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Working Paper No. 455

The Minskyan System, Part III: System Dynamics Modeling of a Stock Flow–Consistent Minskyan Model

By

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ABSTRACT

This is the last part of a three-part analysis of the Minskyan Framework. The paper presents a model that studies some of the features presented in Parts I and II. The model is Post-Keynesian in nature and puts a large emphasis on the role of conventions and the importance of the financial side. In doing so, it provides an innovative way to determine aggregate investment and to introduce nonlinearities in the modeling of Minsky's framework. This nonlinearity relies on the shifting property of conventions and the behavioral and psychological assumptions that they carry. Another specific characteristic of the model is that it is stock-flow consistent and explicitly takes into account the amortization of principal and refinancing loans. All of the modeling is done by using system dynamics, a flexible but rigorous modeling tool that gives the modeler a good understanding of the dynamics of complex models.

JEL classifications: E5
Keywords: Post-Keynesian economics, Minsky, financial fragility

The dynamics of the financial instability hypothesis are complex and varied. They represent tendencies, not automatic trends, which are triggered under specific conditions and can be partly dealt with by appropriate policies. Because of these multiple dynamics, it is very hard to grasp their implications for the behaviors of the economic system, and System Dynamics modeling is of a great help.

The following presents a Minskyan model combining two tools: System Dynamics and a stock-flow table. Based on the in-depth analysis of Minsky's framework made in Part I and Part II, the model emphasizes the importance of conventional decision making for investment determination. Several dynamics are studied among which are the evolution of the normal and actual cash-flow margins over the cycle, the impact of the central bank, and the business cycle. The first part of the paper presents different elements of the model. The second part of the paper shows what the dynamics of specific elements are and under which conditions they generate the dynamics put forward by Minsky. The last part draws conclusions about the model.

1. THE MODEL

The basic model is a three-sector model with a household sector, a firm sector, and a banking sector, and with two different assets, capital assets and demand deposits. There are no secondary markets on which the ownership of capital assets is tradable, and there is no government sector (the central bank is added later but the Treasury is left aside).

The household sector consumes and saves in demand deposits; this sector does not invest and is not involved in any portfolio choices. In addition, workers are exclusively employed in the firm sector; the banking sector does not need any employees to perform its operations.

The firm sector is divided in two sub-sectors, the investment-good sector and the consumption-good sector, but the investment decision is made in common. Production occurs only on demand for the investment goods and is determined by expected demand for consumption goods.

Banks provide loans and maintain a financial record of all economic transactions. Loans are created on demand providing that the firm sector meets the criteria set by banks to get loans. Banks determine the cost of external funds, that is, the maturity term and the interest rate of the loans. Like firms, they do not distribute any of their profit.

1.1. The Accounting Framework

Table 1 below presents the accounting framework of the basic model. The upper part of the table records the flow implications of the model, and the lower part presents the stock implications by presenting the balance sheet of each sector. The upper part is divided in two sub-sections, one that records the flows induced by income production and income distribution (both the income and balance-sheet operations of Minsky are there), and another part (based on the Flow of Funds analysis) that records the portfolio operations (i.e., changes in the balance sheets) induced by the preceding operations. For the firm and banking sectors, a distinction is also made between current account (i.e., flow impacts on the income statement) and capital account (i.e., flow impacts on the balance-sheet statement) because of the double impact of net profit.

The light gray column represents the flow implications on balance sheets, therefore, "+" and "–" in the NIPA table for this column have to be read, respectively, as sources and uses of funds. Changes in balance sheets that are represented in the NIPA table are changes in the assets and liabilities induced by the productive and distributive sides of the system. Changes recorded in the Flow of Funds table are changes in the financial side.[1]

The consistency of stocks and flows, that is the necessity for each stock and each flow to be recorded twice, is verified if the sum for all flows and all stocks, for each sector and across sectors, is zero. If the model does not generate this, it means that one important part of the model has not been taken into account. Appendix C gives an example taken from the model.

One important point to note is that the Flow of Funds table records net amounts; that is, the gross amounts of debts and demand deposits newly created net of the reflux of bank IOUs to the banking sector via the servicing of principal, and the amount of debts written off. Thus, the net change in the amount of debts is:

$$\Delta_n L = \Delta L - aL - zL$$

with ΔL the gross amount of loans (new debts), aL the amount of principal serviced, and zL the amount of debts written off.

[1] Remember that the assets side of a balance sheet can be separated into current assets and fixed assets. Current assets contain inventories and financial assets.

Table 1: Stock and Flow Consistency

Flows

NIPA: Income Transactions Matrix

(+: Inflows, -: Outflows)

Sectors	Households	Firms		Banks		Balancing items	Total flows
		Current	Capital	Current	Capital		
Consumption	$-C$	$+C$					0
Investment		$+I$	$-I$				0
Sales		$[Y]$					
Wage bill	$+W$	$-W$					0
Net profit		$-\Pi_{nF}$	$+\Pi_{nF}$	$-\Pi_{nB}$	$+\Pi_{nB}$		0
Interest on short-term loans		$-i_{st}L_{st}$		$+i_{st}L_{st}$			0
Interest on long-term loans		$-i_{lt}L_{lt}$		$+i_{lt}L_{lt}$			0
Financial balances	$+S_H$	0	$+\Pi_{nF} - I$	0	$+\Pi_{nB}$	0	0

Flow of Funds: Balance-sheet Transactions Matrix (Net Amount)

(+: Sources of Funds *(lower assets/higher liabilities)*, -: Uses of Funds *(higher assets/lower liabilities)*)

Demand deposits	$-\Delta_n DD_H$		$-\Delta_n DD_F$		$+\Delta_n DD$		0
Short-term loans			$+\Delta_n L_{st}$		$-\Delta_n L_{st}$		0
Long-term loans			$+\Delta_n L_{lt}$		$-\Delta_n L_{lt}$		0
Equity capital			$+zL$		$-zL$		0
Total sectors	0		0		0	0	0

Stocks

Balance-Sheet Matrix

(+: Assets, -: Liabilities)

Sectors	Households	Firms		Banks		Balancing items	Total stocks
		Current	Capital	Current	Capital		
Fixed capital			$+P_K K$			$-P_K K$	0
Demand deposits	$+DD_H$		$+DD_F$		$-DD$		0
Debts			$-L$		$+L$		0
Balancing items	$-NW_H$		$-NW_F$		$-NW_B$	$+P_K K$	0
Total sectors	0		0		0	0	0

The gross amount of loans can be detailed more by making a difference between long-term and short-term debts. Then, we have:

$$\Delta L_{st} = \Delta L_W + \Delta L_{REF}$$

$$\Delta L_{lt} = \Delta L_I$$

The gross amount of short-term loans depends on the amount of money necessary to pay the wage bill, and the amount of loans that have been granted to refinance positions. The gross amount of long-term debts depends on the amount of external funds needed by firms to fund investment. Thus, in total, in net terms we have:

$$\Delta_n L_{st} = \Delta L_W + \Delta L_{REF} - a_{st}L_{st} - z_{st}L_{st}$$

$$\Delta_n L_{lt} = \Delta L_I - a_{lt}L_{lt} - z_{lt}L_{lt}$$

Of course, the same is true for demand deposits, except for the writing-off which affects equity capital:[2]

$$\Delta_n DD = \Delta DD - aL$$

$$\Delta_n E_B = \Pi_{nB} - zL$$

$$\Delta_n E_F = \Pi_{nF} + zL$$

One can note, immediately, that short-term loans do not grow exclusively to finance productive economic activities, i.e., activities that contribute to the growth of national income. One can see also that there is no need for unproductive indebtedness other than refinancing to generate this phenomenon.

The rest of the accounting structure is pretty straightforward; for example, the national income identity is:[3]

$$C + I \equiv Y \equiv W + \Pi_{nF} + iL$$

One important thing to understand is, however, that Π_{nF}, the net profit of firms, does *not* represent the amount of funds available for the funding of investment. Indeed, the net cash flow generated by net profit needs to be diminished by aL, which gives the amount of *internal funds* available for investment:

$$\Pi_{nF} = \Pi_F - iL$$

[2] This impact on equity assumes that all loans are unsecured loans and that banks do not provision for expected losses on bad loans. Adding secured loans would imply taking into account changes in the value of collaterals, which have a great impact on the willingness to lend.

[3] iL is the "net interest" component of national income: it does not include the net interest paid by the government to the private sector (it is included in personal income). Thus, in the model with a central bank, $i_H H - i_A A$, the difference between interest earnings on reserves and interest paid on advances is not part of national income.

$$\Pi_{IF} = \Pi_{nF} - aL$$

Cash outflows induced by the amortization of debts are not part of the income account but part of the capital account. This shows the importance of the cash-flow analysis, ignored in the stock-flow table, because internal funds are determined by both income and capital considerations. Therefore, one last important thing to take into account, in addition to the income (flow) and balance-sheet (stock) implications, are the cash-flow implications; the cash box condition will do that.

Finally, a point that is emphasized in Minsky's theory is that the mismatch between assets and liabilities is due to a maturity differential, the loans granted being usually of shorter term than the gestation period of new capital assets. This is taken explicitly into account in the model in which the gestation period of new capital goods is assumed to be twice the maturity of long-term loans.

1.2. The Different Parts of the Model

The model contains a productive side and a financial side. The former explains how production, employment, consumption, investment, prices and profits are determined at the aggregate level. The latter side deals with the method through which economic activity is financed and funded: payment of investment, payment of cash commitments, and determination of the normal cash-flow margin. The distinction between the two sides is sometimes not clear-cut. For example, the level of aggregate profit is determined by the investment and saving decisions of economic agents, and the normal cash-flow margin directly affects the level of investment. However, as shown below, this distinction is essential even though it is usually ignored in models.

1.2.1. The Productive Side

In order to produce, the firm sector needs to employ people and so to pay wages; this payment must be financed. In the model, there are two sectors: the consumption sector and the investment sector. Employment is derived from the amount of output produced O and a given average productivity of workers AP_L:

$$N = O/\mathrm{AP}_L$$

This implies that if no output needs to be produced, then employment goes to zero.

Production is initiated differently in the consumption-good sector and in the investment-good sector. In the former, it is the level of expected profitable demand that determines production, whereas investment goods are produced on demand. The level of expected profitable demand of consumption goods is determined as follows:

$$E(O_{Cd}) = \begin{cases} cwE(N)/E(P_C) & \text{if} \quad E(\Pi_C) > 0 \\ 0 & \text{if} \quad E(\Pi_C) \leq 0 \end{cases}$$

If profit from production is expected to be non-positive, then no production occurs; otherwise production depends on the expected level of employment and of price of consumption goods. The determination of the investment is explained by expectations concerning its funding structure:[4]

$$P_{Is}O_I = \begin{cases} E(\Pi_{IF}) + E(\Delta L_I) & \text{if} \quad P_{Id} > P_{Is} \\ 0 & \text{if} \quad P_{Id} \leq P_{Is} \end{cases}$$

The determination of $E(\Delta L_I)$ has already been presented in Part II and is equal to:[5]

$$E(\Delta L_I) = \left(E(cc) - cc \cdot \frac{\Pi}{E(\Pi)} \right) \cdot \frac{E(\Pi)}{(i+a)}$$

where cc (CC/Π) is the flow leveraging ratio, $E(cc) \equiv cc_n$ is the normal flow-leveraging ration, and $E(\Pi_{IF})$ is based on an initial expectation of internal funds that is progressively modified by the past level of internal funds. All this allows taking into account in the Post Keynesian framework the importance of cash-flow and liquidity positions for investment decision. Fazzari, Hubbard, and Petersen (1988) have shown that these financial factors are central.

The level of aggregate profit of firms is determined by the Kalecki equation of profit which in the model is reduced to:[6]

$$\Pi_F = P_{Is}O_I - S_W$$

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[4] Other solutions would be to run down cash balances or to augment capital so that $P_{Is}O_I \equiv I = \Pi_{IF} + \Delta L_I + \alpha\Delta DD + \Delta E$. Here it is assumed that $I = \Pi_{IF} + \Delta L_I$. ΔE, addition to equity, usually entails a non-contractual (dividend on ordinary shares) or contractual increase in cash commitment (dividends on preferred stocks or any other forms of commitments) that depends on profits. Analytically ΔE can be considered conceptually equivalent to an increase in debt (Minsky 1975, 107; Toporowski 2000). The use of cash balance ($\alpha\Delta DD$) also decreases the margins of security of units (or economy) and so is also conceptually equivalent to ΔL_I (Minsky 1975, 108).

[5] In the case of $E(\Delta L_I)$, if Π is negative, this boosts the desired external funding of investment, which intuitively does not look appropriate. Thus, a boundary has to be put on Π and Q, and if they become negative, their value *in the formula* cannot go below zero. In fact the boundary has to be stricter and $\Pi \geq 1$ has to be imposed to avoid the unrealistic multiplicative effect for $\Pi < 1$.

[6] Indeed, $\Pi_C = c(W_I + W_C) - W_C = W_I - S_W$ and $\Pi_I = I - W_I$, therefore $\Pi_F = I - S_W$.

where $P_{Is}O_I$ is the investment level and S_W is saving out of wage income.

The offer prices of consumer and investment goods are derived from the work done by Weintraub (1978) and Minsky (1986). More formally (knowing that $C = P_C Q_{Cd} = c(w_C N_C + w_I N_I)$) the price level in the consumption-good sector is:

$$P_C = c \cdot \left(1 + \frac{w_I N_I}{w_C N_C}\right) \cdot \frac{w_C}{AP_{LC}} = \lambda_C \cdot \frac{w_C}{AP_{LC}}$$

The offer price of investment good, P_{Is}, is determined by a given mark-up over unit labor cost in the investment sector.

Finally, the difference between the demand price and the supply of investment goods is obtained by taking the equilibrium condition for wealth allocation:[7]

$$P_{Is}K + DD = P_{Id}K + mDD \Rightarrow P_{Id} - P_{Is} = DD(1 - m)/K$$

The problem becomes, then, to explain how cc_n is formed; that is, how cc_a and cc_d are determined. In order to do so, the financial side of the model has to be examined.

1.2.2. The Financial Side

The financial side of the model contains several important elements notably the determination of cash commitments that can be paid, and the determination of cc_a and cc_d. In order to determine the former, *CC* has to be explained and the cash-box condition, i.e., the cash-flow consistency, has to be established (firms cannot spend more money than they have).

a) Cash Commitments

The level of cash commitment is determined as follows:

$$CC = (i + a)L = (i + a)(L_{st} + L_{lt}) = (i + a)(L_W + L_I + L_{REF})$$

There are two important elements here that are usually ignored in the literature: the amortization rate and the amount of debt resulting from refinancing loans (i.e., loans induced by the incapacity to meet cash commitments). To simplify, only the interest payment of the debt service could be analyzed, but, as Minsky recognized, this is not a good approximation of the

[7] Here we made a simplification relative to Minsky's framework because what needs to be compared are P_{Id} and P_I. The latter, the deliver price of investment goods, includes the discounted valued of the cash commitments induced by borrowing external funds to fund investment. More strictly, one should also include the discounted value of expected cash commitments induced by expected refinancing needs: marginal lender's risk.

financial cost when debts are short-term debts because the amortization of the principal becomes important (Caskey and Fazzari 1986):

> In fact, if the financial contracts are sufficiently short, then the cash payments on financial contracts can exceed the total quasi rents. (Minsky 1975, 84).

One of the tendencies of the Minskyan analysis is for the amortization rate to go up during a period of prolonged expansion, even if interest rates are fixed.

The amount of loans resulting from pure financial considerations (speculation, refinancing operations, or any other), is also important to take into account because those have a tendency to grow in level and proportion over a period of prolonged expansion. In the model, there is no speculation because there are no financial markets: capital assets are illiquid.

b) Conventions Regarding the Cash-Flow Margin

The simplest explanation of changes in cc_n concerns the firm sector. In the firm sector, cc_d has an initial value at time 0. This value is progressively corrected over time by a correction factor:

$$cc_{dT} = cc_{d0} + \sum_{t=1}^{T} v_t$$

where v_t represents the correction factor. The latter can be negative or positive depending on the difference between the actual and expected structure of funding. For example, if $\Delta L_I/(\Pi_{IF} + \Delta L_I) < E(\Delta L_I)/(E(\Pi_{IF}) + E(\Delta L_I))$, it means that the firm sector has a lower proportion of external funding than expected, and this leads to an upward change in cc_d: The desired cash-flow margin goes down.

Bankers have a more complex method of correction because not only do they adjust their cc_a progressively, but they also change the basic cc_a from which they do progressive corrections. Let us note $\underline{cc}_a$ the basic flow leveraging ratio with $\underline{cc}_a = cc_{a0}$ at time 0. The method of correction in the banking sector is thus:

$$cc_{aT} = \underline{cc}_{a\tau} + \sum_{t=\tau}^{T} \omega_t$$

$$\underline{cc}_{a\tau} = \begin{cases} x_1 & \text{if} \quad \text{condition 1} \\ x_2 & \text{if} \quad \text{condition 2} \end{cases}$$

Literally, this means that the current acceptable cash-flow margin is the sum of the prevailing basic acceptable cash-flow margin and a degree of correction. The degree of correction ω_t depends on the rate of profit of banks and the proportion of debts not serviced. The conditions that lead to a shift in $\underline{cc_a}$ are related to the same factors plus the proportion of refinancing loans that have been granted by banks.

One important difference between the banking sector and the firm sector concerns their degree of optimism as reflected in the correction factors v_t and ω_t. The bankers are the skeptics of the game, so they have a downward (upward) bias in the correction of their acceptable flow leveraging ratio (cash-flow margin). On the contrary, the upward correction of cc_d is stronger than the downward correction. All this tries to capture the psychological idea that entrepreneurs are more sensitive to good results than bankers. In the end, the normal flow-leveraging ratio, cc_n is determined as follows:

$$cc_n = \min(cc_d, cc_a)$$

c) The Cash Box Condition

This condition is central to the Minskyan system so one has to be sure that it is well modeled, and that it is able to determine well the amount of cash commitments that can and cannot be serviced. In terms of cash commitments, the following condition must be true in order for all cash commitments on debts to be serviced:[8]

$$CC_t \leq \Pi_t + \alpha DD_{Ft} + \Delta L_{REFt}$$

This condition states that, in order for the cash commitments to be paid, there must be enough funds available either from new sources of cash, i.e., gross profit and/or refinancing loans, or from accumulated past net cash inflows, i.e., from dishoarding. If this is not the case, part of CC cannot be serviced. In order to be sure that this condition was always respected, several simulations were run to verify that the difference between CC and the sum of serviced and not serviced cash commitments is nil, and to be sure that the amount of cash commitments *serviced* was never superior to $\Pi + \alpha DD_F + \Delta L_{REF}$.

The servicing of the cash commitments is done in a predefined way: interest payments are serviced first and short-term debts are serviced before long-term debts. Therefore, the first

[8] DD_{Ft} does not include Π_t or ΔL_{REFt} and is defined as $DD_{Ft} \equiv DD_{Ft\text{-}1} + \Delta_n DD_{Ft\text{-}1}$.

payment to meet is the interest payment on short-term debts, then comes the interest payment on long-term debts, followed by the principal payments. At each step, one has to make sure that there is enough funds to serve part or the whole amount due, if this is not the case, writing-off occurs for an amount related to the amount of principal not serviced.

1.2.3. Shortcomings

If the model is able to take into account some important characteristics of the Minskyan analysis like the importance of conventions and of the cash box condition, it leaves aside other important components that will not be developed here. In addition, some rough simplifications have been made.

The first element that has been left aside is the determination of interest rates *and* maturities; related to this is the fact that the propensity to hoard is also given and left unexplained. As stated earlier, the Minskyan analysis does not require that interest rates go up during the boom, but the maturity of debts should have a tendency to decrease via the heavier weight of refinancing loans and the higher optimism of economic agents. The growth of cash commitments, of course, does not need to be based on any change in the unit cost of external funds, so assuming constant unit costs is, from this point of view, not important. There is, however, one source of increase in the cost of external funds via the central-bank rate, and, as shown above, this is a central cause of increase in interest rates that Minsky recognized.

One way to explain the interest-rate structure would be to assume that short-term rates reflect an expectation of the central-bank rate and that long-term rates are a function of expected short-term rates *and* expected long-term rates (Robinson 1953; Kahn 1954). However, in the model, there are no financial markets, so interest rates cannot be determined in this way.

Another problem concerns the productive side of the model. There is no explanation of production and its effect on the investment decision. This will have an impact on the investment demand, either by affecting the needs to replace the capital that wore out, or by affecting net investment because, for example, the rate of utilization of the capacity of production is higher than what is considered a normal rate of utilization (Lavoie 1992). Related to this problem is the fact that investment in the model is a common decision in the firm sector; the investment expenditure is then arbitrarily cut in half between each sector, without any consideration for

their actual needs of capital goods.[9] All this reflects the awkwardness of not distinguishing between funding decisions and investment decisions. Both are important and should be treated independently. The model emphasizes the financial side of the matter to show its importance; this side being usually either ignored or considered as an irrelevant "veil."

Another shortcoming in the model is the fact that the criteria used to determine cc_a are partly fixed. One may think that these threshold values change over time with economic condition and that it is not only the difference between actual level and these thresholds that matters for the change in cc_a.

Another shortcoming concerns the lack of any distribution of dividends or interest income to households. One could think that firms and banks distribute part of their gross profit to households, and that this would affect consumption, inflation, growth, and employment, but this is not taken into account here. A later model could easily develop this part of the model, which is not essential for the main argument.

One shortcoming that puts limits on the applicability of the model is that it assumes that the external cost (both in terms of interest rate and maturity term) is variable for the whole outstanding debt. Thus, a change in interest rates or maturity terms affects all the existing debts and not only new debts. Following Minsky, this implies that the model can never take into account a hedge situation.

Finally, the model does not take into account the role of the Treasury, which is essential for the determination of interest rates (both long- and short-term interest rates) and for the amount of reserves available in the system. The public deficit is also a central element that stabilizes the aggregate macroeconomic profit and that can be used to fight inflation (Lerner 1943; Bell 2000; Wray 1998, 2003, 2004b).

2. SIMULATIONS

Several simulations are presented below that analyze specific dynamics of the Minskyan framework and check under which condition they are verified. In order to do so, two different

[9] This implies that the arbitrage between old and new capital assets, and so the role of the user cost of capital, is left aside. Economic growth will always lead to net investment.

models are used: one in which the unit cost of external funds ($i + a$) is fixed, and another one in which the central bank affects short-term rates.

2.1.1. The Role of the State of Expectations: Normal Ratios and Profit Expectations

The state of expectations, as reflected in expectation of profits and given criteria of decisions used to determine the riskiness of economic projects, is central to the dynamics of the Minskyan model. If one starts with the normal cash-flow margin, we know that it depends on the convention existing in the firm sector and the bank sector about the appropriate cash-flow margin. Depending on the initial value of those two norms of cash-flow margins, the economy can go from a boom to a depressed economic situation as shown in Figures 1 and 2.

Figure 16 shows what happens when cc_n is equal to 1 or is below this value (sales are on the left axis). The economy can never recover from its depressed situation if there is no external intervention or shock (lower cost of external funds, fiscal deficit, etc.). Figure 2 reaches the same conclusion for a boom economy. If the initial value of cc_n is above 1, the economy grows forever. Note that this is in contradiction with the conclusions of Minsky and consistent with Lavoie (1997); in Figure 2 the expansion never stops and is transformed into an inflationary boom: Firms are never in financial difficulty, their financial situation always strengthens (cc tends toward 0), they never have to ask for any refinancing loans. However, this assumes that the cost of external funds stays unchanged over the expansion period, that there is no fiscal policy that tries to contain the growth of the economy, and, of course, that no other external forces emerge to influence cc_n. As stated earlier, if there is a barrier to the non-inflationary growth of income via tight fiscal and monetary policies, the expansion period is overturned. This will be simulated below.

Figure 1: Economic Dynamics with cc_n below 1

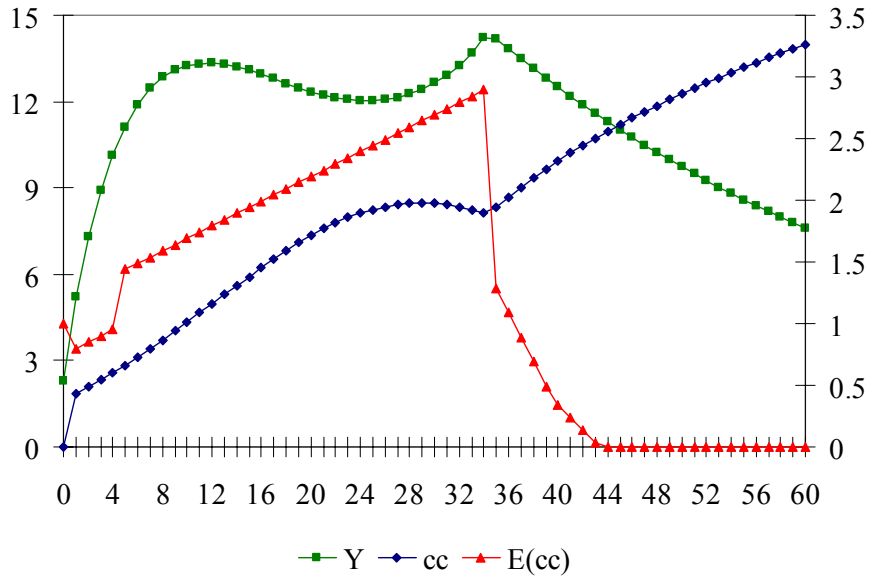
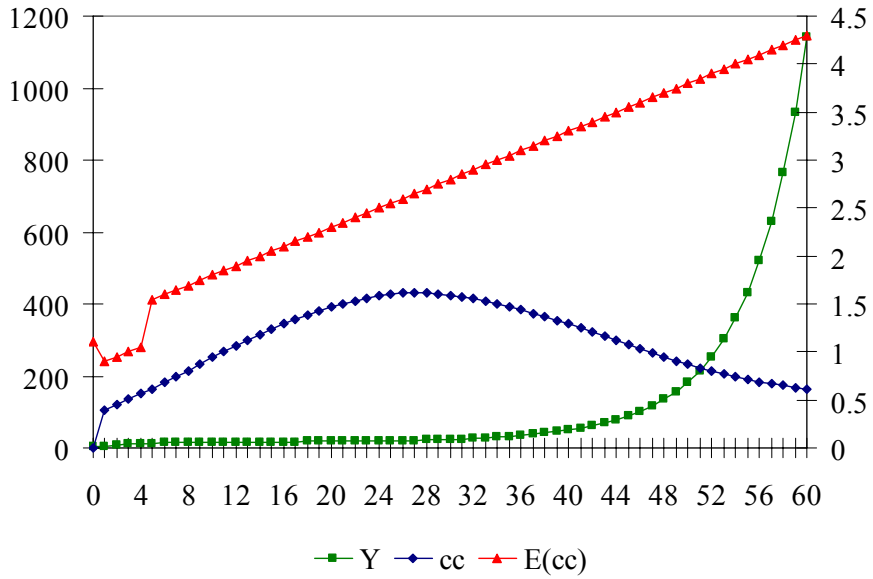


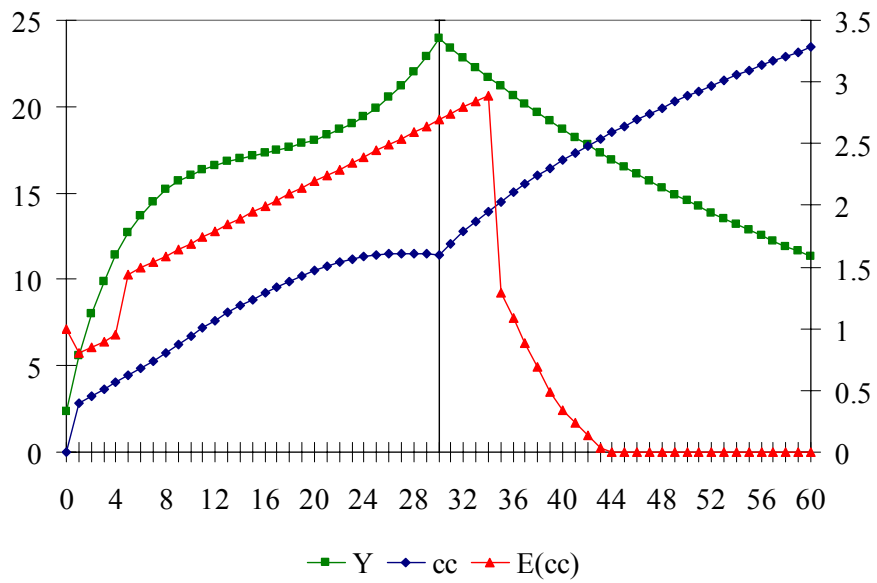
Figure 2: Economic Dynamics with cc_n above 1



If one takes the initial expectations of gross profit, the same results are obtained. Given cc_n, a change in the initial $E(\Pi)$ leads to either an explosive expansion or a permanently depressed economy. In this private economic system, given all other constant values, there are no forces that generate an economic recovery and so no economic business cycle exists.

All the preceding shows that initial economic conditions are crucial for the dynamics of the economic system. If one goes further and includes shocks on cc_n and $E(\Pi)$ at another time than time 0, then the economy can go from a period of depression (expansion) to a period of boom (depression). Figure 3 shows what happens when the state of expectations is shifted by -$68 at quarter 30.

Figure 3: Effect of a Shift in $E(\Pi)$ on the Dynamics of the System



One can see that a shift that is high enough, generates a shift in the economic dynamics from a boom to a depressive situation (sales are on the left axis) even if $cc_n > cc$. This is so because, due to the shift in $E(\Pi)$, the latter becomes negative, and it is assumed that if this is the case, the desired external funding $E(\Delta L_I)$ is zero whatever the relation between cc_n and cc.

The state of expectations, as represented here by Q and cc_n, has dramatic effects on the behavior of the economic system. This importance of expectations is not a particularity of the Minskian or Keynesian frameworks, as Kregel (1977) noted. However, the importance of *conventional* expectations is a particularity of the two preceding approaches. The expectations are not based on a 'true' model but on mental models that try to explain the future performance of the economy. Individuals know they can be systematically wrong. One implication of this is that the comparison of past expectations and current results (the *exante*/*expost* distinction) is not

the way expectations mainly affect the dynamics of the economic system. The comparison of current expectations and current state of affairs if far more important.

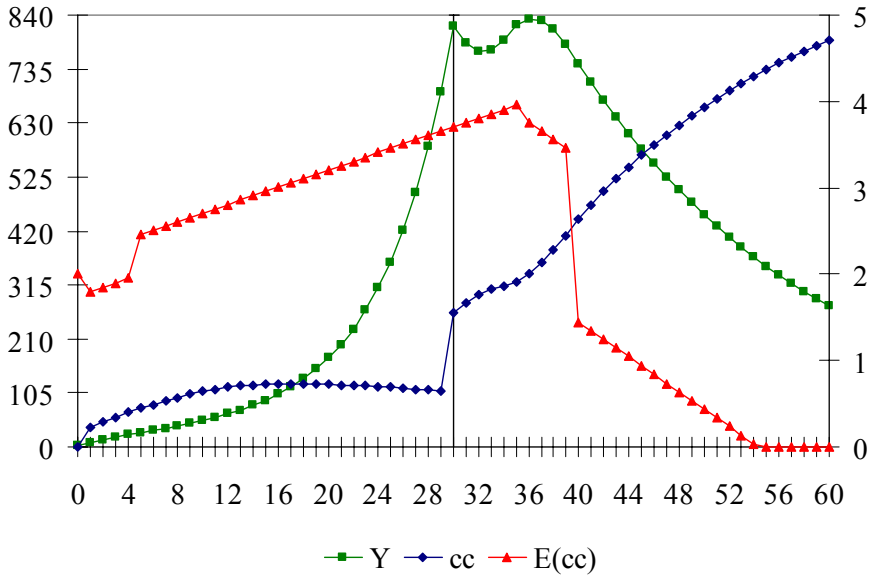
2.1.2. Cost of External Funds

Minsky stated that over the boom period, the unit cost of external funds may have a tendency to rise, either because of higher interest rates or amortization rates. Because of the nature of the first model, this cannot be verified by looking only at the *private* banking system. The basic model can, however, look at the impact of an exogenous increase in the cost of external cost for different economic situations.

Two situations are presented below; one in which the economy is in a favorable expectational environment, and one in which expectations are pessimistic. In both cases, a shock on the cost of external funds is imposed at quarter 30 in the form of higher interest rates (+1000 basis points) and lower maturity terms (cut in half).

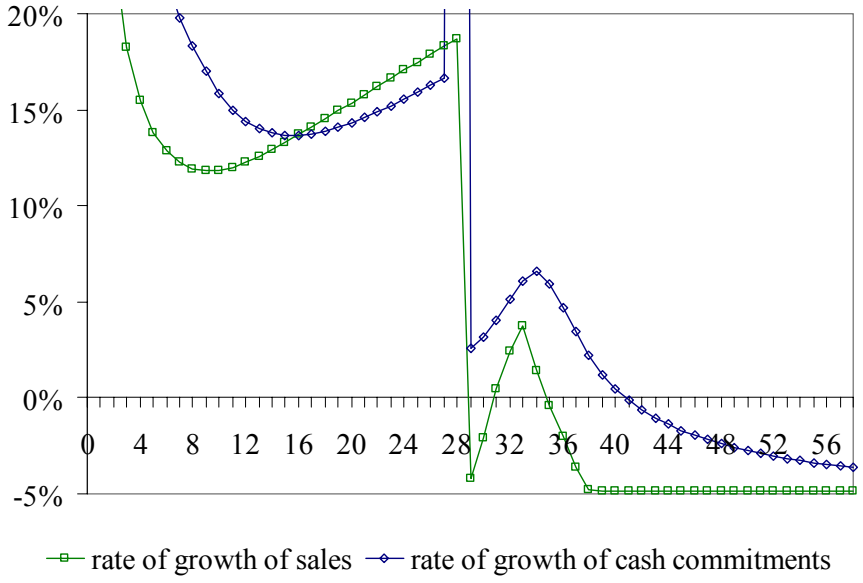
In the first economic situation, presented in Figure 4, the initial conditions concerning expectations of gross profit and normal cash-flow margin are favorable to the emergence of a boom, and without any shock, the economy would grow indefinitely and financial fragility would never occur whatever the refinancing acceptance rate (because no refinancing loans is ever needed). Before the shock, the normal flow-leveraging ratio goes up while the actual flow-leveraging ratio goes down toward zero. However, after the shock, even if the economy still grows, the normal and actual leveraging ratios have their tendency that changes. The downturn occurs at quarter 36, and without any additional shock to reverse the tendency, sales go down forever.

Figure 4: Shock on the Cost of External Funds with an Optimistic State of Expectations



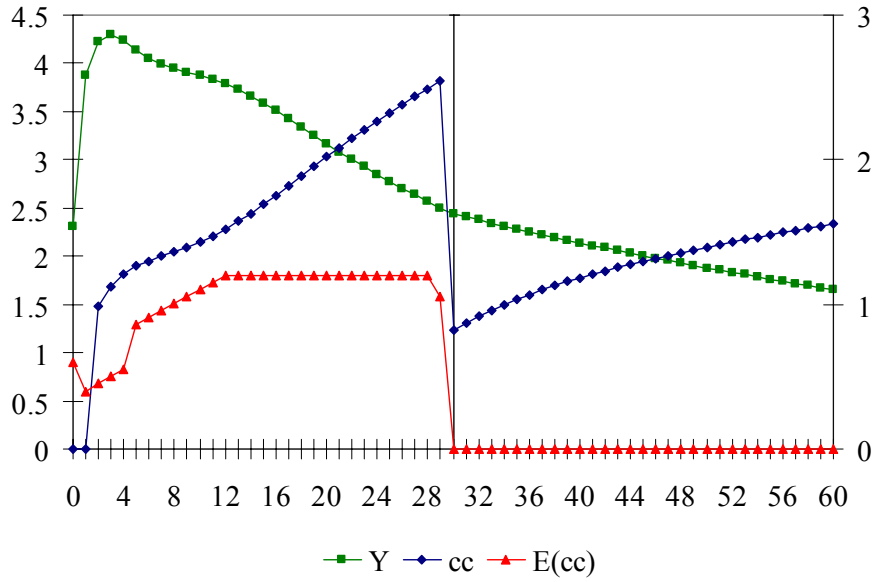
Another way to look at this is in terms of the rate of growth of cash commitments relative to the rate of growth of sales. As shown in Figure 5, before the shock, the rate of growth of *CC* is lower than the rate of growth of sales, whereas after the shock the reverse occurs. This first simulation is, therefore, able to take into account some of the conclusions of Minsky even if the cost of external funds is exogenous.

Figure 5: Rate of Growth of Sales versus Rate of Growth of Cash Commitments



In the second situation, the economy starts with a state of expectations that is pessimistic, which is materialized by higher initial desired and acceptable cash-margins. Figure 6 represents what happens in the economy before and after a shock (sales are on the left axis) for which maturity terms are doubled, and interest rates are decreased close to zero. No shock on the cost of external funds, whatever its size (very low interest rates or very high maturity terms), can change the dynamics of the system. Thus, if the economy is depressed, using the cost of external funds to try to revive the economy is ineffective. This is so in the model because, whatever the cost of external funds, the firm sector is never able to fully service its debts, which depresses its expectations and those of banks. The essential conclusion from this second simulation is that using interest rates or maturity terms to revive the economy will not work if expectations are not affected positively so that income can grow. One suspects that if a fiscal policy that aimed at sustaining private profits were introduced, the economy would be able to go out of its depressed situation.

Figure 6: Shock on the Cost of External Funds with a Pessimistic State of Expectations



The next step is, then, to try to endogenize this increase in the cost of external funds and the possibility that the rate of growth of cash commitments might be lower than the rate of growth of sales, which will be done below. It will be shown that the central bank may have a large role to play in this increase. However, before looking at the role of the central bank, some other important characteristics of the model have to be simulated.

2.1.3. Speed of the Simplification Process

In the Minskyan analysis, a depressed laissez-faire economic system with a high level of debts will not recover until the simplification process is terminated, that is, until most of the non-performing outstanding debts are eliminated from the system so that *CC* is brought down to a reasonable level relative to Π.[10] This simplification process leads to a period of large disinvestments. The longer the period of simplification, the longer it takes for the recovery to proceed. On the contrary, the shorter the simplification period, the faster the liquidity of economic agents is restored.

[10] The problem is, however, that, in the process of simplification, Π goes down as well as cc_n. A decrease in *CC*, therefore, may not be sufficient to restore economic growth.

A simulation was done to look at the implications of different speeds of simplification. In the model, the writing-off of debts depends on the amount of principal not serviced multiplied by a constant factor that reflects the speed of simplification. By default, the multiplicative factor is set to one, that is, the amount of debts written-off is equal to the amount of principal payments not serviced. A higher speed always leads to a faster recovery. In Figure 7, the economy starts in a depressed economic situation, and it is assumed that there is a positive shock on the normal cash-flow margins of +20 in quarter 30. By itself, this shock is not able to provide a durable expansion.

The amount of debts written-off grows but is never enough to remove the burden of cash commitments as shown in Figure 8. However, by multiplying the speed of the writing-off by 2 (i.e., by adding 1 to the parameter "speed of simplification") in quarter 30, the economy first has a period of recovery and then starts to take off. This is shown in Figure 9. The expansion really occurs only after quarter 45 when, as shown in Figure 10, the simplification process is close to be finished. Before that, the amount of debts written-off is higher than in Figure 8, and this amount decreases rapidly as the amount of bad outstanding debts decreases.

Figure 7: Effect of Higher cc_n with no Change in the Speed of Simplification

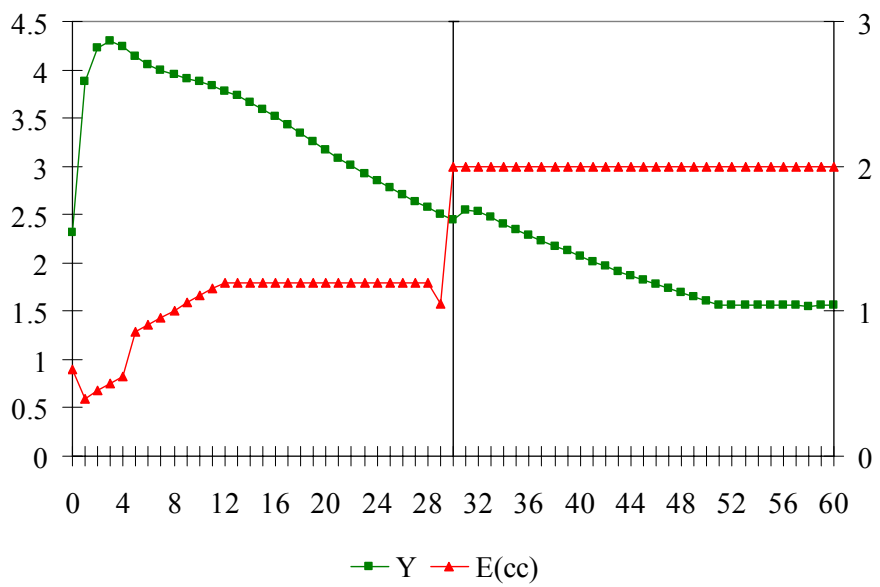


Figure 8: Debts Written-Off and Not Serviced

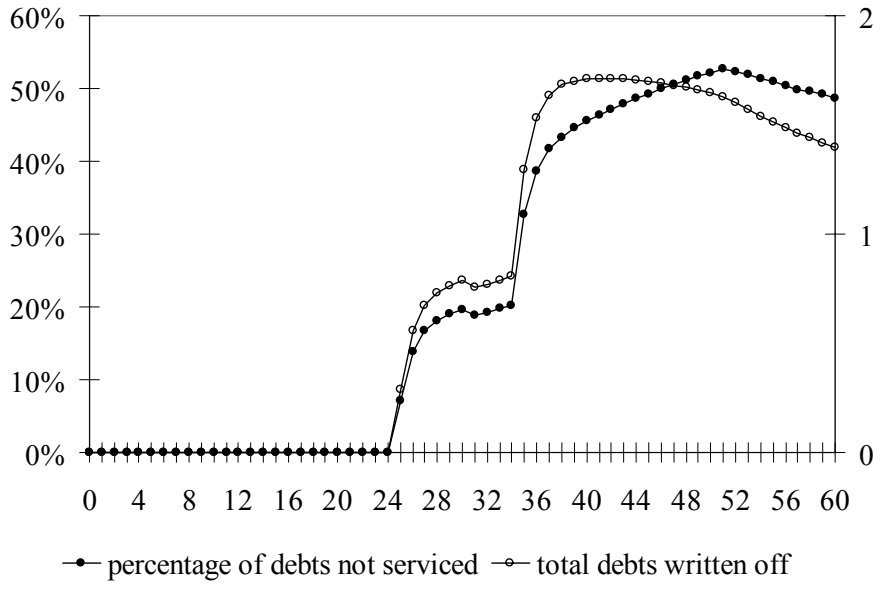


Figure 9: Effect of Higher cc_n with a Doubling in the Speed of Simplification

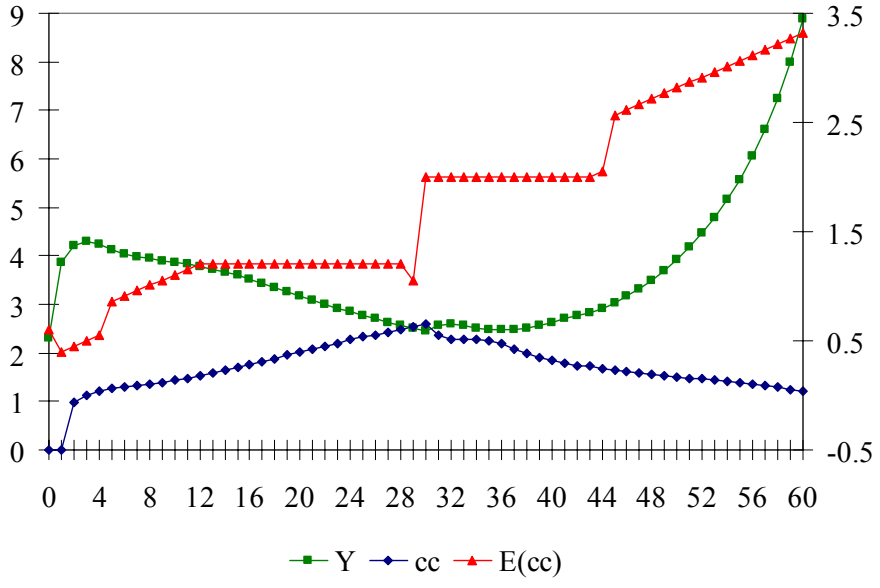
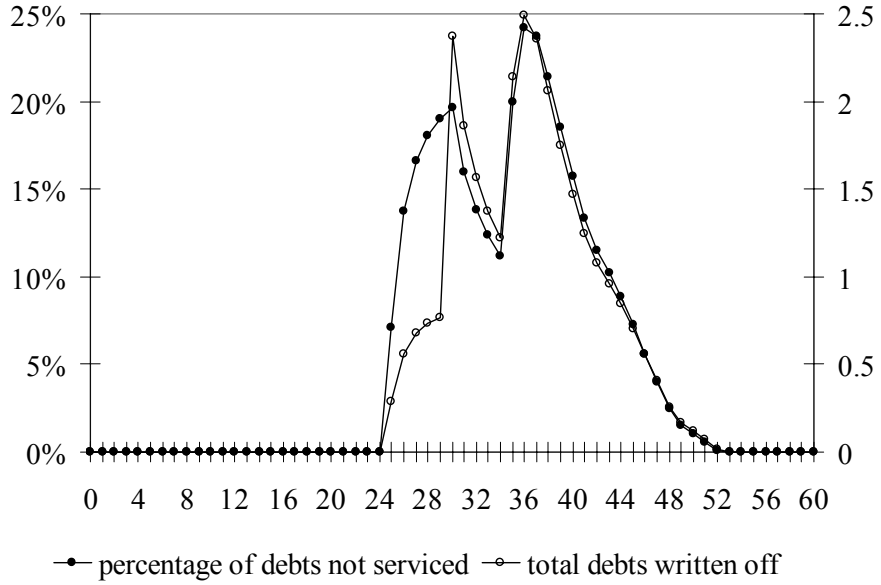


Figure 10: Effect of Higher Speed of Simplification



From the two preceding simulations, one can conclude, as one would have expected, that cleaning accumulated debts from balance sheets helps the recovery and expansion to happen. If debts of firms are left in the balance sheets of banks, the recovery may never happen, whatever the willingness of firms and banks to invest, because the firms cannot face their cash commitments.

2.1.4. Delay of Gestation and Maturity of Debts

One important point in the Minskyan framework is that there is a mismatch in the maturity of assets and liabilities. The higher the mismatch, the higher the fragility of the economy. This can actually be simulated in the model by changing the relation between the gestation period of investment goods and the maturity of long-term loans.

By default, the gestation period is set twice as long as the maturity of long-term loans. Figure 11 shows a period of depressed economic situation and financial weakening. Given everything else, if the gestation period is made equal to the maturity term of long-term loans, then the economy takes an expansionary path that rapidly transforms into a boom. This is shown in Figure 12. This effect depends also, however, on other factors like the state of expectation of

the economy. The economy may actually not start to expand. Nonetheless, by equalizing both maturity periods, the economy reaches a higher level of GDP.

Figure 11: Economic Situation Given the Gestation Period of Investment Goods

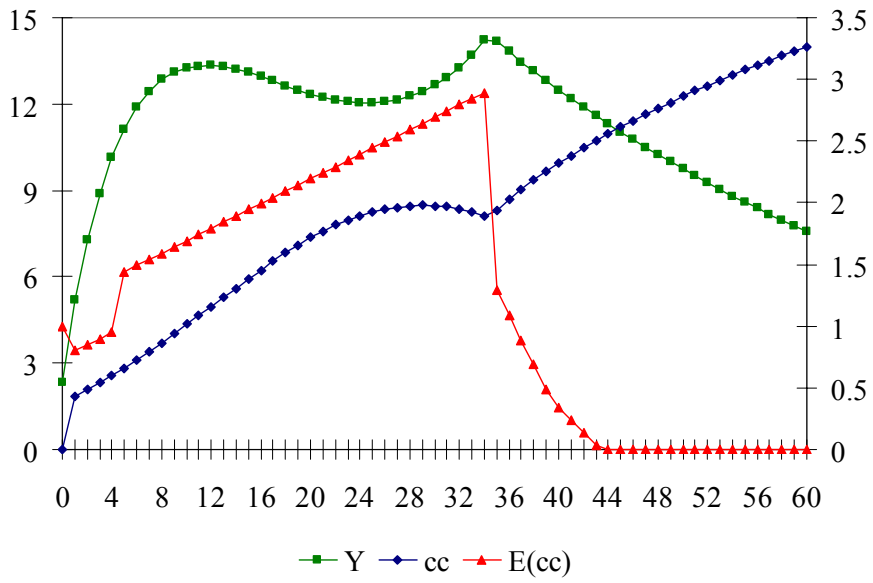
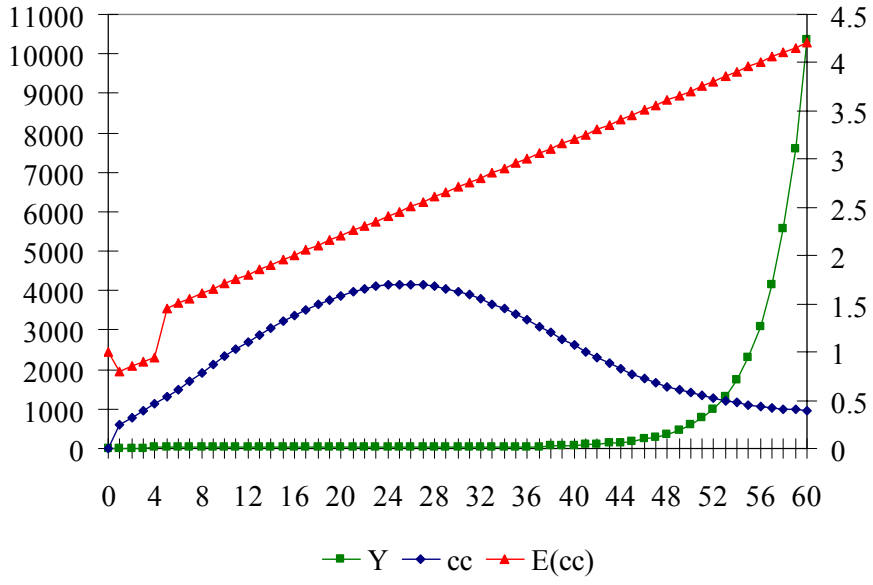


Figure 12: Gestation Period Equal to the Maturity of Long-Term Loans



2.1.5. Monetary Policy

The last simulation looks at the impact of monetary policy. In order to do so, the basic model has to be modified to introduce the intervention of the central bank. It is assumed that the central bank sets the short-term rate on the advances that it grants to banks, and that the short-term rate on private loans is set by private banks via a mark up over the central-bank rate.[11] In the real world, banks need to borrow central bank IOUs in order to be able to clear their positions among each other, and to meet reserve requirements. Thus, even if reserve requirements are nil, there is still a need for central bank IOUs (Fullwiler 2004; Lavoie 2005). In the model, banks need central-bank IOUs only to meet their reserve requirements. If reserve requirements are positive, then, in the model, the higher the reserve-requirement ratio, the lower the profit of banks, and so the lower is their cc_a.

Banks receive an interest rate on the deposits they held at the central bank. By default, it is assumed that the interest rate on advances and the interest rate on reserves are equal. The main tool of the central bank is the rate on advances; the other one just adjusts to it. It is, then, necessary to explain how the rate on advances is set. Several different rules to determine the rate of interest could be used; by default, the model assumes that the central bank reacts only to expected inflation.

$$i_{At} = \begin{cases} i_{At-1} - 0.01 & \text{if} \quad E(\pi) < \pi^{\mathrm{T}} \\ i_{At-1} + 0.01 & \text{if} \quad E(\pi) > \pi^{\mathrm{T}} \\ i_{At-1} + 0.03 & \text{if} \quad E(\pi) > 2\pi^{\mathrm{T}} \end{cases}$$

Of course, in doing all this, one has to make sure that all the accounting constraints are met in terms of cash flow, income, and balance sheet. The stock-flow table is presented in appendix D and the cash-flow constraint for banks was easy to verify.

Several interesting results come out of the simulation of the model with monetary policy; among them are that some Minskian tendencies are endogenously generated by the model. In the following, two main simulations are presented, the impact of monetary policy on the business cycle and on interest rates, and the role of the amount of refinancing loans granted by banks to firms existing in the economy.

[11] Long-term rates are exogenous and there is no rediscounting by the central bank (because there are no securities to rediscount).

a) The Monetary Policy, Business Cycle, and Interest Rate

One of the central results, well known to economists, is that the central bank interest rate has an asymmetrical effect on the economy. If increasing interest rates can lead to a recession, it is, in the model, impossible to bring a recovery by decreasing interest rates even to zero. The source of the recovery must come from other sources like a shift in convention or a simplification process. During the boom period, the central bank increases its interest rate because it expects inflation to go above its targeted inflation (which is set at 7% by default).[12] This increase in the central bank interest rate affects the short-term rates on private loans, which affects the cash commitments due and the profitability of firms and banks, and so the normal margins of safety. A higher short-term interest rate results in higher financial fragility of the firms, i.e., lower cash-flow margin. This higher fragility affects the normal cash-flow margin which, through its shift, is, as shown in Figures 13 and 14, the direct cause of the recession. The abrupt decrease in $E(cc)$ is generated by the growing proportion of debts that is not serviced as shown in Figure 15. This leads to an abrupt revision of expectations. As one can see, the proportion of debts not paid is zero until late in the period of expansion.

Another result that comes from the preceding Figure is that a situation in which the growth of cash commitments is superior to the growth of sales is endogenously generated. This results from the growing interest rate on short-term loans and reproduces pretty well the tendencies that Minsky put forward. It is possible to go back to recovery, but only after an extremely long process of simplification as shown in Figure 16.

[12] Of course, the higher the inflation target, the more the economy growth can go on because short-term interest rates do not grow as steadily.

Figure 13: Central Bank Policy and Business Cycle

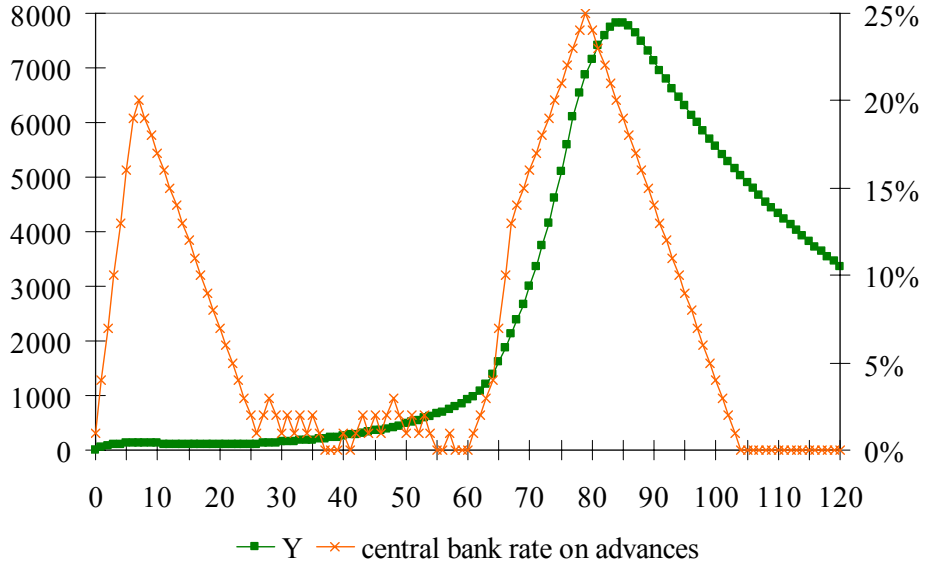


Figure 14: Effect of Increasing Interest Rates

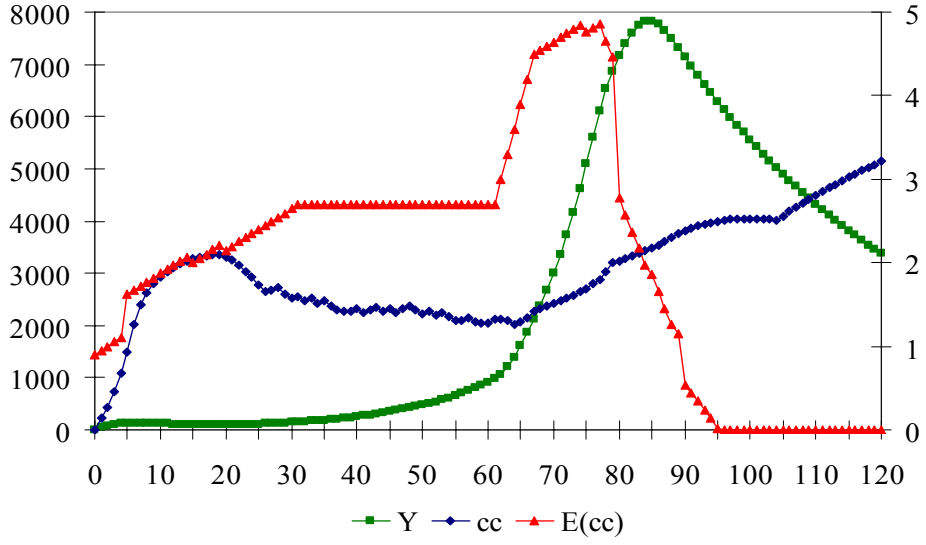
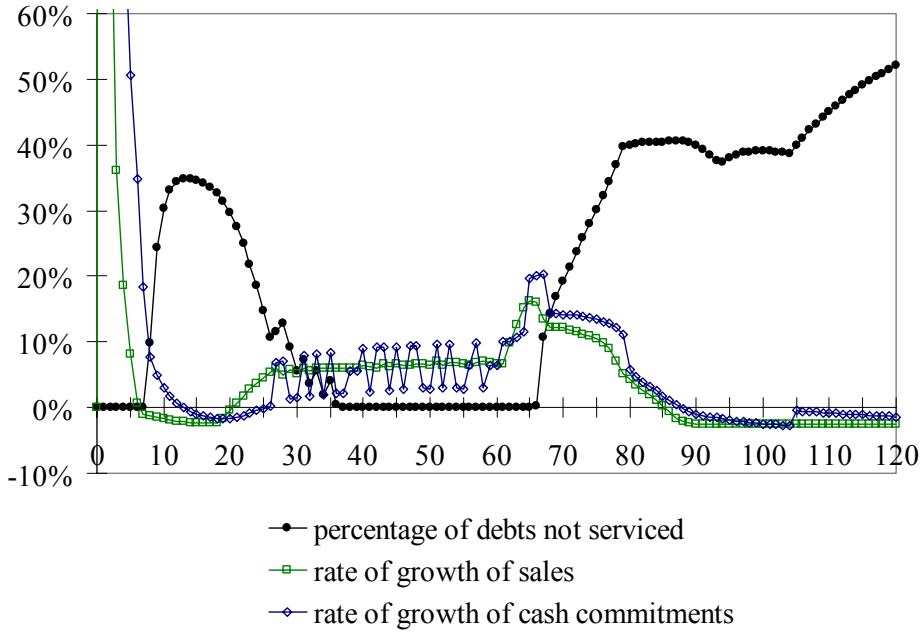


Figure 15: Debt Servicing and Economic Growth



The recovery occurs because, with the simplification process, the amount of debts decreases and the capacity to meet cash commitments increases. This leads to a loosening of the normal cash-flow margin because of the loosening of the acceptable cash-flow margin: cc_n goes up. There are three picks for the percentage of debts not serviced; each of them represents a business cycle even if the scale of sales does not permit the reader to see it clearly. As shown in Figure 17, when cc_n becomes high enough, the economy recovers.

It is, therefore, possible to have an expansion, recession, stagnation and recovery process that is generated endogenously via the introduction of monetary policy. However, the central bank is inefficient in bringing the recovery *by acting on interest rates*. Indeed, in the preceding, the recovery will occur only when the simplification process is close to being finished, and, as Minsky recognized, this can be one way to "manage" the system.

Figure 16: Simplification Process and Economic Recovery

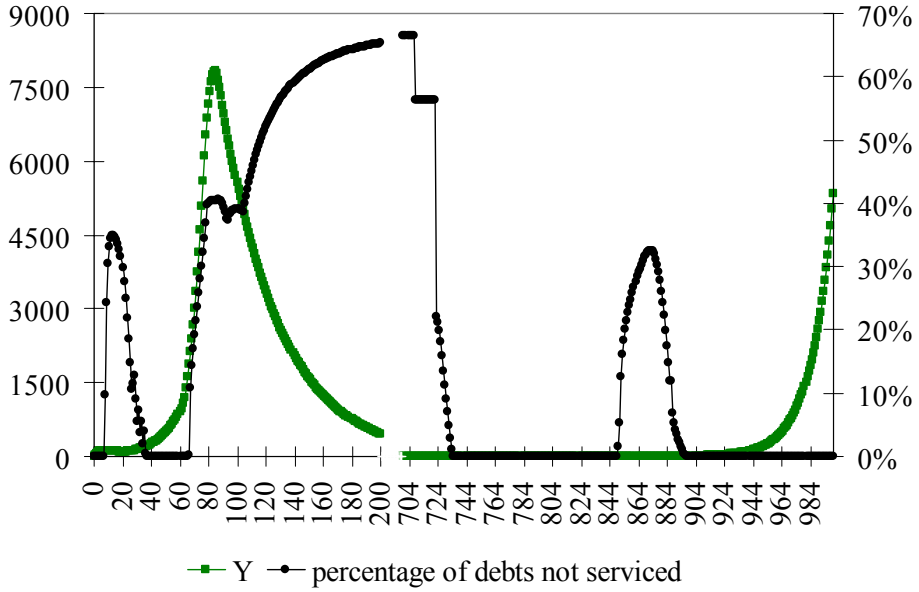
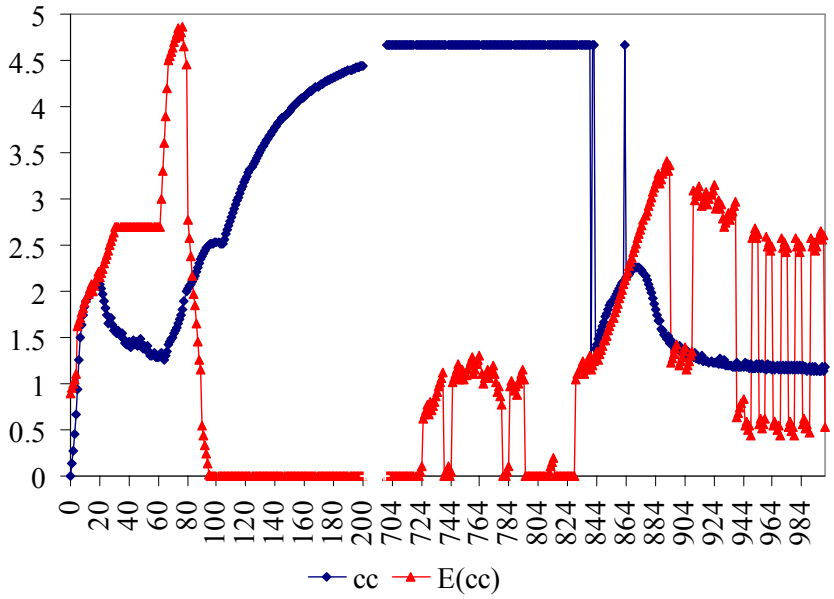


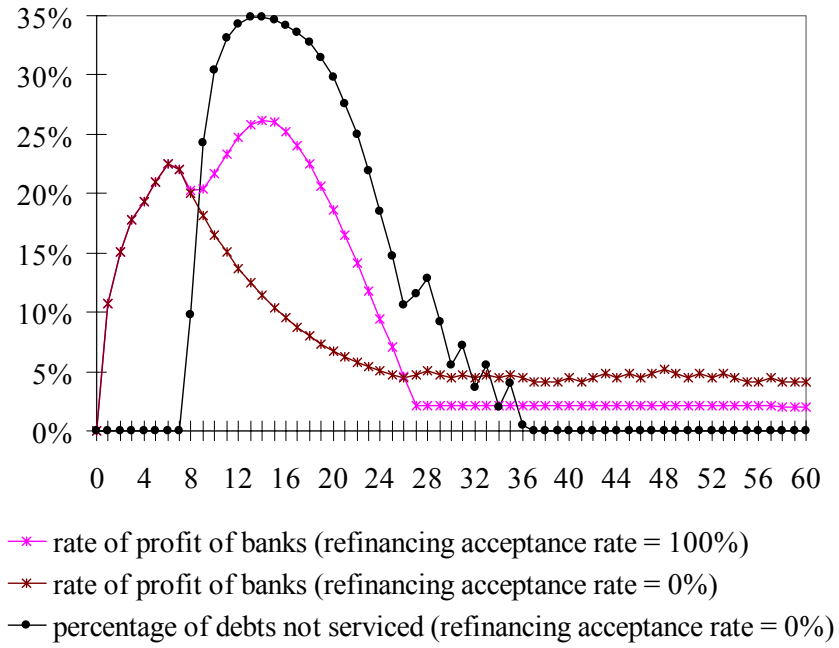
Figure 17. Normal and Actual Cash-Flow Margin



b) Monetary Policy when Refinancing Loans Are Granted

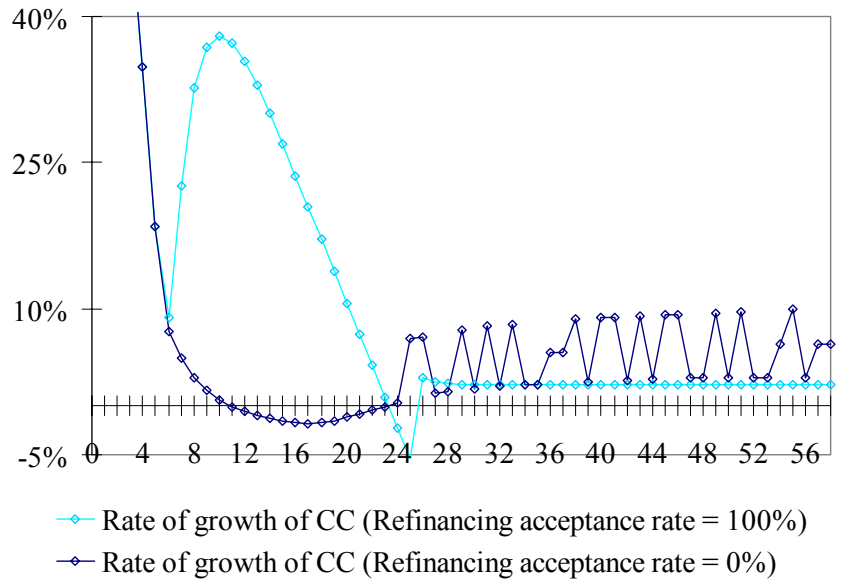
In the preceding simulations, it was assumed that the amount of refinancing loans granted by the private banking system was nil by default. This assumption is quite *ad hoc*, and even illogical, because if cc_n is superior to one, it means implicitly that banks agree to grant refinancing loans. However, for the sake of the simulations, it was assumed that the refinancing acceptance rate was zero. Thus, if firms could not pay their cash commitments, banks just wrote off a multiple of the principal due out of debts, and interest payments not serviced generated a cut in the profit of banks. In the following, it is assumed that the refinancing acceptance rate is equal to one. One immediate implication of this is that the rate of profit of banks is increased as shown in Figure 18. This necessity for banks to grant loans in order to allow firms to pay interest services was put forward by Wray (1991). Granting or not granting refinancing loans has, therefore, a large influence on the banking system.

Figure 18: Profitability of Banks and Refinancing Rate



Another implication, shown in Figure 19, is that, while previously cash commitments could not increase for any other reasons than those related to the financing and funding of production given in the unit cost of external funds, they are now free to go up for reasons unrelated to the preceding ones. The rate of growth of *CC* now changes much faster and with higher amplitude when refinancing needs exist. In addition, the rate of growth of cash commitments is much higher than the rate of interest. This is so for two reasons; first, the amortization rate is higher in the total amount of debts because of the short-term nature of refinancing loans, and second, the amount of cash commitments that cannot be met increases a lot, leading to an increase in the amount of refinancing loans. Figure 20 shows that, depending on the refinancing acceptance rate, the proportion of short-term debts changes a lot.

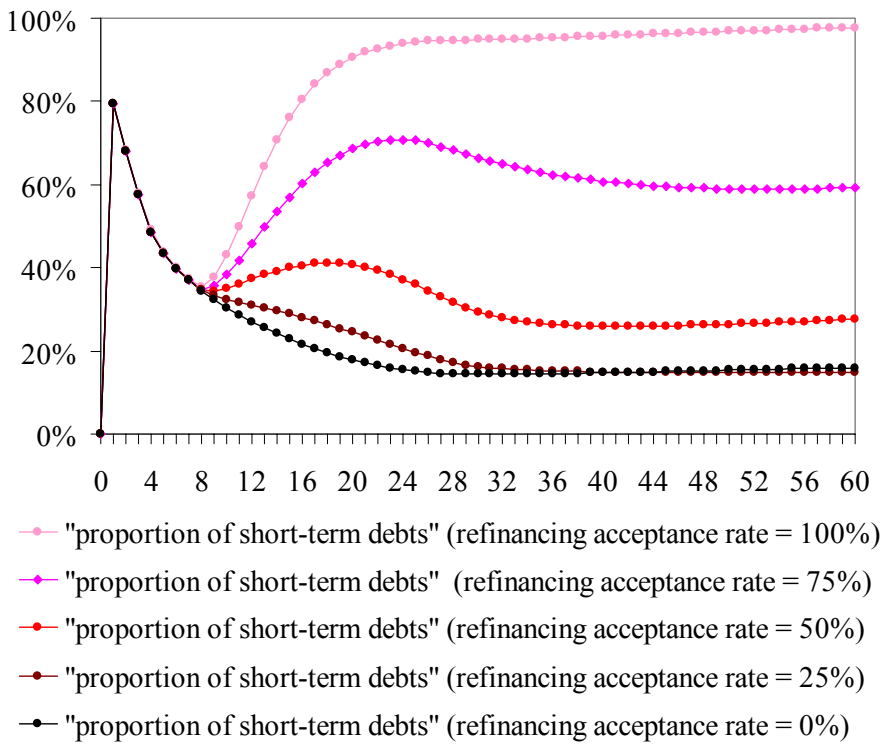
Figure 19: Effect of a Refinancing Rate of 100% on the Growth of *CC*



These Figures have the same initial economic conditions as Figures 28 to 32 except for the refinancing rate. One can, therefore, conclude that an economy with a high proportion of short-term loans is far more delicate to manage via interest-rate changes. Indeed, higher interest rates can rapidly increase the cost of the *whole* outstanding debts as short-term debts are rolled over, and lower interest rates may be inefficient in reducing the growth of cash commitments if

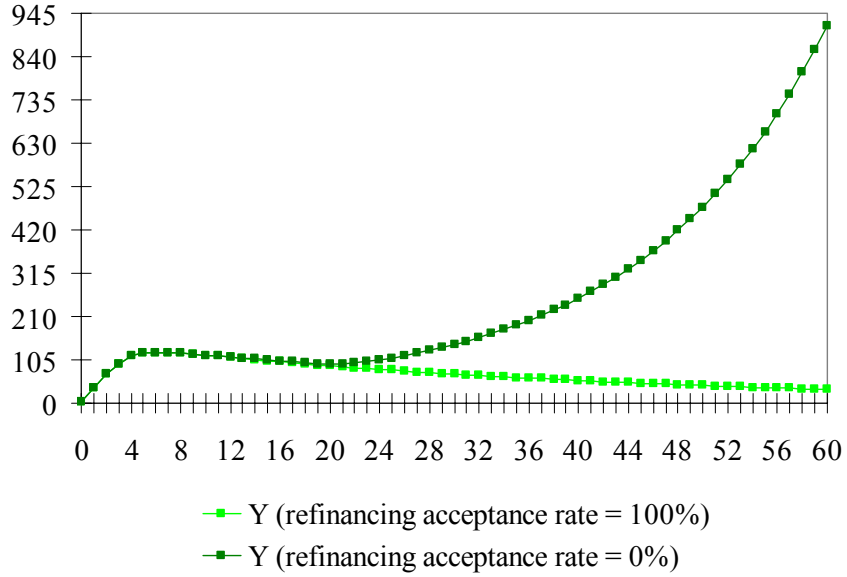
the growth of the latter is related to other reasons than the cost of loans. Another conclusion is that it does not take a high rate of acceptance for refinancing for short-term loans to become a very high proportion of outstanding debts.

Figure 20: Proportion of Short-Term Debts



By intuition, it seems reasonable to think that an economy in which the proportion of refinancing loans is high will grow at a slower path. Indeed, short-term refinancing loans add a burden on the economy by increasing the amount of cash commitments without stimulating the productive side of the economy. This is actually what happens in the model, as shown in Figure 21. However, the effect of different refinancing acceptance rates can be non-linear: higher rates may lead to higher economic growth given the unit cost of external funds. This result is possible because cc_a is affected by both the amount of debts not serviced and the amount of refinancing loans granted: higher refinancing loans is bad for cc_a but helps to improve the servicing of debts, which is good for cc_a. In this context, the manipulation of interest rates by the central bank is very hazardous for the economy.

Figure 21: Sales for Different Refinancing Context



3. CONCLUSION

The preceding exercise allows us to reach several conclusions in terms of Minsky's theory and in terms of monetary policy. In terms of the former, one can first see the practicality of System Dynamics; it allows to detect some dynamics that otherwise are hard to figure out. The most important result is that Minsky's financial instability hypothesis is verified endogenously if one includes a central bank that uses interest rates to try to manage the economy. Without the latter, the model endogenously generates dynamics that are opposite to the financial instability hypothesis and side with Lavoie's (1997) concerns that the hypothesis may not generate automatic tendencies. However, one has to recognize that even Minsky recognized this: "The existence of profit opportunities does not necessarily mean that fragile financing patterns will emerge immediately" (Minsky 1986, 211). Part II reviews in details and which condition fragility may occur. Other important elements that have been verified are the importance of maturity matching and the role of the simplification process in a free-market economy. Matching the maturity of assets and liabilities is extremely important for the stability and the dynamism of the economic system. If liabilities have a shorter maturity than assets, they have a tendency to accumulate faster and, once debt is overwhelming, a simplification process is

necessary before any expansion can occur. The simplification process cleans balance sheets of bad debts and allows economic agents to start over. All this shows the importance of the financial side of capitalist economic system; it affects the behavior of the rest of the system.

In terms of monetary policy, the preceding has several important implications. The first, most obvious one, is that interest-rate policies are ineffective and promote business cycles. The central bank should thus abandon this tool or even any other fine-tuning activities and concentrate on other goals. The central goal that comes out of the model is financial stability: the central bank should promote the liquidity and stability of the system. The model suggests that this can be done by promoting maturity matching and the creation of financial instruments that are perfectly adapted to the needs of borrowers. The central banks should also take an active part in the definition of the normal margins of safety. The latter are pure conventions and there is no reason to assume that the central bank does not know anything about what a reasonable margin is. On the contrary, it can complement that private assessment of the normality by a public assessment that is detached from profitability considerations, and that takes into account the macroeconomic impacts of economic activities. The central bank can also be involved in the management of financial fragility by shortening the simplification process (or eliminating it altogether if conditions require it). If the central bank, or another governmental institution, took the lead in the speed of simplification by accepting to buy private debts so as to remove them from the balance sheet of private banks (instead of having banks writing them off), it would help in bringing the recovery. In the end, therefore, the best policy to implement is to let the central bank interest rate permanently at a low level (why not 0%?) so that no additional disturbance to the payment system are added: financial stability is the only goal that central banks have been able to manage successfully from their creation, so they should concentrate on this goal and improve its management.

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APPENDICES

APPENDIX A

A GRAPHICAL REPRESENTATION OF THE MODEL

Figure A2 represents the productive side of the system and is used to determine the level of aggregate profit. Figure A3 explains offer prices and calculates aggregate sales and the inflation rate. Figure A4 determines the expected quantity of consumption goods consumed. Figure A5 is the heart of the dynamics of the model and determines the private demand for investment (O_{Id}). Figure A6 shows how the desired and normal flow-leveraging ratios are determined. Figure A7 determines the acceptable flow-leveraging ratio. Figure A8 shows how cash commitments are determined and how they can be met out of gross profit, refinancing and dishoarding. Figure A9 explains how the funding of investment is done and Figure A10 represents the cash box condition and determines what proportion of cash commitments can be met.

Figure A2: Employment, Production, and Profit

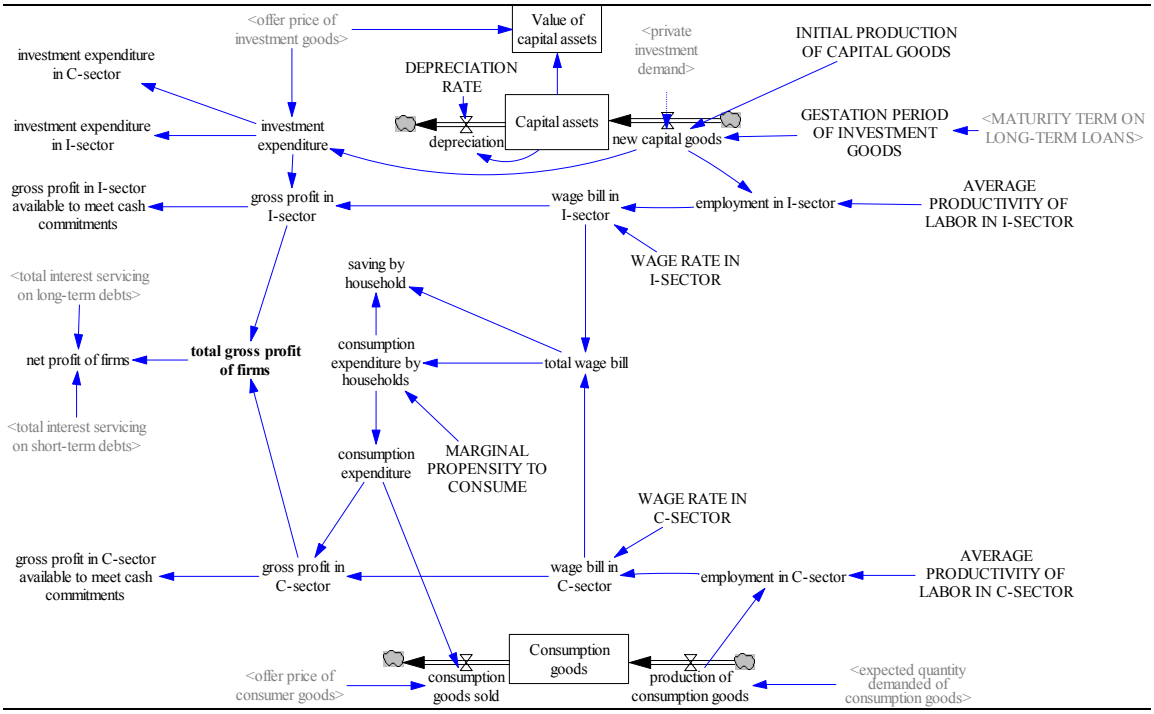


Figure A3: Offer Prices, Inflation and Sales

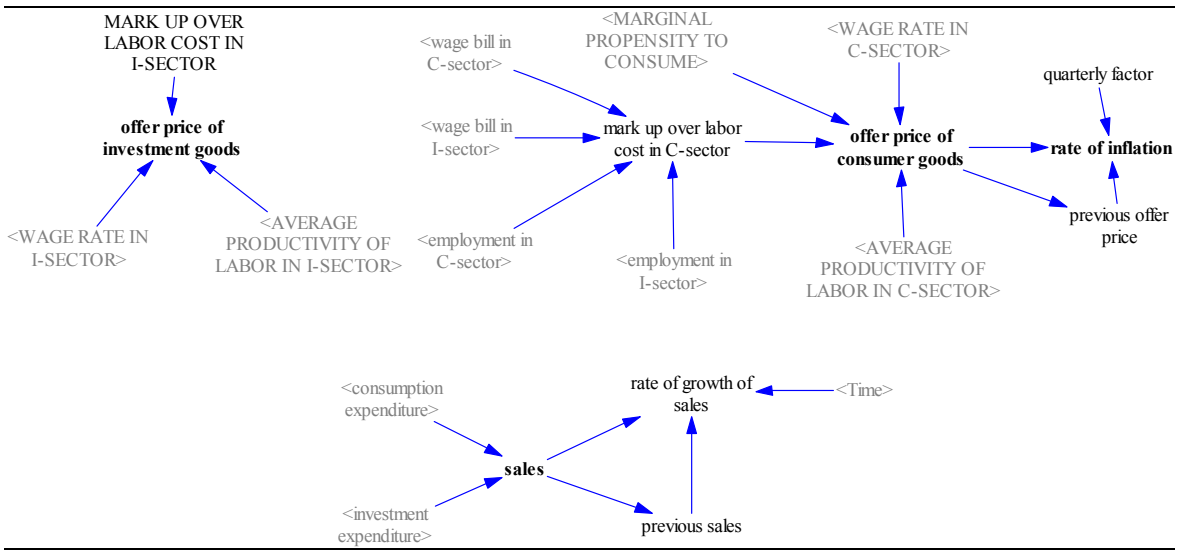


Figure A4: Determination of the Expected Quantity of Consumption Goods Demanded

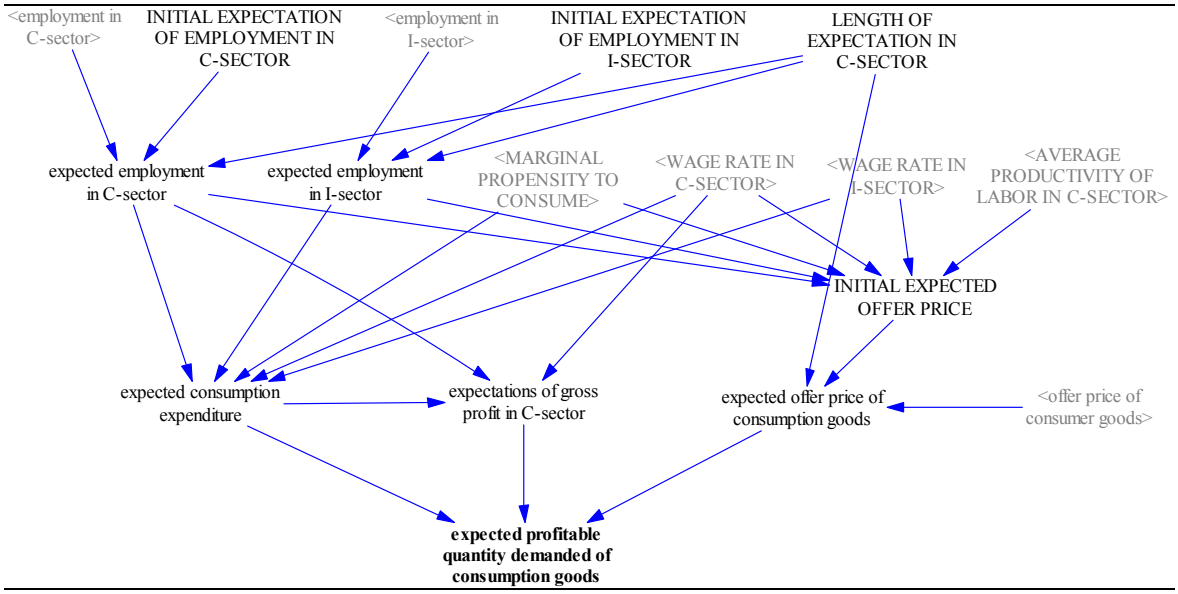


Figure A5: Determination of Quantity of Investment Goods Demanded

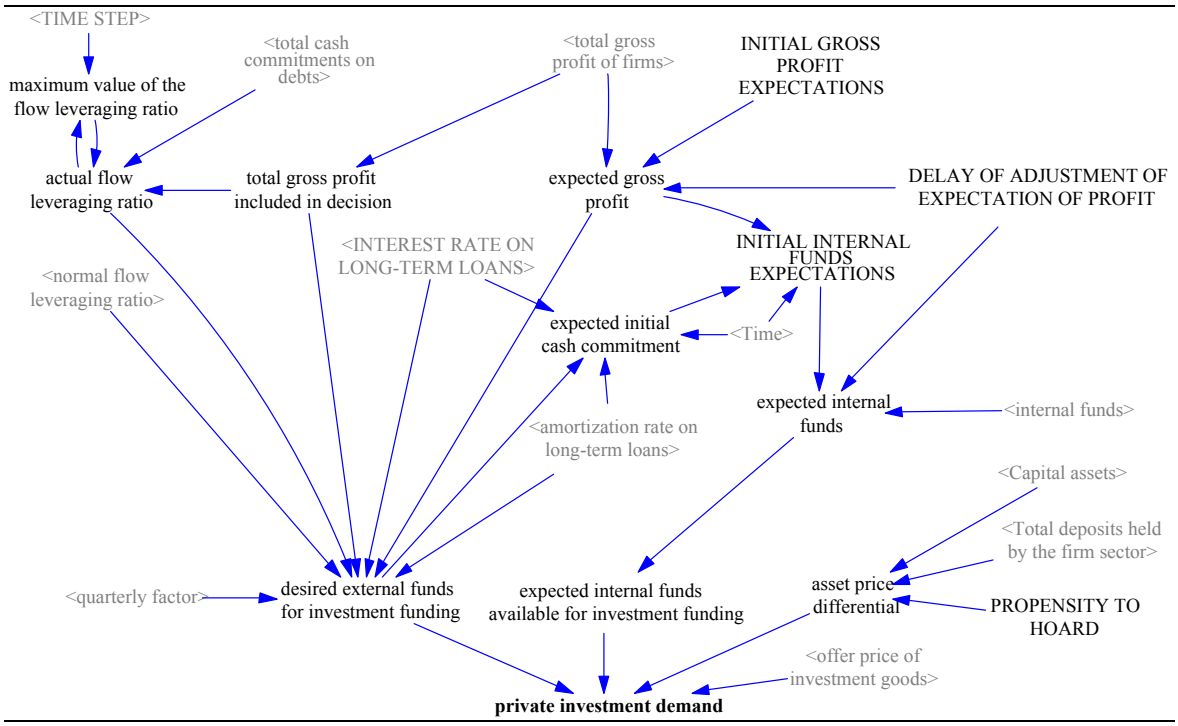


Figure A6: The Desired and Normal Cash-Flow Margin

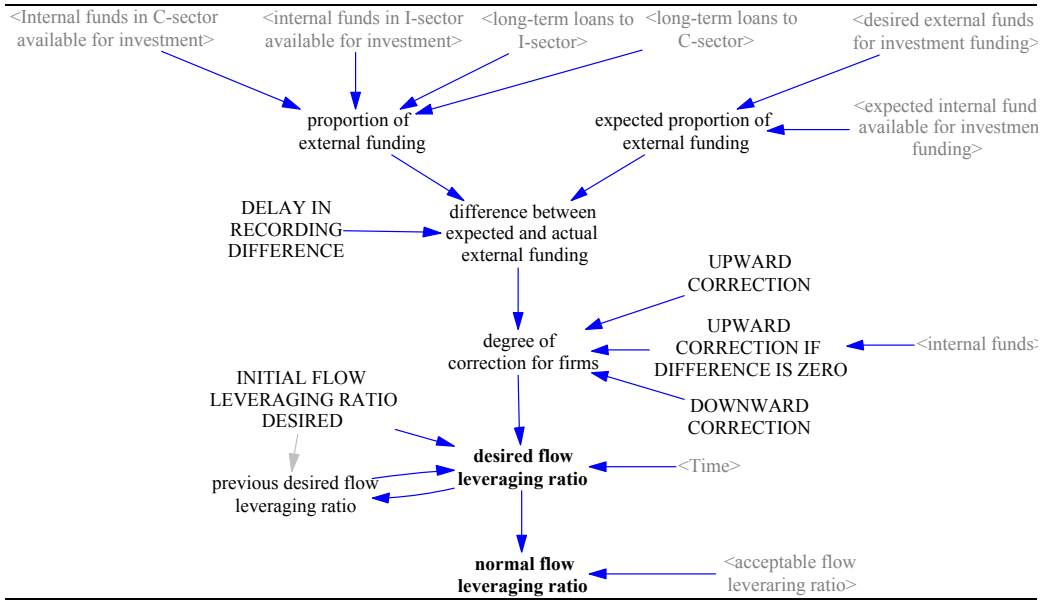


Figure A7: The Acceptable Cash-Flow Margin

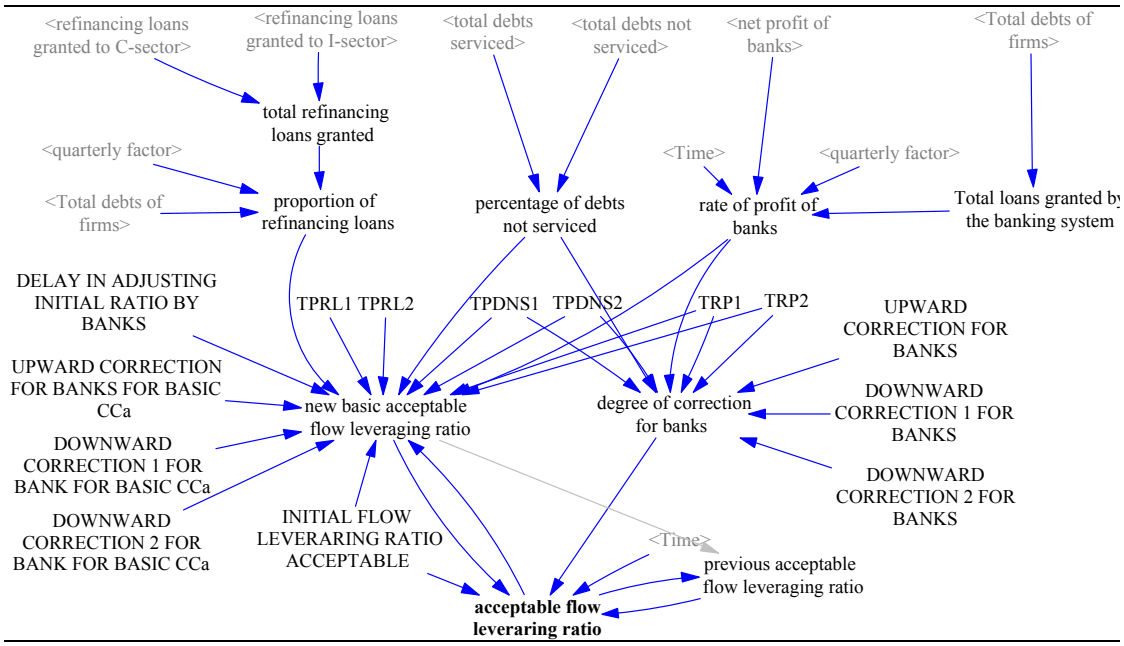


Figure A8: Cash Commitments

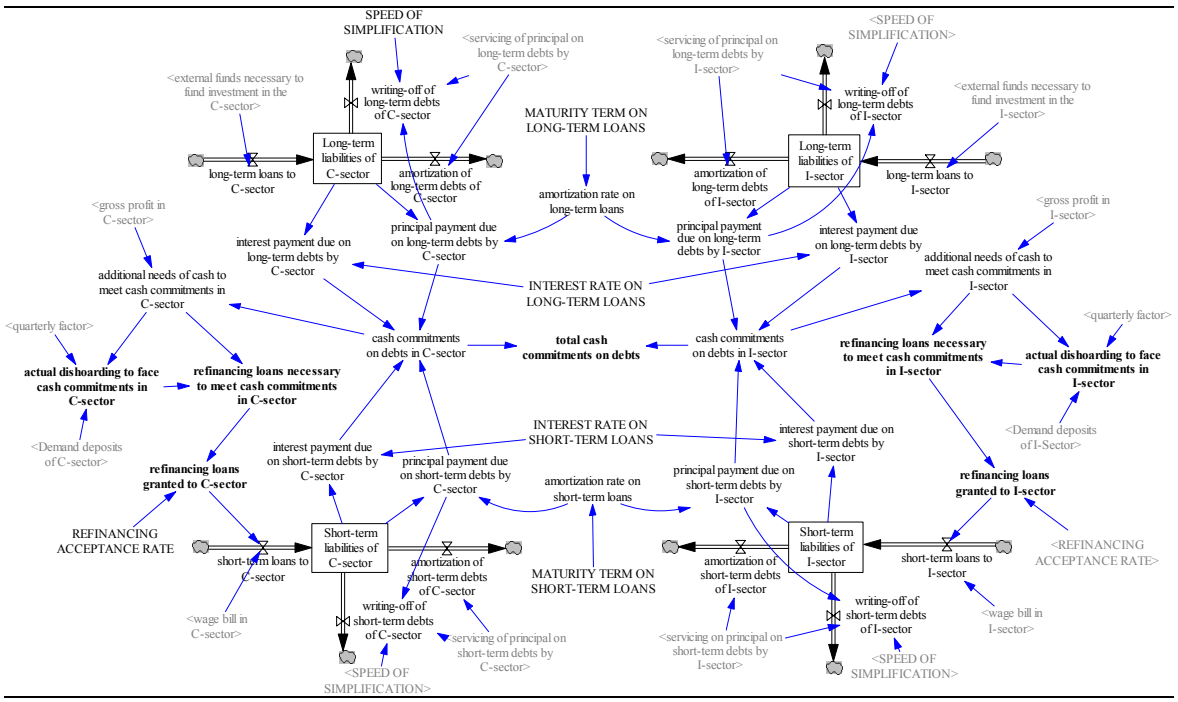


Figure A9: Funding of Investment

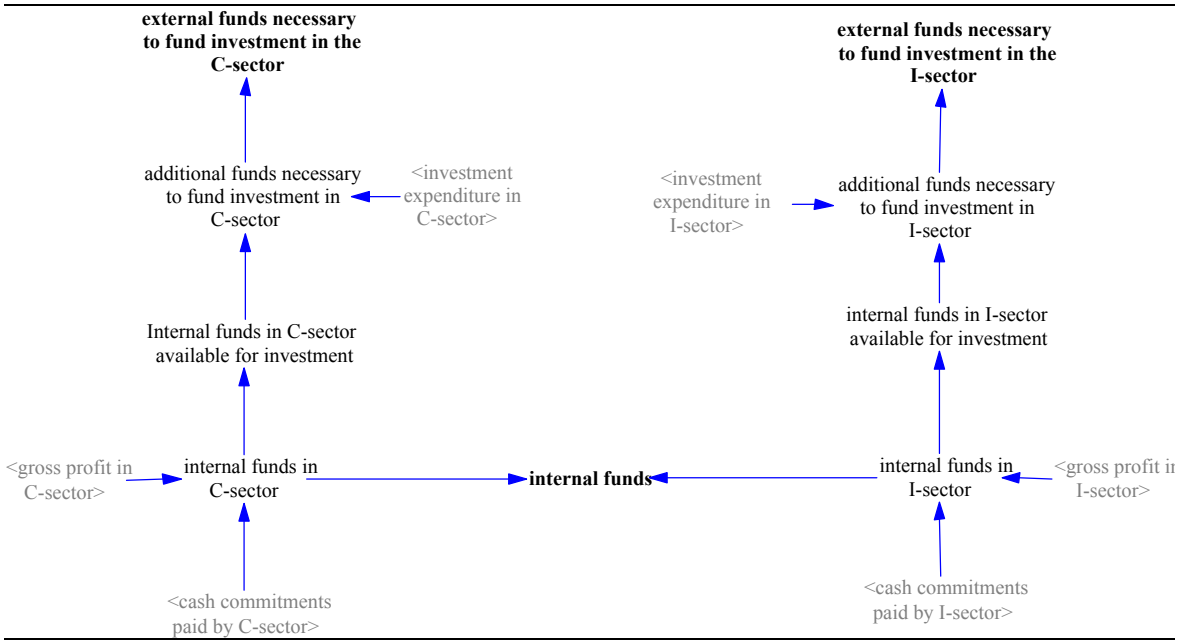
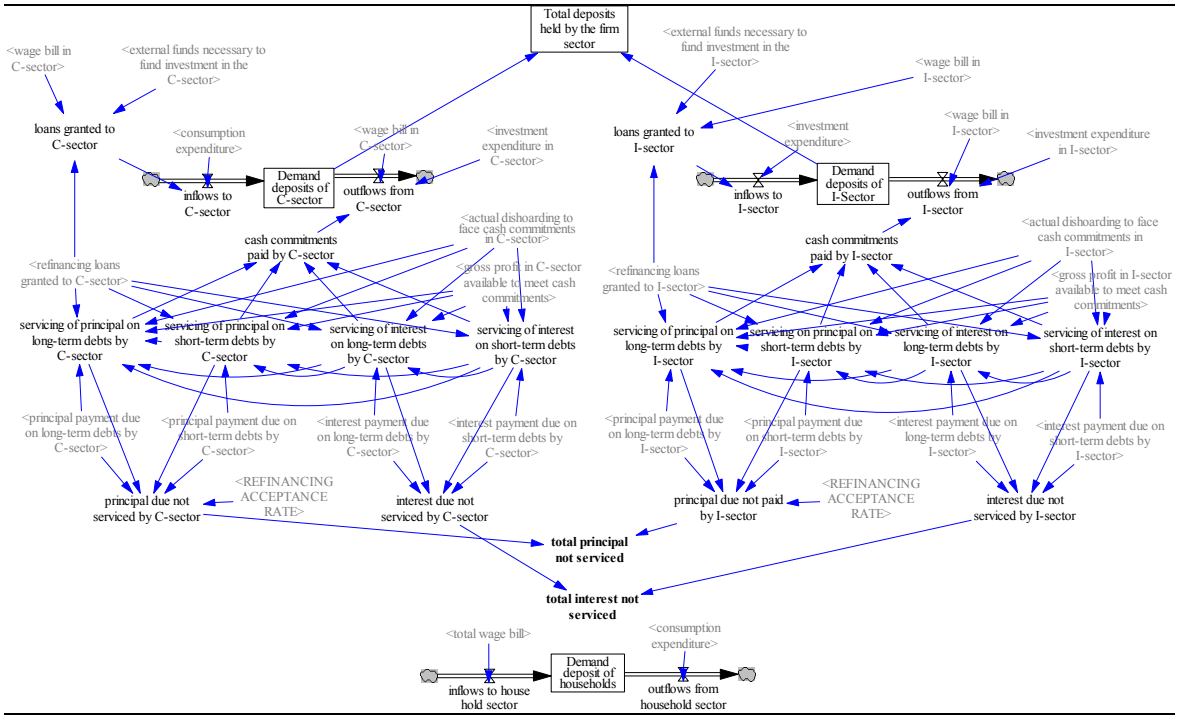


Figure A10: Cash Box Condition



APPENDIX B

THE MODEL IN ANALYTICAL TERMS

The following first presents the model:

(01) “acceptable flow leveraging ratio” = IF THEN ELSE(Time = 0, INITIAL CASHFLOW MARGIN ACCEPTABLE, IF THEN ELSE(integer(Time/5) - Time/5 = 0, “new basic acceptable flow leveraging ratio”, IF THEN ELSE(“previous acceptable flow leveraging ratio” + degree of correction for banks < 0, 0, “previous acceptable flow leveraging ratio” + degree of correction for banks)))

(02) “actual flow leveraging ratio” = XIDZ(total cash commitments on debts, total gross profit included in decision, “maximum value of the flow leveraging ratio”)

(03) “actual dishoarding to face cash commitments in C-sector” = IF THEN ELSE(“Demand deposits of C-sector”*quarterly factor > 0, IF THEN ELSE(“Demand deposits of C-sector”*quarterly factor >= “additional needs of cash to meet cash commitments in C-sector”, “additional needs of cash to meet cash commitments in C-sector”, “Demand deposits of C-sector”*quarterly factor), 0))

(04) “actual dishoarding to face cash commitments in I-sector” = IF THEN ELSE(“Demand deposits of I-sector”*quarterly factor > 0, IF THEN ELSE(“Demand deposits of I-sector”*quarterly factor >= “additional needs of cash to meet cash commitments in I-sector”, “additional needs of cash to meet cash commitments in I-sector”, “Demand deposits of I-sector”*quarterly factor), 0))

(05) “additional funds necessary to fund investment in C-sector” = IF THEN ELSE(“investment expenditure in C-sector” - “Internal funds in C-sector available for investment” > 0, “investment expenditure in C-sector” - “Internal funds in C-sector available for investment”, 0))

(06) “additional funds necessary to fund investment in I-sector” = IF THEN ELSE(“investment expenditure in I-sector” - “internal funds in I-sector available for investment” > 0, “investment expenditure in I-sector” - “internal funds in I-sector available for investment”, 0))

(07) “additional needs of cash to meet cash commitments in C-sector” = IF THEN ELSE(“gross profit in C-sector” <= 0, “cash commitments on debts in C-sector”, IF THEN ELSE(“cash commitments on debts in C-sector” - “gross profit in C-sector” < 0, 0, “cash commitments on debts in C-sector” - “gross profit in C-sector”))

(08) “additional needs of cash to meet cash commitments in I-sector” = IF THEN ELSE(“gross profit in I-sector” < 0, “cash commitments on debts in I-sector”, IF THEN ELSE(“cash commitments on debts in I-sector” - “gross profit in I-sector” < 0, 0, “cash commitments on debts in I-sector” - “gross profit in I-sector”))

(09) “amortization of long-term debts of C-sector” = “servicing of principal on long-term debts by C-sector”

(10) “amortization of long-term debts of I-sector” = “servicing of principal on long-term debts by I-sector”

(11) “amortization of short-term debts of C-sector” = “servicing of principal on short-term debts by C-sector”

(12) “amortization of short-term debts of I-sector” = “servicing on principal on short-term debts by I-sector”
(13) “amortization rate on long-term loans” = 1/“MATURITY TERM ON LONG-TERM LOANS”
(14) “amortization rate on short-term loans” = 1/“MATURITY TERM ON SHORT-TERM LOANS”
(15) asset price differential = IF THEN ELSE(Capital assets > 0, Total deposits held by the firm sector*(1 - PROPENSITY TO HOARD)/Capital assets, 1)
(16) “AVERAGE PRODUCTIVITY OF LABOR IN C-SECTOR” = 2
(17) “AVERAGE PRODUCTIVITY OF LABOR IN I-SECTOR” = 2
(18) capital assets = INTEG(+ new capital goods - depreciation, 0)
(21) “cash commitments on debts in C-sector” = “interest payment due on long-term debts by C-sector” + “interest payment due on short-term debts by C-sector” + “principal payment due on long-term debts by C-sector” + “principal payment due on short-term debts by C-sector”
(22) “cash commitments on debts in I-sector” = “interest payment due on long-term debts by I-sector” + “interest payment due on short-term debts by I-sector” + “principal payment due on long-term debts by I-sector” + “principal payment due on short-term debts by I-sector”
(23) “cash commitments paid by C-sector” = “servicing of principal on long-term debts by C-sector” + “servicing of principal on short-term debts by C-sector” + “servicing of interest on long-term debts by C-sector” + “servicing of interest on short-term debts by C-sector”
(24) “cash commitments paid by I-sector” = “servicing of principal on long-term debts by I-sector” + “servicing on principal on short-term debts by I-sector” + “servicing of interest on long-term debts by I-sector” + “servicing of interest on short-term debts by I-sector”
(25) consumption expenditure = consumption expenditure by households
(26) consumption expenditure by households = total wage bill*MARGINAL PROPENSITY TO CONSUME
(27) Consumption goods = INTEG(+ production of consumption goods - consumption goods sold, 40)
(28) consumption goods sold = consumption expenditure/offer price of consumer goods
(29) degree of correction for banks = IF THEN ELSE(rate of profit of banks < TRP1:OR:percentage of debts not serviced > TPDNS1, IF THEN ELSE(rate of profit of banks < TRP2:OR:percentage of debts not serviced > TPDNS2, - DOWNWARD CORRECTION 2 FOR BANKS, - DOWNWARD CORRECTION 1 FOR BANKS”, UPWARD CORRECTION FOR BANKS “))
(30) degree of correction for firms = IF THEN ELSE(difference between expected and actual external funding > 0, UPWARD CORRECTION, IF THEN ELSE(difference between expected and actual external funding = 0, UPWARD CORRECTION IF DIFFERENCE IS ZERO, DOWNWARD CORRECTION))
(31) DELAY IN ADJUSTING INITIAL MARGIN BY BANKS = 1

(32) DELAY IN RECORDING DIFFERENCE = 3
(33) DELAY OF ADJUSTMENT OF EXPECTATION OF PROFIT = 8
(34) Demand deposit of households = INTEG(+ inflows to household sector - outflows from household sector, 0)
(35) “Demand deposits of C-sector” = INTEG(+ “inflows to C-sector” - “outflows from C-sector”, 0)
(36) “Demand deposits of I-sector” = INTEG(+ “inflows to I-sector” - “outflows from I-sector”, 0)
(37) depreciation = Capital assets*DEPRECIATION RATE
(38) DEPRECIATION RATE = 0.05
(39) desired flow leveraging ratio” = IF THEN ELSE(Time = 0, “INITIAL FLOW LEVERAGING RATIO DESIRED”, IF THEN ELSE(“previous desired flow leveraging ratio” + degree of correction for firms < 0, 0, “previous desired flow leveraging ratio” + degree of correction for firms))
(40) desired external funds for investment funding = IF THEN ELSE(expected gross profit > 0, IF THEN ELSE((“normal flow leveraging ratio” - “actual flow leveraging ratio”*total gross profit included in decision/expected gross profit”*expected gross profit/(“amortization rate on long-term loans” + “INTEREST RATE ON LONG-TERM LOANS”)*quarterly factor > 0, (“normal flow leveraging ratio” - “actual flow leveraging ratio”*total gross profit included in decision/expected gross profit)*expected gross profit/(“amortization rate on long-term loans” + “INTEREST RATE ON LONG-TERM LOANS”)*quarterly factor, 0), 0)
(41) difference between expected and actual external funding = IF THEN ELSE(SMOOTHI(expected proportion of external funding - proportion of external funding, DELAY IN RECORDING DIFFERENCE, 0) < 0, 0, SMOOTHI(expected proportion of external funding - proportion of external funding, DELAY IN RECORDING DIFFERENCE, 0))
(42) DOWNWARD CORRECTION = -0.1
(43) DOWNWARD CORRECTION 1 FOR BANK FOR BASIC CCa = 1.5
(44) DOWNWARD CORRECTION 1 FOR BANKS = 0.2
(45) DOWNWARD CORRECTION 2 FOR BANK FOR BASIC CCa = 1
(46) DOWNWARD CORRECTION 2 FOR BANKS = 0.1
(47) “employment in C-sector” = IF THEN ELSE(production of consumption goods = 0, 0, production of consumption goods/“AVERAGE PRODUCTIVITY OF LABOR IN C-SECTOR”)
(48) “employment in I-sector” = new capital goods/“AVERAGE PRODUCTIVITY OF LABOR IN I-SECTOR”
(49) “expectations of gross profit in C-sector” = expected consumption expenditure - “WAGE RATE IN C-SECTOR”*“expected employment in C-sector”
(50) expected consumption expenditure = MARGINAL PROPENSITY TO CONSUME*(“WAGE RATE IN I-SECTOR”*“expected employment in I-sector”

+ “WAGE RATE IN I-SECTOR”*“expected employment in I-sector”) - “WAGE RATE IN I-SECTOR”*“expected employment in I-sector”

(51) “expected employment in C-sector” = SMOOTHI(“employment in C-sector”, “LENGTH OF EXPECTATION IN C-SECTOR”, “INITIAL EXPECTATION OF EMPLOYMENT IN C-SECTOR”)

(52) “expected employment in I-sector” = SMOOTHI(“employment in I-sector”, “LENGTH OF EXPECTATION IN I-SECTOR”, “INITIAL EXPECTATION OF EMPLOYMENT IN I-SECTOR”)

(53) expected gross profit = SMOOTHI(total gross profit of firms, DELAY OF ADJUSTMENT OF EXPECTATION OF PROFIT, INITIAL GROSS PROFIT EXPECTATIONS “)

(54) expected initial cash commitment = IF THEN ELSE(Time = 0, (“amortization rate on long-term loans”*Time + “INTEREST RATE ON LONG-TERM LOANS”*Time)*desired external funds for investment funding, 0)

(55) expected internal funds = SMOOTHI(internal funds, DELAY OF ADJUSTMENT OF EXPECTATION OF PROFIT, INITIAL INTERNAL FUNDS EXPECTATIONS)

(56) expected internal funds available for investment funding = IF THEN ELSE(expected internal funds > 0, expected internal funds, 0)

(57) expected offer price of consumption goods = SMOOTHI(offer price of consumer goods, “LENGTH OF EXPECTATION IN C-SECTOR”, INITIAL EXPECTED OFFER PRICE”)

(58) expected profitable quantity demanded of consumption goods = IF THEN ELSE(“expectations of gross profit in C-sector” > 0, expected consumption expenditure/expected offer price of consumption goods, 0)

(59) expected proportion of external funding = IF THEN ELSE(desired external funds for investment funding + expected internal funds available for investment funding = 0, 0, desired external funds for investment funding/(desired external funds for investment funding + expected internal funds available for investment funding)

(60) “external funds necessary to fund investment in the C-sector” = IF THEN ELSE(“additional funds necessary to fund investment in C-sector” - “actual dishoarding to fund investment in C-sector” > 0, “additional funds necessary to fund investment in C-sector” - “actual dishoarding to fund investment in C-sector”, 0)

(61) “external funds necessary to fund investment in the I-sector” = IF THEN ELSE(“additional funds necessary to fund investment in I-sector” - “actual dishoarding to fund investment in I-sector” > 0, “additional funds necessary to fund investment in I-sector” - “actual dishoarding to fund investment in I-sector”, 0)

(62) FINAL TIME = 60

(63) GESTATION PERIOD OF INVESTMENT GOODS = 2*“MATURITY TERM ON LONG-TERM LOANS”

(64) “gross profit in C-sector” = consumption expenditure - “wage bill in C-sector”

(65) “gross profit in C-sector available to meet cash commitments” = IF THEN ELSE(“gross profit in C-sector” < 0, 0, “gross profit in C-sector”)
(66) “gross profit in I-sector” = investment expenditure - “wage bill in I-sector”
(67) “gross profit in I-sector available to meet cash commitments” = IF THEN ELSE(“gross profit in I-sector” < 0, 0, “gross profit in I-sector”)
(68) “inflows to C-sector” = consumption expenditure + “loans granted to C-sector”
(69) inflows to household sector = total wage bill
(70) “inflows to I-sector” = investment expenditure + “loans granted to I-sector”
(71) “INITIAL FLOW LEVERAGING RATIO DESIRED” = 0.8
(72) INITIAL CASHFLOW MARGIN ACCEPTABLE = 0.8
(73) “INITIAL EXPECTATION OF EMPLOYMENT IN C-SECTOR” = 1
(74) “INITIAL EXPECTATION OF EMPLOYMENT IN I-SECTOR” = 10
(75) INITIAL EXPECTED OFFER PRICE = MARGINAL PROPENSITY TO CONSUME*(“WAGE RATE IN I-SECTOR”/“AVERAGE PRODUCTIVITY OF LABOR IN I-SECTOR”)*(1 + (“WAGE RATE IN I-SECTOR”*“expected employment in I-sector”)/(“WAGE RATE IN I-SECTOR”*“expected employment in I-sector”))
(76) INITIAL GROSS PROFIT EXPECTATIONS = 10
(77) INITIAL INTERNAL FUNDS EXPECTATIONS = IF THEN ELSE(Time = 0, expected gross profit - expected initial cash commitment, 0)
(78) INITIAL PRODUCTION OF CAPITAL GOODS = 0
(79) INITIAL TIME = 0
(80) “interest due not serviced by C-sector” = “interest payment due on long-term debts by C-sector” - “servicing of interest on long-term debts by C-sector” + “interest payment due on short-term debts by C-sector” - “servicing of interest on short-term debts by C-sector”
(81) “interest due not serviced by I-sector” = “interest payment due on long-term debts by I-sector” - “servicing of interest on long-term debts by I-sector” + “interest payment due on short-term debts by I-sector” - “servicing of interest on short-term debts by I-sector”
(82) “interest payment due on long-term debts by C-sector” = “INTEREST RATE ON LONG-TERM LOANS”*“Long-term liabilities of C-sector”
(83) “interest payment due on long-term debts by I-sector” = “INTEREST RATE ON LONG-TERM LOANS”*“Long-term liabilities of I-sector”
(84) “interest payment due on short-term debts by C-sector” = “INTEREST RATE ON SHORT-TERM LOANS”*“Short-term liabilities of C-sector”
(85) “interest payment due on short-term debts by I-sector” = “Short-term liabilities of I-sector”*“INTEREST RATE ON SHORT-TERM LOANS”
(86) “INTEREST RATE ON LONG-TERM LOANS” = 0.045
(87) “INTEREST RATE ON SHORT-TERM LOANS” = 0.02
(88) internal funds = “internal funds in I-sector” + “internal funds in I-sector”
(89) “internal funds in C-sector” = “gross profit in C-sector” - “cash commitments paid by C-sector”

(90) “Internal funds in C-sector available for investment” = IF THEN ELSE(“internal funds in C-sector” > 0, “internal funds in C-sector”, 0)
(91) “internal funds in I-sector” = “gross profit in I-sector” - “cash commitments paid by I-sector”
(92) “internal funds in I-sector available for investment” = IF THEN ELSE(“internal funds in I-sector” > 0, “internal funds in I-sector”, 0)
(93) investment expenditure = new capital goods*offer price of investment goods
(94) “investment expenditure in C-sector” = 0.5*investment expenditure
(95) “investment expenditure in I-sector” = 0.5*investment expenditure
(96) “LENGTH OF EXPECTATION IN C-SECTOR” = 2
(97) “loans granted to C-sector” = “refinancing loans granted to C-sector” + “wage bill in C-sector” + “external funds necessary to fund investment in the C-sector”
(98) “loans granted to I-sector” = “wage bill in I-sector” + “refinancing loans granted to I-sector” + “external funds necessary to fund investment in the I-sector”
(99) “Long-term liabilities of C-sector” = INTEG(+ “long-term loans to C-sector” - “amortization of long-term debts of C-sector” - “writing-off of long-term debts of C-sector”, 0)
(100) “Long-term liabilities of I-sector” = INTEG(+ “long-term loans to I-sector” - “amortization of long-term debts of I-sector” - “writing-off of long-term debts of I-sector”, 0)
(101) “long-term loans to C-sector” = “external funds necessary to fund investment in the C-sector”
(102) “long-term loans to I-sector” = “external funds necessary to fund investment in the I-sector”
(103) MARGINAL PROPENSITY TO CONSUME = 0.9
(104) “mark up over labor cost in C-sector” = IF THEN ELSE(“employment in C-sector” <= 0:OR:”employment in C-sector” <= 0, 1, 1 + (“wage bill in C-sector”/“wage bill in C-sector”))
(105) “MARK UP OVER LABOR COST IN I-SECTOR” = 1
(106) “MATURITY TERM ON LONG-TERM LOANS” = 20
(107) “MATURITY TERM ON SHORT-TERM LOANS” = 4
(108) “maximum value of the flow leveraging ratio” = INTEG(IF THEN ELSE (“actual flow leveraging ratio” > 0, IF THEN ELSE (“actual flow leveraging ratio” > “maximum value of the flow leveraging ratio”, “actual flow leveraging ratio”/TIME STEP, “maximum value of the flow leveraging ratio”/TIME STEP), “maximum value of the flow leveraging ratio”/TIME STEP) - “maximum value of the flow leveraging ratio”/TIME STEP, 0)
(109) net profit of banks = “servicing of interest on long-term debts by C-sector” + “servicing of interest on long-term debts by I-sector” + “servicing of interest on short-term debts by C-sector” + “servicing of interest on short-term debts by I-sector”
(110) net profit of firms = total gross profit of firms - “total interest servicing on long-term debts” - “total interest servicing on short-term debts”

(111) net variation of demand deposits of firms = “inflows to C-sector” - “outflows from C-sector” + “inflows to I-sector” - “outflows from I-sector”

(112) “net variation of long-term debts of firms” = “long-term loans to C-sector” + “long-term loans to I-sector” - “amortization of long-term debts of C-sector” - “amortization of long-term debts of I-sector” - “writing-off of long-term debts of C-sector” - “writing-off of long-term debts of I-sector”

(113) “net variation of short-term debts of firms” = “short-term loans to C-sector” + “short-term loans to I-sector” - “amortization of short-term debts of C-sector” - “amortization of short-term debts of I-sector” - “writing-off of short-term debts of C-sector” - “writing-off of short-term debts of I-sector”

(114) “new basic acceptable flow leveraging ratio” = IF THEN ELSE(rate of profit of banks < TRP1:OR:percentage of debts not serviced > TPDNS1:OR:proportion of refinancing loans > TPRL1, IF THEN ELSE(rate of profit of banks < TRP2:OR:percentage of debts not serviced > TPDNS2:OR:proportion of refinancing loans > TPRL2, IF THEN ELSE(SMOOTHI(“acceptable flow leveraging ratio” - DOWNWARD CORRECTION 1 FOR BANK FOR BASIC CCa, DELAY IN ADJUSTING INITIAL MARGIN BY BANKS, INITIAL CASHFLOW MARGIN ACCEPTABLE) < 0, 0, SMOOTHI(“acceptable flow leveraging ratio” - DOWNWARD CORRECTION 1 FOR BANK FOR BASIC CCa, DELAY IN ADJUSTING INITIAL MARGIN BY BANKS, INITIAL CASHFLOW MARGIN ACCEPTABLE)), IF THEN ELSE(SMOOTHI(“acceptable flow leveraging ratio” - DOWNWARD CORRECTION 2 FOR BANK FOR BASIC CCa, DELAY IN ADJUSTING INITIAL MARGIN BY BANKS, INITIAL CASHFLOW MARGIN ACCEPTABLE) < 0, 0, SMOOTHI(“acceptable flow leveraging ratio” - DOWNWARD CORRECTION 2 FOR BANK FOR BASIC CCa, DELAY IN ADJUSTING INITIAL MARGIN BY BANKS, INITIAL CASHFLOW MARGIN ACCEPTABLE))), SMOOTHI(“acceptable flow leveraging ratio” + UPWARD CORRECTION FOR BANKS FOR BASIC CCa, DELAY IN ADJUSTING INITIAL MARGIN BY BANKS, INITIAL CASHFLOW MARGIN ACCEPTABLE))

(115) new capital goods = SMOOTHI(private investment demand, GESTATION PERIOD OF INVESTMENT GOODS, INITIAL PRODUCTION OF CAPITAL GOODS)

(116) “normal flow leveraging ratio” = MIN(“desired flow leveraging ratio”, “acceptable flow leveraging ratio”)

(117) offer price of consumer goods = MARGINAL PROPENSITY TO CONSUME*(“WAGE RATE IN C-SECTOR”/“AVERAGE PRODUCTIVITY OF LABOR IN C-SECTOR”)*“mark up over labor cost in C-sector”

(118) offer price of investment goods = (“WAGE RATE IN I-SECTOR”/“AVERAGE PRODUCTIVITY OF LABOR IN I-SECTOR”)*(1 + “MARK UP OVER LABOR COST IN I-SECTOR”)

(119) “outflows from C-sector” = “wage bill in C-sector” + “investment expenditure in C-sector” + “cash commitments paid by C-sector”
(120) outflows from household sector = consumption expenditure
(121) “outflows from I-sector” = “cash commitments paid by I-sector” + “wage bill in I-sector” + “investment expenditure in I-sector”
(122) percentage of debts not serviced = IF THEN ELSE(total debts not serviced + total debts serviced = 0, 0, total debts not serviced/(total debts not serviced + total debts serviced))
(123) “previous acceptable flow leveraging ratio” = DELAY FIXED(“acceptable flow leveraging ratio”, 1, “new basic acceptable flow leveraging ratio”)
(124) “previous desired flow leveraging ratio” = DELAY FIXED(“desired flow leveraging ratio”, 1, “INITIAL FLOW LEVERAGING RATIO DESIRED”)
(125) previous offer price = DELAY FIXED(offer price of consumer goods, 1, 0.9)
(126) previous sales = DELAY FIXED(sales, 1, 18)
(127) “principal due not paid by I-sector” = IF THEN ELSE(REFINANCING ACCEPTANCE RATE = 1, 0, IF THEN ELSE(“principal payment due on long-term debts by I-sector” - “servicing of principal on long-term debts by I-sector” + “principal payment due on short-term debts by I-sector” - “servicing on principal on short-term debts by I-sector” < 0.001, 0, “principal payment due on long-term debts by I-sector” - “servicing of principal on long-term debts by I-sector” + “principal payment due on short-term debts by I-sector” - “servicing on principal on short-term debts by I-sector”))
(128) “principal due not serviced by C-sector” = IF THEN ELSE(REFINANCING ACCEPTANCE RATE = 1, 0, IF THEN ELSE(“principal payment due on long-term debts by C-sector” - “servicing of principal on long-term debts by C-sector” + “principal payment due on short-term debts by C-sector” - “servicing of principal on short-term debts by C-sector” < 0.001, 0, “principal payment due on long-term debts by C-sector” - “servicing of principal on long-term debts by C-sector” + “principal payment due on short-term debts by C-sector” - “servicing of principal on short-term debts by C-sector”))
(129) “principal payment due on long-term debts by C-sector” = “amortization rate on long-term loans”*“Long-term liabilities of C-sector”
(130) “principal payment due on long-term debts by I-sector” = “amortization rate on long-term loans”*“Long-term liabilities of I-sector”
(131) “principal payment due on short-term debts by C-sector” = “amortization rate on short-term loans”*“Short-term liabilities of C-sector”
(132) “principal payment due on short-term debts by I-sector” = “amortization rate on short-term loans”*“Short-term liabilities of I-sector”
(133) private investment demand = IF THEN ELSE(asset price differential <= 0, 0, IF THEN ELSE(expected internal funds available for investment funding = 0:AND:desired external funds for investment funding = 0, 0, IF THEN ELSE (expected internal funds available for investment funding = 0:AND:desired external funds for investment funding > 0, desired external funds for investment

funding/offer price of investment goods, IF THEN ELSE(expected internal funds available for investment funding > 0 :AND: desired external funds for investment funding = 0, expected internal funds available for investment funding/offer price of investment goods, (expected internal funds available for investment funding + desired external funds for investment funding)/offer price of investment goods))))

(134) production of consumption goods = expected profitable quantity demanded of consumption goods

(135) PROPENSITY TO HOARD = 0.2

(136) proportion of external funding = IF THEN ELSE("Internal funds in C-sector available for investment" + "Internal funds in I-sector available for investment" + "long-term loans to C-sector" + "long-term loans to I-sector" = 0, 0, ("long-term loans to C-sector" + "long-term loans to I-sector")/("Internal funds in C-sector available for investment" + "internal funds in I-sector available for investment" + "long-term loans to C-sector" + "long-term loans to I-sector"))

(137) proportion of refinancing loans = XIDZ(total refinancing loans granted, Total debts of firms*quarterly factor, 0)

(138) "proportion of short-term debts" = XIDZ("Short-term liabilities of C-sector" + "Short-term liabilities of I-sector", "Short-term liabilities of C-sector" + "Short-term liabilities of I-sector" + "Long-term liabilities of C-sector" + "Long-term liabilities of I-sector", 0)

(139) quarterly factor = 1

(140) rate of growth of sales = IF THEN ELSE(Time = 0:OR:previous sales = 0, 0, (sales - previous sales)/previous sales)

(141) rate of inflation = IF THEN ELSE(ABS((offer price of consumer goods - previous offer price)/previous offer price) < 0, 0, (offer price of consumer goods - previous offer price)/previous offer price)*quarterly factor

(142) rate of profit of banks = IF THEN ELSE(Time = 0, 0, IF THEN ELSE(net profit of banks < 0, 0, XIDZ(net profit of banks, Total loans granted by the banking system*quarterly factor, 0)))

(143) REFINANCING ACCEPTANCE RATE = 0

(144) "refinancing loans granted to C-sector" = REFINANCING ACCEPTANCE RATE*"refinancing loans necessary to meet cash commitments in C-sector"

(145) "refinancing loans granted to I-sector" = REFINANCING ACCEPTANCE RATE*"refinancing loans necessary to meet cash commitments in I-sector"

(146) "refinancing loans necessary to meet cash commitments in C-sector" = IF THEN ELSE("additional needs of cash to meet cash commitments in C-sector" - "actual dishoarding to face cash commitments in C-sector" > 0, "additional needs of cash to meet cash commitments in C-sector" - "actual dishoarding to face cash commitments in C-sector", 0)

(147) "refinancing loans necessary to meet cash commitments in I-sector" = IF THEN ELSE("additional needs of cash to meet cash commitments in I-sector" - "actual dishoarding to face cash commitments in I-sector" > 0, "additional needs of cash to

meet cash commitments in I-sector” - “actual dishoarding to face cash commitments in I-sector”, 0)

(148) sales = consumption expenditure + investment expenditure

(149) SAVEPER = 1

(150) saving by household = total wage bill - consumption expenditure by households

(151) “servicing of interest on long-term debts by C-sector” = IF THEN ELSE(“gross profit in C-sector available to meet cash commitments” + “actual dishoarding to face cash commitments in C-sector” + “refinancing loans granted to C-sector” - “servicing of interest on short-term debts by C-sector” > 0, IF THEN ELSE(“gross profit in C-sector available to meet cash commitments” + “actual dishoarding to face cash commitments in C-sector” + “refinancing loans granted to C-sector” - “servicing of interest on short-term debts by C-sector” >= “interest payment due on long-term debts by C-sector”, “interest payment due on long-term debts by C-sector”, “gross profit in C-sector available to meet cash commitments” + “actual dishoarding to face cash commitments in C-sector” + “refinancing loans granted to C-sector” - “servicing of interest on short-term debts by C-sector”), 0)

(152) “servicing of interest on long-term debts by I-sector” = IF THEN ELSE(“gross profit in I-sector available to meet cash commitments” + “actual dishoarding to face cash commitments in I-sector” + “refinancing loans granted to I-sector” - “servicing of interest on short-term debts by I-sector” > 0, IF THEN ELSE(“gross profit in I-sector available to meet cash commitments” + “actual dishoarding to face cash commitments in I-sector” + “refinancing loans granted to I-sector” - “servicing of interest on short-term debts by I-sector” >= “interest payment due on long-term debts by I-sector”, “interest payment due on long-term debts by I-sector”, “gross profit in I-sector available to meet cash commitments” + “actual dishoarding to face cash commitments in I-sector” + “refinancing loans granted to I-sector” - “servicing of interest on short-term debts by I-sector”), 0)

(153) “servicing of interest on short-term debts by C-sector” = IF THEN ELSE(“gross profit in C-sector available to meet cash commitments” + “actual dishoarding to face cash commitments in C-sector” + “refinancing loans granted to C-sector” > 0, IF THEN ELSE(“gross profit in C-sector available to meet cash commitments” + “actual dishoarding to face cash commitments in C-sector” + “refinancing loans granted to C-sector” >= “interest payment due on short-term debts by C-sector”, “interest payment due on short-term debts by C-sector”, “gross profit in C-sector available to meet cash commitments” + “actual dishoarding to face cash commitments in C-sector” + “refinancing loans granted to C-sector”), 0)

(154) “servicing of interest on short-term debts by I-sector” = IF THEN ELSE(“gross profit in I-sector available to meet cash commitments” + “actual dishoarding to face cash commitments in I-sector” + “refinancing loans granted to I-sector” > 0, IF THEN ELSE(“gross profit in I-sector available to meet cash commitments” + “actual dishoarding to face cash commitments in I-sector” + “refinancing loans granted to I-sector” >= “interest payment due on short-term debts by I-sector”, “interest payment due on short-term debts by I-sector”, “gross profit in I-sector

available to meet cash commitments” + “actual dishoarding to face cash commitments in I-sector” + “refinancing loans granted to I-sector”), 0)

(155) “servicing of principal on long-term debts by C-sector” = IF THEN ELSE(“gross profit in C-sector available to meet cash commitments” + “actual dishoarding to face cash commitments in C-sector” + “refinancing loans granted to C-sector” - “servicing of interest on short-term debts by C-sector” - “servicing of interest on long-term debts by C-sector” - “servicing of principal on short-term debts by C-sector” > 0, IF THEN ELSE(“gross profit in C-sector available to meet cash commitments” + “actual dishoarding to face cash commitments in C-sector” + “refinancing loans granted to C-sector” - “servicing of interest on short-term debts by C-sector” - “servicing of interest on long-term debts by C-sector” - “servicing of principal on short-term debts by C-sector” >= “principal payment due on long-term debts by C-sector”, “principal payment due on long-term debts by C-sector”, “gross profit in C-sector available to meet cash commitments” + “actual dishoarding to face cash commitments in C-sector” + “refinancing loans granted to C-sector” - “servicing of interest on short-term debts by C-sector” - “servicing of interest on long-term debts by C-sector” - “servicing of principal on short-term debts by C-sector”), 0)

(156) “servicing of principal on long-term debts by I-sector” = IF THEN ELSE(“gross profit in I-sector available to meet cash commitments” + “actual dishoarding to face cash commitments in I-sector” + “refinancing loans granted to I-sector” - “servicing of interest on short-term debts by I-sector” - “servicing of interest on long-term debts by I-sector” - “servicing on principal on short-term debts by I-sector” > 0, IF THEN ELSE(“gross profit in I-sector available to meet cash commitments” + “actual dishoarding to face cash commitments in I-sector” + “refinancing loans granted to I-sector” - “servicing of interest on short-term debts by I-sector” - “servicing of interest on long-term debts by I-sector” - “servicing on principal on short-term debts by I-sector” >= “principal payment due on long-term debts by I-sector”, “principal payment due on long-term debts by I-sector”, “gross profit in I-sector available to meet cash commitments” + “actual dishoarding to face cash commitments in I-sector” + “refinancing loans granted to I-sector” - “servicing of interest on short-term debts by I-sector” - “servicing of interest on long-term debts by I-sector” - “servicing on principal on short-term debts by I-sector”), 0)

(157) “servicing of principal on short-term debts by C-sector” = IF THEN ELSE(“gross profit in C-sector available to meet cash commitments” + “actual dishoarding to face cash commitments in C-sector” + “refinancing loans granted to C-sector” - “servicing of interest on short-term debts by C-sector” - “servicing of interest on long-term debts by C-sector” > 0, IF THEN ELSE (“gross profit in C-sector available to meet cash commitments” + “actual dishoarding to face cash commitments in C-sector” + “refinancing loans granted to C-sector” - “servicing of interest on short-term debts by C-sector” - “servicing of interest on long-term debts by C-sector” >= “principal payment due on short-term debts by C-sector”,

"principal payment due on short-term debts by C-sector", "gross profit in C-sector available to meet cash commitments" + "actual dishoarding to face cash commitments in C-sector" + "refinancing loans granted to C-sector" - "servicing of interest on short-term debts by C-sector" - "servicing of interest on long-term debts by C-sector"), 0)

(158) "servicing on principal on short-term debts by I-sector" = IF THEN ELSE("gross profit in I-sector available to meet cash commitments" + "actual dishoarding to face cash commitments in I-sector" + "refinancing loans granted to I-sector" - "servicing of interest on short-term debts by I-sector" - "servicing of interest on long-term debts by I-sector" > 0, IF THEN ELSE ("gross profit in I-sector available to meet cash commitments" + "actual dishoarding to face cash commitments in I-sector" + "refinancing loans granted to I-sector" - "servicing of interest on short-term debts by I-sector" - "servicing of interest on long-term debts by I-sector" >= "principal payment due on short-term debts by I-sector", "principal payment due on short-term debts by I-sector", "gross profit in I-sector available to meet cash commitments" + "actual dishoarding to face cash commitments in I-sector" + "refinancing loans granted to I-sector" - "servicing of interest on short-term debts by I-sector" - "servicing of interest on long-term debts by I-sector"), 0)

(159) "Short-term liabilities of C-sector" = INTEG(+ "short-term loans to C-sector" - "amortization of short-term debts of C-sector" - "writing-off of short-term debts of C-sector", 0)

(160) "Short-term liabilities of I-sector" = INTEG(+ "short-term loans to I-sector" - "amortization of short-term debts of I-sector" - "writing-off of short-term debts of I-sector", 0)

(161) "short-term loans to C-sector" = "refinancing loans granted to C-sector" + "wage bill in C-sector"

(162) "short-term loans to I-sector" = "refinancing loans granted to I-sector" + "wage bill in I-sector"

(163) SPEED OF SIMPLIFICATION = 1

(164) TIME STEP = 0.0078125

(165) total cash commitments on debts = "cash commitments on debts in C-sector" + "cash commitments on debts in I-sector"

(166) total debts not serviced = total principal not serviced + total interest not serviced

(167) Total debts of firms = "Long-term liabilities of C-sector" + "Long-term liabilities of I-sector" + "Short-term liabilities of C-sector" + "Short-term liabilities of I-sector"

(168) total debts serviced = total interest serviced + total principal serviced

(169) total debts written off = "writing-off of long-term debts of C-sector" + "writing-off of long-term debts of I-sector" + "writing-off of short-term debts of C-sector" + "writing-off of short-term debts of I-sector"

(170) Total deposits held by the firm sector = "Demand deposits of C-sector" + "Demand deposits of I-sector"

(171) total gross profit included in decision = IF THEN ELSE(integer(total gross profit of firms) > 0:OR:total gross profit of firms >= 1, total gross profit of firms, 0)
(172) total gross profit of firms = “gross profit in C-sector” + “gross profit in I-sector”
(173) total interest not serviced = “interest due not serviced by I-sector” + “interest due not serviced by I-sector”
(174) total interest serviced = “total interest servicing on long-term debts” + “total interest servicing on short-term debts
(175) “total interest servicing on long-term debts” = “servicing of interest on long-term debts by C-sector” + “servicing of interest on long-term debts by I-sector”
(176) “total interest servicing on short-term debts” = “servicing of interest on short-term debts by C-sector” + “servicing of interest on short-term debts by I-sector”
(177) Total loans granted by the banking system = Total debts of firms
(178) total principal not serviced = “principal due not serviced by C-sector” + “principal due not paid by I-sector”
(179) total principal serviced = “total principal servicing on long-term debts” + “total principal servicing on short-term debts”
(180) “total principal servicing on long-term debts” = “servicing of principal on long-term debts by I-sector” + “servicing of principal on long-term debts by I-sector”
(181) “total principal servicing on short-term debts” = “servicing of principal on short-term debts by C-sector” + “servicing on principal on short-term debts by I-sector”
(182) total refinancing loans granted = “refinancing loans granted to C-sector” + “refinancing loans granted to I-sector”
(183) total wage bill = “wage bill in C-sector” + “wage bill in I-sector”
(184) TPDNS1 = 0.1
(185) TPDNS2 = 0.2
(186) TPRL1 = 0.1
(187) TPRL2 = 0.2
(188) TRP1 = 0.025
(189) TRP2 = 0.01
(190) UPWARD CORRECTION = 0.3
(191) UPWARD CORRECTION FOR BANKS = 0.05
(192) UPWARD CORRECTION FOR BANKS FOR BASIC CCa = 0.5
(193) UPWARD CORRECTION IF DIFFERENCE IS ZERO = IF THEN ELSE(internal funds > 0, 0.1, 0)
(194) Value of capital assets = offer price of investment goods*Capital assets
(195) “wage bill in C-sector” = “employment in C-sector”*“WAGE RATE IN C-SECTOR”
(196) “wage bill in I-sector” = “employment in I-sector”*“WAGE RATE IN I-SECTOR”
(197) “WAGE RATE IN C-SECTOR” = 3
(198) “WAGE RATE IN I-SECTOR” = 2
(199) “writing-off of long-term debts of C-sector” = SPEED OF SIMPLIFICATION*IF THEN ELSE(“principal payment due on long-term debts by C-sector” - “servicing of principal on long-term debts by C-sector” > 0, “principal payment due on long-

term debts by C-sector" - "servicing of principal on long-term debts by C-sector", 0)

(200) "writing-off of long-term debts of I-sector" = SPEED OF SIMPLIFICATION*IF THEN ELSE("principal payment due on long-term debts by I-sector" - "servicing of principal on long-term debts by I-sector" > 0, "principal payment due on long-term debts by I-sector" - "servicing of principal on long-term debts by I-sector", 0)

(201) "writing-off of short-term debts of C-sector" = SPEED OF SIMPLIFICATION*IF THEN ELSE("principal payment due on short-term debts by C-sector" - "servicing of principal on short-term debts by C-sector" > 0, "principal payment due on short-term debts by C-sector" - "servicing of principal on short-term debts by C-sector", 0)

(202) "writing-off of short-term debts of I-sector" = SPEED OF SIMPLIFICATION*IF THEN ELSE("principal payment due on short-term debts by I-sector" - "servicing on principal on short-term debts by I-sector" > 0, "principal payment due on short-term debts by I-sector" - "servicing on principal on short-term debts by I-sector", 0)

The following explains each equation:

(01) Units: 1 [0, ?]. Determine cc_a. A lower value means stricter criteria of analysis, a higher value means loosening (good for investment). Every 5 quarters, the basic method of evaluation is revised over the 5-quarter period. cc_a cannot be negative.

(02) Units: 1. Determines cc. If $\Pi = 0$, the maximum value of cc for which $\Pi > 0$ is taken into account.

(03) Units: dollar/Quarter [0, ?]. Entrepreneurs of the C-sector may have to draw down the funds they accumulated over the quarters on their demand deposits in order to meet their cash commitments. If DD < CC then the entrepreneurs use what they have and then ask for a loan to pay CC – DD.

(04) Units: dollar/Quarter [0, ?]. Equivalent to (03) applied to the I-sector.

(05) Units: dollar/Quarter [0, ?]. This represents the difference $I - \Pi_{IF}$, that is, the amount of money necessary to fund investment once all the cash from internal funds has been used. This is an extreme assumption because not all of Π_{IF} will be used usually to fund I. Enterprises have cash-management strategy and keep some aside for their routine and non-routine needs.

(06) Units: dollar/Quarter [0, ?]. Equivalent to (05) applied to the I-sector.

(07) Units: dollar/Quarter [0, ?]. This represents the difference CC – Π applied to the C-sector. If the difference is positive some funds must be obtained either from dishoarding (see (03)) or from refinancing loans. This amount cannot be negative.

(08) Units: dollar/Quarter [0, ?]. Equivalent to (07) applied to the I-sector.

(09) Units: dollar/Quarter. Determines the amount of principal due paid. If there are no funds available on demand deposits, or no loan is provided, or if no positive gross profit exists, the amortization cannot occur. In the latter case, it is assumed that banks write-off the amount that could not be paid. This affects the amount of

granted loans by affecting the acceptable flow leveraging ratio; forcing the firm sector to reduce its activity.

(10) See equation (09)

(11) See equation (09)

(12) See equation (09)

(13) Units: 1/Quarter [0, ?]. Defines the value of a_{lt}.

(14) Units: 1/Quarter [0, ?]. Defines the value of a_{st}. Must be higher than a_{lt}.

(15) Units: dollar/unit [0, ?]. Determines $P_{Id} - P_{Is}$.

(16) Units: unit/worker [0, ?]. Defines AP_{LC}.

(17) Units: unit/worker [0, ?]. Defines AP_{LI}.

(18) Units: unit. Defines the stock of capital assets as the sum of all the past quarterly gross investments minus the sum of the quarterly depreciations. The initial value of K is 0.

(19) Units: dollar/Quarter [0, ?]. Determines CC in the C-sector.

(20) Equivalent to (19) applied to the I-sector.

(21) Units: dollar/Quarter [0, ?]. Determines the actual amount of CC due by the C-sector that can be serviced.

(22) Equivalent to (21) applied to the I-sector.

(23) Units: dollar/Quarter [0, ?]. Determines the amount of consumption expenditure. In the present model, this amount is equal to C, the consumption expenditure by households.

(24) Units: dollar/Quarter [0, ?]. Determines C.

(25) Units: unit [0, ?]. Determines the current stock of consumption goods as the sum of past production minus past amount of goods sold.

(26) Units: unit/Quarter [0, ?]. Determines the quantity of consumption goods sold: C/P_C.

(27) Units: 1. Determines how banks correct the cc_a during the 5-quarter period (see equation (01)). Banks are intrinsic skeptical so they have a downward bias in the revision of their margins: they correct faster downward than upward. In order to correct progressively cc_a, banks look at the percentage of debts not serviced and their rate of profit.

(28) Equivalent to (27) applied to firms. There are two differences, however, because it is assumed that firms do not revise their basic cc_d every 5 quarters, and firms are the optimistic actors of the economy so they have an upward bias: in front of good economic results, firms have a tendency to revise upward faster. Finally, firms look at the difference between actual and expected funding structure to correct their desired flow leveraging ratio.

(29) Units: Quarter [0, ?]. Determines the time necessary for banks to adjust the basic cc_a.

(30) Units: Quarter [0, ?]. Determines the time necessary to record the difference between expected funding and actual funding structure.

(31) Units: Quarter [0, ?]. Determines the time necessary to adjust profit expectations.

(32) Units: dollar [0, ?]. Determines the amount of demand deposits held by households. This amount depends on the accumulated amount of past savings.
(33) Equivalent to equation (32) applied to the C-sector.
(34) Equivalent to equation (32) applied to the I-sector.
(35) Units: unit/Quarter [0, ?]. Determines the amount of capital that depreciates per quarter.
(36) Units: 1/Quarter [0, 1]. Defines the depreciation rate, here set at 5%.
(37) Units: 1 [0, ?]. Determines cc_d. This flow leveraging ratio cannot be negative and is progressively corrected as expectations concerning the funding structure are frustrated.
(38) Units: dollar/Quarter. Determines the value of $E(\Delta L_I)$.
(39) Units: 1 [0, 1]. Determine the difference between the actual and expected proportion of external funding. If the actual proportion is superior to the expected proportion, the difference is set to zero.
(40) Units: 1 [?,0]. Determines how firms decrease cc_d if the external funding is higher than expected. This must always be negative.
(41) Units: 1 [0,?]. Determines how $\underline{cc}_a$ is adjusted downward.
(42) Same as equation (40) but for banks. In addition, contrary to firms, banks have a downward bias and this is materialized by the existence of two level of downward correction (see equation (44)) rather than one for firms.
(43) Equivalent to equation (41) but lower value.
(44) Equivalent to equation (42) but lower value.
(45) Units: worker/Quarter [1, ?]. Determines the value of employment in the C-sector.
(46) Units: worker/Quarter [0, ?]. Equivalent to equation (45) applied to I-sector.
(47) Units: dollar/Quarter. Determines the expectation of gross profit in the C-sector.
(48) Units: dollar/Quarter [0, ?]. Determines the expected level of dollar among spent on consumption.
(49) Units: worker/Quarter [0, ?]. Determine the number of people that entrepreneurs expect to employ in the C-sector. This expectations are based on past values of employment in the C-sector.
(50) Equivalent to equation (49) applied to the I-sector.
(51) Units: dollar/Quarter. Determines the expectations of gross profit as an average of past gross profits. These expectations can be positive or negative.
(52) Units: dollar/Quarter [0, ?]. Determines the initial cash commitment expected.
(53) Units: dollar/Quarter. Determines the expectations of internal funds. These expectations can be positive or negative.
(54) Units: dollar/Quarter [0, ?]. Determines the expected new amount of money available to fund investment internally. This must be positive.
(55) Units: dollar/unit [0, ?]. Determined $E(P_C)$.
(56) Units: unit/Quarter [0, ?]. Determines the quantity of consumption goods to produce.
(57) Units: 1 [0, 1]. Determines the expected proportion of external funding: $E(\Delta L_I)/(Q_{IF} + E(\Delta L_I))$.

(58) Units: dollar/Quarter [0, ?]. Determines the amount of external funds actually needed by the C-sector to fund investment. This cannot be negative.
(59) Equivalent to equation (60) applied to the I-sector.
(60) Units: Quarter. Number of quarters in the simulation.
(61) Units: Quarter [0, ?]. Determines the time necessary for investment goods to be included in the production process. Following Minsky, the delay has to be superior to the maturity term of long-term debts. Here it is assumed that the gestation period of capital assets is twice as long as the maturity of long-term loans. This fix relation between the two maturity terms, however, has to be manipulated with care. Indeed, a longer maturity of long-term loans will not always be good for the economy because the gestation period of investment good is assumed to increase too, which increase the time necessary to get profit.
(62) Units: dollar/Quarter. Determines Π_C.
(63) Units: dollar/Quarter [0, ?]. Determines the amount of funds from Π_C that is available to meet cash commitments. If $\Pi_C < 0$ this value is 0.
(64) Determines Π_I.
(65) Equivalent to equation (63) applied to I-sector.
(66) Units: dollar/Quarter [0, ?]. Determines all the sources of cash inflows to the C-sector.
(67) Equivalent to equation (66) applied to the household sector.
(68) Equivalent to equation (66) applied to the I-sector.
(69) Units: 1 [0, ?]. Defines the initial cc_a. Initial conditions are very important in the determination of the dynamics of the system.
(70) Equivalent to equation (69) applied to cc_d.
(71) Units: worker/Quarter [0, ?]. Defines the initial expectations of entrepreneurs in the C-sector regarding employment in C-sector.
(72) Equivalent to equation (71) for the I-sector.
(73) Units: dollar/unit. Equivalent to equation (69) applied to $E(P_c)$.
(74) Units: dollar/Quarter. Equivalent to equation (69) applied to Π. Note that the investment decision is done at the firm sector level, independently of the sector.
(75) Equivalent to equation (73) applied to internal funds.
(76) Units: unit/Quarter [0, ?]. Determines the initial level of production of capital goods.
(77) Units: Quarter. Determines the initial time of the simulation.
(78) Units: dollar/Quarter [0, ?]. Determines the amount of the total interest payment due that cannot be serviced by the C-sector.
(79) Equivalent to equation (78) applied to the I-sector.
(80) Units: dollar/Quarter [0, ?]. Determines the amount of the interest payment on long-term debts for the C-sector.
(81) Equivalent to equation (80) applied to the I-sector.
(82) Equivalent to equation (80) applied to short-term debts.
(83) Equivalent to equation (81) applied to the I-sector.

(84) Units: 1/Quarter [0, ?, 0.01]. Determines i_{lt}. This is a quarterly interest rate. Financial contracts are implicitly assumed to include flexible interest rates because a change in interest rates will affect the outstanding debt.
(85) Equivalent to equation (84) applied to the short-term loans.
(86) Units: dollar/Quarter. Determines the quarterly amount of internal funds generated in the firm sector. This amount can be negative.
(87) Equivalent to equation (86) applied to C-sector.
(88) Units: dollar/Quarter [0, ?]. Determines the amount of internal funds available for investment in C-sector. If internal funds are negative then the amount available is zero.
(89) Equivalent to equation (87) applied to I-sector.
(90) Equivalent to equation (89) applied to I-sector.
(91) Units: dollar/Quarter [0, ?]. Determines $P_{Is}O_I$. This amount cannot be negative because it represents the amount of gross investment.
(92) Units: dollar/Quarter [0, ?]. Determines the amount spent on investment by the C-sector. Here it is arbitrarily assumed that each sector contributes for half of the total investment spending.
(93) Equivalent to equation (92) applied to I-sector.
(94) Units: Quarter. Determines the length of expectation in the C-sector
(95) Units: dollar/Quarter [0, ?]. Determines the gross amount of loans granted to the C-sector.
(96) Equivalent to equation (95) applied to I-sector.
(97) Units: dollar [0, ?]. Determines L_{ltC}. This amount depends on the accumulated amount of debts that have not been reimbursed or written-off.
(98) Equivalent to (97) applied to the I-sector.
(99) Units: dollar/Quarter [0, ?]. Determines the amount of long-term loans granted to the C-sector. These are always granted because the rationing process occurs at the investment decision level. Once produced, investment goods are always funded and so loans are always granted even if bigger than expected. However, the actual structure of funding, compared to the expected structure, will react back on the demand for investment goods.
(100) Equivalent to (99) applied to the I-sector.
(101) Units: 1 [0, 1]. Defines c, the marginal propensity to consume out of wage.
(102) Units: 1 [0, ?]. Determines the aggregate mark-up over labor cost in the C-sector. The mark up on consumer goods depends on the structure of employment and the marginal propensity to consume. See Minsky (1986a).
(103) Equivalent to equation (102) applied to I-sector.
(104) Units: Quarter [1, ?]. Determines the maturity term of long-term loans. It cannot be lower than the maturity of short-term loans and its minimum value is 1 quarter.
(105) Equivalent to equation (104) for short-term loans.
(106) Units: 1 [0, ?]. Gives the maximum value of cc. This value is used when $\Pi = 0$.
(107) Units: dollar/Quarter. Determines the net profit of banks. Banks do not distribute any profit so their gross profit and their net profit are equal.

(108) Equivalent to equation (107) applied to the firm sector.
(109) Units: dollar/Quarter. Determines the net change in the demand deposits of firms over a quarter.
(110) Equivalent to equation (109) applied to long-term debts. This amount also deduced the amount of debt written-off.
(111) Equivalent to equation (110) applied to short-term debt.
(112) Units: 1 [0, ?]. Determines how the basic cc_a changes every 5 quarters. Depending on how interest payments and debts are serviced, and on the amount of refinancing loans, cc_a shifts by taking into account what happened in the past 5 quarters. The analysis of all this takes one quarter so there is a delay in the adjustment of the basic cc_a. The latter, then, is progressively corrected over the next 5 quarters until it is changed again.
(113) Units: unit/Quarter [0, ?]. Amount of new capital goods available for production. It is assumed that production occurs only on demand; therefore, supply = demand all the time. This value cannot be negative. In addition, the production of new capital assets does not depends directly on profit perspective because private investment demand already depends on that.
(114) Units: 1 [0, ?]. Determines the normal flow leveraging ratio E(cc).
(115) Units: dollar/unit [0, ?]. Determines P_C.
(116) Equivalent to equation (115) applied to I-sector.
(117) Units: dollar/Quarter [0, ?]. Determines the outflow of funds from the C-sector. This depends on what can be paid. Investment expenditure and wages can always be paid because loans are always advanced for that. The amount of loans granted for investment, however, will depend on the capacity to pay cash commitments, which may not be refinanced.
(118) Equivalent to equation (117) applied to the household sector.
(119) Equivalent to equation (117) applied to the I-sector.
(120) Units: 1 [0, 1]. Determines the proportion of debts not serviced by firms.
(121) Units: 1 [0, ?]. Record the previous cc_a.
(122) Equivalent to equation (121) for cc_d.
(123) Units: dollar/unit [0, ?]. Equivalent to equation (121) for P_C.
(124) Units: dollar/Quarter [0, ?]. Equivalent to equation (121) for sales.
(125) Units: dollar/Quarter [0, ?]. Determines the total amount of principal that is not serviced by the I-sector. Because Vensim can become imprecise for some values of the unit cost of external funds and for some refinancing acceptance rate, it is necessary to add boundaries. For example, when the refinancing rate is equal to one, all interest payments due are serviced.
(126) Equivalent to equation (125) applied to the C-sector.
(127) Units: dollar/Quarter [0, ?]. Amount of principal payment due by C-sector on its long-term debts.
(128) Equivalent to equation (127) for I-sector.
(129) Equivalent to equation (127) for short-term debts.
(130) Equivalent to equation (128) for short-term debts.

(131) Units: unit/Quarter [0, ?]. Determination of the quantity of investment goods demanded, O_{Id}.
(132) Units: unit/Quarter [0, ?]. Determines the amount of consumer goods produced. This cannot be negative.
(133) Units: 1 [0, 1]. Determines the propensity to hoard.
(134) Units: 1 [0, 1]. Determines the actual proportion of external funds necessary to fund investment: $\Delta L_I/(Q_{IF} + \Delta L_I)$
(135) Units: 1 [0, 1]. Determines the proportion of refinancing loans relative to the total amount of loans outstanding.
(136) Units: 1 [0, 1]. Determine the proportion of short-term debts.
(137) Units: 1/Quarter. Defines a unit-adjustment factor for level variables and auxiliary/constant variables.
(138) Units: 1. Determines the rate of growth of sales.
(139) Units: 1. Determines the rate of inflation.
(140) Units: 1 [0, ?]. Determines the rate of profit of banks.
(141) Units: 1 [0, 1, 0.01]. Determines the proportion of refinancing loans that banks are willing to grant.
(142) Units: dollar/Quarter [0. ?]. Amount of refinancing loans granted to the C-sector.
(143) Equivalent to equation (142) applied to the I-sector.
(144) Units: dollar/Quarter [0. ?]. Amount of refinancing loans needed by the C-sector.
(145) Equivalent to equation (144) applied to the I-sector.
(146) Units: dollar/Quarter [0. ?]. Determines the amount of sales.
(147) Units: Quarter [0, ?]. Command function that determines with which frequency to save the data generated by the model.
(148) Units: dollar/Quarter [0, ?]. Determines the part of the income of households that is not spent.
(149) Determines how interest payments on long-term debts are serviced in the C-sector. See equation (155) for more explanations.
(150) Equivalent to equation (149) applied to the I-sector. See equation (155) for more explanations.
(151) Equivalent to equation (149) applied to short-term debts. See equation (155) for more explanations.
(152) Equivalent to equation (150) applied to short-term debts. See equation (155) for more explanations.
(153) Units: dollar/Quarter [0, ?]. Determines how principal payments on long-term debts are serviced in the C-sector. See equation (155) for more explanations.
(154) Equivalent to equation (153) applied to the I-sector. See equation (155) for more explanations.
(155) Equivalent to equation (153) applied to short-term debts. The idea behind the fulfillment of cash-commitments is that they are fulfilled in a predefined order. Firms first pay the interest on short-term debts out of their gross profit, demand deposits, and funds obtained from refinancing loans. If the preceding three sources are enough to pay the previous component of the cash commitments, then firms try

to pay the interest payment due on long-term debts. If possible, then, firms try to pay all the principal payment on short-term debts. Finally, if there is still some money left, firms try to pay principal on long-term debts. More formally, if $CC_t > \Pi_t + \alpha DD_{Ft} + \Delta L_{REFt}$ at a given time t (with $\alpha \leq 1$ the proportion of demand deposits dishoarded. $\alpha = 1$ if $\Delta L_{REF} > 0$), then not all the cash commitments can be paid. One important point to note is that it is DD_{Ft}, and not DD_{Ft-1}, that is used to fulfill cash commitments because DD_{Ft} does not contains Π_t and ΔL_{REFt}. Indeed the calculation of stocks variables in Vensim is done in the following way: $DD_{Ft} \equiv DD_{Ft-1} + \Delta_n DD_{Ft-1}$.

(156) Equivalent to equation (154) for short-term debts.

(157) Units: dollar [0, ?]. Determines the stock of short-term liabilities in the C-sector. It is the sum of past outstanding short-term loans (i.e. loans not repaid or not written off).

(158) Equivalent of equation (157) applied to the I-sector.

(159) Units: dollar/Quarter [0, ?]. Determines why short-term loans are necessary. Loans for the payment of wages are always granted contrary to the refinancing loans

(160) Equivalent of equation (159) applied to the I-sector.

(161) Units: 1 [0, ?]. Defines the speed at which debts are written-off.

(162) Units: Quarter [0, ?]. Command function that determines what step to take in order to approximate the flow impacts on stocks. A very small step was applied to be sure to have accurate results ('accuracy' meaning that the cash flow, flow, and stock accounting restrictions could be verified to lead to 0 (or whatever restriction they have to meet) with great precision), especially when the model is explosive.

(163) Units: dollar/Quarter [0, ?]. Determines the total amount of cash commitments that the firm sector has to meet in a given quarter.

(164) Units: dollar/Quarter [0, ?]. Determines the part of the cash commitments not serviced.

(165) Units: dollar/Quarter [0, ?]. Determines the sum of all outstanding debts in the firms sector.

(166) Units: dollar/Quarter [0, ?]. Determine the amount of cash commitment that can be serviced.

(167) Units: dollar/Quarter [0, ?]. Determines the total amount of debts written off.

(168) Units: dollar/Quarter [0, ?]. Determines the total amount of deposits held by the firm sector.

(169) Units: dollar/Quarter [0, ?]. Determines the amount of profit that is available to make the decision concerning the amount of external funds. This value cannot be negative because otherwise it would have a perverse effect on the decision about $E(\Delta L_I)$: negative profit would generate a boost on investment demand. Another important constrain to put is that if $\Pi < 1$ then the value included in the decision process is zero. This is so to avoid explosive value of cc. In addition, Vensim cannot calculate integer value for numbers above 2e+009 so ":OR: total gross profit > 1" is added for this purpose so that integer(x) is not 0 when x is above this threshold value.

(170) Units: dollar/Quarter. Determines the total amount of gross profit.
(171) Units: dollar/Quarter [0, ?]. Determines the total amount of the interest payment due that cannot be serviced.
(172) Determines the total amount of the interest payment due that can be serviced.
(173) Equivalent to equation (172) for long-term debts only.
(174) Equivalent to equation (172) for short-term debts only.
(175) Units: dollar/Quarter [0, ?]. Determines the total amount of loans granted by banks. Only firms take loans.
(176) Units: dollar/Quarter [0, ?]. Determines the total amount of the principal payment due that cannot serviced.
(177) Units: dollar/Quarter [0, ?]. Determines the total amount of the principal payment due that can be serviced.
(178) Equivalent of equation (160) applied to long-term debts.
(179) Equivalent of equation (160) applied to short-term debts.
(180) Units: dollar/Quarter [0, ?]. Determines the total amount of refinancing loans granted to the firm sector.
(181) Units: dollar/Quarter [0, ?]. Determines the total wage bill.
(182) Units: 1 [0, 1]. Determines the first threshold for the percentage of debts not serviced.
(183) Units: 1 [0, 1]. Determines the second threshold for the percentage of debts not serviced. Given the formula it which it is used, it must be superior to TPDNS1.
(184) Units: 1 [0, 1]. Determines the first threshold for the proportion of refinancing loan granted.
(185) Units: 1 [0, 1]. Determines the second first threshold for the proportion of refinancing loan granted. It must be superior to TPRL1.
(186) Units: 1 [0, 1]. Determines the first threshold for the rate of profit of banks that banks use in their criteria to define their cc_a.
(187) Units: 1 [0, 1]. Determines the second first threshold for the rate of profit of banks that banks use in their criteria to define their cc_a. This threshold must be lower.
(188) Units: 1 [0, 1]. Determines the upward correction of cc_d. Because firms have a tendency to be optimistic they have an upward bias in their correction of cc_d. This is reflected in the relatively high value of the correction factor and also in the fact that even if the funding structure conform to expectation entrepreneurs correct their cc_d upward as shown in equation (191).
(189) Units: 1 [0, 1]. This is one and only upward correction for cc_a. It must be lower than the upward correction factor for cc_d.
(190) Equivalent to equation (190) but for $\underline{cc}_a$.
(191) Equivalent to equation (188) but for the case in which actual and expect funding structure are the same. Psychologists have shown that even in this situation confidence is boosted.
(192) Units: dollar [0, ?]. Determines the value of capital assets. Capital assets are here valued at the price of new investment goods (a market valuation using P_K would

not change anything in the behavior of the model because the value of equipment is not used anywhere in the model).

(193) Units: dollar/Quarter [0, ?]. Determines the wage bill in the C-sector.

(194) Equivalent to equation (193) applied to the I-sector.

(195) Units: dollar/worker [0, ?]. Defines the wage rate in the C-sector

(196) Equivalent to equation (166) applied to the C-sector.

(197) Units: dollar/Quarter [0, ?]. Determines the amount of outstanding long-term debts in the C-sector that is written-off. The writing-off is equal to the amount of principal that cannot be serviced multiplied by a factor that represents the speed of simplification.

(198) Equivalent to equation (197) applied to the I-sector.

(199) Equivalent to equation (197) for short-term debts.

(200) Equivalent to equation (198) for short-term debts.

APPENDIX C

STOCK AND FLOW CONSISTENCY OF THE MODEL

The following table was generated by the model.

Flows							
NIPA: Income Transactions Matrix (+: Inflows, -: Outflows)							
Sectors	**Households**	**Firms**		**Banks**		**Balancing items**	**Total flows**
		Current	Capital	Current	Capital		
Consumption	-2.48	2.48					0.00
Investment		4.49	-4.49				0.00
Sales		6.97					
Wage bill	2.75	-2.75					0.00
Net profit		-3.80	3.80	-0.42	0.42		0.00
Interest on short-term loans		-0.22		0.22			0.00
Interest on long-term loans		-0.20		0.20			0.00
Financial balances	0.28	0.00	-0.70	0.00	0.42	0.00	0.00
Flow of Funds: Balance-sheet Transactions Matrix (Net Amount) (+: Sources of Funds (lower assets/higher liabilities), -: Uses of Funds (higher assets/lower liabilities))							
Demand deposits	-0.28		0.11		0.16		0.00
Short-term loans			-0.05		0.05		0.00
Long-term loans			0.63		-0.63		0.00
Equity capital			0.00		0.00		
Total sectors	0.00		0.00		0.00	0.00	0.00

Stocks							
Balance-Sheet Matrix (+: Assets, -: Liabilities)							
Sectors	**Households**	**Firms**		**Banks**		**Balancing items**	**Total stocks**
		Current	Capital	Current	Capital		
Fixed capital			30.20			-30.20	0.00
Demand deposits	3.17		9.75		-12.93		0.00
Debts			-15.58		15.58		0.00
Balancing items	-3.17		-24.38		-2.65	30.20	0.00
Total sectors	0.00		0.00		0.00	0.00	0.00

APPENDIX D

THE MODEL WITH THE CENTRAL BANK

The following presents what needs to be added or changed in order to introduce the central bank. Figures A11 and A12 are the graphical introduction of the central bank operations and the needs for reserves:

Figure A11: Reserve and Advance Accounting

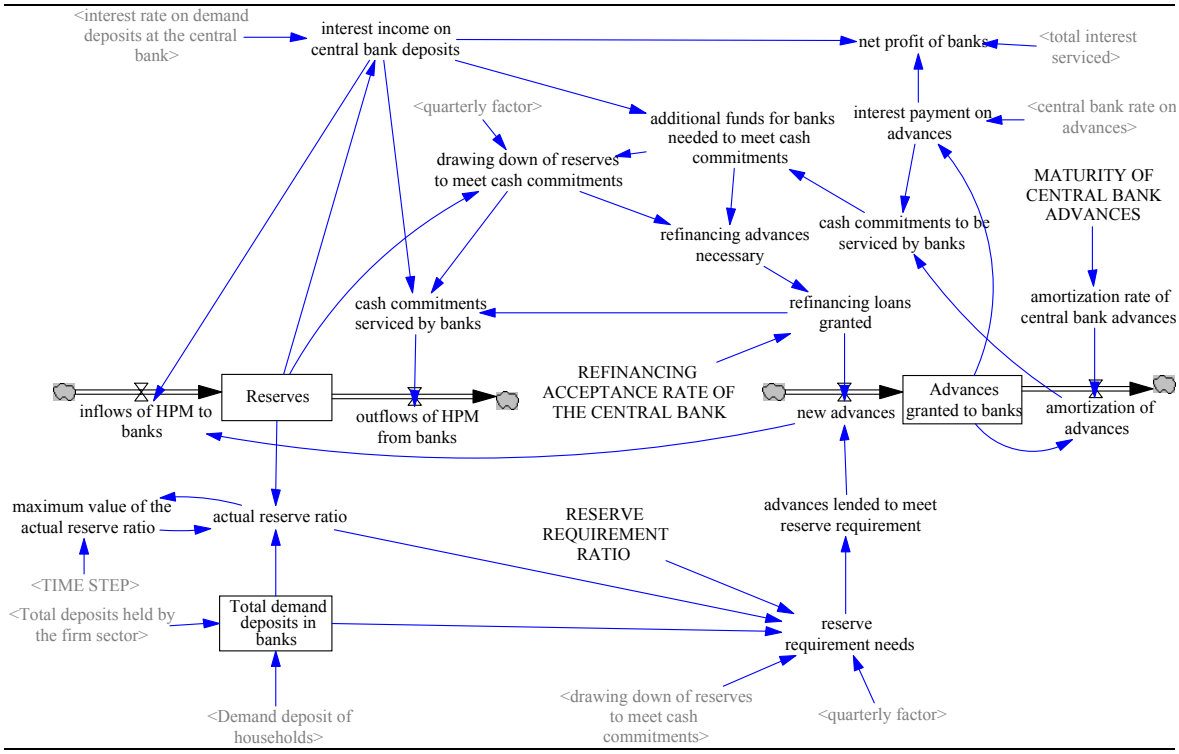
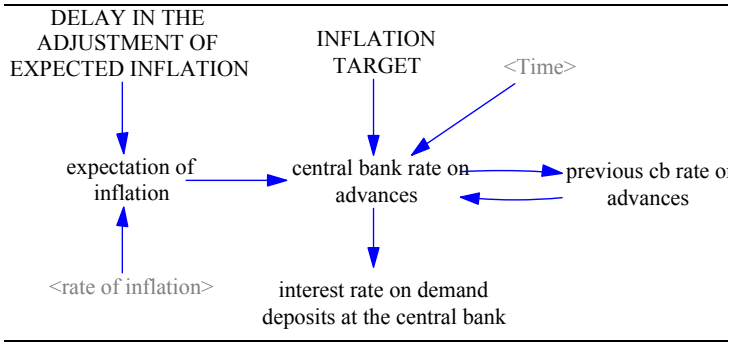


Figure A12: Monetary Policy



The additional equations are:

(01) actual reserve ratio = XIDZ(Reserves, Total demand deposits in banks, maximum value of the actual reserve ratio)
(02) additional funds for banks needed to meet cash commitments = IF THEN ELSE(interest income on central bank deposits - cash commitments to be serviced by banks < 0, cash commitments to be serviced by banks - interest income on central bank deposits, 0)
(03) Advances granted to banks = INTEG (+ new advances - amortization of advances, 0)
(04) advances lent to meet reserve requirement = reserve requirement needs
(05) amortization of advances = Advances granted to banks*amortization rate of central bank advances
(06) amortization rate of central bank advances = 1/MATURITY OF CENTRAL BANK ADVANCES
(07) cash commitments serviced by banks = drawing down of reserves to meet cash commitments + refinancing loans granted + interest income on central bank deposits
(08) cash commitments to be serviced by banks = amortization of advances + interest payment on advances
(09) central bank rate on advances = IF THEN ELSE(Time = 0,0.01, IF THEN ELSE(expectation of inflation < INFLATION TARGET, IF THEN ELSE(previous cb rate on advances - 0.01 < 0, 0, previous cb rate on advances - 0.01), IF THEN ELSE(expectation of inflation > 2*INFLATION TARGET, IF THEN ELSE(previous cb rate on advances + 0.03 > 1, 1, previous cb rate on advances + 0.03), IF THEN ELSE(previous cb rate on advances + 0.01 > 1, 1, previous cb rate on advances + 0.01))))
(10) DELAY IN THE ADJUSTMENT OF EXPECTED INFLATION = 1
(11) drawing down of reserves to meet cash commitments = IF THEN ELSE(Reserves*quarterly factor > 0, IF THEN ELSE(Reserves*quarterly factor > additional funds for banks needed to meet cash commitments, additional funds for banks needed to meet cash commitments, Reserves*quarterly factor), 0)
(12) expectation of inflation = IF THEN ELSE(rate of inflation = 0, 0, SMOOTH(rate of inflation, DELAY IN THE ADJUSTMENT OF EXPECTED INFLATION))
(13) INFLATION TARGET = 0.07
(14) inflows of HPM to banks = interest income on central bank deposits + new advances
(15) interest income on central bank deposits = interest rate on demand deposits at the central bank*Reserves
(16) interest payment on advances = central bank rate on advances*Advances granted to banks
(17) interest rate on demand deposits at the central bank = 0.5*central bank rate on advances
(18) MATURITY OF CENTRAL BANK ADVANCES = 1
(19) maximum value of the actual reserve ratio = INTEG (IF THEN ELSE (actual reserve ratio > 0, IF THEN ELSE (actual reserve ratio > maximum value of the actual reserve ratio, actual reserve ratio/TIME STEP, maximum value of the actual reserve ratio/TIME STEP), maximum value of the actual reserve ratio/TIME STEP) - maximum value of the actual reserve ratio/TIME STEP, 0)
(20) net profit of banks = interest income on central bank deposits + total interest serviced - interest payment on advances
(21) net variation of advance granted = new advances - amortization of advances
(22) net variation of demand deposits at central bank = inflows of HPM to banks - outflows of HPM from banks

(23) new advances = advances lent to meet reserve requirement + refinancing loans granted
(24) outflows of HPM from banks = cash commitments serviced by banks
(25) previous cb rate on advances = DELAY FIXED(central bank rate on advances,1, 0.01)
(26) REFINANCING ACCEPTANCE RATE OF THE CENTRAL BANK = 1
(27) refinancing advances necessary = IF THEN ELSE(additional funds for banks needed to meet cash commitments - drawing down of reserves to meet cash commitments > 0, additional funds for banks needed to meet cash commitments - drawing down of reserves to meet cash commitments, 0)
(28) refinancing loans granted = REFINANCING ACCEPTANCE RATE OF THE CENTRAL BANK*refinancing advances necessary
(29) reserve requirement needs = IF THEN ELSE(RESERVE REQUIREMENT RATIO > actual reserve ratio, (RESERVE REQUIREMENT RATIO - actual reserve ratio)*Total demand deposits in banks*quarterly factor + drawing down of reserves to meet cash commitments, 0)
(30) RESERVE REQUIREMENT RATIO = 0.1
(31) Reserves = INTEG (inflows of HPM to banks - outflows of HPM from banks, 0)

Each equation is explained as follows:

(01) Units: 1 [0, 1]. Determines the actual reserve ratio of banks.
(02) Units: dollar/Quarter [0, ?]. Determines how much funds banks need to draw down from their free reserves and or by borrowing at the central bank, if the interest income on central-bank deposit is too low. It is important to note that interest serviced by the private sector is not a source of reserves because they do not use central bank IOUs. Thus gross profit of banks is not the right source of reserves
(03) Units: dollar [0, ?]. Determines the stock of advances at the central bank.
(04) Units: dollar/Quarter [0, ?]. Determines the amount of reserves the central bank must lend in order for banks to meet their reserve requirements.
(05) Units: dollar/Quarter [0, ?]. Determines the amount of principal repayment due on advances
(06) Units: 1/Quarter [0, ?]. Determines the speed of principal repayment for banks.
(07) Units: dollar/Quarter [0, ?]. Determines the amount of cash commitment that banks can service. Today this amount in always 100% because the central bank acts as lender of last resort. As stated in equation (02), the gross profit of banks is not a source of reserves.
(08) Units: dollar/Quarter [0,?]. Determines the amount of cash commitments due on advances.
(09) Units: 1/Quarter [0, ?]. Determines the reaction function of the central bank. The central bank decreases its interest rate toward zero if expected inflation is below its target. If inflation is expected to be twice the targeted rate, the central bank increases its interest rates by 300 basis points each quarter.
(10) Units: Quarter [0, ?]. Determines the time it takes for the central bank to change its expectations of inflation in regard of actual inflation. Expectations of inflation are assumed to be backward looking.
(11) Units: dollar/Quarter [0, ?]. Determines the amount of reserves that can be drawn down to meet cash commitments. The rest must be borrowed. This has to be added to the needs because of the timing: R_{t-1} + $outflow_t$ – interest income on central bank $deposit_t$ –

refinancing loans granted to banks$_t$ = R_{t-1} + drawing down of reserves to meet cash commitments$_t$. If the latter was not included the new advances to meet reserve requirement would never be enough because R would have decreased by this amount at the next period and not be compensated for it. Say alternatively, the period of reserve calculation must assume fixed reserves, that is, here in the case of System Dynamics, taking into account the outflows and inflows of the next period, because no instantaneous adjustment is possible.

(12) Units: 1/Quarter. Determines the way the central bank forms its inflation expectation. Expectations of inflation are assumed to be backward looking.

(13) Units: 1/Quarter. Determines the inflation target.

(14) Units: dollar/Quarter [0, ?]. Determines the inflow of reserves to banks.

(15) Units: dollar/Quarter [0, ?]. Determines the amount of interest income received by banks on their deposits at the central bank.

(16) Units: 1/Quarter [0, ?]. Determines the rate of interest on advances at the central bank. This rate can be superior to 100%.

(17) Equivalent to equation (16) for the rate of interest on deposits at the central bank.

(18) Units: Quarter [0, ?]. Determines the maturity of the advances granted by the central bank.

(19) Units: 1 [0, ?]. Record the highest value reached by the reserve ratio. This is used if deposits are nil.

(20) Units: dollar/Quarter [0, ?]. Determines the net profit of banks.

(21) Units: dollar/Quarter [0, ?]. Determines the net amount of new advances granted during the quarter by the central bank.

(22) Equivalent to equation (21) for demand deposits at the central bank.

(23) Equivalent to equation (21) for the gross amount of new advances.

(24) Units: dollar/Quarter [0, ?]. Determines the amount of reserves flowing out of banks.

(25) Units: 1/Quarter [0, ?]. Determines the previous rate on advances.

(26) Units: 1 [0, 1]. Determines the proportion of refinancing loans granted by the central bank relative to the needs of banks. It is assumed to be equal to one by default: the central bank is a lender of last resort.

(27) Units: dollar/Quarter [0, ?]. Determines the amount of funds banks need to borrow in order to meet their cash commitments.

(28) Units: dollar/Quarter [0, ?]. Determines the amount of refinancing loans granted.

(29) Units: 1/Quarter [0, 1]. Defines the reserve requirement ratio.

(30) Units: dollar [0, ?]. Determines the stock of reserves.

(31) Units: dollar/Quarter [0, ?]. Determines the amount of reserves banks need to borrow to meet reserve requirements. One thing important to note is that this amount depends on the amount of outflows because what needs to be determined is how much to inflow into reserves after the *net* variation reserves. This must be equal to the stock of advances granted if interest rates on reserves and advances are the same.

The accounting table has also to be changed. Below is presented the formal accounting table and an example.

Flows

NIPA: Income Transactions Matrix

(+: Inflows, -: Outflows)

Sectors	**Households**	**Firms**		**Banks**		**Central bank**		**Balancing items**	**Total flows**
		Current	Capital	Current	Capital	Current	Capital		
Consumption	-C	+C							0
Investment		+I	-I						0
Sales		[Y]							
Wage bill	+W	-W							0
Net profit		$-\Pi_{nF}$	$+\Pi_{nF}$	$-\Pi_{nB}$	$+\Pi_{nB}$	$-\Pi_{nCB}$	$+\Pi_{nCB}$		0
Interest on advances				$-i_A A$		$+i_A A$			0
Interest on central bank deposits				$+i_H H$		$-i_H H$			0
Interest on short-term loans		$-i_{st}L_{st}$		$+i_{st}L_{st}$					0
Interest on long-term loans		$-i_{lt}L_{lt}$		$+i_{lt}L_{lt}$					0
Financial balances	$+S_H$	0	$+\Pi_{nF} - I$	0	$+\Pi_{nB}$	0	$+\Pi_{nCB}$		0

Flow of Funds: Balance-sheet Transactions Matrix (Net Amount)

(+: Sources of Funds (lower assets/higher liabilities), -: Uses of Funds (higher assets/lower liabilities))

Reserves					$-\Delta_n H$		$+\Delta_n H$		0
Advances					$+\Delta_n A$		$-\Delta_n A$		0
Demand deposits	$-\Delta_n DD_H$		$-\Delta_n DD_F$		$+\Delta_n DD$				0
Short-term loans			$+\Delta_n L_{st}$		$-\Delta_n L_{st}$				0
Long-term loans			$+\Delta_n L_{lt}$		$-\Delta_n L_{lt}$				0
Equity capital			+zL		-zL				0
Total sectors	0		0		0		0		0

Stocks

Balance-Sheet Matrix

(+: Assets, -: Liabilities)

Sectors	**Households**	**Firms**		**Banks**		**Central bank**		**Balancing items**	**Total stocks**
		Current	Capital	Current	Capital	Current	Capital		
Fixed capital			$+P_K K$					$-P_K K$	0
Demand deposits at the central bank					+H		+H		0
Advances					-A		+A		0
Demand deposits	$+DD_H$		$+DD_F$		-DD				0
Debts			-L		+L		0		0
Balancing items	$-NW_H$		$-NW_F$		$-NW_B$		$-NW_{CB}$	$+P_K K$	0
Total sectors	0		0		0		0	0	0

Flows

NIPA: Income Transactions Matrix

(+: Inflows, -: Outflows)

Sectors	Households	Firms		Banks		Central bank		Balancing items	Total flows
		Current	Capital	Current	Capital	Current	Capital		
Consumption	-33.68	33.68							0.00
Investment		71.63	-71.63						0.00
Sales		105.31							
Wage bill	37.42	-37.42							0.00
Net profit		7.57	-7.57	-72.81	72.81	-2.65	2.65		0.00
Interest on advances				-3.37		3.37			0.00
Interest on central bank deposits				0.72		-0.72			0.00
Interest on short-term loans		-61.80		61.80					0.00
Interest on long-term loans		-13.65		13.65					0.00
Financial balances	3.74	0.00	-79.20	0.00	72.81	0.00	2.65	0.00	0.00

Flow of Funds: Balance-sheet Transactions Matrix (Net Amount)

(+: Sources of Funds (lower assets/higher liabilities), -: Uses of Funds (higher assets/lower liabilities))

Reserves					-0.05		0.05		0.00
Advances					2.70		-2.70		0.00
Demand deposits	-3.74		2.29		1.45				0.00
Short-term loans			3.98		-3.98				0.00
Long-term loans			35.36		-35.36				0.00
Equity capital			37.57		-37.57				0.00
Total sectors	0.00		0.00		0.00		0.00	0.00	0.00

Stocks

Balance-Sheet Matrix

(+: Assets, -: Liabilities)

Sectors	Households	Firms		Banks		Central bank		Balancing items	Total stocks
		Current	Capital	Current	Capital	Current	Capital		
Fixed capital			493.23					-493.23	0.00
Demand deposits at the central bank					8.46		-8.46		0.00
Advances					-32.08		32.08		0.00
Demand deposits	32.08		53.09		-85.16				0.00
Debts			437.13		-437.13				0.00
Balancing items	-32.08		-983.45		545.91		-23.61	493.23	0.00
Total sectors	0.00		0.00		0.00		0.00	0.00	0.00