

# A Stock-Flow Consistent Model of the Shadow Banking System with Some Minsky Dynamics

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## Abstract

This paper examines the internal dynamics of an artificial economy by use of the stock-flow consistent (SFC) macroeconomic modelling. Two (2) financial subsectors –commercial banks and investment banks – are incorporated to delineate their interactions. The commercial banks originate mortgages, and issue mortgage-based securities (MBS) whose price is positively correlated with housing prices, while the investment banks purchase the securities.

An increase in autonomous consumption by households leads to higher levels of economic activities. The time path shows cyclical dynamics resulting from investment behaviour of the producing firm sector and mortgage management of households. Commercial banks and investment banks react differently. In the new steady state, leverage of commercial banks is higher and leverage of investment banks is lower than the initial baseline levels.

Changes in the interest rate on mortgages influence the time path significantly. A lower interest rate on mortgages increases housing demand, and output goes up. Both housing prices and security prices decrease, which lowers the net worth of investment banks. The leverage of investment banks goes up in the new steady state.

A lower MBS price decreases the net worth of investment banks and increases leverage, which pushes down housing demand, and mortgage demand decreases. Therefore, output and household income decline. Commercial banks' leverage is higher, while investment banks' leverage is lower than that in the initial baseline solution.

The model demonstrates that investment banks are counter-cyclical with asset management and price changes in MBS. However, financial factors can act as sources of financial fragility.

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# Introduction

The global financial crisis of 2007-9 demonstrated a recent culmination of the inherent instability of the financial system, rampant with convoluted financial innovations such as securitization. The systemic risk implied by the internal dynamics can be debilitating forces. The capitalist economy is prone to Minskyian cyclical business cycles.

In hindsight, the world's most advanced economies saw a great recession after the Great Moderation, but did not succumb to a total economic decimation. Historically, it looks like the Morris Theorem, which articulates that "Change is caused by lazy, greedy, frightened people looking for easier, more profitable and safer ways to do things. And they rarely know what they're doing" (Morris, 2010: p. 28).

Fortunately, established on a solid accounting framework, the stock-flow consistent (SFC) modelling offers a glimpse into the workings of the monetary economy – at least the methodology helps people know more about what to do. This paper will discuss how an artificial economy evolves with a housing market and two financial subsectors, and under what conditions the Minskyian business cycles can be generated by addressing the structure of leverage.

# Chapter 1

## The Shadow Banking System

The term “shadow bank” was created in 2007 referring mainly to nonbank financial institutions such as money-market mutual funds. Due to the plethora of ever-evolving characteristics of shadow banking, various definitions exist such as that by Lysandrou and Nesvetailova (2015). According to the Financial Stability Board (FSB), the “shadow banking system” can broadly be classified as “credit intermediation involving entities and activities (fully or partially) outside the regular banking system” (FSB, 2012).

To emphasize the essential characteristics of shadow banking, Claessens and Ratnovski (2014) describe shadow banking as “all financial activities, except traditional banking, which require a private or public backstop to operate”, while backstops can be in the form of the franchise value of a bank or insurance company or a government guarantee. On the other hand, the functional approach specifies shadow banking as a collection of specific financial activities, such as securitization and collateral services. This paper emphasizes the securitization process of residential mortgages.

Money Manager Capitalism is naturally intended to tinker with the financial system and the economy for profitable opportunities. The financial sector has proliferated enormously in the last three decades, and securitization went together with the growth of shadow banking (Greenwood and Scharfstein, 2013). Similar to commercial banks, shadow banks engage in maturity transformation. However, shadow banks are not subject to traditional commercial banking regulations. Consequently, these entities do not have traditional depositors whose funds are protected by insurance. Furthermore, shadow banks do not have explicit access to the central bank’s lender-of-last-resort guarantees. The conglomerate of shadow banking and traditional

banking poses systemic risks to the functioning of the economy in bewildering ways (Roubini, 2011: chapter 3).

History does not repeat itself, but it rhymes. According to Hyman Minsky's iconoclastic financial instability hypothesis (FIH), "stability ..... is destabilizing" (Minsky, 2008: p. 11). Furthermore, "..... the fundamental instability is 'upward'" (ibid., p. 162). The decentralized capitalist economy is at best "conditionally coherent" (Minsky, 1986: p. 117). "A rise in price may thus breed conditions conducive to another such rise" since a rise in the relative prices of some capital assets may increase their quantity demanded (ibid., p. 117).

In unfolding these processes the present paper models how investment is financed in an artificial economy with a real estate market where securitization takes place between two financial subsectors. The phenomenon that the economy "naturally" moves towards a more fragile financial system (Lavoie, 1986-87) will be discussed.

## Chapter 2

### Literature Review

With a perfect capital market, the dwelling is a normal good. However, if a liquidity constraint is imposed, a hedging effect against a liquidity crisis exists when the role of the dwelling as a form of saving becomes more prominent, so that housing cannot be regarded as a normal good. Both income and interest rates can have perverse effects on housing demand (Salo, 1994).

The demand for owner-occupied housing depends positively on income expectations, negatively on the user cost of housing capital and negatively on the availability of housing loans (Kenny 1999).

The innovative contribution by Lavoie and Godley (2001-02) leads to a plethora of work on the SFC macroeconomic modelling. The literature on the SFC modelling of the housing market with securitization is summarized below.

In a stock-flow consistent accounting framework, Zezza (2008) splits households into two categories. The workers rent houses, or purchase dwellings by obtaining mortgages. The model shows that an increase in the expected housing price will generate a price bubble if new housing supply lags behind the increase in speculative demand. Furthermore, output will increase due to capital gains on the existing stock of homes and residential investment, and the saving rate will go down.

By introducing the securitization of mortgages, Eatwell *et al.* (2008) explore the driving force behind the expansion of sub-prime mortgage lending. The pro-cyclical leverage management of the “shadow banking system” leads to unstable scenarios.

Nikolaïdi (2010) develops a stock-flow consistent model that encompasses a three-sector financial system with the process of securitization. A more intensive securitization process and

the investment banking sector's higher preference for mortgage-backed securities are likely to affect positively both the real and the financial side of the economy. However, these positive outcomes generate financial fragility.

Fontana and Godin (2013) discuss the balance sheet management behaviours of private banks and worker households. Through the securitization process mortgage loans are converted into tradable securities held by investment banks for profits. Active balance sheet management by investment banks leads to a pro-cyclical leverage ratio, while the leverage of workers is counter-cyclical.

## Chapter 3

### Methodology

The stock-flow consistent (SFC) modelling is utilized in this paper. To ensure that money stocks and flows satisfy accounting identities in sectoral budgets and in the economy as a whole, an SFC model incorporates a proper balance sheet matrix and a transactions flow matrix; therefore, SFC models are intrinsically dynamic. The SFC approach captures quintessentially interactions between the real and the financial parts of the industrial capitalist economy in a single, coherent framework. Since time is an integral ingredient of the modelling, the path of the economy through time can be readily simulated.

#### 2.1 The balance sheet matrix

The balance sheet specifies the stock level of each sector at the end of the period. This paper follows the revised balance sheet matrix suggested by Lavoie (2008: p. 32), which is presented in Table 1, while Table 2 gives the starting values of the stock variables for computer simulation.

Instead of historical cost accounting, in the balance sheet the evaluation of all entries, except inventories, follows the mark-to-market accounting principles; i.e., they are evaluated at market prices. In Table 1 all assets carry a plus sign while liabilities appear with a minus sign. In the penultimate row, the net worth of each sector is also assigned a negative sign, so that all the columns must sum to zero. However, the rows that record tangible capital do not sum to zero, such as rows 1 and 2 in Table 1.

In the SFC framework corporate equities are treated as a liability for accounting coherence. Accordingly, the resultant net worth of production firms is of no practical significance. However, in the model presented in this paper, mortgage-backed securities (MBS) are the only type of assets of investment banks.

## 2.2 The revaluation matrix

This matrix records the changes in assets arising from revaluation gains. The capital gains comprise two components: gains on housing units and mortgage-backed securities.

## 2.3 The transactions-flow matrix

This matrix records all inter-sectoral transactions in the current period. Table 3 describes the accounting transactions-flow matrix corresponding to the balance sheet of Table 1. In the matrix the sources of funds appear with a plus sign, while the uses of funds take a minus sign.

Each row of the transactions-flow matrix depicts monetary transactions for the respective asset or flow; therefore, each row must sum to zero. Each column represents the sources and uses of all flows to and from a sector or a subsector so that all columns must sum to zero as well. Consequently, the zero-sum rule represents the budget constraint of each sector. The fact that every row and every column sum to zero necessitates the respect of a quasi-Walras' Law, so that one redundant equation exists in the SFC model and must be dropped in numerical simulation *per se*.

The economy can be viewed as a complex system (Bezemer, 2012). The economy is shaped by balance sheets; however, other factors may affect the time path of the model as well. These include: (1) the configuration of the behavioural equations, (2) the starting values of the stock variables and lagged variables, and (3) the specifics of the parameters employed in simulation.

## Chapter 4

### The Model

The paper discusses a closed economy with instantaneous production of services. Uncertainties are non-existent in that economic agents have perfect foresight, although expectations are also taken into consideration for comparison. Information asymmetry and, consequently, the imbalance of power in transactions are not germane.

The model is based on the revised balance sheet matrix presented by Lavoie (2008: p. 32). There are four sectors, but no public sector, in this artificial economy. These are the household sector, the non-financial production firm sector, the financial sector and the central bank. Furthermore, the financial sector is composed of two subsectors: commercial banks and investment banks. The main business of the commercial banks is deposit-taking and making loans, while the investment banks are predominantly active in the securities market.

All variables present in the model are measured at current prices. All profits are immediately distributed. However, two elements of wealth are prone to changing prices, which are homes and the mortgage-based securities (MBS). Consequently, these two assets may incur capital gains or losses.

The interest rates on the financial assets are assumed to depend on the interbank credit rate, which serves as the base rate in the current model. The structure of the interest rates is such that the interest rate on loans is higher than the interest rate on mortgages, which is higher than the interest rate on repos. The interest rate on term deposits is the lowest and is identical to the interbank credit rate. Due to the institutional settings of the current model, the interest rate on central bank advances is set to be zero. Furthermore, for simplification, the mortgage interest

payments are assumed to be the revenue received by the investment banks instead of the commercial banks. Subsequently, the dividend payments on the MBS are not directly introduced.

### 3.1 The housing market

The demand for housing, in equation (4.1), depends (a) negatively on the price of houses  $p_h$ , (b) positively on the rate of change in housing prices  $\Delta p_h/p_{h(-1)}$  (the capital gains), (c) negatively on the interest rate on mortgages  $r_m$ , (d) negatively on the leverage ratio of the households  $LEV_h$ , and (e) negatively on the leverage ratio of the investment banks,  $LEV_{ib}$  (Eatwell *et al.*, 2008).

$$\Delta H_h/H_{h(-1)} = \beta_0 - \beta_1 \cdot p_{h(-1)} + \beta_2 \cdot \Delta p_h/p_{h(-1)} - \beta_3 \cdot r_m - \beta_4 \cdot LEV_h - \beta_5 \cdot LEV_{ib} \quad (4.1)$$

Equation (4.2) shows that the demand for housing mortgages depends negatively on the interest rate on mortgages  $r_m$ , and follows a partial adjustment process towards a targeted level of leverage  $LEV_h^T$ , which can be interpreted as a variation of credit rationing imposed on the households. The price of housing is derived from equation (4.3). In equation (4.4) leverage is defined as the ratio of total debts on total assets.

$$\Delta M_h/M_{h(-1)} = \beta_6 - \beta_7 \cdot r_m + \beta_8 \cdot [LEV_h^T - LEV_{h(-1)}]/LEV_{h(-1)} \quad (4.2)$$

$$p_h = M_h/H_h \quad (4.3)$$

$$LEV_h = M_h/(p_h \cdot H_h + D_h + TD) \quad (4.4)$$

### 3.2 Households

Households do not borrow for consumption purposes but they take on mortgages. As shown in equation (4.5), household consumption depends on two factors: disposable income  $YD$  and total wealth accumulated,  $V_{h(-1)}$ .

$$C = \alpha_0 + \alpha_1 \cdot YD + \alpha_2 \cdot V_{h(-1)} \quad (4.5)$$

The disposable income  $YD$  is composed of wages  $WB_s$ , interest payments from investment banks  $r_d \cdot TD_{(-1)}$ , and profits from the firm sector and the financial sector. Firms and the financial sector distribute all profits to households immediately.

$$YD = WB_s + F_f + F_{cm} + F_{ib} + r_d \cdot TD_{(-1)} - r_m \cdot M_{h(-1)} \quad (4.6)$$

The allocation of checking deposits  $D_h$  and term deposits  $TD$  depends on the liquidity preference of households, as shown in equations (4.7) and (4.8), where  $V_{fma}$  is financial market asset (investible) wealth of households.

$$TD = V_{fma} \cdot [\lambda_0 + \lambda_1 \cdot r_d - \lambda_2 \cdot (YD/V_{fma})] \quad (4.7)$$

$$D_h = V_{fma} - TD \quad (4.8)$$

The net worth of households  $V_h$  is given by the accounting identity in equation (4.9), where  $CG_h$  is housing capital gains.

$$\Delta V_h \equiv (YD - C) + CG_h \quad (4.9)$$

$$CG_h = H_{h(-1)} \cdot \Delta p_h \quad (4.10)$$

### 3.3 Producing firms

The firm sector does not issue equities or hold high-powered money. The firms do not have any net worth in that the price level in the goods market remains constant. Furthermore, the production firms do not carry inventories in the goods market.

Total production  $Y$  is defined as the sum of consumption, investment and new housing.

$$Y \equiv C + I + p_h \cdot \Delta H_s \quad (4.11)$$

The mechanisms adjusting supply and demand for housing in equation (4.12) and other similar identities follow the discussions by Godley and Lavoie (2012: chapter 3).

$$H_s \equiv H_h \quad (4.12)$$

The wage bill  $WB_d$  is assumed to be a constant share of output,  $Y$ .

$$WB_d = \omega \cdot Y \quad (4.13)$$

Amortization funds  $AF$  are a constant proportion of the fixed capital  $K_{(-1)}$  at the end of last period.

$$AF = \delta \cdot K_{(-1)} \quad (4.14)$$

The investment behaviour of the firms follows Model *BMW* by Godley and Lavoie (2012, Chapter 7). The change in the stock of fixed capital is identical to the balance between gross investment  $I$  and amortization funds  $AF$ .

$$K = K_{(-1)} + (I - AF) \quad (4.15)$$

Firms have a targeted capital stock level  $K^T$ , which is a constant fraction of output of the previous period.

$$K^T = \kappa \cdot Y_{(-1)} \quad (4.16)$$

Investment function (4.17) is a partial adjustment accelerator model. Gross investment  $I$  is the sum of net investment and amortization funds  $AF$ .

$$I = \gamma \cdot [K^T - K_{(-1)}] + AF \quad (4.17)$$

Equation (4.18) describes the firm sector's external financial requirements. Required bank loans  $L_f$  act as a buffer, absorbing changes in financial requirements.

$$L_f \equiv L_{f(-1)} + I - AF \quad (4.18)$$

### 3.4 The commercial banks

It is hypothesized that the commercial banks will supply whatever amount of loans is being demanded by the firms. The commercial banks are subject to the fractional reserve rule in that the sector holds a portion of deposits in the form of high-powered money *HPM* at the central

bank. The compulsory reserve ratio, which is equal to 8% in the model, is at the discretion of the central bank.

$$HPM_d = \rho \cdot D_h \quad (4.19)$$

In equation (4.20) the securitization process is such that each “unit” of securities is backed by a “unit” of housing mortgages (Fontana and Godin, 2013). The price of securities  $p_s$  is proportional to the housing price  $p_h$ .

$$s = M_h \quad (4.20)$$

$$p_s = \sigma \cdot p_h \quad (4.21)$$

### 3.5 The investment banks

The two accounting identities of the investment banks are derived directly from the transactions-flow matrix. The amount of repos borrowed from the commercial banks arises from the need to finance the securities purchased in the current period.

$$\Delta Repo_d \equiv p_s \cdot \Delta s - \Delta TD \quad (4.22)$$

### 3.6 The central bank

The central bank is assumed to be run without capital of its own. A government sector is not present in the current model; consequently, due to this specific institutional setting, the central bank advances do not bear interest. The central bank provides advances on the basis of its balance-sheet constraint.

$$HPM_s \equiv HPM_d \quad (4.23)$$

$$A_s \equiv HPM_s \quad (4.24)$$

### 3.7 Stability analysis

There is no growth in the model so that the steady state is a stationary state. Since household saving is zero in the steady state, household consumption is equal to disposable income.

The profits of firms  $F_f$ , commercial banks  $F_{cm}$  and investment banks  $F_{ib}$  are defined by the following three accounting identities derived from the transactions-flow matrix, respectively:

$$F_f \equiv Y - WB_d - AF - r_l \cdot L_{f(-1)} \quad (4.25)$$

$$F_{cm} \equiv r_l \cdot L_{f(-1)} + r_r \cdot Repo_{s(-1)} \quad (4.26)$$

$$F_{ib} \equiv r_m \cdot M_{h(-1)} - r_d \cdot TD_{(-1)} - r_r \cdot Repo_{d(-1)} \quad (4.27)$$

Substitute these three equations into equation (4.6), the latter becomes

$$YD^* = Y^* - AF^* \quad (4.28)$$

Substitute equations (4.14) and (4.16) into (4.28), equation (4.28) becomes

$$YD^* = (1 - \delta \cdot \kappa) Y^* \quad (4.29)$$

Therefore, the relationship between  $Y^*$  and  $YD^*$  is the same as equation (7.28) by Godley and Lavoie (2012, Chapter 7: p. 229):

$$Y^* = \frac{YD^*}{(1 - \delta \cdot \kappa)} \quad (4.30)$$

Consequently, partial stability analysis can be done for the production firm sector. However, stability analysis for the current model as a whole is difficult due to the presence of non-linear behavioural relationships.

Table 1 The balance sheet with mortgage-based securities

	Households	Firms	Commercial banks	Investment banks	Central bank	$\Sigma$
	(1)	(2)	(3)	(4)	(5)	(6)
1 Productive capital		$+ K_f$				$+ K_f$
2 Homes	$+ p_h \cdot h_h$					$+ K_h$
3 Cash			$+ HPM$		$- HPM$	0
4 Advances			$- A$		$+ A$	0
5 Checking deposits	$+ D_h$		$- D$			0
6 Term deposits	$+ TD_h$			$- TD$		0
7 Loans		$- L_f$	$+ L$			0
8 Repos			$+ Repo$	$- Repo$		0
9 Mortgages	$- M_h$		$+ M$			0
10 MBS			$- p_s \cdot s$	$+ p_s \cdot s$		0
11 Balance (net worth)	$- V_h$	$- V_f$	$- V_{cm}$	$- V_{ib}$	0	$- K_f - K_h$
12 $\Sigma$	0	0	0	0	0	0

Table 2 The balance sheet with initial values

	Households	Firms	Commercial banks	Investment banks	Central bank	$\Sigma$
	(1)	(2)	(3)	(4)	(5)	(6)
1 Productive capital		+ 5,000				+ 5,000
2 Homes	+ 2,800					+ 2,800
3 Cash			+ 59.6		- 59.6	0
4 Advances			- 59.6		+ 59.6	0
5 Checking deposits	+ 745		- 745			0
6 Term deposits	+ 6,255			- 6,255		0
7 Loans		- 5,000	+ 5000			0
8 Repos			+ 45	- 45		0
9 Mortgages	- 2,800		+ 2,800			0
10 MBS			- 7,000	+ 7,000		0
11 Balance (net worth)	- 7,000	0	- 100	- 700	0	- 7,800
12 $\Sigma$	0	0	0	0	0	0

Table 3 The revaluation matrix

		Households	Firms	Commercial banks	Investment banks	Central bank	$\Sigma$
		(1)	(2)	(3)	(4)	(5)	(6)
1	Homes	$+ h_{(-1)} \cdot \Delta p_h$					$+ h_{(-1)} \cdot \Delta p_h$
2	MBS			$- s_{(-1)} \cdot \Delta p_s$	$+ s_{(-1)} \cdot \Delta p_s$	0	

Table 4 The accounting transactions-flow matrix

	Households	Firms		Commercial banks		Investment banks		Central bank	$\Sigma$
		Current	Capital	Current	Capital	Current	Capital		
Consumption	$-C$	$+C$							0
Investment		$+I$	$-I$						0
Housing investment	$-p_h \cdot \Delta h_h$	$+p_h \cdot \Delta h_s$							0
[Production]		[Y]							
Wages	$+WB_s$	$-WB_d$							0
Depreciation allowances		$-AF$	$+AF$						0
Firm profits	$+F_f$	$-F_f$							0
Commercial bank profits	$+F_{cm}$			$-F_{cm}$					0
Investment bank profits	$+F_{ib}$					$-F_{ib}$			0
Interest on									0
Term deposits	$+r_{d(-1)} \cdot TD_{h(-1)}$					$-r_{d(-1)} \cdot TD_{(-1)}$			0
Loans		$-r_{l(-1)} \cdot L_{f(-1)}$		$+r_{l(-1)} \cdot L_{(-1)}$					0
Repos				$+r_{r(-1)} \cdot Repo_{s(-1)}$		$-r_{r(-1)} \cdot Repo_{d(-1)}$			0
Mortgages	$-r_{m(-1)} \cdot M_{h(-1)}$					$+r_{m(-1)} \cdot M_{(-1)}$			0
Change in stocks of									0
Cash					$-\Delta HPM_d$			$+\Delta HPM_s$	0
Advances					$+\Delta A_d$			$-\Delta A_s$	0
Checking deposits	$-\Delta D_h$				$+\Delta D$				0
Term deposits	$-\Delta TD_h$						$+\Delta TD$		0
Loans			$+\Delta L_f$		$-\Delta L$				0
Repos					$-\Delta Repo_s$		$+\Delta Repo_d$		0
Mortgages	$+\Delta M_h$				$-\Delta M$				0
MBS					$+p_s \cdot \Delta s$		$-p_s \cdot \Delta s$		0
$\Sigma$	0	0	0	0	0	0	0	0	0

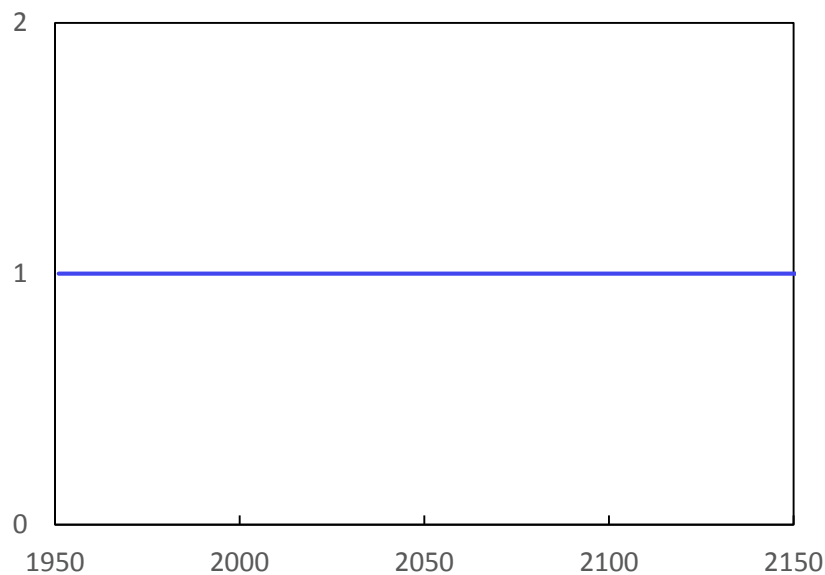
## Chapter 5

### Results and Discussion

The time path of the model is examined by the use of numerical simulation. Initial values for parameters and lagged endogenous variables are assigned to approximate stylized facts such as the proportion of different types of assets in the household's portfolio choice. A steady state or baseline solution is obtained first, and shocks to the system are subsequently applied and analyzed.

The water-tight accounting of the stock-flow modelling necessitates that a redundant equation exists and must always be respected. Figure 5.1 demonstrates that the amount of repos supplied is always identical to the amount demanded for all scenarios discussed thereafter.

*Figure 5.1* The redundant equation ( $Repo_s = Repo_d$ ) demonstrated with the ratio being unity



## 5.1 Effects of an increase in autonomous consumption

Figure 5.2 Evolution of output, disposable income and consumption following a one-step permanent increase in autonomous consumption

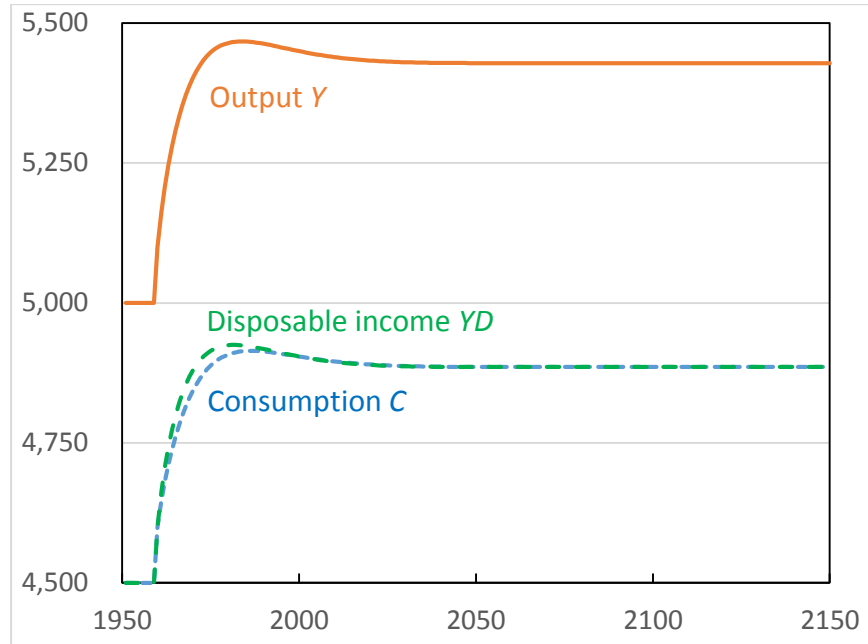


Figure 5.3 Evolution of gross investment and replacement investment following a one-step permanent increase in autonomous consumption

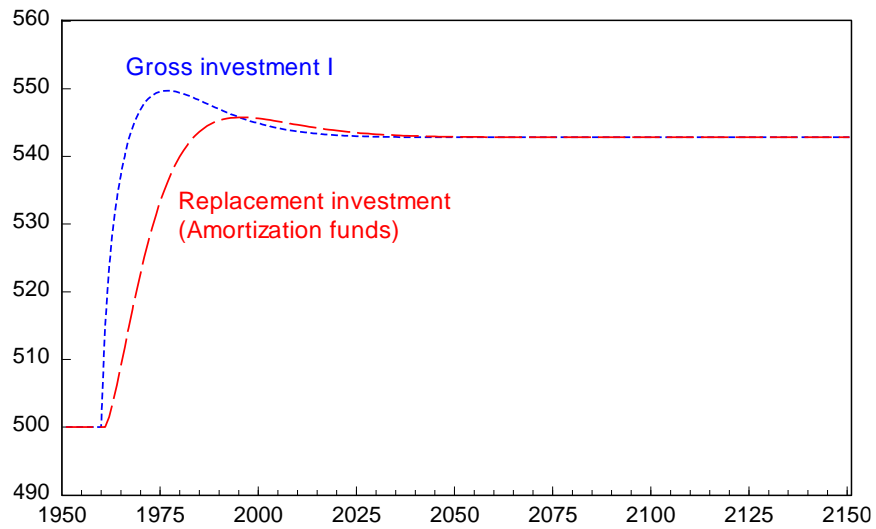


Figure 5.2 illustrates that output, disposable income and consumption go up with a one-step permanent increase in autonomous consumption from 425 to 450. Furthermore, the time path shows Minskyian dynamics, which is generated by investment behaviour and mortgage demand.

Before reaching the new steady state, output augmentation results in positive gross investment in productive capital. Net investment dwindles down to zero once beyond the steady state (Figure 5.3). This partial adjustment process takes place in the housing mortgage demand as well. During the transition, household leverage decreases initially since the sector's net worth growth outpaces mortgages.

However, the cyclical behaviour is not a necessary feature of the model since simulations demonstrate that the same model with different parameters can generate smooth trajectories. Furthermore, if expectations are introduced into the model, the cyclical behaviour may vanish as well. For example, households can be assumed to base consumption on expected income in the following equations:

$$C = \alpha_0 + \alpha_1 \cdot YD^e + \alpha_2 \cdot V_{h(-1)} \quad (5.1)$$

$$YD^e = YD_{(-1)} + \varepsilon \cdot (YD_{(-1)} - YD_{(-1)}^e) \quad (5.2)$$

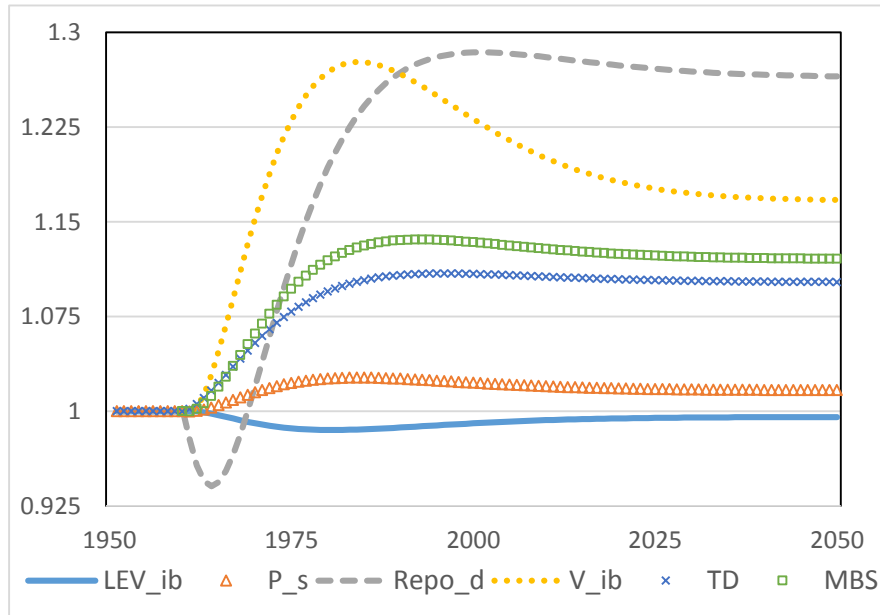
where  $\varepsilon$  is a reaction parameter related to expectations and is equal to 0.5. The simulation shows a smooth transition without cyclicity from the baseline solution to the new steady state.

The higher levels of economic activity induce different reactions from the commercial banks and the investment banks, respectively. More household net worth increases term deposits, which induces the investment banks to borrow less repos from the commercial banks in the early stages of the transition. More housing mortgages lead to higher housing prices, MBS prices and capital gains on MBS; therefore, the net worth of the investment banks increases (Figure 5.4).

Consequently, the leverage ratio of the investment banks goes down in the initial stages of the transition period.

In the later stages of the transition, incremental housing mortgages induce the commercial banks to issue more mortgage-backed securities (MBS). The investment banks need to borrow more from the commercial banks, and the leverage of the investment banks levels up and remains slightly below that of the baseline position (Figure 5.5). However, the total liabilities of investment banks are higher at the new steady state.

*Figure 5.4* Evolution of term deposits, repos, investment bank net worth, MBS, MBS price and investment bank leverage ratio, relative to their initial steady-state values, following a one-step permanent increase in autonomous consumption



For the commercial banks it is another story. Higher economic activity stimulates the production firms to borrow more from the commercial banks. In the later stages of the transition, the investment banks borrow more from the commercial banks as well. However, the new

borrowing grows more slowly than the MBS so that the leverage of the commercial banks is higher at the new steady state.

*Figure 5.5* Evolution of leverage ratios of households, commercial banks and investment banks, relative to their initial steady-state values, following a one-step permanent increase in autonomous consumption

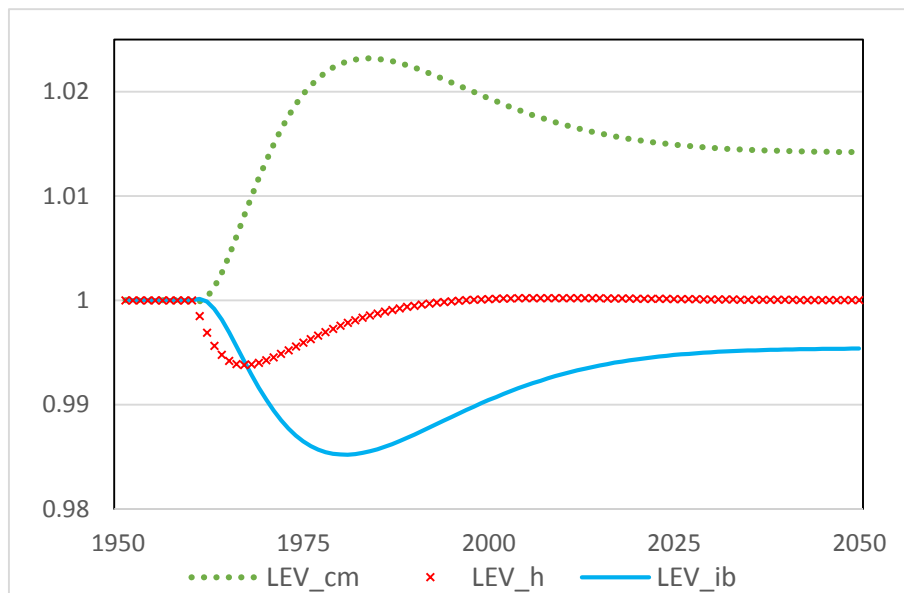
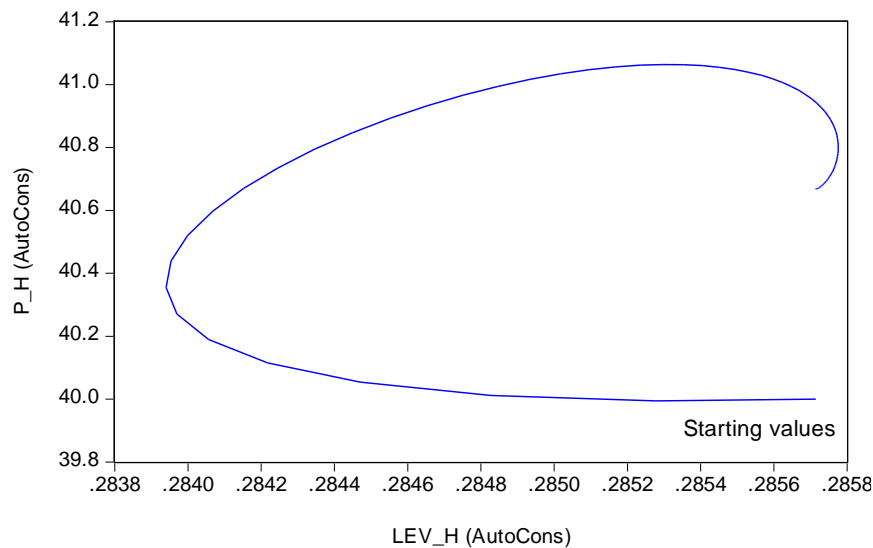


Figure 5.6 demonstrates the relationship between housing prices and the household leverage ratio following a one-step permanent increase in autonomous consumption. Initially the leverage ratio goes down since household total assets increase faster than total debts (mortgages) and then goes up with an incremental housing price. Housing prices decrease before reaching the steady state, and the leverage ratio returns to the level it had in the baseline scenario because of the partial adjustment process of housing mortgage demand (equation 4.2).

Figure 5.6 Housing price vs. household leverage ratio following a one-step permanent increase in autonomous consumption (clockwise trajectory)



Investment banks seek active balance sheet management and the pro-cyclical leveraging leads to a financial crisis (Eatwell *et al.*, 2008). In a financial system in which balance sheets are marked to market, leverage is strongly pro-cyclical (Adrian and Shin, 2010). However, in the current model, the investment banks respond passively to the counter-cyclical forces since there is a negative relationship between the banks' assets (MBS) and the leverage ratio (Figure 5.4). Therefore, in the current model the investment banks are passive in the face of fluctuating asset prices.

Figure 5.7 shows the negative relationship between MBS prices and the investment banks leverage ratio following a one-step permanent increase in autonomous consumption. When the MBS price goes up, leverage decreases and vice versa. A comparable phenomenon can be observed in the time path of the amount of repos with respect to leverage ratio of the investment banks (Figure 5.8).

However, a counter-cyclical leverage ratio does not necessarily indicate economic health. Mouakil (2014) proposes to use an interest coverage ratio and a debt-service coverage ratio to measure financial fragility so that maturity mismatch between long-term assets and short-term debts in borrowers' balance sheets can be incorporated. To do this, endogenous interest rates are needed. Furthermore, firms and banks do not keep retained earnings, and profits are distributed to households in the current model. Caverzasi (2013) reports that if profits are distributed and households save a part of the profits, debt-financed investments give rise to a higher indebtedness level of firms. Therefore, the choice of behavioural equations in the model can have an impact on the evolution of the artificial economy.

The cumulative flows of interest and financial fees between the real economy (households and firms) and the financial sector (commercial banks and investment banks) are equal to

$$F_{cm} + F_{ib} + r_d \cdot TD_{(-1)} - r_m \cdot M_{h(-1)} - r_l \cdot L_{f(-1)} \quad (5.3)$$

By substituting equations (4.26) and (4.27) into (5.3), one finds that the above cumulative amount is zero. The reason is that firms and banks do not keep retained earnings and all profits are distributed to households immediately. Consequently, due to this specific configuration of the transactions-flow matrix, this paper does not discuss the role of the flows of interest and financial fees on the real economy.

Figure 5.7 MBS price vs. investment bank leverage ratio in the stable regime following a one-step permanent increase in autonomous consumption (clockwise trajectory)

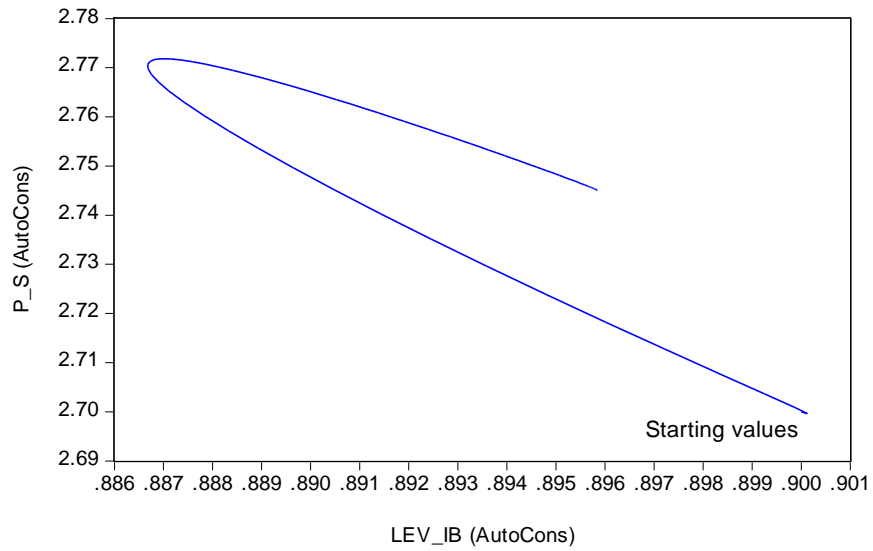
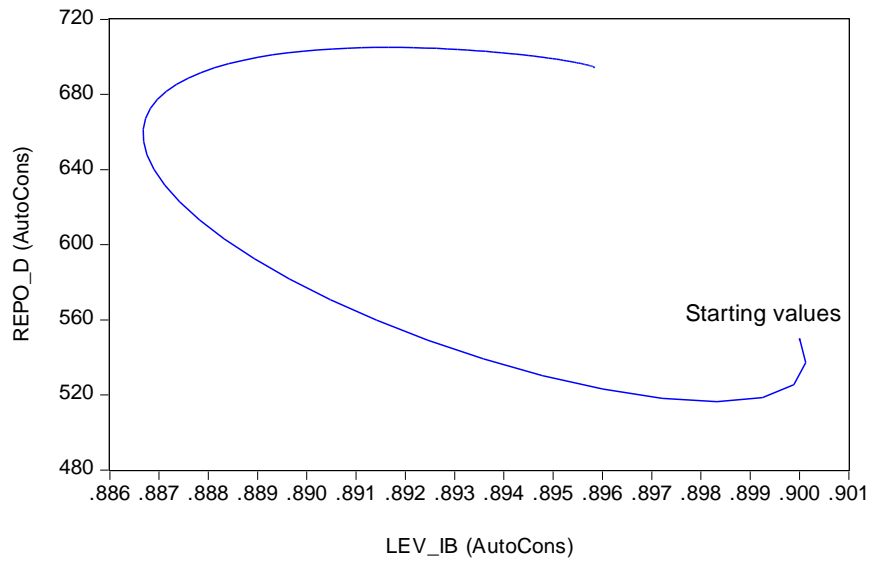


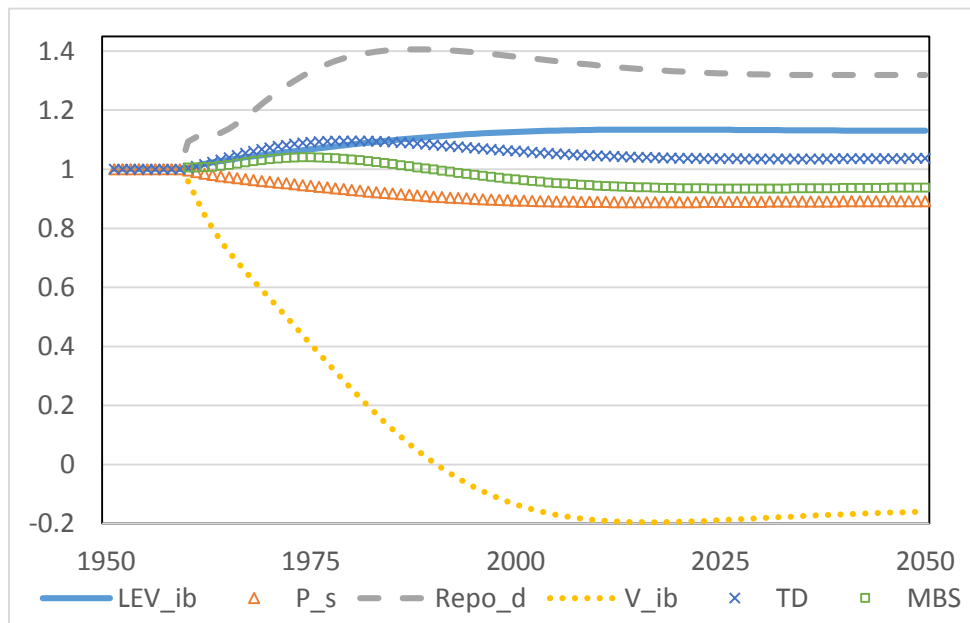
Figure 5.8 Repos demanded vs. leverage ratio of the investment banks following a one-step permanent increase in autonomous consumption



## 5.2 Effects of a decrease of 50 points in the interest rate on mortgages

The interest rate on mortgages plays a substantial role, in the sense that a decrease from 5% to 4.5% alters the time path of the system significantly (Figure 5.9). Furthermore, the model is sensitive to changes in the interest rate on mortgages.

*Figure 5.9* Evolution of term deposits, repos, investment bank net worth, MBS, MBS price and investment bank leverage ratio, relative to their initial steady-state values, following a one-step permanent decrease of 50 points in the interest rate on mortgages



Lower interest rate on mortgages increases housing demand, which pushes up output and the wage bill so that households have higher net worth and save more. Although both housing demand and mortgages depend negatively on the mortgage interest rate, housing demand (equation 4.1) increases faster than mortgages (equation 4.2), which pushes down housing prices (Figure 5.10). Proportionally, the MBS price decreases as well, which leads to a lower net worth of the investment banks. The investment banks have to borrow more repos from the commercial banks. In the new steady state, the leverage of the investment banks is about 13% higher than in the baseline, while the leverage of the commercial banks is about 10% lower (Figure 5.11).

Figure 5.10 Evolution of housing units and mortgages, relative to their initial steady-state values, following a one-step permanent decrease of 50 points in the interest rate on mortgages

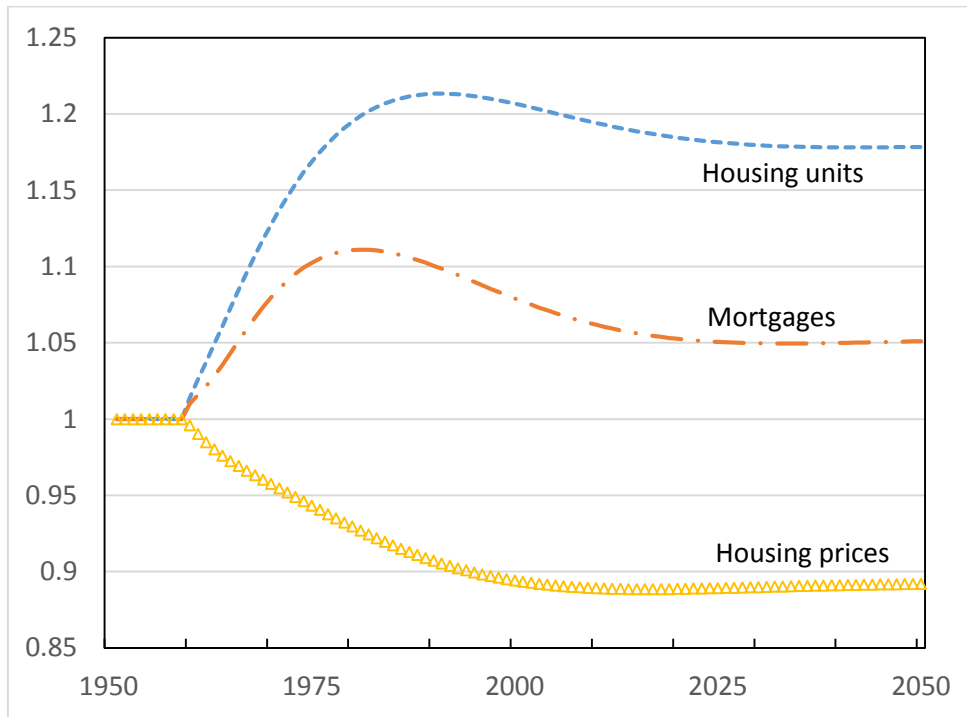
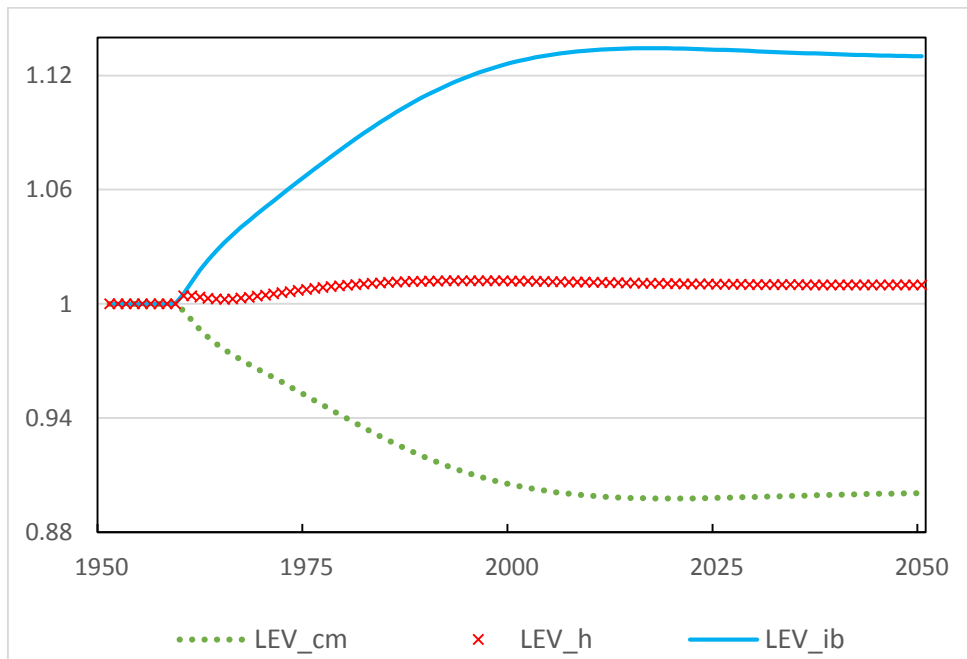


Figure 5.11 Evolution of leverage ratios of households, commercial banks and investment banks, relative to their initial steady-state values, following a one-step permanent decrease of 50 points in the interest rate on mortgages



### 5.3 Effects of a decrease in MBS price

In the model, the parameter  $\sigma$ , which is the ratio of MBS price to housing price, is decreased from 0.0675 to 0.06, so that the MBS price declines from 2.7 to 2.4. The immediate effect of a decrease in the MBS price is lower net worth and higher leverage for the investment banks, which lowers housing demand (equation 4.1). Consequently, housing prices and the leverage ratio of households go up (equations 4.3 and 4.4), and housing mortgages decrease. Depressed housing demand exerts a downward pressure on output, wage bills and household disposable income (Figure 5.12). Households are dissaving since disposable income is lower than consumption, and household net worth declines.

Therefore, in the current model, the securitization process introduces instability into the economy when securities price is depressed.

There are two stabilizing factors that return the economy to a new steady state. One is the production firm sector through the accelerator equation; the other is the household sector with its targeted leverage level. At the new steady state, housing mortgages are restored to their original baseline level with lower housing demand and a higher price. Since the MBS price is correspondingly higher (Figure 5.13), the leverage ratio of the investment banks goes down while the leverage of the commercial banks rises with respect to the baseline values (Figure 5.14).

Figure 5.12 Evolution of output, disposable income and consumption following a decrease in MBS price

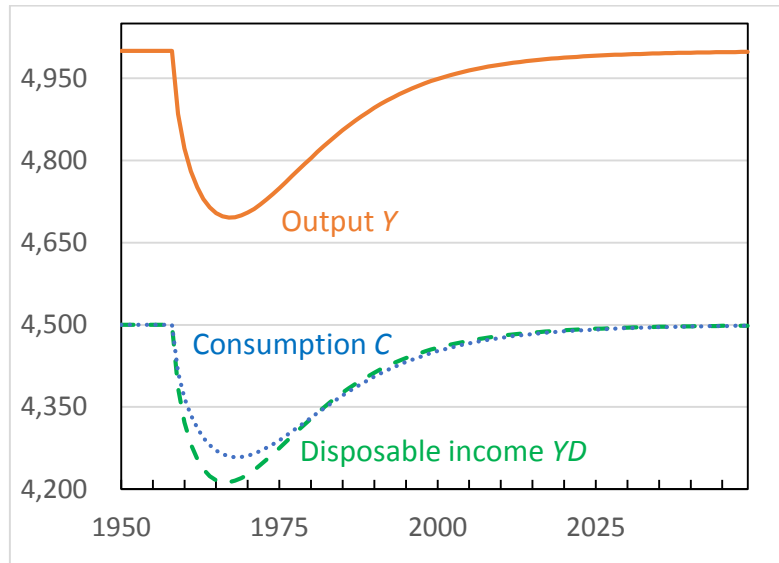


Figure 5.13 Evolution of term deposits, repos, investment bank net worth, MBS, MBS price and investment bank leverage ratio, relative to their initial steady-state values, following a decrease in MBS price

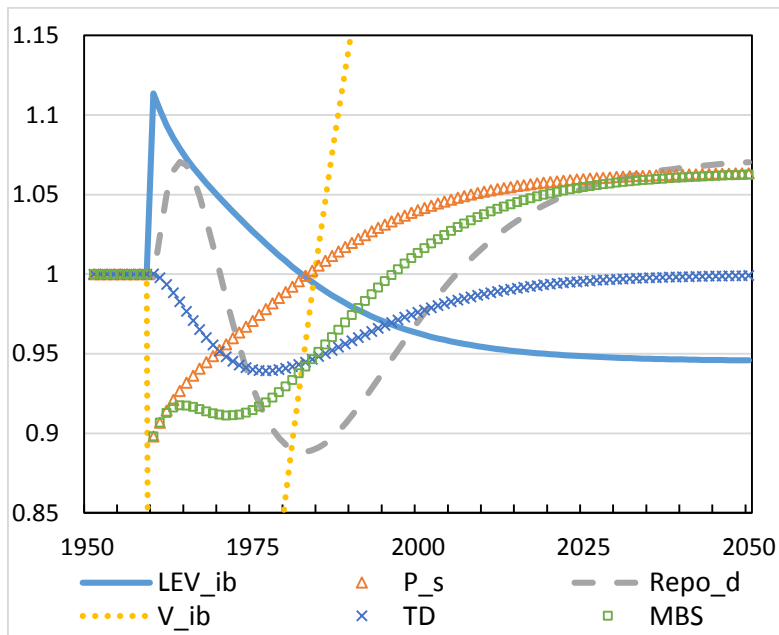
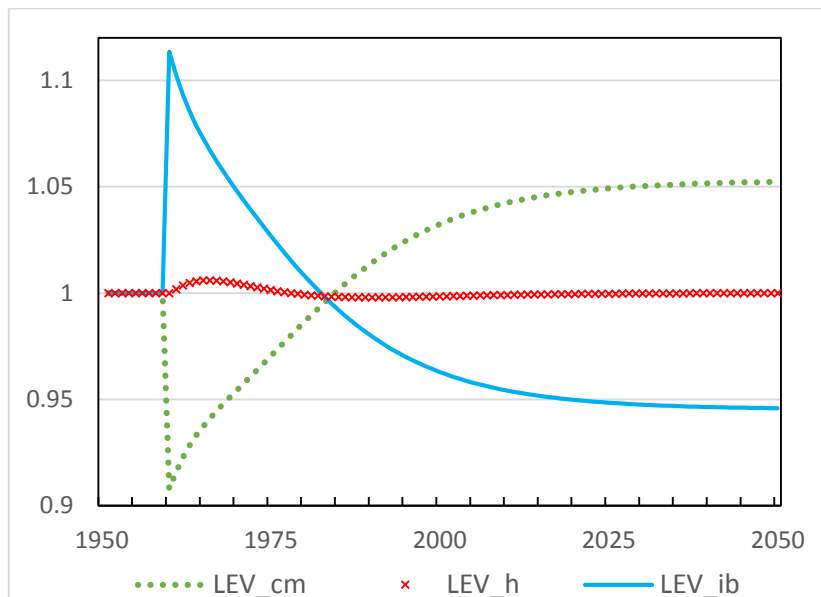


Figure 5.14 Evolution of leverage ratios of households, commercial banks and investment banks, relative to their initial steady-state values, following a decrease in the MBS price



## Chapter 6

### Conclusion

This paper attempts to show the time path of an artificial economy with a housing market and two banking subsectors by use of the stock-flow consistent (SFC) macroeconomic modelling.

An increase in autonomous consumption by households has a positive effect on output with Minskyian cyclical dynamics, which results from the firm sector's investment behaviour and households' mortgage demand. The firms need to borrow more from the commercial banks. The net worth of the investment banks increases due to higher mortgage demand since incremental housing mortgages induce the commercial banks to issue more mortgage-backed securities (MBS). In the later stages of the transition, the investment banks need to borrow more from the commercial banks. In the new steady state, the total liabilities of the investment banks are higher, and leverage of the investment banks is slightly below that of the baseline position. On the contrary, leverage of the commercial banks at the new steady state is higher than that of the baseline level.

In the current model, the investment banks seem to act in a counter-cyclical way rather than in a pro-cyclical manner since the banks' assets are negatively related to the leverage ratio – the investment banks are passive when encountering fluctuating asset prices.

The model is sensitive to changes in the interest rate on mortgages. The lower interest rate augments housing demand. The MBS price goes down so that the net worth of the investment banks decreases, which prompts the investment banks to borrow more from the commercial banks. In the new steady state, the leverage of the investment banks is higher, while the leverage of the commercial banks becomes lower than in the original baseline.

A decrease in security prices elicits lower net worth and higher leverage for the investment banks and, consequently, depressed housing demand with higher housing prices. The leverage of households goes up, resulting in less mortgage demand. Output, the wage bill and household disposable income decrease accordingly. Due to lower security prices, the securitization process introduces instability into the economy.

In numerical simulations the selection of parameter values, the initial stock levels and specific behavioural relationships influence the evolution of the economic system in the stock-flow consistent framework.

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## Appendix

### A1 Notations and initial values

	Notation	Description	Value
1	$A_d$	Advances demanded by private banks	59.6
2	$A_s$	Central bank advances made to private banks	59.6
3	$add_d$	Spread of term deposit rate over the bank rate	0
4	$add_l$	Spread of loan rate over the bank rate	0.3125
5	$add_m$	Spread of mortgage rate over the bank rate	0.25
6	$add_r$	Spread of repo rate over the bank rate	0.125
7	$AF$	Amortization funds	500
8	$C$	Consumption goods	4,500
9	$CG_h$	Capital gains of housing units	0
10	$D_h$	Checking deposits held by households	745
11	$F_{cm}$	Profits of commercial banks	264.525
12	$F_f$	Profits of production firms	1,237.5
13	$F_{ib}$	Profits of investment banks	- 112.225
14	$H_h$	Housing units demanded by households	70
15	$H_s$	Housing units supplied by firms	70
16	$HPM_d$	Reserves demanded by banks	59.6
17	$HPM_s$	High-powered money supplied by the central bank	59.6
18	$I$	New fixed capital goods	500
19	$K$	Fixed capital stock of firms	5,000
20	$K^T$	Targeted capital stock	5,000
21	$LEV_h$	Leverage ratio of households	0.285714

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22	$LEV_h^T$	Targeted leverage ratio of households	0.285714
23	$LEV_{ib}$	Leverage ratio of investment banks	0.9
24	$L_f$	Loans demanded by firms from commercial banks	5,000
25	$M_h$	Mortgages demanded by households	2,800
26	$p_s$	Price of mortgage-based securities	2.5
27	$p_h$	Price of housing units	400
28	$r$	Rate of interest on bank credit	0.04
29	$r_d$	Rate of interest on term deposits	0.04
30	$r_l$	Rate of interest on bank loans	0.0525
31	$r_m$	Rate of interest on household mortgages	0.05
32	$r_r$	Rate of interest on repos	0.045
33	$Repo_d$	Repos demanded by investment banks	549
34	$Repo_s$	Repos supplied by commercial banks	549
35	$s$	Amount of mortgage-backed securities	2,800
36	$TD_h$	Term deposits held by households	6,255
37	$V_{fma}$	Financial market asset (investible) wealth of households	7,000
38	$V_h$	Wealth of households, in nominal terms	7,000
39	$WB$	The wage bill, in nominal terms	3,000
40	$Y$	National income, in nominal terms	5,000
41	$YD$	Disposable income of households, in nominal terms	4,500
42	$YD^e$	Expected disposable income of households, in nominal terms	4,500

---

## A2 Model parameters and values

	Parameter	Description	Value
1	$\alpha_0$	Autonomous consumption	425
2	$\alpha_1$	Propensity to consume out of regular income	0.75
3	$\alpha_2$	Propensity to consume out of past wealth	0.10
4	$\beta_0$	Autonomous housing demand parameter	0.63
5	$\beta_1$	Housing demand parameter on housing price	0.00125
6	$\beta_2$	Housing demand parameter on leverage ratio of households	1
7	$\beta_3$	Housing demand parameter on mortgage rate of interest	4
8	$\beta_4$	Housing demand parameter on leverage ratio of households	0.7
9	$\beta_5$	Housing demand parameter on leverage ratio of investment banks	0.2
10	$\beta_6$	Mortgage parameter on leverage ratio of households	0.1
11	$\beta_7$	Mortgage parameter on mortgage rate of interest	2
12	$\beta_8$	Mortgage parameter on leverage ratio of households	1
13	$\gamma$	Partial adjustment function that applies to fixed capital	0.15
14	$\delta$	Depreciation rate	0.1
15	$\varepsilon$	Reaction parameter related to expectations	0.5
16	$\kappa$	Target fixed capital to output ratio	1
17	$\lambda_0$	Reaction parameter in portfolio choice of households	0.7
18	$\lambda_1$	Reaction parameter in portfolio choice of households	5
19	$\lambda_2$	Reaction parameter in portfolio choice of households	0.01
20	$\rho$	Compulsory reserve ratios on bank deposits	0.08
21	$\sigma$	Ratio of MBS price to price of housing units	0.0625
22	$\omega$	Share of wages in national income	0.6

## A3 Equations of the model

### A3.1 Housing market

$$\Delta H_h/H_{h(-1)} = \beta_0 - \beta_1 \cdot p_{h(-1)} + \beta_2 \cdot \Delta p_h/p_{h(-1)} - \beta_3 \cdot r_m - \beta_4 \cdot LEV_h - \beta_5 \cdot LEV_{ib} \quad (1)$$

$$\Delta M_h/M_{h(-1)} = \beta_6 - \beta_7 \cdot r_m + \beta_8 \cdot [LEV_h^T - LEV_{h(-1)}]/LEV_{h(-1)} \quad (2)$$

$$p_h = M_h/H_h \quad (3)$$

$$LEV_h = M_h/(p_h \cdot H_h + D_h + TD) \quad (4)$$

### A3.2 Household sector

$$C = \alpha_0 + \alpha_1 \cdot YD + \alpha_2 \cdot V_{h(-1)} \quad (5)$$

$$YD = WB_s + F_f + F_{cm} + F_{ib} + r_d \cdot TD_{(-1)} - r_m \cdot M_{h(-1)} \quad (6)$$

$$WB_s \equiv WB_d \quad (7)$$

$$\Delta V_h \equiv (YD - C) + CG_h \quad (8)$$

$$CG_h = H_{h(-1)} \cdot \Delta p_h \quad (9)$$

$$V_{fma} = V_h + M_h - p_h \cdot H_h \quad (10)$$

$$TD = V_{fma} \cdot [\lambda_0 + \lambda_1 \cdot r_d - \lambda_2 \cdot (YD/V_{fma})] \quad (11)$$

$$D_h = V_{fma} \cdot [(1 - \lambda_0) - \lambda_1 \cdot r_d + \lambda_2 \cdot (YD/V_{fma})] \quad (12A)$$

$$D_h = V_{fma} - TD \quad (12)$$

### A3.3 Production firms

$$Y \equiv C + I + p_h \cdot \Delta H_s \quad (13)$$

$$H_s \equiv H_h \quad (14)$$

$$F_f \equiv Y - WB_d - AF - r_l \cdot L_{f(-1)} \quad (15)$$

$$WB_d = \omega \cdot Y \quad (16)$$

$$AF = \delta \cdot K_{(-1)} \quad (17)$$

$$K = K_{(-1)} + (I - AF) \quad (18)$$

$$K^T = \kappa \cdot Y_{(-1)} \quad (19)$$

$$I = \gamma \cdot [K^T - K_{(-1)}] + AF \quad (20)$$

$$L_f \equiv L_{f(-1)} + I - AF \quad (21)$$

#### A3.4 Commercial banks

$$HPM_d = \rho \cdot D_h \quad (22)$$

$$F_{cm} \equiv r_l \cdot L_{f(-1)} + r_r \cdot Repo_{s(-1)} \quad (23)$$

$$A_d \equiv A_s \quad (24)$$

$$\Delta Repo_s \equiv \Delta A_d + \Delta D_h + p_s \cdot \Delta s - \Delta HPM_d - \Delta L_f - \Delta M_h \quad (25)$$

$$s = M_h \quad (26)$$

$$p_s = \sigma \cdot p_h \quad (27)$$

#### A3.5 Investment banks

$$F_{ib} \equiv r_m \cdot M_{h(-1)} - r_d \cdot TD_{(-1)} - r_r \cdot Repo_{d(-1)} \quad (28)$$

$$\Delta Repo_d \equiv p_s \cdot \Delta s - \Delta TD \quad (29)$$

#### A3.6 Central bank

$$HPM_s \equiv HPM_d \quad (30)$$

$$A_s \equiv HPM_s \quad (31)$$

#### A3.7 The redundant, or hidden, equation

$$Repo_d = Repo_s \quad (32)$$

## A4 EViews codes

```
create a 1950 2151
smpl 1950 2151
genr year = @trend
smpl @all

' Parameters
genr alpha0 = 425
genr alpha1 = 0.75
genr alpha2 = 0.1
genr beta0 = 0.63
genr beta1 = 0.00125
genr beta2 = 1
genr beta3 = 4
genr beta4 = 0.7
genr beta5 = 0.2
genr beta6 = 0.10
genr beta7 = 2
genr beta8 = 1
genr lambda0 = 0.7
genr lambda1 = 5
genr lambda2 = 0.01
genr lev_h_t = 0.2857142857
genr sigma = 0.0675
genr omega = 0.6
genr delta = 0.1
genr gamma = 0.15
genr kappa = 1
genr ro = 0.08
genr r = 0.04
genr add_l = 0.3125
genr add_m = 0.25
genr add_r = 0.125
genr r_d = r
genr r_l = (1 + add_l)*r
genr r_m = (1 + add_m)*r
genr r_r = (1 + add_r)*r

' Initial values for lagged endogenous
genr v_h = 7000
genr m_h = 2800
genr td = 6255
genr d_h = 745
genr p_h = 40
genr h_h = m_h/p_h
genr h_s = h_h
genr y = 5000
genr k = 5000
genr l_f = 5000
```

```

genr yd = 4500
genr cons = 4500
genr wb_d = 3000
genr wb_s = wb_s
genr af = 500
genr repo_d = 549
genr repo_s = repo_d
genr hpm_d = ro*d_h
genr hpm_s = hpm_d
genr a_s = hpm_s
genr a_d = a_s
genr s = m_h
genr p_s = sigma*p_h
genr lev_h = m_h/(p_h*h_h + d_h + td)
genr lev_ib = (repo_d + td)/(p_s*s)

```

```

delete *model
model Bank_mod

```

' (1) Households

```

Bank_mod.append cons = alpha0 + alpha1*yd + alpha2*v_h(-1)
Bank_mod.append yd = wb_s + f_f + f_cm + f_ib + r_d*td(-1) - r_m*m_h(-1)
Bank_mod.append wb_s = wb_d
Bank_mod.append v_h = v_h(-1) + (yd - cons) + cg_h
Bank_mod.append cg_h = h_h(-1)*d(p_h)
Bank_mod.append v_fma = v_h + m_h - p_h*h_h
Bank_mod.append td = v_fma*(lambda0 + lambda1*r_d - lambda2*(yd/v_fma))
' Bank_mod.append d_h = v_fma*(1 - lambda0 - lambda1*r_d + lambda2*(yd/v_fma))
Bank_mod.append d_h = v_fma - td
Bank_mod.append h_h = h_h(-1) + h_h(-1)*(beta0 - beta1*p_h(-1) + beta2*d(p_h)/p_h(-1) -
beta3*r_m - beta4*lev_h - beta5*lev_ib)
Bank_mod.append m_h = m_h(-1) + m_h(-1)*(beta6 - beta7*r_m + beta8*(lev_h_t/lev_h(-1) - 1))
Bank_mod.append p_h = m_h/h_h
Bank_mod.append lev_h = m_h/(p_h*h_h + d_h + td)

```

' (2) Firms

```

Bank_mod.append y = cons + i + p_h*d(h_s)
Bank_mod.append h_s = h_h
Bank_mod.append f_f = y - wb_d - af - r_l*l_f(-1)
Bank_mod.append wb_d = omega*y
Bank_mod.append af = delta*k(-1)
Bank_mod.append k = k(-1) + (i - af)
Bank_mod.append i = gamma*(k_t - k(-1)) + af
Bank_mod.append k_t = kappa*y(-1)
Bank_mod.append l_f = l_f(-1) + i - af

```

' (3) Commercial Banks

```

Bank_mod.append hpm_d = ro*d_h
Bank_mod.append f_cm = r_l*l_f(-1) + r_r*repo_s(-1)
Bank_mod.append a_d = a_s
Bank_mod.append repo_s = repo_s(-1) + d(a_d) + d(d_h) + d(s)*p_s - d(hpm_d) - d(l_f) - d(m_h)

```

```
Bank_mod.append s = m_h  
Bank_mod.append p_s = sigma*p_h
```

```
'(4) Investment Banks
```

```
Bank_mod.append f_ib = r_m*m_h(-1) - r_d*td(-1) - r_r*repo_d(-1)
```

```
Bank_mod.append repo_d = repo_d(-1) + d(s)*p_s - d(td)
```

```
Bank_mod.append lev_ib = (repo_d + td)/(p_s*s)
```

```
'(5) Central Bank
```

```
Bank_mod.append hpm_s = hpm_d
```

```
Bank_mod.append a_s = hpm_s
```

```
Bank_mod.scenario "Baseline"
```

```
Bank_mod.solve(i=p)
```