in turn help ensure that the banking sector serves as a shock absorber, instead of a transmitter of risk to the financial system and broader economy according to BCBS (September 2009). In addition, the Committee introduced a series of measures to address pro-cyclicality and raise the resilience of the banking sector in good times (TingTing, 2011). The objectives of these measures are to; dampen any excess cyclicality of the minimum capital requirement; to promote more forward looking provisions; to conserve capital to build buffers at individual banks and the banking sector that can be used in stress and to achieve the broader macro-prudential goal of protecting the banking sector from periods of excess credit growth (BCBS, July 2009).

1.2. Main Questions

The main questions about securitization in this article are listed below.

- Question 1.1 (Dynamic multiplier: Shocks to the economy): How do inter-temporal shocks to the economy affect LQ- and HQ-entities equilibrium path? (Section 2).
- Question 1.2 (Dynamic multiplier: Steady-state linearization): How does linearizing around the steady-state ruling out bursting bubbles affect asset price, CDOs and profit? (Section 3).
- Question 1.3 (Uncollateralized RABS): How does the introduction of uncollateralized RABS into the securitization model affect LQ-entities? (Section 4).
- Question 1.4 (Static multiplier: Shocks to asset price): How does the non-bursting of the asset bubble during the securitization process affect asset price and input? (Section 5 and 6).
- Question 1.5 (Asset securitization examples): Can numerical examples that show asset securitization and give recommendations in relation to Basel III be given? (Section 6).

2. DYNAMIC MULTIPLIER: SHOCK EQUILIBRIUM PATH

In order to understand the effect of unexpected inter-temporal shocks to the economy (Kiyotaki and Moore., 1996) analysis of credit cycles, suppose at date $m-1$, the economy is in steady-state with,

$A^* = A_{m-1}$ and $T^* = T_{m-1}$

Unexpected inter-temporal shock where the CDO output of LQ- and HQ-entities at date m are $1-\Sigma$ times their expected levels are introduced. In order for this model to resonate with the 2007-2009 financial crisis, Σ is taken to be positive using similar mathematical analysis from (Protter, 2004).

Combining the market-clearing condition with the LQ-entity's asset demand under a temporary shock and borrowing constraint, the study obtains,

$$u\left(A_m\right)A_m = \left(\mu - \mu\Sigma + p_m^A - p^{A^*}\right)A^*, (date\, m) \tag{2.1}$$

$$u\left(A_{m+s}\right)A_{m+s} = \mu A_{m+s-1}, (dates\, m+1, m+2, \ldots) \quad (2.2.)$$

The formulae (2.1) and (2.2) imply that at each date the LQ-entity can hold assets up to the level A at which the required cost of funds, $u(A)A$, is covered by its net value.

From (2.1), subsequent to the shock, it can be seen that the LQ-entity's net worth at date m is more than only their current output given by,

$$(1-\Sigma)\mu A^* \quad (2.3.)$$

Because p_m^A changes due to shocks,

$$\left(p_m^A + p^{A^*}\right)A^* \tag{2.4}$$

Result on their asset holdings.

Debt repayment is given by,

$$\left(1+r^T\right)T^* = p^{A^*}A^* \tag{2.5}$$

In the sequel, proportional changes in A_m, p_m^A and Π_m relative to their steady-state values, A^*, p^{A^*} and Π^* respectively, are given by:

$$\hat{A}_m = \frac{A_m - A^*}{A^*}, \hat{p}_m^A = \frac{p_m^A - p^{A^*}}{p^{A^*}} \text{ and } \hat{\Pi}_m = \frac{\Pi_m - \Pi^*}{\Pi^*} \tag{2.6}$$

respectively. For the purpose of this study, it is assumed that steady-state profit, Π_m^*, represents profit when the asset value and borrowings are in steady-state. Thus steady-state profit for LQ-and HQ-entities are represented by,

$$\Pi_m^* = \left(r_m^A + c_m^p r_m^f - \left(1 - r_m^R\right)r_m^s\right)p_m^{A^*}A_{m-1}^* + r^B B_m - r^T T_m^* \tag{2.7}$$

and,

$$\Pi_m^{'*} = r^A p_m^{A^*} A_{m-1}^{'*} + r^B B_m^{'} - r^T T_m^{'*} \tag{2.8}$$

respectively. Then, by using the steady-state, transaction fee, it can be given from equations (2.1) and (2.2) that,

$$\left(1+\frac{1}{\eta}\right)\hat{A}_m = \frac{1+r^T}{r^T}\hat{p}_m^A - \Sigma, (date\, m) \tag{2.9}$$

$$\left(1+\frac{1}{\eta}\right)\hat{A}_{m+s} = \hat{A}_{m+s-1}, \text{for } s \geq 1, (\text{denotes } m+1, m+2, \ldots) \tag{2.10}$$

Where $\eta > 0$, denotes the elasticity of the residual asset supply to the LQ-entity with respect to the transaction fee at the steady-state.

Theorem 2.1 (Dynamic multiplier: Shocks to asset price and input, CDO price and output and profit): Assume that the asset bubble does not burst during the securitization process and that, $p_m^A \le \bar{\bar{p}}_m$ for all m. In this case, it can be said that the proportional change in asset price and input, CDO price and output as well as profit subject to a negative shock is given by,

$$\hat{p}_m^A = -\frac{1}{\eta}\frac{\lambda\pi + (1-\lambda)\left(\pi\left(1+r^T\right)-r^T\right)}{1-\lambda+\lambda\pi}\frac{\mu}{\mu+\lambda\rho}\Sigma \tag{2.11}$$

$$\hat{A}_m = -\frac{1}{1+\dfrac{\theta}{\eta}(1-\lambda+\lambda\pi)}\left[1+\frac{1+r^T}{r^T}\frac{\pi}{1-\lambda+\lambda\pi\eta}\right] \times[\lambda\pi+(1-\lambda)(\pi\left(1+r^T\right)-r^T)]\frac{\mu}{\mu+\lambda\rho} \tag{2.12}$$

$$\hat{C}_m = -\frac{1}{\alpha}\frac{\mu}{\mu+\lambda\rho} \left\{\begin{matrix} \pi\left(1+r^T\right)-r^T-\dfrac{\lambda(1-\pi)r^T\rho}{\mu+\lambda\rho-\rho}+(1-\lambda)\left(\pi\left(1+r^T\right)-r^T\right) \\ \dfrac{\theta}{\eta}\left[\dfrac{\mu+\lambda\rho}{\mu+\lambda\rho-\rho}+\dfrac{1+r^T}{r^T}\dfrac{\pi}{1-\lambda+\lambda\pi}\right]\end{matrix}\right\}\Sigma \tag{2.13}$$

and,

$$\hat{\Pi}_m = \frac{\left(r_m^A + c_m^p r_m^f - \left(1-r_m^R\right)r_m^s\right)p_m^A A_{m-1} + r^B B_m - r^T \mathrm{T}_m}{\left(r_m^A + c_m^p r_m^f - \left(1-r_m^R\right)r_m^R\right)p_m^{A^*} A_{m-1}^* + r^B B_m - r^T \mathrm{T}_m^*} - 1 \tag{2.14}$$

respectively.

In percentage terms, the impact on the asset price, given by (2.11) is of the same magnitude as the temporary shock Σ.

A 1% rise in asset price increases the LQ-entities' aggregate net value by $[(1 + r^B)/(r^B-1)][(\pi/(1-\lambda)(\pi(1+\lambda))]\theta$ percent.

By considering that $d = 0$ the study solves simultaneously for $\hat{p}_m^A$, $\hat{A}_m$ and $\hat{C}_m$. Since there are no bursting bubbles, the asset price p_m^A, is intimated to be the discounted sum of future opportunity costs given by,

$$u_{m+d} = u(A_{m+d}),\ d \ge 0$$

Replacing from (2.10) given by,

$$\left(1+\frac{1}{\eta}\right)\hat{A}_{m+d} = \hat{A}_{m+d-1}, \text{for } d \ge 1, (dates\ m+1, m+2, \ldots),$$

The study obtains,

$$\hat{p}_m^A = \frac{1}{\eta}\frac{r^T}{1+r^T}\sum_{d=0}^{\infty}\left(1+r^T\right)^{-d}\hat{A}_{m+d} = \frac{1}{\eta}\frac{r^T}{1+r^T}\frac{1}{1-\dfrac{\eta}{(1+r^T)(1+\eta)}}\hat{A}_m \tag{2.15}$$

It has to be verified that,

$$\sum_{d=0}^{\infty}\left(1+r^T\right)^{-d}\hat{A}_{m+d} = \frac{1}{1-\dfrac{\eta}{(1+r^T)(1+\eta)}}\hat{A}_m = \frac{(1+r^T)(1+\eta)}{\left(1+r^T\right)(1+\eta)-\eta}$$ is standard for infinite series. The dynamic multiplier,

$$\left[1-\frac{\eta}{(1+r^T)(1+\eta)}\right]^{-1} = \frac{(1+r^T)(1+\eta)}{\left(1+r^T\right)(1+\eta)-\eta} \tag{2.16}$$

in (2.15) captures the effects of persistence in entities' reference asset portfolio holdings.

In order to find $\hat{p}_t^A$ and $\hat{A}_t$ in terms of the size of the shock Σ, a utilization of 2.9 and 2.15 is made. The calculations above verify that 2.11 and 2.12 hold. Next it is proved that (2.13) holds.

Suppose that the proportional change in aggregate output, $\hat{C}_{m+d}$ is given (compare with $\hat{p}_m^A$ and $\hat{A}_m$ above) by,

$$\hat{C}_m = \frac{C_m - C^*}{C^*}, C_m = \left(\hat{C}_m + 1\right)C^* \text{and } C^* = \frac{C_m}{C_m + 1}$$

In this case, it can be verified that at date $m + 1$ the change in output, $\hat{C}_{m+d}$, may be shown by,

$$\hat{C}_{m+d} = \frac{\mu+\nu-(1+r^T)\mu}{\mu+\nu}\frac{(\mu+\nu)A^*}{C^*}\hat{A}_{m+d-1}, \text{for } d \ge 1 \tag{2.17}$$

The RHS of (2.17) yields,

$$\frac{\mu+\nu-(1+r^T)\mu}{\mu+\nu}\frac{(\mu+\nu)A^*}{C^*}\hat{A}_{m+d-1} = \frac{C_{m+s} - [\left(1+r^T\right)\mu A_{m+d-1} + (\mu+\nu-(1+r^T)\mu)A^*]}{C^*}$$

In order to verify (2.17) the study shows that,

$$C^* = \left(1+r^T\right)\mu A_{m+d-1} + \left(\mu+\nu-\left(1+r^T\right)\mu\right)A^* = [\left(1+r^T\right)\mu\hat{A}_{m+d-1} + \mu+\nu]A^*$$

This, of course is true since,

$C^* = (\mu+\nu)A^*$ and $\left(1+r^T\right)\mu A_{m+d-1} = \left(1+r^T\right)\mu A^*$ or

$$aA_{m+d-1} = A^*$$

The proportional change in profit, $\hat{\Pi}_m$, given by (2.14) is a direct consequence of this definition. The proportional changes in CDO output, $\hat{C}$, and profit, $\hat{\Pi}$ given by (2.13) and (2.14) respectively have important connections with the financial crisis. This relationship stems from the terms involving the asset and prepayment rates, refinancing as well as house equity.

3. DYNAMIC MULTIPLIER: SHOCKS TO LQA PROFIT

In the LQA context, the paper (Elliehausen et al., 2008) provides a relationship between the asset rate, r^A LTVR, L and prepayment cost, c^p, by means of the simultaneous equations model,

$$r_m^A = \alpha^0 L_m + \alpha^1 c_m^p + \alpha^2 X_m + \alpha^3 Z_m^{r^A} + u_m$$
$$L_m = \psi^1 r_m^A + \psi^2 X_m + \psi^3 Z_m^L + v_m$$
$$c_m^p = \gamma^1 r_m^A + \gamma^2 X_m + \gamma^3 Z_m^{c^p} + w_m \quad (3.1.)$$

Investors typically have a choice of r^A and L, while the choice of c^p triggers an adjustment to r^A. Thus, L and c^p are endogenous variables in the r^A-equation. There is no reason to believe that L and c^p are simultaneously determined. Therefore, c^p does not appear in the L-equation and L does not make an appearance in the c^p-equation. From Elliehausen et al. (2008), X comprises explanatory variables such as asset characteristics (owner occupied, asset purpose, documentation requirements); investor characteristics (income and Fair Isaac Corporation (FICO) score) and distribution channel (broker origination). The last term in each equation Z^{r^A} ; Z^L or Z^{r^A} ; Z^L or Z^{c^p} comprises the instruments excluded from either of the other equations. According to Elliehausen et al. (2008), the model is a simplification of other terms such as type of interest rate, the term to maturity and distribution channel possibly also being endogenous.

Corollary 3.1 (Dynamic multiplier: Shocks to LQ-asset profit): Suppose that the hypothesis of Theorem 2.1 holds. Then the relative change in profit may be expressed in terms of r^A, c^p and L as,

$$\hat{\Pi}_m\left(r^A\right) = \frac{F_m p_m^A A_{m-1} + r^B B_m - r^T T_m}{F_m p_m^{A*} A_{m-1}^* + r^B B_m - r^T T_m^*} - 1; \quad (3.2)$$

$$\hat{\Pi}_m\left(c^p\right) = \frac{G_m p_m^A A_{m-1} + r^B B_m - r^T T_m}{G_m p_m^{A*} A_{m-1}^* + r^B B_m - r^T T_m^*} - 1; \quad (3.3)$$

$$\hat{\Pi}_m\left(L\right) = \frac{H_m p_m^A A_{m-1} + r^B B_m - r^T T_m}{H_m p_m^{A*} A_{m-1}^* + r^B B_m - r^T T_m^*} - 1, \quad (3.4)$$

Respectively. Here, it is given in (3.2), (3.3) and (3.4) that,

$$F_m = r_m^A\left(1+\gamma^1 r_m^f\right) + \left(\gamma^2 X_m + \gamma^3 Z_m^{c^p} + w_m\right)$$
$$r_m^f - \left(1 - r_m^R\right) r_m^S,$$

$$G_m = c_m^p\left(1/\gamma^1 + r_m^f\right) - 1/\gamma^1\left(\gamma^2 X_m + \gamma^3 Z_m^{c^p} + w_m\right) - (1 - r_m^R) r_m^S$$

And,

$$H_m = \left[\gamma^1\left\{\frac{1}{\psi^1} L_m - \frac{\psi^2}{\psi^1} X_m - \frac{\psi^3}{\psi^1} Z_m^L - \frac{1}{\psi^1} v_m\right\} + \gamma^2 X_m + \gamma^3 Z_m^{c^p} + w_m\right]$$
$$\left[\gamma^1 + r_m^f\right] + \alpha^0 L_m + \alpha^2 X_m + \alpha^3 Z_m^{r^A} + u_m - \left(1 - r_t^R\right) r_m^S,$$

respectively.

The most important contribution of the aforementioned result is that it demonstrates how the proportional change in profit subsequent to a negative shock is influenced by quintessential LQ asset features such as asset and prepayment rates, refinancing and house equity given by r^A, c^p, r^f and L respectively. The default rate is also implicitly embedded in formulas (3.2) to (3.4) in Corollary 3.1. In this regard, by consideration of simultaneity in the choice of r^A and c^p, it is possible to address the issue of possible bias in estimates of the effect of c^p on r^A.

4. THE ROLE OF UNCOLLATERALIZED ABSs

There are several significant consequences of introducing uncollateralized RABSs into the model. Firstly, it increases the degree of persistence. Secondly, it shifts the focus from quantities to asset prices. Finally, it assists in reducing the LQ-entities' debt-to-asset ratio to reasonable levels. ρ has more significant effects on the dynamics of the economy, as will be seen. It is clearest to look at the special case where there is no heterogeneity among the LQ-entities: π = 1. The argument of Section 2 carries over to the case ρ > 0 Equation (2.12) becomes,

$$A_m = \frac{1}{\rho + p_m^A - \frac{1}{1+r^T} p_{m+1}^A} \left[\left(\mu + p_m^A + \curlywedge\rho\right) A_{m-1} - \left(1 + r^T\right) \mathrm{T}_{m-1}\right] \quad (4.1)$$

Notice that ρ appears twice in (4.1). The $\curlywedge\rho A_{m-1}$ term in the numerator is the depreciated value of LQ assets inherited from date $m-1$, which is part of the LQ entities' net value at date m. The ρ in the denominator reflects the fact that the sort after payment per unit of asset includes the cost of LQ assets (Since LQ assets cannot be collateralized), in addition to the user cost, $p_m^A - \frac{1}{1+r^T} p_{m+1}^A$. Consider the counterpart to (2.9) and (2.10). Following the unexpected temporary shock Σ at date m, the proportional changes in asset price, p_m^A and the LQ entities' future path asset holdings, $\hat{A}_m, \hat{A}_{m+1}\ldots,$ satisfy,

$$\left[1 + \frac{\rho}{\eta}\right]\hat{A}_m = \frac{\mu}{\mu + \curlywedge\rho}\Sigma + \frac{1+r^T}{r^T}\rho\hat{p}_m^A\left(dates\, m\right) \quad (4.2)$$

$$\left[1 + \frac{\rho}{\eta}\right] A_{m+d} = A_{m+d-1} \text{ for } m \geq 1\left(dates\, m+1, m+2, \ldots\right) \quad (4.3)$$

Where the parameter $\theta = \frac{\mu - (1-\curlywedge)\rho}{\mu + \curlywedge\rho}$ lies between 0 and 1. There are two kinds of differences between (4.2), (4.3) and (2.9), (2.10). First, the coefficients of Σ and p_m^A in (4.2) are both smaller than in (2.9), ρ reduces the impact of both Σ and $\hat{p}_m^A$ on the LQ entities' net value which is because ρ reduces leverage.

Secondly, the bracketed coefficients on the left hand sides of (4.2) are smaller than in (2.9) which increases the impact of the shock on LQ entities asset holdings at all dates $m + d$, $d \geq 0$. It can be learnt from (4.3) that ρ makes the changes in the LQ entities' future asset holdings and hence the future user costs are more persistent; the depreciation factor is $\eta/(\theta + \eta)$, compared to only $\eta/(1 + \eta)$, without LQ assets. This additional persistence is reflected in asset price. To see this, consider the counterpart to (3.1) for $\rho > 0$.

$$\hat{p}_m^A = \frac{1}{\eta}\frac{r^T}{1+r^T}\sum_{d=0}^{\infty}\left(1+r^T\right)^{-d}\hat{A}_{m+d}$$
$$= \frac{1}{\eta}\frac{r^T}{1+r^T}\frac{1}{1-\frac{1}{1+r^T}\frac{\eta}{\theta+\eta}}\hat{A}_m \tag{4.4}$$

Equation (4.4) tells us that ρ causes the asset price to change more relative to the LQ entities' asset holdings; without LQ assets, the factor $\eta/(\theta + \eta)$ in the denominator reduces to $\eta/(1 + \eta)$. Altogether then, there are a number of competing effects, to find out which one dominates, the paper solves (4.2) and (4.4) for $\hat{A}_m$ and $\hat{p}_m^A$,

$$\hat{p}_m^A = \frac{\mu}{\mu+\lambda\rho}\frac{1}{\eta}\Sigma \tag{4.5}$$

$$\hat{A}_m = \frac{1}{1+\frac{\theta}{\eta}}\left[1+\frac{1+r^T}{r^T}\frac{\theta}{\eta}\right]\frac{\mu}{\mu+\lambda\rho}\Sigma \tag{4.6}$$

(4.5) and (4.6) are the counterparts to $\hat{p}_m^A = \frac{1}{\eta}\Sigma$ and $\hat{A}_m = \frac{1}{1+\frac{1}{\eta}}\left[1+\frac{1+r^T}{r^T}\frac{1}{\eta}\right]\Sigma$ for $\rho > 0$.

Overall, it can be seen that ρ reduces the input of the shock on asset price and LQ entities' asset holdings. Put differently, the reduction in leverage is the dominant impact effect. From the discussion of (4.4), it is known that although ρ may reduce the impact of a shock on both the price (p_m^A) and quantity (A_m), it reduces the impact on quantity by more, the ratio $\hat{p}_m^A / \hat{A}_m$ is greater than the equivalent ratio. Therefore ρ helps explain greater movements in asset prices, relative to quantities.

The introduction of uncollateralized assets into the model increases the degree of persistence. The only drawback is that impulse responses are reduced. However, the impulse responses in Section 2 are too strong anyway. All the conclusions that have been reached at in this section hold for the full model of Section 3 where the LQ entities are heterogeneous. In (2.11) and (2.12), $\hat{p}_m^A / \hat{A}_m$ increases with ρ. Also there is greater persistence; the deterioration rate $1-\sqrt{\gamma/\alpha}$ is a decreasing function of ρ in the characteristic equation for the eigenvalues x of the jacobian;

$$(\alpha-(1 + r^T)(\alpha x^2-\beta x + \gamma)) = 0$$

Where;

$$\alpha = 1+\frac{\theta}{\eta}(1-\lambda+\lambda\pi)$$

$$\beta = 1+\lambda\left(1+r^T\right)(1-\pi)+\frac{\theta}{\eta}(1+r^T)(1-\pi)(1-\lambda)$$

$$\gamma = \lambda(1 + r^T)(1-\pi)$$

5. STATIC MULTIPLIER: RESPONSE TO TEMPORARY SHOCKS

This section considers the response of asset price to a temporary shock in a static multiplier set up.

Imagine, hypothetically, that there were no dynamic multiplier. In this case, suppose p_{m+1}^A were artificially pegged at the steady-state level p^{A^*}. Equation (2.9) would remain unchanged. However, the right-hand side of (2.15) would contain only the first term of the summation, the term relating to the change in transaction fee at date m so that the multiplier (2.16) would disappear. Combining the modified equation, it is given that,

$$\hat{p}_m^A = \left[\frac{r^T}{\eta(1+r^T)}\right]\hat{A}_m$$

The following result follows from the above,

$$\hat{p}_m^A : p_{m+1}^A = p^{A^*} = -\frac{r^T}{\eta\left(1+r^{Ta}\right)}\Sigma, \tag{5.1}$$

$$\hat{A}_m : p_{m+1}^A = p^{A^*} = -\Sigma \tag{5.2}$$

Proof: The result can be proved by considering (2.9) and (2.15) where the changes in the asset price and the LQ-entity's asset holdings can be connected to the static multiplier.

$$\frac{\mu+\nu-(1+r^T)\mu}{\mu+\nu}$$

Reflects the difference between the LQ-entity's securitization (equal to $\mu + \nu$) and the HQ-entities securitization (equal to $(1 + r^T)\mu$) in the steady-state.

The ratio $(\mu+\nu)A^*C^{*-1}$ is the share of the LQ-entity's output. If aggregate securitization were measured by $C_{m+d}\overline{A}^{-1}$, it would be persistently above its steady-state level, even though there are no positive securitization shocks after date m. The explanation lies in a composition effect. In this regard, there is a persistent change in asset usage between LQ- and HQ-entities, which is reflected in increased aggregate output.

6. ILLUSTRATIVE EXAMPLE OF ASSET SECURITIZATION

In this section, an example of LQ-asset securitization is presented. For LQ-asset securitization, the main results contained in Elliehausen et al. (2008) are brought into play.

6.1. Example of LQ-asset Securitization

LQ- Assets are usually adjustable rate assets where high step-up rates are charged in period $m + 1$ after low teaser rates in period

m: Secondly, this higher step-up rate causes an incentive to refinance in period $m + 1$. Refinancing is subject to the fluctuation in house prices. When house prices rise, the entity is more likely to refinance. This means that investors could receive further assets with lower interest rates as house prices increase. Thirdly, a high prepayment penalty is charged to dissuade investors from refinancing.

6.2. Numerical Example: Asset Securitization Σ = 0.002

In this section, numerical examples to illustrate the effects of shocks to asset and CDO prices are provided. Asset securitization parameter choices are given in Table 1.

The 2007-2009 financial crisis exposed the limits of liability management and the proposed regulation will make the retreat from liability management permanent. To a much greater extent than at any time since the 1970s, banks will be forced back towards asset management, in other words towards a business model in which balance sheet size is determined from the liabilities side of the balance sheet, by the amount of funding which the bank can raise, and in which asset totals have to be adjusted to meet the available liabilities. This amounts to a macro prudential policy that is, a policy designed to prevent credit creation from getting out of hand as it did in the run-up to the recent crisis as expressed in Basel III on the macro prudential overlay, (BCBS, July 2013).

6.3. Numerical Example: Entity Equilibrium

Suppose that the LQ- and HQ-entities' deposits, borrowings, marketable securities and capital are equal. In this case, notice that the LQ- and HQ-entities' asset holdings, A and A′ are a proportion, α and 1−α of the aggregate assets, $\bar{A}$ respectively.

Table 1: Asset securitization parameter choices

Parameter	Value
μs	0.002
p_{m+1}	0.113
$\bar{A}_m$	720,000
r^R	0.5
T_{m-1}	\$2600
r^B	0.205
Σ	0.002
ν	0.2
c^p	0.03
$\bar{A}_{m-1}$	460,000
r^S	0.15
r^T	0.2
K_m	\$3000
C^*	240,000
α	0.3
r^f	0.2
r^f	0.061
T_m	\$4800
B_m	\$5000
n	1
$P(A'_{m-1})$	240,000

Thus, it is given that,

$$A = \alpha\bar{A} = 0.3720000 = 216,000; A' = (1-\alpha)\bar{A}$$
$$= (0.6-0.3)720,000 = 216,000$$

The LQ-entity's derivative output in period $m + 1$ is computed by considering the securitization function. Therefore, the derivative output can be computed by,

$$C_{m+1} = (\mu+\nu)A_m = (\mu+\nu)\alpha\bar{A}_m$$
$$= (0.002+0.2)\times 0.3\times 720,000 = 43632$$

Next, the upper bound of the LQ-entity's retention rate should be less that the discount factor β, thus,

$$\beta\left(\frac{0.002}{0.002+0.2}\right) = 0.0099099$$

The value of the LQ-entity assets in period m is computed by using,

$$p_m^A A_{m-1} = D_m + B_m + K_m - B_m = 1200 + 4800$$
$$+3000 - 5000 = 4000$$

The asset price in period m is therefore,

$$p_m^A = 4000 / \left(A_{m-1} = 4000 / \left(\alpha\bar{A}_{m-1} = 4000 / (0.3\times 460000)\right)\right)$$
$$= 0.0289855072$$

The LQ-entity's profit is computed by considering the cash flow constraint,

$$\Pi_m = \left(r^A + c_m^p r_m^f\right)p_m^A A_{m-1} + r^B B_m - r^D D_m - r^B B_m$$

$$\Pi_m = (0.061 + 0.03 \times 0.2) \times 4000 + 0.205 \times 5000 - 0.205 \times 1200 - 0.2 \times 4800 = 87$$

Furthermore, the LQ-entity's profit is subject to the constraint (2.9), thus,

$$\Pi_m = (0.061 + 0.03 \times 0.2)\ 4000 + 0.205 \times 5000 - 0.205 \times 1200 - 0.113 \times 0.3 \times 720,000 + 4800 = -18,561$$

The study computes the LQ-entity's additional consumption, $x_m - \nu A_{m-A}$ by considering the flow of funds constraint given by,

$$0.002 \times 0.3 \times 460,000 + 800 - (1 + 0.2) \times 2600 - 0.011904761\ (0.3 \times 720,000 - 0.3 \times 460,000) = 4227.4286$$

Next, the study concentrates on HQ-entity constraints. HQ-entities' secondary securitization at date m is computed by using,

$$x'_m = 280,000 + 4800 - 0.011904761(1-0.3)720,000 - (1-0.3)$$
$$\times 460,000 - (1+0.2)\times 2600 = -46319.99954$$

Thus $x_m = 54103.64210$.

Next, the HQ-entity's profit at face value is considered to compute profit at date m, thus,

$$\Pi_m^{'} = 0.061\times 4000 + 0.205\times 5000 - 0.205 \times 150 - 0.2\times 4800 = 123.5$$

In this regard, the value of assets can be computed as,

$$p_m^A A_{m-1}^{'} = \frac{123.5 - 0.205\times 5000 + 0.205\times 1200 + 0.2\times 4800}{0.061} = 4991.8$$

The HQ-entity's cash flow constraint is given by,

$$\Pi_m^{'} \geq 0.061\times 4000 + 0.205\times 5000 - 0.205\times 1200 - 0.113(1-0.3) \times 720,000 + 4800 = -51007$$

The screening cost an LQ-entity has to pay to purchase an asset unit is financed by the HQ-entity's net worth. This screening cost is represented by,

$$u_m = p_m^A - \frac{p_{m+1}^A}{1+r^B} = 0.011904761 - \frac{0.113}{1+0.2} = -0.082261905$$

The asset holding and borrowing, A_m and B_m of the entity may be computed as,

$$A_m = \frac{1}{0.082261905}[(0.002 + 0.011904761) \times 0.3\times 460000 - (1+0.2)\times 2600 = 14601.44865]$$

And,

$$B_m = \frac{1}{1+0.2} 0.113\times 0.3\times 720,000 = 20,340$$

The sum of the aggregate asset demand from asset originators by LQ- and HQ-entities' is computed by,

$$\bar{A} = A_m + nA_m^{'} = 0.3\times 720,000 + 1(1-0.3)720,000 = 720,000$$

The steady-state asset price and borrowings for the LQ-entity,

$$p^{A^*} = 0.002\frac{1+0.2}{0.2} = 0.012 \text{ and } B^* = \frac{0.002}{0.2} 260,000 = 2600$$

Notice that the required screening costs per asset unit equals the LQ-entity's securitization of marketable output $u^* = \mu = 0.001$. Also, it is given that $A_{m-1} = A^*$ and $B_{m-1} = B^*$.

6.4. Numerical Example: Shocks to LQ-assets and their SAPs

LQ-entity's asset demand and borrowings under a temporary shock at date m are computed by,

$$A_m = \frac{1}{-0.082261905}\begin{bmatrix}(0.002 - 0.002\times 0.002 + 0.011904761) \\ \times 0.3\times 460,000 - (1+0.2)\times 2600\end{bmatrix} = 14,608.15893$$

And,

$$B_m = \frac{1}{1+0.2} 0.113\times 0.3\times 720,000 = 20340 \text{ respectively.}$$

In this regard, the cost of funds in period m is computed as:

$$u(A_m)A_m = (0.002 - 0.002\times 0.002 + 0.011904761 - 0.022)\times 0.3 \times 460,000 = -1117.69$$

Also, LQ-entity's net value at date m is more than their current output just after the shock, thus,

$$(1-\Sigma)uA^* = (1-0.002)002\times 0.3\times 460,000 = 275.448$$

With unexpected capital gains,

$$\left(p_m^A + p^{A^*}\right)A^* = (0.011904761 + 0.022)\times 0.3\times 460,000 = 4679$$

While the debt repayment is given by,

$$\left(1+r^B\right)B^* = p^{A^*}A^* = (1+0.2)2600 = 3120$$

Proportional change in A_m and p_m^A can be computed as,

$$\hat{A}_m = \frac{0.3(720,000 - 460,000)}{0.3\times 460,000} = 0.565217391$$

And,

$$\hat{p}_m^A = \frac{0.011904761 - 0.022}{0.022} = -0.4588745$$

The steady-state profit for the LQ-entity is,

$$\Pi_m^* = (0.061 + 0.03\times 0.2)0.022\times 0.3\times 460000 + 0.205\times 5000 - 0.205\times 1200 - 0.2\times 2600 = 462.412$$

And steady-state profit for HQ-entities are,

$$\Pi_m^{'*} = 0.061\times 0.022(1-0.3)\times 460,000 + 0.205 \times 5000 - 0.205\times 1200 - 0.2\times 2600 = 691.124$$

Thus, the proportional changes in Π_m and $\Pi_m^{'}$ are,

$$\hat{\Pi}_m = \frac{87 - 462.412}{462.412} = -0.81186$$

And,

$$\hat{\Pi}_m^{'} = \frac{123.5 - 691.124}{691.124} = -0.82131$$

Residual for elasticity of LQ-entity at date t is given by,

$$\eta = \left[\frac{\frac{2+0.2}{0.2}0.4588745 - 0.002}{0.565217391} - 1\right]^{-1} = 0.126718931$$

The proportional changes for $\hat{p}_m^A$ and $\hat{A}_m$ are computed by,

$$\hat{p}_m^A = \frac{1}{0.126718931}0.002 = -0.015782961$$

And,

$$\hat{A}_m = -\frac{1}{1+\frac{1}{0.126718931}}\left(1+\frac{1+0.2}{0.126718931\times 0.2}\right)0.002$$
$= -0.010875327$ respectively.

By considering (2.9), it can be observed from (2.17) and (3.1) that $\hat{p}_m^A$ and $\hat{A}_m$ become,

$$\hat{p}_m^A \Big| p^A_{m+1=p^{A^*}} = -\frac{0.2}{0.126718931(2+0.2)}0.002 = -0.001434814$$

And,

$$\hat{A}_m \Big| p^A_{m+1=p^{A^*}} = -0.002 \text{ respectively.}$$

The proportional change in aggregate output, C_{m+1}, represented by (4.13) is given by,

$$\hat{C}_{m+1} = \frac{0.002+0.2-(1+0.2)0.002}{0.002+0.2}\frac{(0.002+0.2)0.3\times 460{,}000}{240{,}000}$$
$0.565217391 = 0.064869$

A summary of computed asset securitization parameters is provided in Table 2.

The computed shock parameters show that the aggregate asset output $\hat{C}_{m+1}$ with an economic shock of 0.002 is found to be \$ 43,632 and the value of LQ-entity assets $p_m^A A_{m-1}$ comes to \$ 5000. LQ-entity asset demand, A_m, declines to \$ 14,608.15893 while the borrowings B_m is maintained at \$ 20,340 respectively. This implies that HQ-assets were more sensitive to changes in market conditions and that asset transformation may have been a greater priority. The proportional negative change in profit for the LQ-entity subsequent to a temporary shock is higher than that of the HQ-entities. In addition, the steady-state asset price p^{A^*} and the borrowings B^* for the LQ-entity increased to \$ 0.012 and \$ 2600, respectively. In summary, this example shows that when the shock is minimal the LQ-entity suffers less losses on their asset holdings and the rate of borrowing to refinance increases as compared to having been hit by a bigger shock. This explains why most people could not pay back their loans during the 2007-2009 financial crisis.

6.5. Simulation

Figure 1 displays the simulation results for the full nonlinear model, using parameters π, arrival rate of investment opportunities, ρ, the cost of investing in RABS, temporary shock Σ, $1 + r^T$ and $U(A)$. Where $U(A) = A - \nu$ with ν which is used to compute LQ-entity supply. The values used are $\pi = 0.1$, $\rho = 10$, $\Sigma = 0.95$, $1 + r^T = 1.1$ and $\nu = 2.0$.

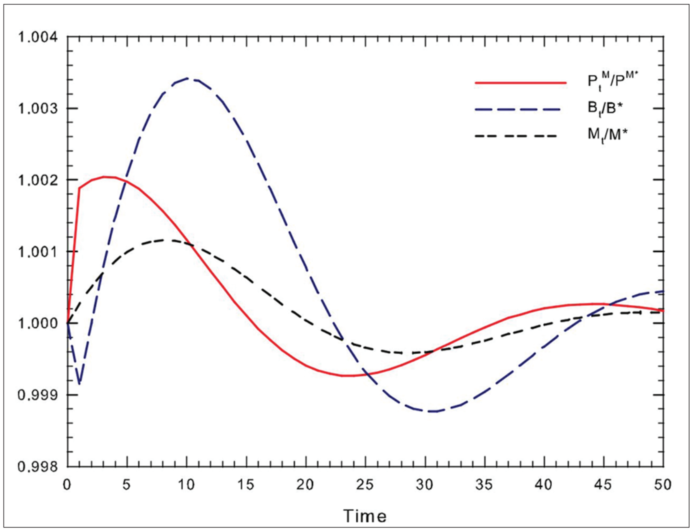
$$p_{m+1}^A / [(1+r^B)(p_m^A+\rho)]$$

Aggregate debt-asset ratio for assets is defined as $T_t / [(p_m^A+\rho)A_m]$ while the marginal debt-asset ratio is defined as $p_{m+1}^A / [(1+r^B)(p_m^A+\rho)]$ for an LQ-entity who is investing at time m. These ratios are given by 24% and 48%. The asset price increased by 0.20% and the LQ-entity's asset holding and debt increased by 0.12% and 0.34% respectively.

Table 2: Computed asset securitization parameters

Parameter	Value
C_{m+1}	43,632
$p_m^A A_{m-1}$	\$ 4000
$\Pi_m \geq$	\$ 18561
$x_m^{'}$	\$ 46,319.9995
$p_m^A A_{m-1}^{'}$	\$ 4991.8
u_m	−0.082261905
Aggregate T_m	\$ 20,340
p^{A^*}	0.012
A_m under shock	\$ 14,608.15893
$u(A_m) A_m$	−1117.69
$(p_m^A + p^{A^*})A^*$	\$ 4679
$\hat{A}_m$	0.565217391
Π_m^*	\$ 462.412
$\hat{\Pi}_m$	\$ −2.1118
η	0.126718931
$\hat{A}_m$ in terms of shock	0.01
$\hat{A}_m$ where $p_{m+1}^A = p^{A^*}$	−0.002
β >	0.0099099
Π_m	\$ 87
x_m	\$ 54,103.6421
$\Pi_m^{'}$	\$ 123.5
$\Pi_m^{'} \geq$	\$ −51,007
Aggregate A_m	14,601.44865
$\bar{A}$	720,000
T^*	\$ 2600
T_m under shock	\$ 20340
$(1-\Sigma)\mu A^*$	275.448
$(1+r^T)T^*$	\$ 3120
$\hat{p}_m^A = \hat{p}_m^C$	−0.4588745
$\Pi^{*'}$	\$ 275.31
$\hat{\Pi}_m^{'}$	\$ 691.124
$\hat{p}_m^A$ in terms of shock	−0.015782961
$\hat{p}_m^A$ where $p_{m+1}^A = p^{A^*}$	−0.001434814
$\hat{C}_{m+1}$	0.064869

Figure 1: The ratios of p_m^A/p^{A^*}, A_m/A^* and T_t/T^* for π = 10% and ρ = 10



7. CONCLUSION

The findings of this paper are interesting and can be explained as follows: Firstly, the Question 1.1 is answered by determining the securitization of assets into HQ- and LQ-assets by HQ- and LQ-entities respectively. In the presence of a multiplier, changes to asset price and holdings, CDO output as well as profit are quantified subsequent to negative shocks. Also, changes to profit in terms of asset and prepayment rates as well as equity subsequent to negative shocks are quantified (refer to Questions 1.2 and 1.3). Finally, the article shows that an example can be produced to illustrate the impact of negative shocks on asset securitization by LQ- and HQ-entities. In this regard, a numerical example that illustrates the impact of negative shocks on assets and CDOs is illustrated. It shows that when parameter choices are altered and the size of the shock increased, the LQ-entity suffers significant losses to their asset holdings and the rate of borrowing increases (compare with Question 1.4). Also, the paper illustrated that asset price is most significantly affected by unexpected negative shocks from asset rates, while, for CDO price, shocks to speculative asset funding, investor risk characteristics and prepayment rate elicit statistically significant responses. Problems from the financial crisis relate to the models for assets and CDOs with respect to the reduction in incentives for banks to monitor entities, transaction costs, manipulation of CDO price and structure, CDO market opacity, self-regulation, systemic risks associated with CDOs and the mispricing of debt. The BCBS should insure that it imposes high penalty charges for banks that do not have sufficient capital and liquidity but are in the business of securitizing assets. There should be a minimum capital and liquidity level set up for each bank to adhere to before they indulge in securitization practices. Governments of each respective country should insure that they set up regulatory boards that will insure sound banking principles are followed by each bank operating in the country.

8. CONFLICT OF INTERESTS

I the author of this manuscript, do not have a direct financial relationship with the commercial entities mentioned in this article that might lead to a conflict of interest.

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