Contingent Convertible Bonds and Macroeconomic Stability in a Stock-Flow Consistent Model

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This paper develops a kaleckian economy in a stock-flow consistent (SFC) model to assess the effect of contingent convertible bonds (CoCos) in terms of stability through numerical simulations. The specific characteristics of the model are a dual sector of households (workers and investors) and a dual banking system (retail banks and investment banks). Two simulations are implemented. One focuses on an increase in defaults on workers' loans which triggers a write-down of CoCos issued by retail banks and the other is examining the effects of a decrease in companies' equities prices which triggers a write-down of CoCos issued by investment banks. The overall effects are qualitatively similar. There is a shift of risks and adjustment costs from issuers to holders of CoCos which reduces companies' investment and investing-households' consumption. The simulations show that the triggering of CoCos has a positive effect on the balance sheet of Cocos issuers.

Keywords: stock-flow modelling, contingent convertible bonds, bail-in

Subject classification codes: N1, N2, E1

Introduction

The financial crisis of 2008 brought to light the problem caused by an over-leveraged financial sector.

First, it is likely to suffer significant losses that could ultimately be transferred to the taxpayer. Second, an over-indebted financial sector is encouraged to invest in risky assets to maximize returns. Finally, the shareholders of this sector oppose the issuance of new shares likely to rebalance the balance sheets because they do not want to dilute their power. Therefore, once a bubble is initiated, it is unlikely that a rollback will occur. We know indeed that unlike the demand for most goods and services, the demand for financial assets tends to increase with their price due to capital gains

expectations (Minsky, 1992b). Rising prices are pushing investors to get more debt to buy more assets, pushing up prices. This will likely have negative effects on business decisions, especially financial institutions such as banks, which may choose to invest more and more in these assets. In short, banks are induced to take risks as asset prices rise. These risks then constitute a sort of macro-Ponzi scheme that eventually collapses (Minsky, 1992a). Leverage is then pro-cyclical, generating instability in the financial sector and causing crises such as the 2008 GFC.[1] In times of prosperity, the financial sector is left with excess capacity. To use it, it has to expand its balance sheet. On the liabilities side, it is moving towards short-term debt. On the asset side, it seeks to buy and lend more and more. In the period prior to 2008, balance sheets increased so rapidly that the banking sector lent to households that could obviously not repay their debts. This resulted in a financial crisis that then spread to the real sector via other balance sheet effects (a drop in the net worth of the household sector and therefore in its consumption, a sharp contraction in credit etc).[2] Such an accounting approach of financial meltdowns has been advocated by the IMF for several decades (Allen et al., 2002, Adrian & Shin, 2010).

To prevent this from happening again, national and international regulators are promoting "second generation mechanisms" by forcing banks to deal with this type of problem ex ante (Tropeano, 2011). Two solutions have been more particularly considered since the 2008 crisis. The first is to ensure that banks can deal with it alone. Thus, under Basel III, they are encouraged to set aside larger, higher quality capital and

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[1]The amount of publications on the 2008-9 GFC is very important but a decade later the special issue of the *Cambridge Journal of Economics* in 2009 remains a reference.

[2] There is an extensive literature on the subprime crisis and its linkages with securitisation, for an introduction see Reinhart and Rogoff (2008), Dymski (2010),Peicuti (2013), Lysandrou (2011) and Lavoie (2012).

reduce their debt (Blundell-Wignall and Atkinson, 2010; Howarth and Quaglia, 2016). In addition, the agreement allows contingent capital instruments to be included in a special compartment called additional Tier 1 (AT1) which can substitute for up to 1.5% of the common equity in Tier 1. The second solution is to transfer part of the risk to private investors. In the Euro Area, this has resulted in the implementation of the Recovery and Resolution Directive in May 2014: when a bank threatens to go bankrupt, the bondholders are called upon (Thole, 2014; Howarth and Quaglia, 2014).

In this perspective, the banking sector has created a new type of asset: contingent convertible bonds ("coco bonds" or "CoCos"). When the banks' ratio of assets and liabilities exceed a certain threshold, these bonds either convert into shares, which then boosts the capitalization of the bank, or are written-off (principal write-down, PWD). PWD can be either full or partial. These two possibilities (conversion vs. PWD) define the loss absorption mechanism. Contingent convertible bonds are intended to strengthen the stability of the banking system and to ensure that the government is not required to fully assume the bailout of banks in the event of a new financial crisis. They theoretically allow banks to raise capital very quickly (Avdjiev *et al.*, 2013). CoCos are hence useful for banks both *ex ante* as they comply with AT1 requirements and *ex post* as their trigger improves solvability. An important feature of CoCos convertible into equities is that they induce issuers to be more cautious. As a result, convertible CoCos may have the property of reducing the ex ante risks of a banking crisis. Indeed, insider shareholders are under threat of a dilution of their power and dividends in the event of the triggering of convertible CoCos which fosters a more cautious behaviour from the bank. This anticipated internalisation of the cost of bail-in is specific to convertible CoCos. It is less obvious in the case of PWD-type CoCos.

These aspects are not examined by the model presented in this paper which focuses only on PWD-type CoCos.

As no coco bond has yet been activated, their effectiveness remains hypothetical (Avdjiev*et al.*, 2017). The main question in this paper is whether or not they could fulfil their mission of stabilising the banking sector. Given that CoCos holders might endure a total write-down of what they were supposed to earn what kind of behaviour can be expected from them in the event of an activation? How does this risk shifting translate for the whole economy versus a system without coco bonds?

This article addresses these issues with simulations on a Kaleckian stock-flow consistent (SFC) model based on Godley and Lavoie (2001) with two types of households and two types of banks issuing PWD-type CoCos[3]. This model is also inspired by Caverzasi and Godin (2015) who update Minsky's views by extending them to the banking sector and highlighting the role of financial deregulation. Such a macro approach to CoCos is useful and necessary as most publications on the subject are focused on a micro level. Aiyar et al (2015) focus on the trigger mechanism and insist on the need for accounting ratios instead of an arbitrary decision. Flannery (2014) analyzes the effects of CoCos on a single bank and shows that an obvious improvement in stability occurs as it deleverages without selling assets. Bulow and Kemperer (2013) concentrate their attention on current shareholders and insist on the dilution effect of shareholder power while Dudley (2013) investigates management incentives and shows that CoCos induce to take fewer risks and foster bonuses reinvestment. More recently two papers grasped CoCos from the point of view of systemic risk. Echevarria-Icaza and Sosvilla-Rivero (2017) show by decomposing banks' capital that the regulatory

[3] For a critical review of some mainstream macroeconomic approaches since the 1980's see Chatelain & Ralf (2018).

capital requirements imposed since 2009 have led systemic banks to favour the issuance of PWD CoCos in order to minimize dilution effects. In another empirical analysis of CoCos Fajardo and Mendes (2019) show that the the first issuance is reducing systemic risk but they also find that subsequent issuances may adversely increasing it. In another empirical analysis of CoCos, Fajardo and Mendes (2019) showed that the first issuance reduced systemic risk, but they also found, surprisingly, that later emissions could increase it. The macroeconomic approach of CoCos presented in this article paves the way for subsequent empirical evaluations at the macro level in terms of risk shifting and instability.

Section 2 examines the functioning of CoCos and put their use in empirical context since the 2008 crisis. Section 3 gives a presentation of the structure of the model with the main features of each institutional sector. Section 4 presents the two simulations. Section 5 provides a final discussion.

Contingent convertible bonds: objectives, design and effects

Contingent convertible capital instruments (CoCos) have been developed for a decade in the wake of the 2008 financial crisis. A Coco is a hybrid security that has characteristics of both debt and equity. It works like bonds in normal times and absorbs losses in a crisis. How are CoCos different from convertible bonds, some of which have been around for more than a century (Lummer and Riepe, 1993)?

Convertible bonds are mainly issued by companies. The holder of a convertible bond has a right to convert her bond into a specified number of shares of the issuing company at a strike price. This type of security can be interpreted as a combination of a regular bond and an option to buy the issuer's stocks at some predetermined price or ratio, and some convertible bonds are explicitly designed that way. Very often, the

conversion price is higher than the price of the stock at the issuance moment. Since the conversion right increases the value of the convertible bond compared to a normal bond, the interest paid by the issuer might be lower. In addition to a reduction of cash interest payments, another advantage for the issuer is that debt disappears when bonds are converted into stocks. But the disadvantage is that a relative dilution is expected which reduces the value of shares. From the point of view of investors, they can bet on a rise of the issuer's stock price while enjoying the usual advantages of a debt security. This type of hybrid investment vehicle is traditionally used by companies as a debt management device. For instance, contingent bonds can be used to restructure illiquid but solvent debt-laden companies. They are of some interest as well for start-ups at the very beginning of their development as a way to delay the valuation of the company. If the start-up is successful the stock price goes beyond the strike price. This induces debt holders to transform their convertible bonds into shares. It brings also potentially more money to the investors than the modest interest rate on the convertible bonds and, at the same time, the conversion cleans the company's balance sheet of its debts, which further stimulates its expansion. If the share price is below the conversion price, the bondholder has an interest in requesting the redemption of her bond at par.[4]

While convertible bonds are made to trigger conversion upwards, CoCos are designed to trigger conversion on the down side. Convertible bonds are an instrument for the development of new industries from which very high returns are likely to be expected while CoCos are an instrument for the bail-in of banks in distress situation. More precisely, Cocos are sending the signal that the issuer is credibly conforming to Basel III.

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[4]Certain bonds are automatically converted at maturity, which amounts to selling futures shares.

CoCos are hybrid capital securities designed to solve the problem of overleveraged financial companies. They are made to improve solvency but they do not provide liquidity. Two types of Cocos exist. Some are made to convert bonds into equity while others are designed to write off the debt (principal write down, PWD). Contrary to convertible bonds, the conversion mechanism of CoCos depends on a trigger principle that specifies a minimum threshold of the equity to assets ratio. If the ratio goes below a certain pre-specified level of loss-absorbing capacity then the debt is either written-off or turned into equity.[5] Cocos may include a redeemable at par option (call) for the issuing bank from a certain date, which confer the property of a quasi-perpetual bond. This option translates into a higher interest paid by the debtor. Most of CoCos issued are PWD which feature is to increase the value of common equity to the detriment of bondholders by placing shareholders ahead in debt seniority in difficult times.PWD CoCos are therefore riskier for creditors and costlier for debtors than CoCos convertible into equities.

Another significant difference with convertible bonds is that CoCos convertibility does not depend on individual choice and calculation, but on an event objectified ex ante in an indicator that cannot be manipulated. After the 2008 Great Financial Crisis (GFC), regulators have agreed that the construction of a credible resolution regime is part of the quest for greater resiliency of the financial system. One important issue here is the credibility of the supervisor's intervention (Aiyar *et al.*, 2015). If the conversion depends only on supervisory discretion, evidences show that it occurs often too late and only when the solvency of the financial institution is already seriously degraded. This prevents from issuing new shares at that critical moment.

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[5]The ratio specification plays a very important role at the micro level (accounting ratio / market valued ratio, high / low threshold, etc.) but is of less importance for a macro-analysis.

Bulow & Klemperer (2013) argue that the failure of the banking regulation is due to the fact that regulatory capital system is able to reflect the changes in financial health only very slowly. As accounts can be legally manipulated, incentives can be distorted so that investment is pro-cyclical and losses are tackled only once solvency is highly degraded. In addition, the authors point out a structural excess of regulatory forbearance. It is difficult for a third party to know what the exact condition of a bank is. Considering this uncertainty, it can be difficult to resist from waiting for more information and hence to repeat forbearance. On the one hand, government supervisors are under the pressure of share-holders lobbies and they are aware of incomplete information. On the other hand, banks are caught in a competition process that encourages to under-price risks, i.e. to move towards higher-risk portfolios. When a bank is recapitalised, whatever the mechanism, the outcome is a better solvency ratio which both dilutes former share-holders' portion and benefits in the first place to risky debt holders. For all these reasons, a mechanic trigger ratherthan one depending on human arbitration is likely to produce a better credibility of the issuer's commitment for a prudential behaviour.

In addition, it is now acknowledged that when a financial crisis occurs, large financial corporations pose a systemic risk to the rest of the economy. In order to avoid a major crisis, the government have no choice but to put in place a bailout at the ultimate expense of taxpayers. Faced with such a situation, states generally do not let the big banks crash because this would cause significant damage to the rest of the economy and to market liquidity. As this implicit backing is common knowledge, it amounts to a form of non-priced insurance for large financial corporations. To reframe it in the words of modern finance, with bailout plans governments are providing call options for free to big financial institutions, but these potential losses are not reflected in the public budget (Bryan and Rafferty 2006, Martin 2014, Bryan *et al.* 2019). From a

taxpayer's perspective, a potential bailout represents a rise in future taxes or a decline in the quality or the quantity of future public services. In this “too big to fail” paradigm, banks managers and share-holders can indefinitely take advantage of possibly inflicting large negative externalities to the rest of the economy to enjoy bigger risks and profits through overleveraged financial companies at the expense of governments and tax payers (Haldane 2009, 2013, Siegert and Willison 2015). After the GFC, national and international authorities have coordinated to both reduce the incentives of banks to take excessive risks and to reduce the impact of the failure of systemic financial companies (BIS, 2017). Regulators have, among other things, promoted higher capital ratios. The problem with this single constraint is that when the solvency ratio of a financial company goes down its share-holders are induced to shrink assets instead of reducing the debt to equity ratio by issuing new shares. This contributes to further destabilise financial markets and other institutions in case of fire sales.

How to make private claimants -shareholders and debt holders- bear losses in case of bankruptcy without destabilising the whole economy? A side problem is that bankruptcy procedures take time. This might complicate a resolution as customers of insolvent institutions are also creditors and they could be encouraged by a potential failure of their bank to move their business away (Flannery, 2014). This is where CoCos are important. Their feature is to set up a bail-in that is determined in advance, before the default. With CoCos, financial firms can rapidly deleverage without selling their assets. Such hybrid security is a means of automatic recapitalization that allows avoiding potentially both taxpayer contribution and market disruption.

CoCos are intended to provide large financial companies with more stability and to prevent them from shifting to the rest of the economy their own risks and imbalances. Instead of trying to reduce the size of the assets through fire sales when solvency goes

down as often observed, CoCos create a mechanism which modifies the composition of the right hand side of the issuers' balance-sheet by substituting equity for the debt once a solvency ratio goes beyond a certain threshold. Such a device puts an explicit limit to the leverage effect that banks can take advantage of. In other words, the growth of a financial company that issues CoCos can rely to a more limited extent on debt and leverage. The growing firm has also to increase sufficiently its equity to secure its solvency ratio.

This tool provides an incentive to improve prudential behaviour and to limit the probability of a financial meltdown but it is not a magic wand against systemic crisis. Many other financial institutions and actors can have good reasons to proceed to fire sales that pull down asset prices. CoCos have no specific power against this. They can only reduce the incentives of their issuers to do so because 1/ they reduce the incentives to get excessive debt and 2/ if the company is overleveraged they change automatically debt into equity (or they write it off) so there is no need to sell assets hurriedly. CoCos can also contribute to reduce default probability when used as a device to shape compensation practices so that financial companies' leaders avoid taking excessive risks. Dudley (2013) proposes that in order to deter senior managers to take excessive risks a significant portion of their bonuses should be deferred each year so as to cover future capital losses by investing for instance in PWD CoCos if the capital ratio is too low.

In a recent paper, Avdjiev et al. (2017) provide comprehensive empirical evidence about CoCos issuance by banks between January 2009 and December 2015. They find that banks around the world issued $521 billion in CoCos through 731 different issues, which is modest in view of the size of the bond market - estimated around $100.130 billions in 2017 by the bank for international settlements (BIS, 2019) -

but represents nonetheless a segment large enough to produce interesting data. As PWD CoCos are junior to equity in difficult times, they are particularly attractive to share-holders. Banks with strong balance sheets are more likely to issue such CoCos rather than those converting into equity. The study finds also that CoCos issuances are interpreted as a promise for a better prudential behaviour as their impact on CDS spreads is both negative and significant. This effect is particularly stronger with CoCos that convert into equity, which are interpreted as disciplining share-holders and managers better because conversion may pose a threat of dilution of their claims.

Presentation of the model

The model involves seven institutional sectors: working-households, investing-households, firms, retail banks, investment banks, the government and the central bank.

It takes into account fourteen types of financial and non-financial assets: inventories, fixed capital, high-powered money, treasury bills, loans granted to households, loans granted to firms, capital from retail banks, capital from investment banks, equities issued by firms, deposits with retail banks, time deposits with investment banks, advances from the central bank, coco bonds issued by retail banks and coco bonds issued by investment banks.

It is a closed economy model with an integrated growth. The matrices of stocks, flows and revaluation are presented in the appendix (see Table 1, Table 2 and Table 3). A list of the different variables and their description is also presented in the appendix.

This model is designed for exploratory purposes rather than trying to reproduce stylized facts like the financialization of companies (van Treeck, 2009), or past events such as the subprime crisis (Nikolaidi, 2015; Caverzasi& Godin, 2015).The model presented in this paper aims to explore what would happen in the economy as a whole if

CoCos were to be activated and therefore proposes a counterfactual analysis.Such a forward-looking perspective implies certain methodological particularities.

Elements that are not directly related to the activation of CoCos such as household, corporate and public sector behaviours are deliberately kept at a low level of complexity.Thus, unlike other models (Le Heron &Mouakil, 2008), the monetary policy of the central bank is reduced to a simple rule consisting of a fixed interest rate, the same rule applies for the rates set by commercial banks and institutional investors.Real estate assets are not taken into account, unlike Caverzasi& Godin (2015).Some models refine the differences between households, as shown by Dafermos and Papatheodorou (2015), who study the distribution of income with more varied household profiles such as low-skilled and skilled workers, employed, unemployed or entrepreneurs. The present model only includes two types of households, workers and investors like in Botta et al. (2015).

The model focuses mainly on the complexity of the financial sector and is similar to what is observed in Le Heron &Mouakil (2008) and Caiani et al. (2016) with "non-Wicksellian" banks imposing credit restrictions to part of the economy, or two types of banks (investment and retail)like in Botta et al. (2015) to differentiate the effect of the activation of CoCos according to the main activity of financial institutions.It also takes into account the financialization of firms as they issue shares to finance their activities (as in Michell & Toporowski, 2012).The portfolio rules of the different sectors are sufficiently detailed to account for how CoCos enter into their composition and the impact of their price changes and their activation.The originality of this analysis lies in the introduction of CoCos for the first time in a SFC model.

The structure of the model is inspired from Godley and Lavoie (2007) in particular the growth model presented in chapter 11. Even though the model is

dedicated to exploratory analysis, it is anchored in a realistic theoretical framework which is therefore able to reproduce stylised facts illustrating the strong links between real and financial spheres listed by Stockhammer (2008):

- Consumption expenditures can at times become the driving force for growth as households gain improved access to credit. However, this creates new potential for instability as servicing high debt levels may become difficult in recessions.
- Investment expenditures are sluggish due to shareholder value orientation. Increased profits do not necessarily translate into higher investment.

Having posed the main hypotheses, written the equations and attributed values to parameters and variables (for the first period), simulations are computed without imposing constraints on the results with Python and the pysolve package which is very helpful for such a model with many nested variables[6].

Working-households sector

Income and consumption choices

The disposable income of working-households is given by their incomes (wage and interest on deposits) minus their taxes and interest rates on loans. The consumption function of workers depends on several factors. In a standard way, it is determined by expected disposable income and past net worth. There is also a positive effect on consumption coming from expected new granted loans. This variable is introduced in several other stock-flow consistent models (Godley & Lavoie, 2006; Fontana & Godin, 2013; Nikolaidi, 2015), based on the observation that households tend to use new granted loans to finance part of their consumption expenditures. This has been verified

[6] The code can be found here : https://github.com/elskr/sfc_cocos/tree/master

in empirical works such as in Lusardi et al. (2011) who provide an analysis of households' consumption data for 13 countries extracted from the 2009 TNS Global Economic Crisis Survey for 13 countries.

The amount of workers' net worth is equal to its past value plus savings, given by the difference between disposable income and consumption.

Borrowing decisions

The gross amount of new loans demanded by working-households corresponds to a fraction of their disposable income. This fraction depends negatively on the real interest rate on bank loans. The net amount of new loans demanded by working- households corresponds to their gross amount minus their loans repayments. These repaid loans are a fixed fraction of the total stock of loans in the previous period. The burden of household debt is the ratio of the sum of their interest payments and repayments to their disposable income. In each period, there are some defaults on loans. The fraction of defaulted loans to total loans is endogenous as it depends positively on the burden of households' debt and negatively on credit availability. When household defaults increase, banks react and reduce available credit. Without such an endogenous booster effect, the model would simply collapse after the onset of a crisis.

Asset choices

Part of working-households' net wealth is kept as cash (a fraction of consumption expenditures) while the rest is held as deposits.

Investing-households sector

Income and consumption choices

Incomes and consumption equations are the same for both types of households but investing-households don't borrow from the banking sector so there is no borrowing equation.

Asset choices

Investor households manage their portfolio according to a Tobin principle (Tobin, 1958). Their demand for an asset depends positively on its rate of return and negatively on the rate of return on other assets. These portfolio choices are subject to constraints *à la* Tobin (Tobin, 1982) that guarantee the accounting consistency of the model. The very first constraint states that all things being equal, agents cannot allocate more of their wealth to a financial asset without allocating less to another one. The second one implies that if a change in a variable causes the relative share of an asset in a sector's portfolio to increase, the share of other assets must decrease. The last one implies that rate of return change effects are symmetrical. An increase in the rate of return on equities will cause a drop in the share of deposits, similar to the fall in the share of equities that would result in the same rise in the interest rate on deposits. This ensures the accounting consistency of the model.

If there are anticipations errors, households are left with more or less savings than expected and adjust by adding or subtracting to their deposits. It is an adjustment variable.

Firm sector

Production and investment decisions

The present model resumes the investment function tested by Ndikumana (1999) and reused by Godley and Lavoie (2001) with an extensive analysis of firm behaviour. The difference between production and sales for the given period is equal to the accumulation of inventories. Inventories exist because production takes time and also because firms make mistakes as regard to the amount of sales they anticipate. Firms decide to produce what they expect to sell plus a possible planned inventory change. Expected sales are a weighted average of current sales and past sales (adjusted for the rate of productivity growth which represents long-term trends in sales). It is assumed that there is a target of long-term inventories that corresponds to a fraction of anticipated sales. However, firms know that their expectations can be mistaken. Consequently, they only partially seek to reach this long-term target. The accumulation of fixed capital is realized at an endogenous rate that depends positively on the utilization rate of production capacity, their cash flows and their Tobin's Q[7], and negatively on their leverage ratio.

From cost to price decisions

Inflation in the model depends mainly on the demands of workers on the goods market. Workers arrive at the bargaining table and demand a real wage which depends on the trend of labor productivity and labor demand. The nominal wage then changes according to the difference between the targeted wage and the actual wage. This makes inflation endogenous into the model (wage inflation)through a form of "fair pay"

[7] The Tobin Q is defined here as the total amount of financial assets held by companies divided by the total amount of their fixed capital and inventories.

theorized by Wood (1978). According to him, the real wage is determined by two types of factors:

- "Normative pressures": if there is a rise in productivity, workers then increase their demands when negotiating wages (considering that they contribute to the increase in production)
- "Anomic pressures": in relation to external supply-demand conditions there is a standard Phillips relation effect. Workers bargaining power depends inversely on the pressure of unemployment.

As a result, wage inflation depends on the difference between what workers perceive as a "fair pay" and the effective real wage of the previous period. Sequentially, workers first target a real wage then the actual real wage converges more orless.Once the wage is decided, firms set their prices according to a mark-up based on normal historic costs.

The growth rate of labor productivity is considered as exogenous. It simplifies the model. But one could possibly make it endogenous and in particular link it with effective demand, in line with the work of Kaldor (1960) and Robinson (1956).

The desired level of employment depends on the productivity trend and production decisions. Actual employment is partially adjusted from period to period. There is a short-term increase in productivity when production exceeds its trend. Thus, output fluctuates around its trend and labor productivity will evolve pro-cyclically. This partial adjustment results of a mismatch between the fluctuations of output (which may be temporary) and the response of firms in terms of hiring or firing. It can also be explained by the fact that a whole share of employment is not necessarily sensitive to fluctuations in production (Lavoie 1992, chapter 5). In the end, wages depend on

negotiations on the basis of an exogenous but non-constant variable (productivity) and an endogenous variable (the employment rate). Normal historic unit costs depend on:

- Past and present normal unit costs
- A targeted ratio of inventories to sales
- The interest rate

Since firms pricing depends on their costs, interest to be paid back to the banks and wages, there is an inflation mechanism that does not solely depend on the banks rate but also on what happens on the production side. It is assumed that firms set their prices according to this normal historic unit costs and a mark-up. This mark-up is partly arbitrary (it depends on the experience of the firm) but it adjusts towards a target mark-up. This target mark-up varies over time. It is a sort of ideal mark-up as firms would achieve a targeted profit level with their actual sales equal to their desired sales.

When actual sales equal targeted sales, then expected historical costs equal actual historical costs and the target mark-up equals the actual mark-up. It is supposed here that firms do not optimize. They are not perfectly rational in the sense that they do not perform impossible calculations. They just set approximate targets. As a consequence, their actual mark-up will generally not match the targeted level of profit. The generated profit level is then either too low or too high. Companies partially adjust this mark-up towards its targeted value, ensuring that generated profits are generally sufficient to finance investment, dividends and interest payments.

Financial consequences for firms

The rule of thumb that firms follow is not accurate enough to make them generate exactly the required profits because sales, inventories and interest rates are subject to unexpected short term variations. Realized profits are therefore likely to be different

from targeted profits. Any deviation from the desired profit is reflected in the retained profits.

Firms finance their investment expenditures with some part of their retained profits, with new equities issuance and with loans supplied by commercial banks. Loans demanded by firms play a buffer role and help to absorb variations in their financing needs. Any additional profits (relative to expected profits) will lead to a decline in the demand for credit. The other part of their retained profits that is not used for investment expenditures is allocated to financial investments. These are made according to a Tobin principle, like investing-households.

Public sector

Government

The evolution of public expenditures is driven by an exogenous growth rate decided by the government (it may want to increase the growth rate of the economy or increase its part of national expenditure).

Central Bank

Profits made by the central bank are equal to the interest earned on advances granted to commercial and investment banks. The fact that public assets issued by the government are provided on demand makes possible to consider both short-term rates on treasury bills and the long-term rates on government bonds as exogenous variables.

Financial sector

Retail banks

Deposits and credits to firms are supplied on demand while credits to worker households are restricted. This restriction depends on leverage effects measured by a ratio of credits to personal net worth within the household sector, on the gap between the effective capital adequacy ratio of retail banks and their targeted capital adequacy ratio, on the burden of household debt measured by the share of interest payments in household disposable income and on the importance of loans defaults.

Retail banks use Central Bank advances as an adjustment variable. In a standard fashion, their profits correspond to what they earn minus what they must repay. Interest rates on loans and deposits depend on the rate on advances set by the central bank as well as spreads which are considered here as constant in order to simplify the model. However, the model is designed to make them endogenous, like Godley and Lavoie (2001) who make the spreads dependent on profit targets set by the banks themselves.

Contingent convertible bonds (CoCos) are issued to cover variations in household deposits. They are triggered when the ratio of loans to net wealth of retail banks goes above an exogenous threshold fixed by the banking regulation framework or by the contract signed when the CoCo bond has been issued. This contingent condition is modelled thanks to indicator functions. Once triggered, CoCos either become equities and result in the payment of dividends from banks to shareholders, or are simply written off.

Investment banks

Investment banks look like a generic form of institutional investor. They gather part of the savings of investing-households (term deposits) and make a portfolio choice

according to Tobin principles (like investor households and firms) between financial assets that retail banks do not demand. Just like retail banks, investment banks issue contingent convertible bonds to cover variations in investor households time deposits. They are triggered when the ratio of equities to net wealth exceeds a fixed threshold.

Sequential events

For each period, there is the same series of sequential events. First, companies determine their output level by taking into account their expected sales and the level of their inventories. Then, they assess the number of workers needed to achieve this level of production and set their prices according to the costs they face and determine their investment for this period. After that, firms estimate their credit demands which are satisfied by banks without restrictions. Firms then produce their objective level. Wages are paid, taxes levied and dividends are distributed. The government pays interest on bonds issued. Banks pay interest on deposits and CoCos. Households and the government consume production. Firms repay their loan interest and interest on advances is repaid. Households modify their bank deposits. Portfolio arbitrages are made and banks request advances from the Central Bank.

Numerical simulations

The model is used to compare the effects on an economy with and without CoCos of a series of shocks that destabilize the financial sector. The dynamics of key variables like leverage ratios, net wealth, GDP, consumption or investment in both conditions are compared. The idea is to provide an appraisal of CoCos in terms of both financial and macroeconomic stability.

The simulations consist in checking the accounting effects of two different shocks: one linked to retail banks (a sudden increase in defaulted loans) and one linked

to investment banks (a sudden decrease in equities price).These two shocks are equivalent to a weakening of the banking sector likely to trigger a financial crisis. Both shocks are supposed to cause a deterioration in net worth and solvency ratios of the two types of banks. What is at stake here is whether triggering CoCos would mitigate or even fully offset these shocks, and how this activating would alter the balance sheets and transactions of the sectors.

As a pure simulated macroeconomic model, there is neither microfoundation nor estimated parameters. As it stands, the model is not designed to give overall quantified effects or to make accurate economic policy assessment. Nevertheless, it is able to provide insights on how the activation of contingent convertible bonds could affect the different sectors in the economy by identifying direct and indirect effects.

An initial deterioration of the situation of the banking sector should trigger CoCos to be written off. As for the banks, one must then expect an improvement in their solvency ratio. The effects on holders of CoCos (investing-households and companies) should be multiple. A direct expected effect is that they should experience a decrease in their net worth, which should affect their decisions. Regarding investing-households, on may expect a decline in their consumption. As for companies, they should encounter a profit reduction. These direct effects should in turn induce indirect effects. The decline in the consumption of the investing-households should lead to a fall in firms' profit, which should imply a fall of the wages paid to working households.

First scenario: increase in defaults on workers' loans

This scenario explores an increase in the share of defaulted loans granted to working-households. It compares an economy were CoCos are activated with an economy without CoCos (formally, CoCos are still in the model but their level of activation is made unattainable so they always behave like normal bonds). The idea is to check

whether the activation reduces or even compensates the negative impact on retail banks of more defaults.

The share of defaulted loans depends on the debt burden of households, the availability of credit and an exogenous constant (cf. equation W18 in appendix). The first shock is implemented onto the exogenous constant nplw0, which is being increased. This change simulates a sudden augmentation in defaults on workers' loans. Depending on the capital adequacy ratio threshold (discussed below), the rise in percentage of nplw0 has always the same type of effects on the rest of the economy, the change is only in terms of magnitude as the sign of the variables are not affected.

Several shock values in terms of increases in credit defaults are used to perform the simulations: 40%, 60% and 80%.

As a very first step, the crisis scenario is compared with the baseline scenario without crisis. The increase in loan defaults deteriorates the net worth of the retail banking sector. This reduces the capital adequacy ratio (CAR) of retail banks measured by a ratio of their net worth to the stock of supplied loans(see figure 1 in appendix), leading to an activation of contingent convertible bonds issued by retail banks (see figure 2). The threshold value of the CAR defining the activation and the shock value triggering this activation are strongly related. The higher this threshold value, the greater the risk of activation for lower shock values. In the model, all CoCos issued by retail banks are activated following the shock. Later, once their net worth increases, banks are then issuing new CoCos again. After this first step, the baseline non crisis scenario is no longer a benchmark in the following analysis. From now on, the crisis assessment focuses on the deviation occurring with CoCos activation compared with an economy without CoCos. The effects on the five sectors composing the economy are now subject to scrutiny.

For firms, the activation of coco bonds leads to two direct effects on stock and flow variables. The first one is a further decrease in their net worth since suddenly they lose a part of their assets (see figure 3). The second one is a decrease in their Tobin's Q (see figure 4), which measures their financing capacity via financial incomes. Indeed, they lose part of these financial incomes since they don't get interest payments on CoCos anymore. This results in a decrease in their investment (see figure 5).

For investing-households, the activation of coco bonds leads to two other direct effects. The first one is a further decrease in their net worth for the same reasons as firms (see figure 6). The second one is a further decrease in their disposable income since they earn less financial interests (see figure 7). These two effects cause a decrease in their consumption (see figure 8).

Effects concerning working-households are minimal. They don't hold any contingent convertible bonds. Thus, their activation doesn't have any direct effects on their stock and flow variables. There are some indirect effects, such as a slight decrease in wages earned by working households because of a decline in aggregate demand leading to a decrease in economic activity. This results in a slight decrease in their consumption but it is a marginal effect compared to the others described just above.

Concerning retail banks, the activation of contingent convertible bonds has positive effects. They don't fully prevent the decrease in net worth following an increase in defaulted loans but they help mitigate their impact (see figure 9).[8] Another effect is to limit the profit loss of retail banks compared to a situation without CoCos

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[8]Since the model is not empirically calibrated, only the trajectories of the variables are of interest, the level and the relative level do not deserve to be interpreted because they depend on the value of the parameters. Therefore, it is not significant for the present discussion that the variable of figures 9 and 10 and 17 stabilises below its initial level.

since they stop paying bonds interests (see figure 10). This leads to further increase their net worth.

It should be noted that a conversion into CoCo equities makes the situation better for investors who earn dividends and whose net worth decreases less than when CoCos are totally cancelled. Nevertheless, equity conversions make the situation worse for the initial owners of the banks as they have to pay dividends to these new investors and thus earn fewer profits.

Up to this point, the direct effects of a CoCos activation on the different sectors of the economy have been highlighted but nothing has been said about the stability of the overall economy. Table 4 provides an indicator of potential gains or losses of stability. Standard deviations are derived from the series of growth rates of relevant variables with and without CoCos. The indicator is a ratio of the standard deviation of the variable with CoCos to that without CoCos. If this ratio is greater than 1, then it can be said that the activation of CoCos has a destabilizing effect on the growth rate of the variable under consideration compared to a crisis scenario without CoCos, and a stabilizing effect if the ratio is smaller than 1.Since the model follows a stable growth path, the growth rate of these variables is constant. Any deviation from the ratio relative to 1 is therefore attributable to the activation of CoCos and makes it possible to comment on the effects on the stability of the economy.

[Insert Table 4 here]

There is an increase in volatility for all variables relating to the real sphere. It is very strong for the investing-household sector whose net worth depends heavily on changes in their asset portfolio, as their only activity is to make financial investments.

The working household sector is virtually unaffected, which is consistent because it does not hold CoCos. Conversely and as expected, volatility in the net worth of the retail banking sector declines. As there is growth in the model, it helps firms and investing-households to endure the CoCos cancellation but the economy shifts to a lower growth path anyway.

These results confirm our previous hypotheses. In case of a crisis, an activation of contingent convertible bonds has an immediate positive effect on the stock and flow variables of retails banks compared to a scenario without any activation of coco bonds. This recovery in the banking sector is paid by investors who experience as holders of CoCos a decrease in their net worth and earned interests. The increase in the stability of the financial sector comes at the cost of an increase in the instability of the real sphere. With CoCos, risk is automatically shifted from banks to bank creditors. The real sector is affected indirectly by the change in behaviour of bank creditors and by the degree of financialisation of companies.

Second scenario: decrease in companies' equities prices

This scenario examines the effects of increased market risk. The starting point is a sudden decline in investors' preferences for corporate stocks. Just like in the previous section, this outline compares a crisis situation with and without CoCos activation. The idea here is to check whether the activation of CoCos reduces or even offsets the negative effects of a crash on investment banks/institutional investors.

The demand of investors for companies' shares depends on their yield and on the yield of other possible assets plus a constant that represent their preference (all things equal) for such kind of financial asset (see equations R13 and BI18). The second shock is implemented through this constant which is reduced. This change simulates a sudden panic regarding companies' shares, comparable to a crash. The reduction of

investor preferences for corporate shares has always the same kind of effect on the rest of the economy whatever the activation threshold. The signs of the variables do not change, only the magnitude of the effects differs. Two shock values are examined in the following simulation: a 35 and 45 percentage point reduction in preference for equities.

Just as previously, the crisis scenario is compared with the baseline scenario without crisis. Lowering of preferences triggers a sudden drop in stock prices, which increases volatility (see figure 11).This leads to the activation of CoCos issued by investment banks (figure 12).As before, the volatility threshold of the actions price that triggers the activation and the value of the shock inducing the activation are linked. The lower the threshold, the higher the risk of activation for low shock values. In the model, all CoCos issued by the investment banks are activated as a result of the shock. Once the preferences and therefore the equities prices are stable again, the banks issue CoCos again.

After this first step, the baseline "no crisis" scenario no longer serves as a reference in the analysis. From this point on, the shock assessment is done by comparing the differences in trajectories of a crisis economy with CoCos compared to a crisis economy without CoCos. The effects are examined on each sector one after another. The results are very similar albeit not identical to those in section 4.1.

For firms, the activation of coco bonds leads to a further decrease in their net worth since suddenly they lose a part of their assets (see figure 13) and a decrease in their Tobin's Q (see figure 14). This results in a decrease of their investment (see figure 15).

For investing-households, the activation of cocobonds leads to a further decrease in their net worth for the same reasons as firms (see figure 16). Activation leads initially to a decline in their disposable income (figure 17) because they no longer receive any

interest from CoCos. The preference decline for corporate equities and the activation of CoCos induces a rebalancing of portfolios as investing-households put more on their term deposits. The overall relative effect on their consumption is negative (figure 18).

As working-households don't hold any CoCos, the activation has no direct effect on their stock and flow variables but indirect effects occur. There is a slight decline in wages due to the decline in corporate profits, which itself results from the drop in demand. This causes a slight reduction in the consumption, but this effect is marginal compared to the other effects described above.

As regard to investment banks, the activation of contingent convertible bonds has positive effects. It leads to a relative improvement in their net worth (figure 19).Another effect is to limit the profit loss of investment banks compared to a situation without CoCos since they stop paying bonds interest (see figure 20). This leads to further increase their net worth.

Up to this point, nothing has been said about the stability of the overall economy. Table 4 shows the same indicator as in table 5, applied to this new shock.

[Insert Table 2 here]

There is an increase in the volatility of production, consumption and the net worth of investing-households and companies. As expected, there are no effects on the volatility of the net worth of the working households because they do not hold CoCos. Above all, there is a drop in volatility in the net worth of investment banks, which was the first objective pursued by the issuance of this type of instrument.

However, the variations are smaller compared to the shock presented in part 4.1. This is explained by the fact that the magnitude of the shock that can be imposed on the

constant reflecting the preference for the actions of companies is limited. Its value indicates the share of corporate stocks in the investors' portfolio, adjusted according to the evolution of the rates of return of each available financial asset. If the shock is too great, that is to say if we reduce too much the value of the constant, the demand for shares of companies and therefore their price become negative. The shock implemented here avoids such a problem but is of a modest magnitude compared to that presented in the previous section. Thus, the variations have a smaller amplitude. Finally, the value of these variations matters less than their direction here.

In case of a market crisis, an activation of contingent convertible bonds has an immediate positive effect on the stock and flow variables of investment banks compared to a scenario without any activation of coco bonds. This improvement of the investment banking sector is paid by CoCos holders who experience a decrease in their net worth and earned interests. As in Section 4.1, the activation of CoCos results in increased volatility in the rest of the economy and improved issuer stability. This research highlights some possible risk transmission channels of such kind of automatic bail-in procedures. This paves the way for a comparative assessment at the macro-level of the cost and risks between a bail-in and outright bankruptcy.

Final discussion

This article has analysed the behaviour of a Kaleckian economy that grows at a constant rate, inspired by the model of Godley and Lavoie (2001).This model is designed to study the macroeconomic effects of a CoCo bonds write-off (principal write-down type).The household sector and the banking sector are both divided into two subsectors. Working-households receive a salary from their work in companies and have no financial wealth. Investing-households own and manage a financial wealth composed of

seven different types of assets issued by the other institutional sectors (cash, Treasury bills, companies' shares, deposits with retail banks, term deposits with investment banks, CoCos issued by retail banks and investment banks). The banking sector is made up of commercial banks, specialising in loans to households and businesses, and of investment banks, which manage the same types of assets as investing-household. Both types of banks issue CoCos that can be automatically written-off in the event of the issuer's insolvency.

Since the model is neither micro-founded nor econometrically estimated, the two banking sectors are deliberately modeled independently of one another. It would be possible to create more interactions between these two subsectors, for example by assuming that they can reciprocally buy and sell their debt securities. Such a sophistication would be more realistic but it would scramble the message because the effects of the simulations would then crucially depend on the combinations of parameters, which makes no sense in the approach adopted here.

CoCos are held by investing-households and companies. The government and the central bank play a passive role. They issue securities (overnight loans to banks and treasury bonds) that serve to balance the portfolios of other agents. The central bank collects reserves from the banking sector. The government collects taxes and buys goods from companies, and public expenditure rises at a steady rate.

Two simulations were conducted. In the first case, the shock implemented consists in increasing the share of defaults on workers' loans, by acting on an exogenous variable. This sharply degrades the net worth of retail banks, which reduces their CAR whose level sets the CoCos trigger. Their activation amounts to a cancellation of part of the banks' debts. For simplicity, it is assumed that all CoCos issued by retail banks are then activated and therefore canceled. Later, once the banks' net worth improves, they

start issuing CoCos again. The good side of CoCos' write-down is their disappearance of bank liabilities. The bad side of this story is that companies and investing-households are enduring the cancellation of some of their assets.For both types of actors, this amounts to a decrease in their net worth. Companies respond to this decline in their financial income by lowering their level of investment. Meanwhile, investing-households' disposable income shrinks, inducing them to reduce their consumption.

At the macroeconomic level, there is an impact on the trajectory of the entire economy. Aggregate demand declines, which translates into a slight drop-off in wages and consumption for working households. With regard to the retail banks issuing these CoCos, their activation has a beneficial effect against this type of shock because the decrease in their net worth and their profits is less than in the absence of CoCos. In terms of volatility of the key variables at the level of the whole economy, the existence and the triggering of the CoCos resulting from an increase in the households defaults on their loans produces an intuitive result. There is a shift in risk from CoCos issuers (retail banks) to CoCos holders (companies and investing-households).They react by restructuring their portfolios and changing their actual behaviour, which seems to have a limited impact on the rest of the economy, especially on working households.

The second simulation focuses on the effects of a stock market crisis. It goes beyond the initial issue of banking regulation and supervision as it focuses more particularly on what we call here "investment-banks" which correspond in fact to a generic form of institutional investor. Such a simulation paves the way for research to determine the worst between a private financial bankruptcy, which would have possible domino effects throughout the financial sector, and a bail-in paid by the private creditors holding CoCos but which would destabilize the rest of the economy by transferring risk to the real sphere via wealthy households and financialized enterprises.

To induce this simulation, an exogenous variable in the corporate share demand function is drastically reduced. This leads to a fall in share prices and a deterioration in the balance sheet of investment banks that triggers the activation of CoCos they have issued in the previous periods. This degrades companies' balance sheets, which react by changing their portfolio allocation and reducing their investment, and the balance sheet of investing-households that modify their portfolio allocation and reduce their consumption due to a decline in their disposable income. This decline in aggregate demand has a limited impact on the wages and consumption of working-households. Although the initial shock is not identical, the transmission mechanisms are similar to the first simulation. On the investment bank side, net worth deteriorates less and profit losses are less than in the absence of CoCos. Regarding instability at the aggregate level, risks and adjustment costs are shifted from CoCos issuers to CoCos holders.

This method shows that an automatic bank bail-in resorting to CoCos would effectively improve the bank balance sheet in an efficient and therefore credible manner without government intervention. Thus, the direct burden of bank rescue is more focused, it is now shifted from all taxpayers to bank creditors. In this sense, the CoCos fulfil their objectives: they are able to help stabilize bank balance sheets and they are able to affect the cost of rescue in a more targeted way than a bail-out. Since bailouts operated by governments and control institutions are always late in nature, it can also be considered that the automatic nature of CoCos means that the bail-in takes place earlier and faster than a bailout, which limits all losses. However, this research shows that by shifting the risks and costs of rescue to other actors, CoCos help to destabilise the rest of the economy. It seems that the destabilisation of the real sphere induced by CoCos is relatively limited but such a model does not allow more to say until a specific work has been done to estimate the parameters. Further research is required to measure whether

the stabilising effects of CoCos on bank balance sheets can offset the destabilising effects on the rest of the economy. Such an arbitration depends in particular on the effects on public finance and the distribution of the tax burden. For ordinary households, what is not paid as additional taxes (bailout) is paid as lower wages and increase in unemployment induced by the bail-in. These effects should be developed in another article. This article specifies some important channels of transmission through which destabilization can take place: the elasticity of business investment and of wealthy household consumption to fluctuations in the value of their financial portfolio. It remains to be developed as part of a SFC model a comparative analysis between CoCos that lead to principal write-down and CoCos that convert into equity. The latter provide banks with greater incentives to reduce their ex ante risks and thereby reduce the risk of crisis. One could thus imagine international legislation requiring institutional investors that a fraction of total debts be issued in convertible CoCos, thus automatically inducing a kind of prudential self-discipline.

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Appendices:

List of equations: The subscripts denote the sector involved with the considered variable ("w" for working-households, "r" for investing-households, "f" for firms, "b1" for retail banks, "b2" for investment banks, "g" for government and "cb" for central bank) as well as expected variables ("e"). Capital letters denote nominal variables and lowercase denote real variables.

(W1): Nominal income of working-households

$$YP_w = WB + r_{d-1}.D_{wh-1}$$

(W2): Income taxes of working-households

$$T_w = \theta.YP_w$$

(W3): Nominal disposable nominal income of working-households

$$YD_w = YP_w - T_w - r_{l-1}.L_{ws-1}$$

(W4): Nominal net worth of working-households

$$V_w = V_{w-1} + YD_w - C_w$$

(W5): Real net worth of working-households

$$v_w = \frac{V_w}{p}$$

(W6): Real consumption of working-households

$$c_w = \alpha_1.(yd_{ws} + nl_{wse}) + \alpha_2.v_{w-1}$$

(W7): Nominal consumption of working-households

$$C_w = c_w.p$$

(W8): Real expected disposable income of working-households

$$yd_{we} = \varepsilon.yd_w + (1-\varepsilon).yd_{w-1}.(1+gr_{pr})$$

(W9): Real disposable income of working-households

$$yd_w = \frac{YD_w}{p}$$

(W10): Gross amount of new loans demanded by working-households

$$GL_{wd} = \eta.YP_w$$

(W11): New loans – personal income ratio

$$\eta = \eta_0 - \eta_w.rr_l$$

(W12): Net real supply of loans to working-households

$$nl_{wse} = \varepsilon_1.nl_{ws-1} + (1-\varepsilon_1).nl_{wse}$$

(W13): Net nominal supply of loans to working-households

$$NL_{wd} = GL_{wd} - REP_{w}$$

(W14): Repayment of loans by working-households

$$REP_{w} = \delta_{rep}.L_{ws-1}$$

(W15): Nominal demand in loans from working-households

$$L_{wd} = L_{wd-1} + NL_{wd}$$

(W16): Burden of working-households' debt

$$BUR_{w} = \frac{(REP_{w} + r_{l-1}.L_{wd-1})}{YP_{w}}$$

(W17): Defaulted working-households' loans

$$NPLW = nplw.L_{ws-1}$$

(W18): Share of defaulted working-households' loans

$$nplw = nplw_{0} + nplw_{1}.BUR_{w-1} - nplw_{2}.klim_{-1}$$

(W19): Nominal investible net worth of working-households

$$Vfma_{w} = V_{w} + L_{ws} - HPM_{wh}$$

(W20): Demand in deposits from working-households

$$D_{wd} = Vfma_{w}$$

(W21): Supply in deposits to working-households

$$D_{ws} = D_{wd}$$

(W22): Deposits held by working-households

$$D_{wh} = D_{ws}$$

(W23): Demand in cash from working-households

$$HPM_{wd} = \lambda_{C}.C_{w}$$

(W24): Supply in cash to working-households

$$HPM_{ws} = HPM_{wd}$$

(W25): Cash held by working-households

$$HPM_{wh} = HPM_{ws}$$

(R1): Nominal income of investing-households

$$YP_r = r_{d-1}.D_{rh-1} + r_{td-1}.TD_{rh-} + indicKRb1.BCO1_{rh-1} + indicKRb2.BCO2_{rh-1} + r_{b-1}.B_{rh-1} + FD_{rf} + FD_{rb1} + FD_{rb}$$

(R2): Income taxes of investing-households

$$T_r = \theta.YP_r$$

(R3): Nominal disposable income of investing-households

$$YD_r = YP_r - T_r$$

(R4): Capital gains of investing-households

$$CG_r = (pbco1 - pbco1_{-1}).indicKRb1.BCO1_{rh-1} + (pbco2 - pbco2_{-1}).indicKRb2.BCO2_{rh-1} + (pe - pe_{-1}).e_{rh-1}$$

(R5):Haigh-Simons disposable income of investing-households

$$YDHS_r = YD_r + CG_r$$

(R6): Nominal net worth of investing-households

$$V_r = V_{r-1} + YDHS_r - C_r$$

(R7): Real net worth of investing-households

$$v_r = \frac{V_r}{p}$$

(R8): Real consumption of investing-households

$$c_r = \alpha_1.yd_{re} + \alpha_2.v_{r-1}$$

(R9): Nominal consumption of investing-households

$$C_r = c_r.p$$

(R10): Real disposable income of investing-households

$$yd_r = \frac{YD_r}{p}$$

(R11): Real expected disposable income of investing-households

$$\mathrm{yd_{re}} = \varepsilon.\mathrm{yd_r} + (1-\varepsilon).\mathrm{yd_{r-1}}.\left(1+\mathrm{gr_{pr}}\right)$$

(R12): Nominal investible net worth of investing-households

$$\mathrm{Vfma_r} = \mathrm{Vr} - \mathrm{HPM_{rh}} - (\mathrm{OFB1_{rh}} + \mathrm{OFB2_{rh}})$$

(R13): Portfolio arbitrage of investing-households

$$\begin{bmatrix} \mathrm{D_{rd}} \\ \mathrm{TD_{rd}} \\ \mathrm{B_{rd}} \\ \mathrm{pe.\_e_{rd}} \\ \mathrm{pbco1.BCO1_{rd}} \\ \mathrm{pbco2.BCO2_{rd}} \end{bmatrix} . \frac{1}{\mathrm{Vfma_{r-1}}}$$

$$= \begin{bmatrix} \lambda_{10} \\ \lambda_{20} \\ \lambda_{30} \\ \lambda_{40} \\ \lambda_{50} \\ \lambda_{60} \end{bmatrix} + \begin{bmatrix} +\lambda_{11} & -\lambda_{12} & -\lambda_{13} & -\lambda_{14} & -\lambda_{15} & -\lambda_{16} \\ -\lambda_{21} & +\lambda_{22} & -\lambda_{23} & -\lambda_{24} & -\lambda_{25} & -\lambda_{26} \\ -\lambda_{31} & -\lambda_{32} & +\lambda_{33} & -\lambda_{34} & -\lambda_{35} & -\lambda_{36} \\ -\lambda_{41} & -\lambda_{42} & -\lambda_{43} & +\lambda_{44} & -\lambda_{45} & -\lambda_{46} \\ -\lambda_{51} & -\lambda_{52} & -\lambda_{53} & -\lambda_{54} & +\lambda_{55} & -\lambda_{56} \\ -\lambda_{61} & -\lambda_{62} & -\lambda_{63} & -\lambda_{64} & -\lambda_{65} & +\lambda_{66} \end{bmatrix} . \begin{bmatrix} \mathrm{r_d} \\ \mathrm{r_{td}} \\ \mathrm{r_b} \\ \mathrm{r_K} \\ \mathrm{r_{BCO1}} \\ \mathrm{r_{BCO2}} \end{bmatrix}$$

(R14): Constraints on parameters

$$\lambda_{10} + \lambda_{20} + \lambda_{30} + \lambda_{40} + \lambda_{50} + \lambda_{60} = 1$$

$$\lambda_{11} - (\lambda_{21} + \lambda_{31} + \lambda_{41} + \lambda_{51} + \lambda_{61}) = 0$$

$$\lambda_{22} - (\lambda_{12} + \lambda_{32} + \lambda_{42} + \lambda_{52} + \lambda_{62}) = 0$$

$$\lambda_{33} - (\lambda_{13} + \lambda_{23} + \lambda_{43} + \lambda_{53} + \lambda_{63}) = 0$$

$$\lambda_{44} - (\lambda_{14} + \lambda_{24} + \lambda_{34} + \lambda_{54} + \lambda_{64}) = 0$$

$$\lambda_{55} - (\lambda_{15} + \lambda_{25} + \lambda_{35} + \lambda_{45} + \lambda_{65}) = 0$$

$$\lambda_{66} - (\lambda_{16} + \lambda_{26} + \lambda_{36} + \lambda_{46} + \lambda_{56}) = 0$$

(R15): Redundant equation in the portfolio arbitrage of investing-households

$$\mathrm{D_{rd}} = \mathrm{Vfma_r} - \mathrm{TD_{rs}} - \mathrm{B_{rs}} - \mathrm{pe.e_{rs}} - \mathrm{pbco1.BCO1_{rs}} - \mathrm{pbco2.BCO2_{rs}}$$

(R16): Demand in cash from investing-households

$$\mathrm{HPM_{rd}} = \lambda_{\mathrm{C}}.\mathrm{C_r}$$

(R17): Supply in cash to investing-households

$\mathrm{HPM_{rs}} = \mathrm{HPM_{rd}}$

(R18): Cash held by investing-households

$\mathrm{HPM_{rh}} = \mathrm{HPM_{rs}}$

(R19): Demand in firms' equities by investing-households

$\mathrm{e_{rd}} = \mathrm{e_{rs}}$

(R20): Firms' quities held by investing-households

$\mathrm{e_{rh}} = \mathrm{e_{rs}}$

(R21): Supply in treasury bills to investing-households

$\mathrm{B_{rs}} = \mathrm{B_{rd}}$

(R22): Treasury bills held by investing-households

$\mathrm{B_{rh}} = \mathrm{B_{rs}}$

(R23): Supply in checking deposits to investing-households

$\mathrm{D_{rs}} = \mathrm{D_{rd}}$

(R24): Checking deposits held by investing-households

$\mathrm{D_{rh}} = \mathrm{D_{rs}}$

(R25): Coco equities issued by retail banks held by investing-households (when applicable)

$\mathrm{OFB1_{rh}} = \mathrm{OFB1_{rh-1}} + \mathrm{convrateb1.BCO1_{rh-1}.indicKRb1bis}$

(R26): Coco equities issued by investment banks held by investing-households (when applicable)

$\mathrm{OFB2_{rh}} = \mathrm{OFB2_{rh-1}} + \mathrm{convrateb2.BCO2_{rh-1}.indicKRb2bis}$

(F1): Real production of firms

$\mathrm{y} = \mathrm{s_e} + \mathrm{in_e} - \mathrm{in_{-1}}$

(F2): Real expected sales of firms

$\mathrm{s_e} = \beta.\mathrm{s_{-1}} + (1-\beta).\mathrm{s_{e-1}}.\left(1+\mathrm{gr_{pr}}\right)$

(F3): Long-term real inventories target of firms

$$in_T = \sigma_T . s_e$$

(F4): Real inventories of firms

$$in = in_{-1} + (y - s)$$

(F5): Growth rate of the real stock of capital of firms

$$gr_k = \gamma_0 + \gamma_1 . u_{-1} - \gamma_2 . rr_l . l_{-1} + \gamma_3 . rr_{cf-1} + \gamma_4 . rr_{q-1}$$

(F6): Real stock of capital of firms

$$k = k_{-1} . (1 + gr_k)$$

(F7): Rate of capacity utilization of firms

$$u = \frac{y}{k_{-1}}$$

(F8): Real interest rate on loans

$$\frac{(1 + r_l)}{1 + \pi} - 1$$

(F9): Real investment of firms

$$inv = (k - k_{-1}) + \delta . k_{-1}$$

(F10): Leverage ratio of firms

$$l = \frac{L_{fs}}{K}$$

(F11): Cash flow rate of firms

$$r_{cf} = \frac{FU_f}{K_{-1}}$$

(F12): Real cash flow rate of firms

$$rr_{cf} = \frac{(1 + r_{cf})}{1 + \pi} - 1$$

(F13): Tobin's Q of firms

$$r_q = \frac{L_{fd} + B_{fh} + pe . e_s + pbco1 . indicKRb1 . BCO1_{fh} + pbco2 . indicKRb2 . BCO2_{fh}}{K + IN}$$

(F14): Real Tobin's Q of firms

$$rr_q = \frac{(1 + r_q)}{1 + \pi} - 1$$

(F15): Real sales of firms

$$s = c_w + c_r + g + inv$$

(F16): Nominal sales of firms

$$S = s.p$$

(F17): Nominal inventories of firms

$$IN = in.UC$$

(F18): Nominal investment of firms

$$INV = inv.p$$

(F19): Nominal capital of firms

$$K = k.p$$

(F20): Nominal production of firms

$$Y = s.p + (in - in_{-1}).UC$$

(F21): Real wage bargained by workers at the moment of negociations

$$\Omega_T = \Omega_0 + \Omega_1.pr + \Omega_2.ER$$

(F22): Employment rate

$$ER = \frac{N_{-1}}{N_{fe-1}}$$

(F23): Nominal effective wage paid by firms

$$W = W_{-1} + \Omega_3.(\Omega_T.p_{-1} - W_{-1})$$

(F24): Productivity

$$pr = pr_{-1}.(1 + gr_{pr})$$

(F25): Employment desired by firms

$$N_T = \frac{y}{pr}$$

(F26): Effective employment

$$N = N_{-1} + \Omega_4(N_T - N_{-1})$$

(F27): Wage bill paid by firms

$$WB = N.W$$

(F28): Unit costs paid by firms

$$UC = \frac{WB}{y}$$

(F29): Normal unit costs paid by firms

$$NUC = \frac{W}{pr}$$

(F30): Normal historic unit costs paid by firms

$$NHUC = (1 - \sigma_N).NUC + \sigma_N.(1 + r_{l-1}).NUC_{-1}$$

(F31): Price charged by firms

$$p = (1 + \varphi).NHUC$$

(F32): Inflation rate

$$\pi = \frac{p - p_{-1}}{p_{-1}}$$

(F33): Profits realized by firms

$$F_f = S - WB + (IN - IN_{-1}) - r_l.IN_{-1} + r_{fTOT} + CG_f + FD_{fb} \quad + FD_{fb2}$$

(F34): Total profits distributed by firms

$$FD_f = \psi_D.F_{f-1}$$

(F35): Profits distributed by firms to investing-households

$$FD_{rf} = \frac{e_{rs}}{e_s}.FD_f$$

(F36): Profits distributed by firms to investment banks

$$FD_{b2f} = \frac{e_{b2s}}{e_s}.FD_f$$

(F37): Profits retained by firms

$$FU_f = F_f - FD_f - r_{l-1}.(L_{fd-1} - IN_{-1})$$

(F38): Loans demanded by firms

$$L_{fd} = L_{fd-1} + INV + (IN - IN_{-1}) - \zeta.FU_f - (e_s - e_{s-1}).pe$$

(F39): Equities issued by firms

$$e_s = e_{s-1} + (1 - \psi_U).\frac{INV_{-1}}{pe}$$

(F40): Return rate of firms' equities

$$r_K = \frac{FD_f}{e_{s-1}.pe_{-1}}$$

(F41): Price earning ratio of firms

$$PE = \frac{(pe.e_{s-1})}{F_f}$$

(F42): Financial interests earned by firms

$$r_{fTOT} = r_{b-1}.B_{fh-1} + indicKRb1.BCO1_{fh-1} + indicKRb2\,.BCO2_{fh-1}$$

(F43): Capital gains of firms

$$CG_f = BCO1_{fh-1}.(pbco1 - pbco1_{-1}) + BCO2_{fh-1}.(pbco2 - pbco2_{-1})$$

(F43): Nominal net worth of firms

$$V_f = V_{f-1} + (1 - \zeta).FU_f$$

(F44): Nominal investible net worth of firms

$$Vfma_f = V_f - (OFB1_{fh} + OFB2_{fh})$$

(F45): Portfolio arbitrage of firms

$$\begin{bmatrix} B_{fd} \\ pbco1.BCO1_{fd} \\ pbco2.BCO2_{fd} \end{bmatrix} = \begin{bmatrix} \tau_{10} \\ \tau_{20} \\ \tau_{30} \end{bmatrix} + \begin{bmatrix} +\tau_{11} & -\tau_{12} & -\tau_{13} \\ -\tau_{21} & +\tau_{22} & -\tau_{23} \\ -\tau_{31} & -\tau_{32} & +\tau_{33} \end{bmatrix} \begin{bmatrix} r_b \\ r_{BCO1} \\ r_{BCO2} \end{bmatrix}$$

(F46): Constraints on parameters

$$\tau_{10} + \tau_{20} + \tau_{30} = 1$$

$$\tau_{11} - (\tau_{21} + \tau_{31}) = 0$$

$$\tau_{22} - (\tau_{12} + \tau_{32}) = 0$$

$$\tau_{33} - (\tau_{13} + \tau_{23}) = 0$$

(F47): Redundant equation in the portfolio arbitrage of firms

$$B_{fd} = Vfma_f - pbco1.indicKRb1.BCO1_{fs} - pbco2.indicKRb2.BCO2_{fs}$$

(F48): Equities supplied by firms to investing-households

$$e_{rs} = \upsilon.e_s$$

(F49): Equities supplied by firms to investment banks

$$e_{b2s} = e_s - e_{rs}$$

(F50): Treasury bills supplied to firms

$$B_{fs} = B_{fd}$$

(F51): Treasury bills held by firms

$$B_{fh} = B_{fs}$$

(F52): Coco bonds issued by retail banks held by firms

$$OFB1_{fh} = OFB1_{fh-1} + convrateb1.BCO1_{fh-1}.indicKRb1bis$$

(F53): Coco bonds issued by investment banks held by firms

$$OFB2_{fh} = OFB2_{fh-1} + convrateb2.BCO2_{fh-1}.indicKRb2bis$$

(G1): Total taxes collected by the government

$$T = T_r + T_w$$

(G2): Real public expenditures

$$g = \frac{G}{p}$$

(G3): Nominal public expenditures

$$G = G_{-1}.(1 + gr_g)$$

(G4): Public deficit

$$PSBR = G + r_{b-1}.B_{s-1} - (T + F_{cb})$$

(G5): Public debt

$$GD = GD_{-1} + PSBR$$

(G6): Total supply of Treasury Bills issued by the government

$$B_s = B_{rs} + B_{fs} + B_{b2s}$$

(G7): Interest rate on Treasury Bills

$$r_b = r_a$$

(CB1): Profits realized by the central bank

$$F_{cb} = r_{a-1}.(A_{b1s-1} + A_{b2s-1})$$

(CB2): Interest rate on advances granted by the central bank

$$r_a = r_a^*$$

(BD1): Total deposits supplied by retail banks

$$D_s = D_w + D_r$$

(BD2): Loans supplied by retail banks to firms

$$L_{fs} = L_{fd}$$

(BD3): Loans supplied by retail banks to working-households

$$L_{ws} = L_{ws-1} + NL_{ws} - REP_w$$

(BD4): New loans supplied by retail banks to working-households (in nominal terms)

$$NL_{ws} = klim.NL_{wd}$$

(BD5): New loans supplied by retail banks to working-households (in real terms)

$$nl_{ws} = \frac{NL_{ws}}{p}$$

(BD6): Share of new loans granted to working-households relative to their demand of new loans

$$\mathrm{klim} = \mathrm{klim}_0 - \mathrm{klim}_1 . \mathrm{LEV}_{w-1} + \mathrm{klim}_2 . (\mathrm{CAR}_{b1} - \mathrm{CAR}_{Tb1}) - \mathrm{klim}_3 . \mathrm{BUR}_{w-1} - \mathrm{klim}_4 . \mathrm{nplw}$$

(BD7): Leverage ratio of working-households

$$\mathrm{LEV}_w = \frac{\mathrm{L}_{ws}}{\mathrm{V}_w}$$

(BD8): Capital adequacy ratio of retail banks

$$\mathrm{CAR}_{b1} = \frac{\mathrm{V}_{b1}}{\mathrm{L}_{ws} + \mathrm{L}_{fs}}$$

(BD9): Central bank reserves demanded by retail banks

$$\mathrm{HPM}_{b1d} = \rho_1 . \mathrm{D}_s$$

(BD10): Central bank reserves supplied to retail banks

$$\mathrm{HPM}_{b1s} = \mathrm{HPM}_{b1d}$$

(BD11): Notional demand in central bank advances from retail banks

$$\mathrm{A}_{Nb1d} = \mathrm{L}_{ws} + \mathrm{L}_{fs} + \mathrm{HPM}_{b1d} - \mathrm{D}_s - \mathrm{OFB1}_s - \mathrm{pbco1} . \mathrm{indicKRb1} . \mathrm{BCO1}_s - \mathrm{V}_{b1}$$

(BD12): Parameter involved in the notional demand in central bank advances from retail banks

$$z_5 = 1 \text{ if } \mathrm{A}_{Nb1d} > 0 \text{ ; } 0 \text{ else}$$

(BD13) Demand in central bank advances from retail banks

$$\mathrm{A}_{b1d} = \mathrm{A}_{Nb1d} . z_5$$

(BD14): Supply of central bank advances to retail banks

$$\mathrm{A}_{b1s} = \mathrm{A}_{b1d}$$

(BD15): Profits realized by retail banks

$$\mathrm{F}_{b1} = \mathrm{r}_{l-1} . (\mathrm{L}_{fs-1} + \mathrm{L}_{ws-1} - \mathrm{NPLW}) - \mathrm{r}_{d-1} . \mathrm{D}_{s-1} - \mathrm{r}_{a-1} . \mathrm{A}_{b1s-1} - \mathrm{BCO1}_{s-1} . \mathrm{indicKRb1}$$

(BD16): Interest rate on loans

$$\mathrm{r}_l = \mathrm{r}_a + \chi_1$$

(BD17): Interest rate on deposits

$$r_d = r_a - \chi_2$$

(BD18): Nominal net worth of retail banks

$$V_{b1} = V_{b1-1} + FU_{b1} - NPLW$$

(BD19): Profits retained by retail banks

$$FU_{b1} = F_{b1} - FD_{b1}$$

(BD20): Profits distributed by retail banks

$$FD_{b1} = indicKRb1bis.\sigma_{b1}.F_{b1-1}$$

(BD21): Profits distributed to investing-households by retail banks

$$FD_{rb1} = indicKRb1bis.\sigma_{rb1}.FD_{b1-1}$$

(BD22): Profits distributed to firms by retail banks

$$FD_{fb1} = indicKRB1bis.(FD_{b1} - FD_{rb1})$$

(BD23): Total supply of coco bonds issued by retail banks

$$BCO1_s = indicKRb1.BCO1_{s-1} + z_1.indicKRb1.\frac{(D_{s-1} - D_{s-2})}{pbco1}$$

(BD24): Total notional supply of coco bonds issued by retail banks

$$BCO1_{sN} = BCO1_{sN-1} + z_1.\frac{D_{s-1} - D_{s-2}}{pbco1}$$

(BD25): Conversion mechanism of coco bonds in coco equities (when applicable)

$$OFB1_s = OFB1_{s-1} + pbco1_{-1}.BCO1_{s-1}.indicKRb1bis.convrateb1$$

(BD26): Triggering ratio for coco bonds issued by retail banks

$$KR_{b1} = CAR_{b1}$$

(BD27): Return rate of coco bonds issued by retail banks

$$r_{BCO1} = indicKRb1.\frac{BCO1_{s-1}}{pbco1_{-1}.BCO1_{sN-1}}$$

(BD28): Indicator function for coco bonds issued by retail banks

$\text{indicKRb1} = 1 \text{ if} \text{KR}_{\text{b1}-1} > K\text{R}_{\text{Tb1}}$; 0 else

(BD29): Indicator function for coco equities issued by retail banks

$\text{indicKRb1bis} = 1 \text{ if } \text{KR}_{\text{b1}-1} \leq \text{KR}_{\text{Tb1}}$; 0 else

(BD30): Supply of coco bonds issued by retail banks to investing-households

$\text{BCO1}_{\text{rs}} = \sigma_{\text{rb}} \ . \text{BCO1}_{\text{s}}$

(BD31): Supply of coco bonds issued by retail banks to firms

$\text{BCO1}_{\text{fs}} = \text{BCO1}_{\text{s}} - \text{BCO1}_{\text{rs}}$

(BD32): Coco bonds issued by retail banks demanded by investing-households

$\text{BCO1}_{\text{rd}} = \text{BCO1}_{\text{rs}}$

(BD33): Coco bonds issued by retail banks held by investing-households

$\text{BCO1}_{\text{hd}} = \text{BCO1}_{\text{rh}}$

(BD34): Coco bonds issued by retail banks demanded by firms

$\text{BCO1}_{\text{fd}} = \text{BCO1}_{\text{fs}}$

(BD35): Coco bonds issued by retail banks held by firms

$\text{BCO1}_{\text{fd}} = \text{BCO1}_{\text{fh}}$

(BI1): Time deposits supplied by investment banks to investing-households

$\text{TD}_{\text{rs}} = \text{TD}_{\text{rd}}$

(BI2): Time deposits held by investing-housholds

$\text{TD}_{\text{rh}} = \text{TD}_{\text{rs}}$

(BI3): Growth rate of firm equities' price

$$\text{gr}_{\text{pe}} = \frac{\text{pe} - \text{pe}_{-1}}{\text{pe}_{-1}}$$

(BI4): Central bank reserves demanded by investment banks

$\text{HPM}_{\text{b2d}} = \rho_2 . \text{TD}_{\text{rs}}$

(BI5): Central bank reserves supplied to investment banks

$\text{HPM}_{\text{b2s}} = \text{HPM}_{\text{b2d}}$

(BI6): Notional demand in central bank advances from investment banks

$$A_{Nb2d} = HPM_{b2d} + B_{b2d} + pe.e_{b2d} - TD_{rs} - OFB2_s - pbco2.indicKRb2.BCO2_s - V_{b2}$$

(BI7): Parameter involved in the notional demand in central bank advances from investment banks

$z_6 = 1$ if $A_{Nb2d} > 0$; 0 else

(BI7) Demand in central bank advances from investment banks

$$A_{b2d} = A_{Nb2d}.z_6$$

(BI8): Supply of central bank advances to retail banks

$$A_{b2s} = A_{b2d}$$

(BI9): Profits realized by investment banks

$$F_{b2} = FD_{b2f} + CG_{b2} - r_{td-1}.TD_{rs-1} - indicKRb2.BCO2_{s-1} + r_{b-1}.B_{b2s-1} - r_{a-1}.A_{b2s-1}$$

(BI10): Interest rate on time deposits

$$r_{td} = r_a - \chi_3$$

(BI11): Nominal net worth of investment banks

$$V_{b2} = V_{b2-1} - FU_{b2}$$

(BI12): Capital gains of investment banks

$$CG_{b2} = e_{b2h-1}.(pe - pe_{-1})$$

(BI13): Profits retained by investment banks

$$FU_{b2} = F_{b2} - FD_{b2}$$

(BI14): Profits distributed by investment banks

$$FD_{b2} = indicKRb2bis.\sigma_{b2}.F_{b2-1}$$

(BI15): Profits distributed by investment banks to investing-households

$$FD_{rb2} = indicKR2bis.\sigma_{rb2}.FD_{b2}$$

(BI16): Profits distributed by investment banks to firms

$$\mathrm{FD_{fb2}} = \mathrm{indicKRb2bis.}\,(\mathrm{FD_{b2}} - \mathrm{FD_{rb2}})$$

(BI17): Nominal investible net worth of investment banks

$$\mathrm{Vfma_{b2}} = \mathrm{V_{b2}} - \mathrm{HPM_{b2s}}$$

(BI18): Portfolio arbitrage of investment banks

$$\begin{bmatrix} \mathrm{B_{b2d}} \\ \mathrm{pe.\,e_{b2d}} \end{bmatrix} = \begin{bmatrix} \epsilon_{10} \\ \epsilon_{20} \end{bmatrix} + \begin{bmatrix} +\epsilon_{11} & -\epsilon_{12} \\ -\epsilon_{21} & +\epsilon_{22} \end{bmatrix} \begin{bmatrix} \mathrm{r_b} \\ \mathrm{r_K} \end{bmatrix}$$

(BI19): Constraints on parameters

$$\epsilon_{10} + \epsilon_{20} = 1$$

$$\epsilon_{11} - \epsilon_{21} = 0$$

$$\epsilon_{22} - \epsilon_{12} = 0$$

(BI20): Redundant equation in the portfolio arbitrage of investment banks

$$\mathrm{B_{b2d}} = \mathrm{Vfma_{b2}} - \mathrm{pe.\,e_{b2s}}$$

(BI21): Total supply of coco bonds issued by investment banks

$$\mathrm{BCO2_s} = \mathrm{indicKRb2.\,BCO2_{s-1}} + \mathrm{z_2.\,indicKRb2.}\frac{(\mathrm{TD_{s-1}} - \mathrm{TD_{s-2}})}{\mathrm{pbco2}}$$

(BI22): Total notional supply of coco bonds issued by investment banks

$$\mathrm{BCO2_{sN}} = \mathrm{BCO2_{sN-1}} + \mathrm{z_2.}\frac{\mathrm{TD_{s-1}} - \mathrm{TD_{s-2}}}{\mathrm{pbco2}}$$

(BI23): Conversion mechanism of coco bonds in coco equities (when applicable)

$$\mathrm{OFB2_s} = \mathrm{OFB2_{s-1}} + \mathrm{pbco2_{-1}.\,BCO2_{s-1}.\,indicKRb2bis.\,convrateb2}$$

(BI24): Triggering ratio for coco bonds issued by investment banks

$$\mathrm{KR_{b2}} = \mathrm{Var(gr_{pe})}$$

(BI25): Return rate of coco bonds issued by investment banks

$$\mathrm{r_{BCO}} = \mathrm{indicKRb2.}\frac{\mathrm{BCO2_{s-1}}}{\mathrm{pbco2_{-1}.\,BCO2_{sN-1}}}$$

(BI26): Indicator function for coco bonds issued by investment banks

$\text{indicKRb2} = 1 \text{ if} \text{KR}_{\text{b2}-1} < K\text{R}_{\text{Tb}}$; 0 else

(BI27): Indicator function for coco equities issued by investment banks

$\text{indicKRb2bis} = 1 \text{ if } \text{KR}_{\text{b2}-1} \geq \text{KR}_{\text{Tb}}$; 0 else

(BI28): Supply of coco bonds issued by investment banks to investing-households

$\text{BCO2}_{\text{rs}} = \sigma_{\text{rb2}}.\text{BCO2}_{\text{s}}$

(BI29): Supply of coco bonds issued by investment banks to firms

$\text{BCO2}_{\text{fs}} = \text{BCO2}_{\text{s}} - \text{BCO2}_{\text{rs}}$

(BI30): Coco bonds issued by investment banks demanded by investing-households

$\text{BCO2}_{\text{rd}} = \text{BCO2}_{\text{rs}}$

(BI31): Coco bonds issued by investment banks held by investing-households

$\text{BCO2}_{\text{hd}} = \text{BCO2}_{\text{rh}}$

(BI32): Coco bonds issued by investment banks demanded by firms

$\text{BCO2}_{\text{fd}} = \text{BCO2}_{\text{fs}}$

(BI33): Coco bonds issued by investment banks held by firms

$\text{BCO2}_{\text{fd}} = \text{BCO2}_{\text{fh}}$

Tables:

	Worker households	Investor households	Firms	Retail banks	Investment banks	Central bank	Government	Σ
Inventories			+IN					+IN
Fixed capital			+K					+K
High powered money	$+HPM_w$	$+HPM_r$		$+HPM_{b1}$	$+HPM_{b2}$	-HPM		0
Bills		$+B_r$	$+B_f$		$+B_{b2}$		-B	0
Household loans	$-L_w$			$+L_w$				0
Firm loans			$-L_f$	$+L_f$				0
Retail banks capital		$+OFB1_r$	$+OFB1_f$	-OFB1				0
Investment banks capital		$+OFB2_r$	$+OFB2_f$		-OFB2			0
Firms' equities		$+pe.E_r$	$-pe.E_f$		$+pe.E_{b2}$			0
Checking deposits	$+D_w$	$+D_r$		-D				0
Time deposits		$+TD_r$			$-TD_r$			0
Advances central bank				$-A_{b1}$	$-A_{b2}$	+A		0
Coco bonds retail banks		$+pbco1.BCO1_r$	$+pbco1.BCO1_f$	-pbco1.BCO1				0
Coco bonds investment banks		$+pbco2.BCO2_r$	$+pbco2.BCO2_f$		-pbco2.BCO2			0
Net wealth	$-V_w$	$-V_r$	$-V_f$	$-V_{b1}$	$-V_{b2}$	0	$-V_g$	-(IN+K)
Σ	0	0	0	0	0	0	0	0

Table 1. Stock matrix

	Worker households	Investor households	Firms		Retail banks		Investment banks		Central bank		Government	Σ
			Current	Capital	Current	Capital	Current	Capital	Current	Capital		
Consumption	$-C_w$	$-C_r$	$+C_w+C_r$									0
Public expenditures			$+G$									0
Fixed capital investment			$+I$									0
Inventories accumulation			$+\Delta IN$	$-\Delta IN$								0
Income taxes	$-T_w$	$-T_r$									$+T$	0
Wages	$+WB$		$-WB$									0
Inventories costs			$-r_{l-1} \cdot IN_{-1}$		$+r_{l-1} \cdot IN_{-1}$							0
Firms profits		$+FD_{rf}$	$-F_f$	$+FU_f$				$+FD_{b2f}$				0
Central bank profits									$-F_{CB}$		$+F_{CB}$	0
Retail banks profits		$+FD_{rb1}$		$+FD_{fb1}$	$-F_{b1}$	$+FU_{b1}$						0
Investment banks profits		$+FD_{rb2}$		$+FD_{fb2}$			$-F_{b2}$	$+FU_{b2}$				0
Interest on household loans	$-r_{l-1}.L_{w-1}$				$+r_{l-1}.L_{w-1}$							0
Interest on Bills		$+r_{b-1}.B_{r-1}$	$+r_{b-1}.B_{f-1}$				$+r_{b-1}.B_{b2-1}$				$-r_{b-1}.B_{-1}$	0
Interest on coco bonds (1)		$+BCO1_{r-1}$	$+BCO1_{f-1}$		$-BCO1_{-1}$							0
Interest on coco bonds (2)		$+BCO2_{r-1}$	$+BCO2_{f-1}$				$-BCO2_{-1}$					0
Interest on checking deposits	$+r_{d-1}.D_{w-1}$	$+r_{d-1}.D_{h-1}$			$-r_{d-1}.D$							0
Interest on time deposits		$+r_{td-1} \cdot TD_{r-1}$					$-r_{td-1} \cdot TD_{r-1}$					0
Interest on advances					$-r_{A-1} \cdot A_{b1,-1}$		$-r_{A-1} \cdot A_{b2,-1}$		$+r_{A-1} \cdot A_{-1}$			0
Δ checking deposits	$-\Delta D_w$	$-\Delta D_r$				$+\Delta D$						0
Δ time deposits		$-\Delta TD_r$						$+\Delta TD_r$				0
Δ high powered money	$-\Delta HPM_w$	$-\Delta HPM_r$				$-\Delta HPM_{b1}$		$-\Delta HPM_{b2}$		$+\Delta HPM$		0
Δ firms' equities		$-pe \cdot \Delta e_r$		$+pe \cdot \Delta e$				$-pe \cdot \Delta e_{b2}$				0
Δ advances from central bank						$+\Delta A_{b1}$		$+\Delta A_{b2}$		$-\Delta A$		0
Δ households loans	$+\Delta L_w$					$-\Delta L_w$						0
Δ firms loans				$+\Delta L_f$		$-\Delta L_f$						0
Δ Bills		$-\Delta B_r$		$-\Delta B_f$				$-\Delta B_{b2}$			$+\Delta B$	0
Δ coco bonds (1)		$-pbco1 \cdot \Delta BCO1_r$		$-pbco1 \cdot \Delta BCO1_f$		$+pbco1 \cdot \Delta BCO1$						0
Δ coco bonds (2)		$-pbco2 \cdot \Delta BCO2_r$		$-pbco2 \cdot \Delta BCO2_f$				$+pbco2 \cdot \Delta BCO2$				0
Defaulted households loans	$+NPLW$					$-NPLW$						0
Σ	0	0	0	0	0	0	0	0	0	0	0	0

Table 2 : Flow matrix

	Worker households	Investor households	Firms	Retail banks	Investment banks	Central bank	Government	Σ
Coco bonds (1)		$+\Delta pbco1.BCO1_{h-1}$	$+\Delta pbco1.BCO1_{f-1}$	$-\Delta pbco1.BCO1_{-1}$				0
Coco bonds (2)		$+\Delta pbco2.BCO2_{h-1}$	$+\Delta pbco2.BCO2_{f-1}$		$-\Delta pbco2.BCO2_{-1}$			0
Firms' equities		$+\Delta pe.E_{h-1}$	$-\Delta pe.E_{f-1}$		$+\Delta pe.E_{b2-1}$			0
Inventories			$+\Delta pIN.IN_{-1}$					$+\Delta pIN.IN-1$
Fixed capital			$+\Delta p.K_{-1}$					$+\Delta p.K_{-1}$

Table3. Revaluation matrix

	Relative standard deviations
Production	1.06
Total consumption of households	1.31
Net worth of working households	1.01
Net worth of investing households	3.28
Net worth of firms	1.04
Net worth of retail banks	0.98

Table 4. Standard deviations in case of a crisis with a CoCos activation scenario relative to standard deviations in case of a crisis without CoCos scenario.

	Relative standard deviations
Production	1.06
Total consumption of households	1.14
Net worth of investing households	1.08
Net worth of working households	1.00
Net worth of firms	1.02
Net worth of investment banks	0.98

Table 5. Standard deviations in case of a crisis with a CoCos activation scenario relative to standard deviations in case of a crisis without CoCos scenario.

Figures :

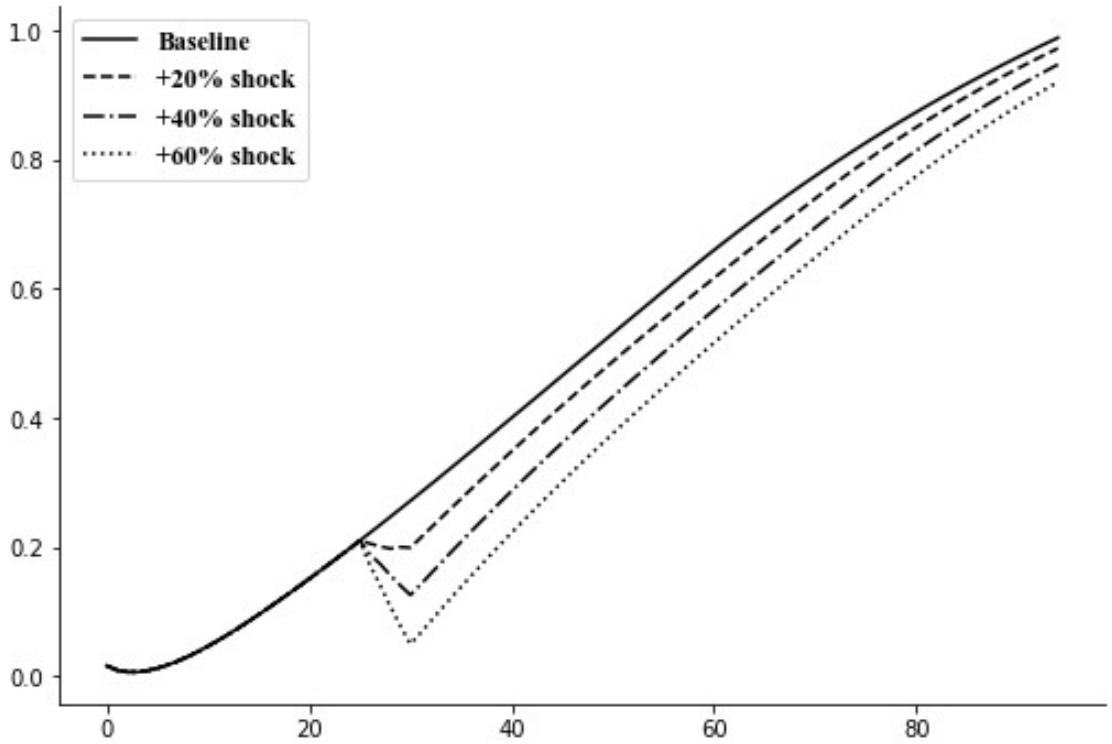

Figure 1. CAR of retail banks following an increase in defaulted loans.

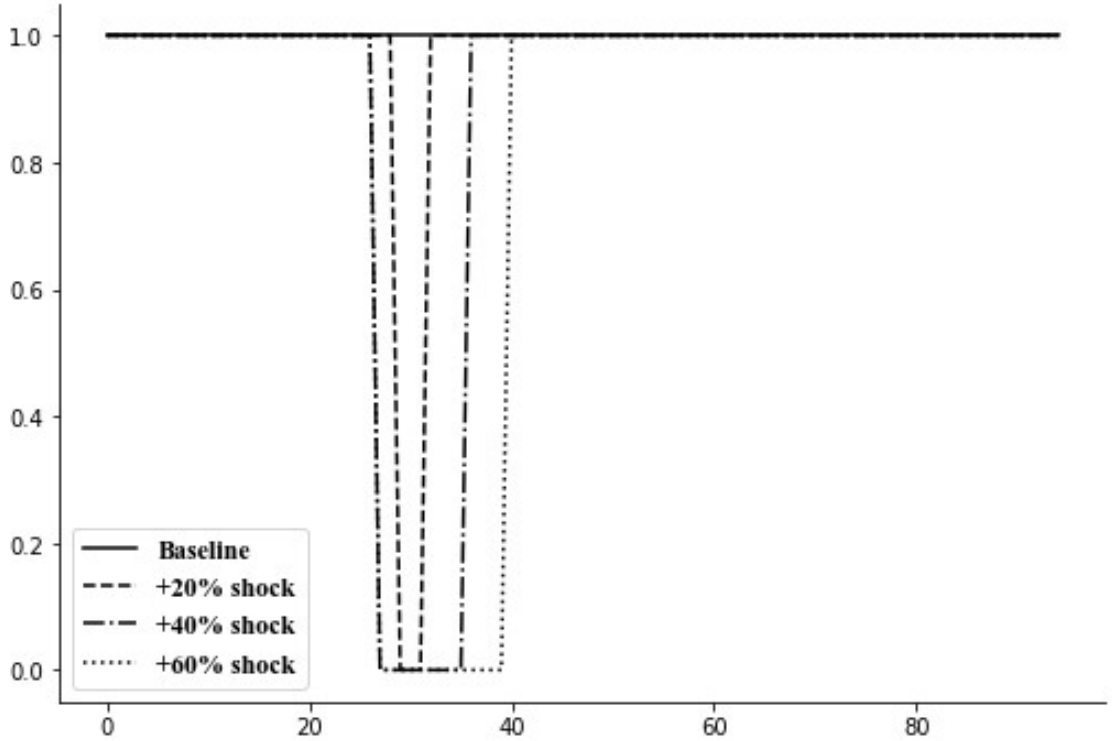

Figure 2. State of the contingent convertible trigger following an increase in defaulted loans (1 = not activated ; 0 = activated).

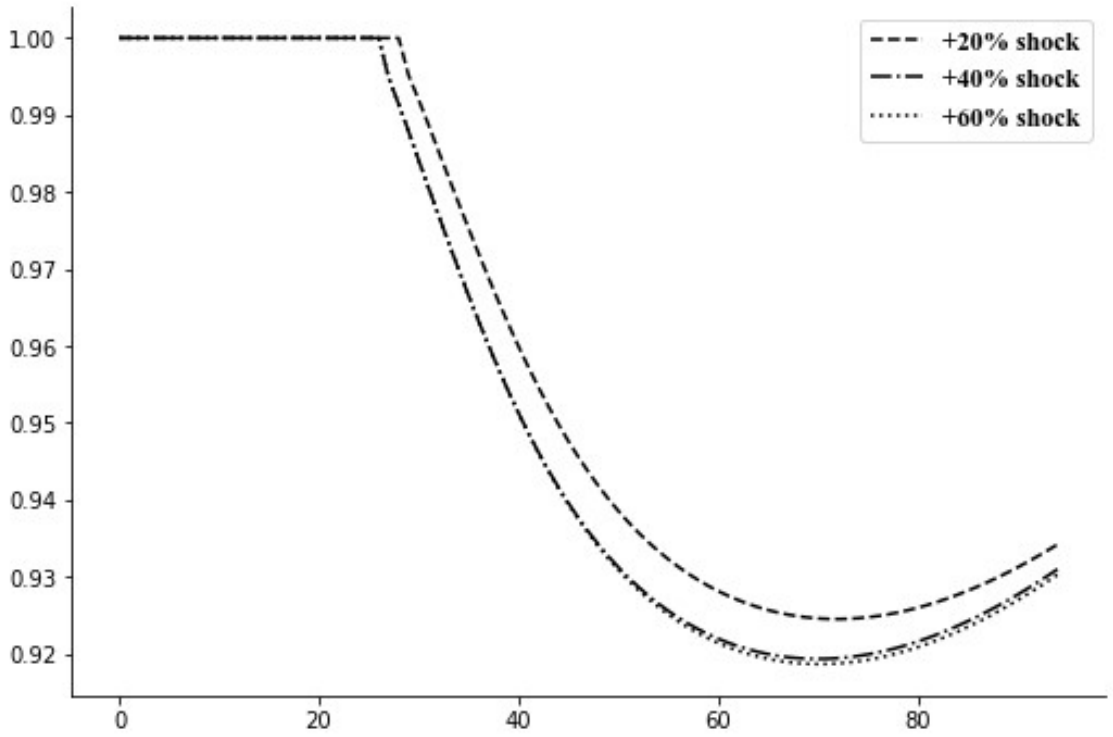

Figure 3. Evolution of the net values of firms, relative to the scenario without any activation of coco bonds, following an increase in the share of defaulted loans.

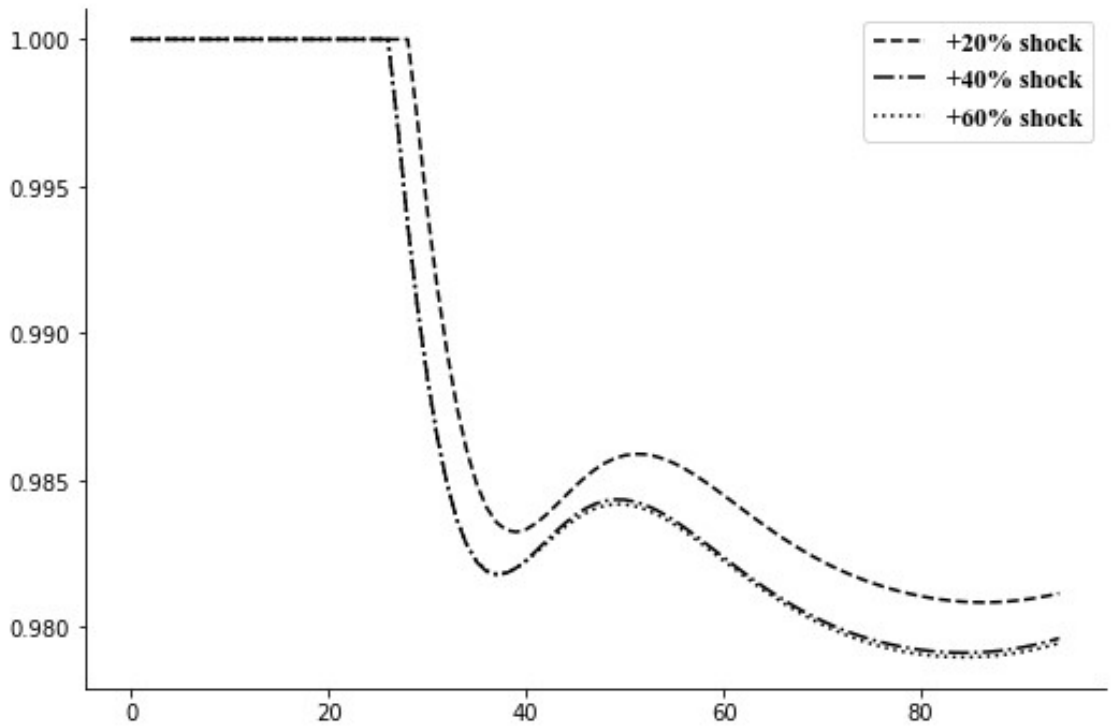

Figure 4. Evolution of Tobin's Q, relative to the scenario crisis without any activation of coco bonds, following an increase in defaulted loans.

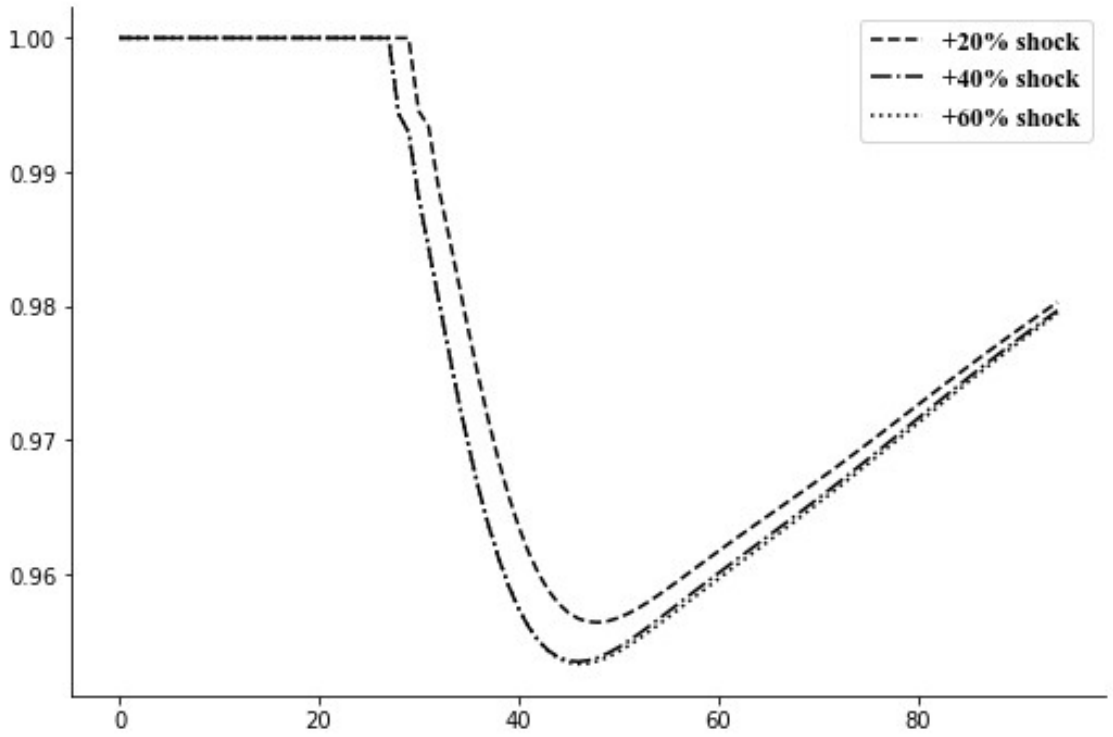

Figure 5. Evolution of the investment of firms, relative to the scenario without any activation of coco bonds, following an increase in the share of defaulted loans.

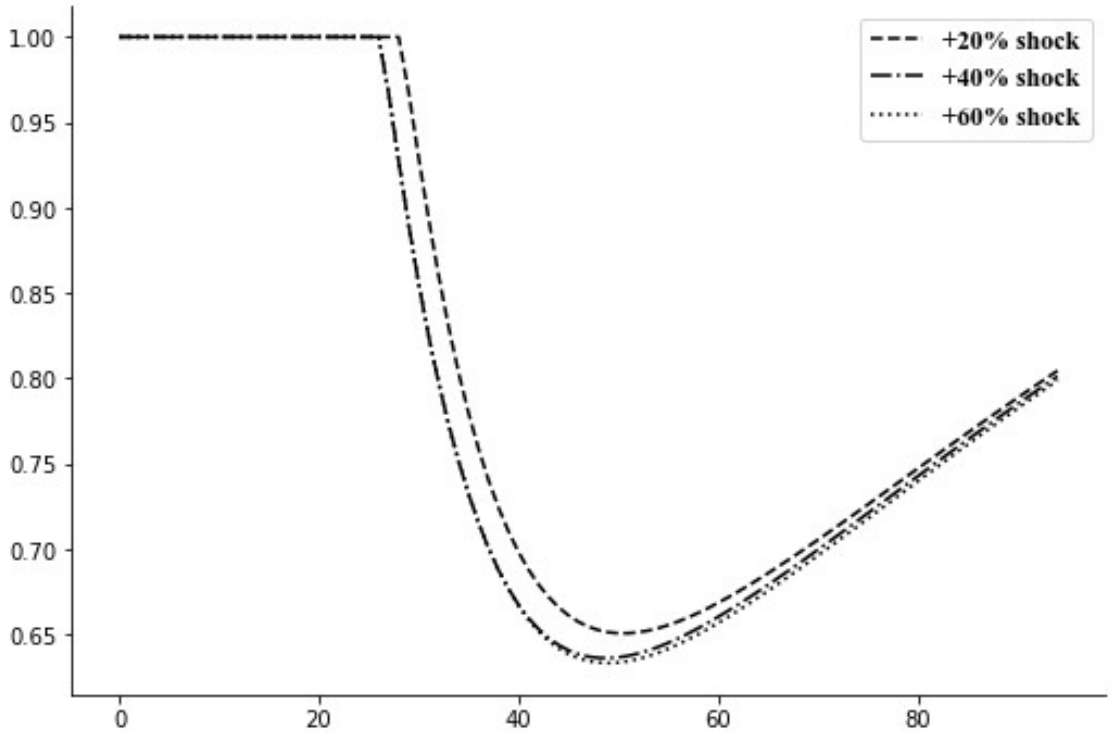

Figure 6. Evolution of the net value of investing households, relative to the scenario without any activation of coco bonds, following an increase in the share of defaulted loans.

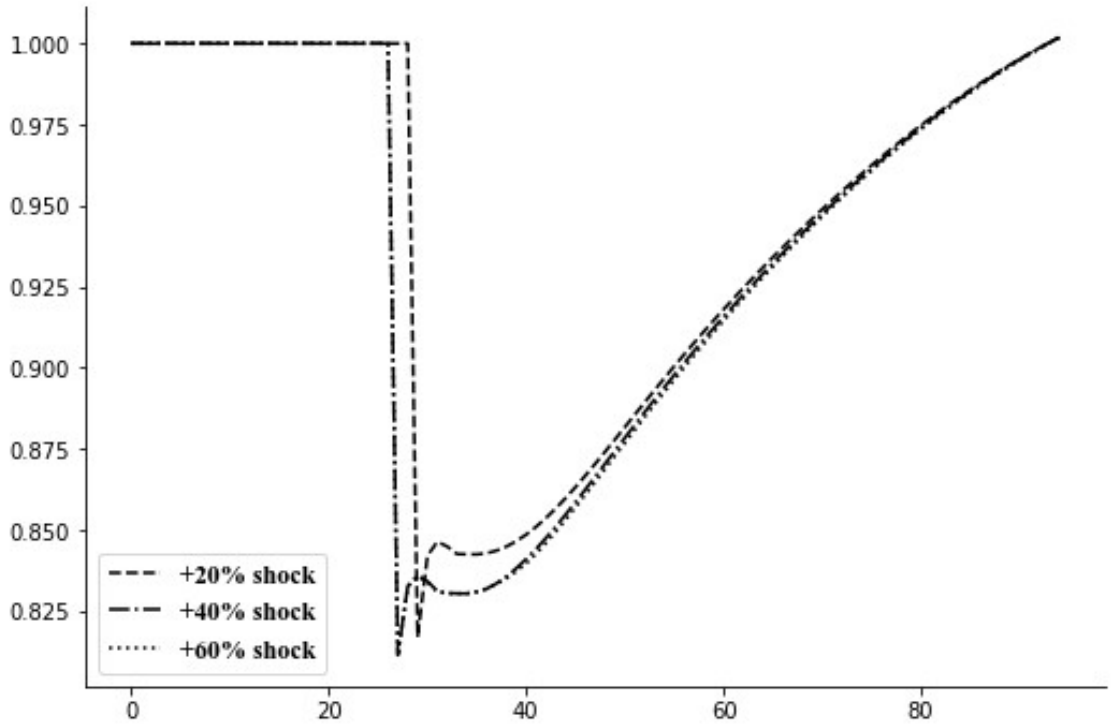

Figure 7. Evolution of the disposable income of investing households, relative to the scenario without any activation of coco bonds, following an increase in the share of defaulted loans.

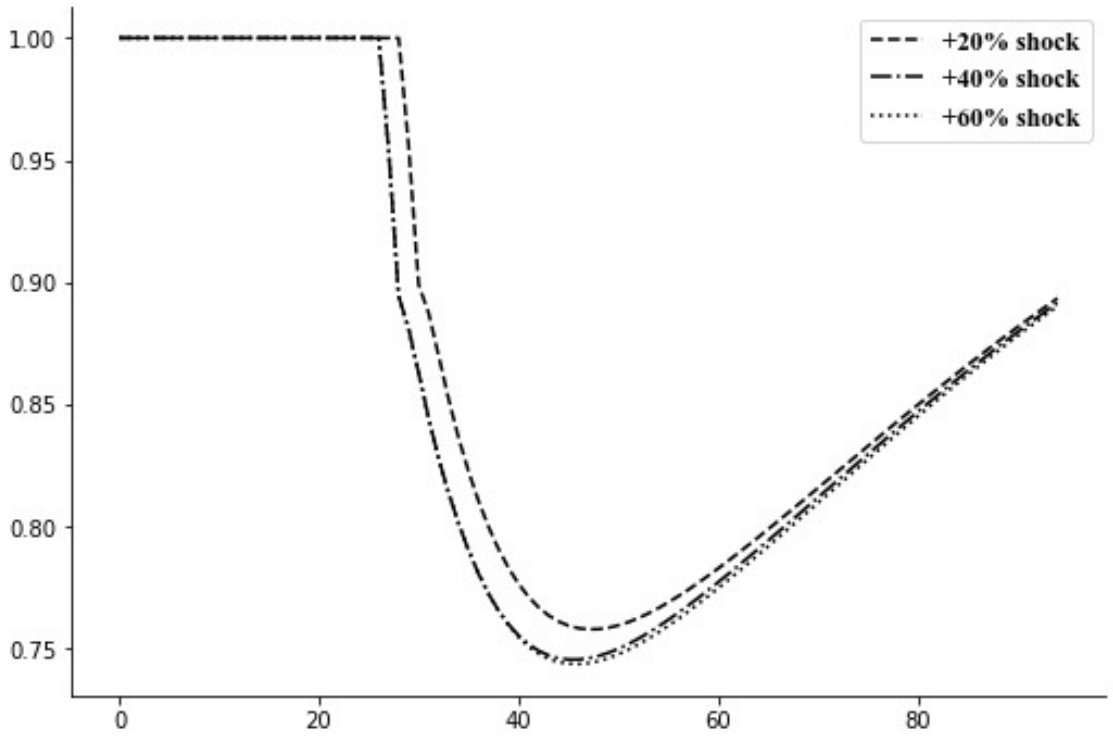

Figure 8. Evolution of the consumption of investing households, relative to the scenario without any activation of coco bonds, following an increase in the share of defaulted loans.

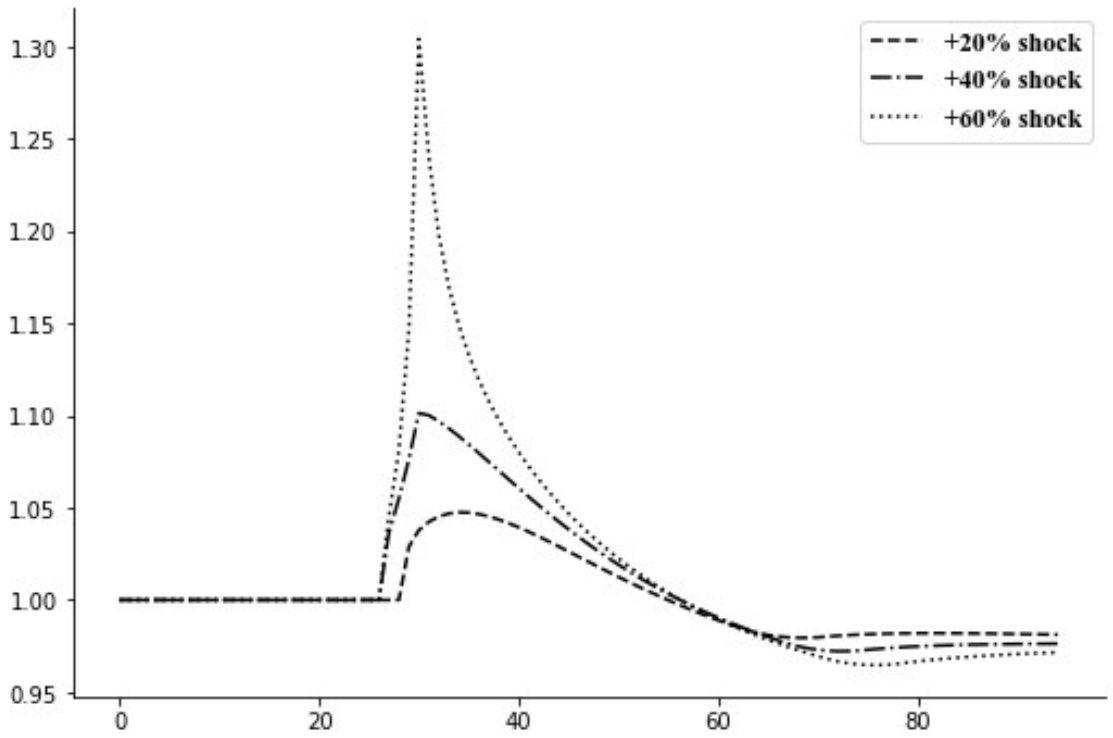

Figure 9. Evolution of the net value of retails banks, relative to the scenario without any activation of coco bonds, following an increase in the share of defaulted loans.

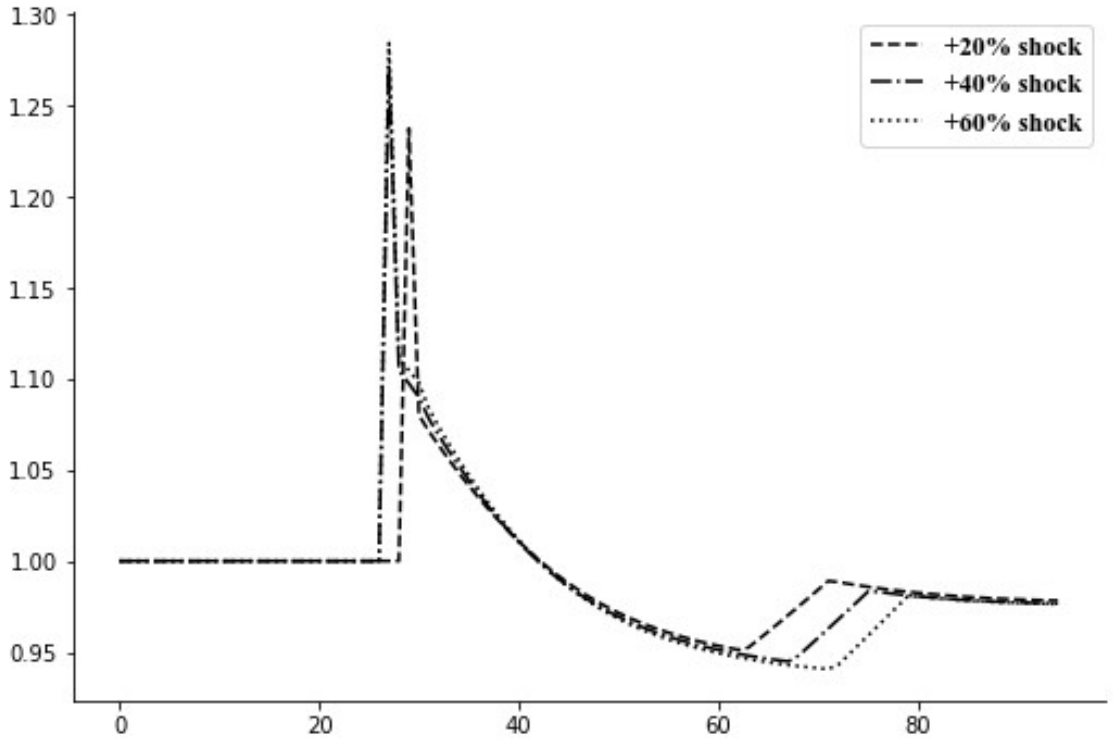

Figure 10. Evolution of profits of retails banks, relative to the scenario without any activation of coco bonds, following an increase in the share of defaulted loans.

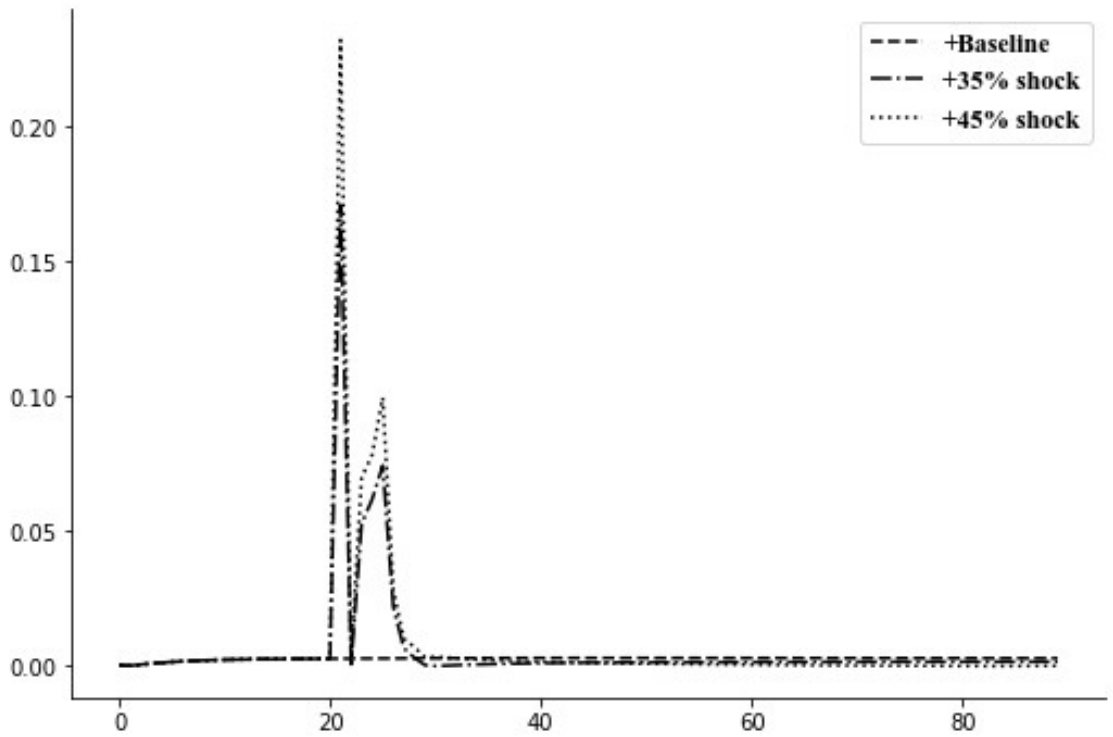

Figure 11. Standard deviation of firm equity prices following a decrease in preferences for them.

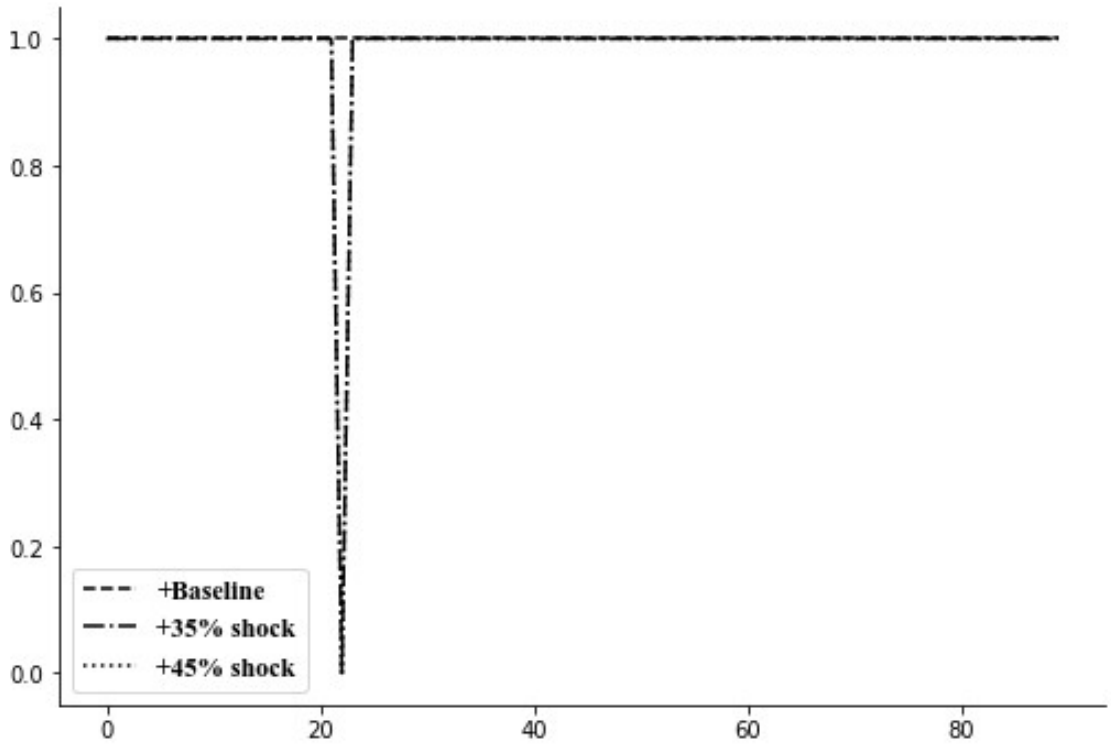

Figure 12. State of the contingent convertible trigger following a decrease in preferences for firm equities (1 = not activated ; 0 = activated).

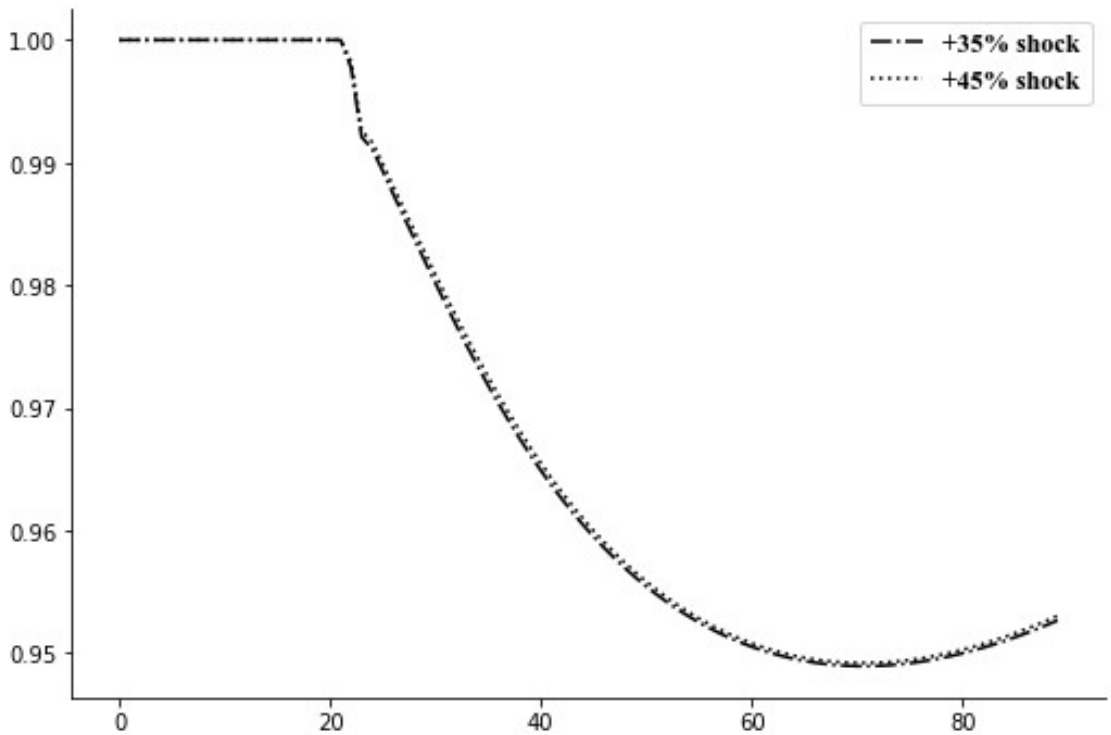

Figure 13. Evolution of the net values of firms, relative to the scenario without any activation of coco bonds, following a decrease in preferences for firm equities.

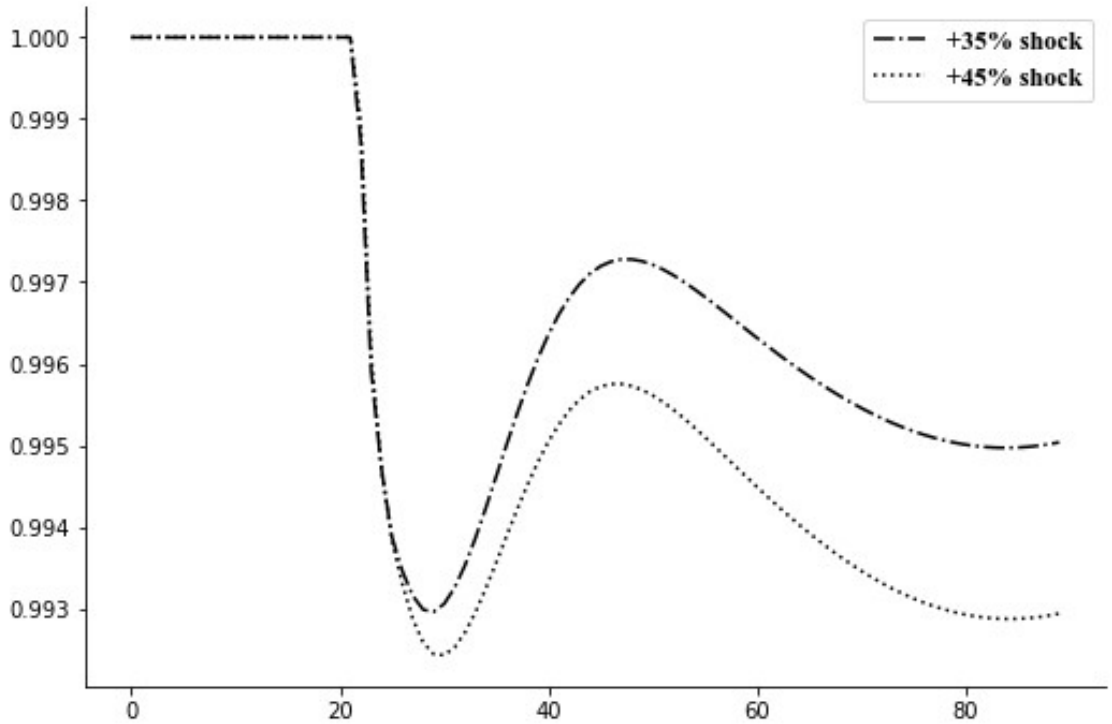

Figure 14. Evolution of Tobin's Q, relative to the scenario crisis without any activation of coco bonds, following a decrease in the preference for firm equities.

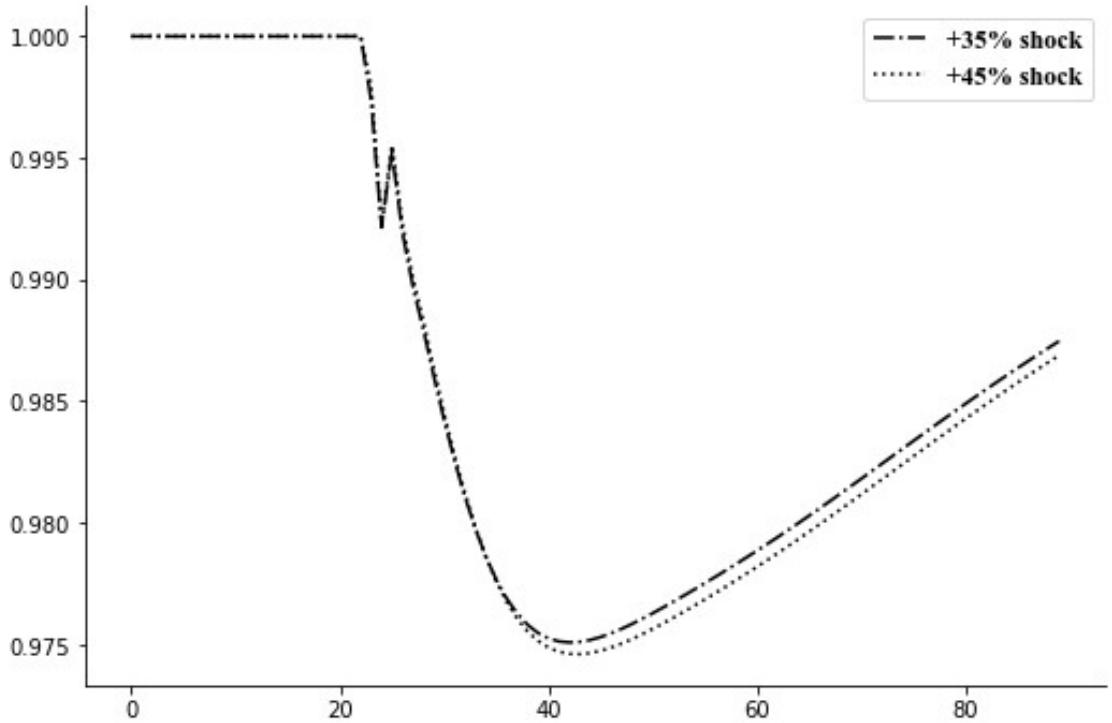

Figure 15. Evolution of the investment of firms, relative to the scenario without any activation of coco bonds, following a decrease in preferences for firm equities.

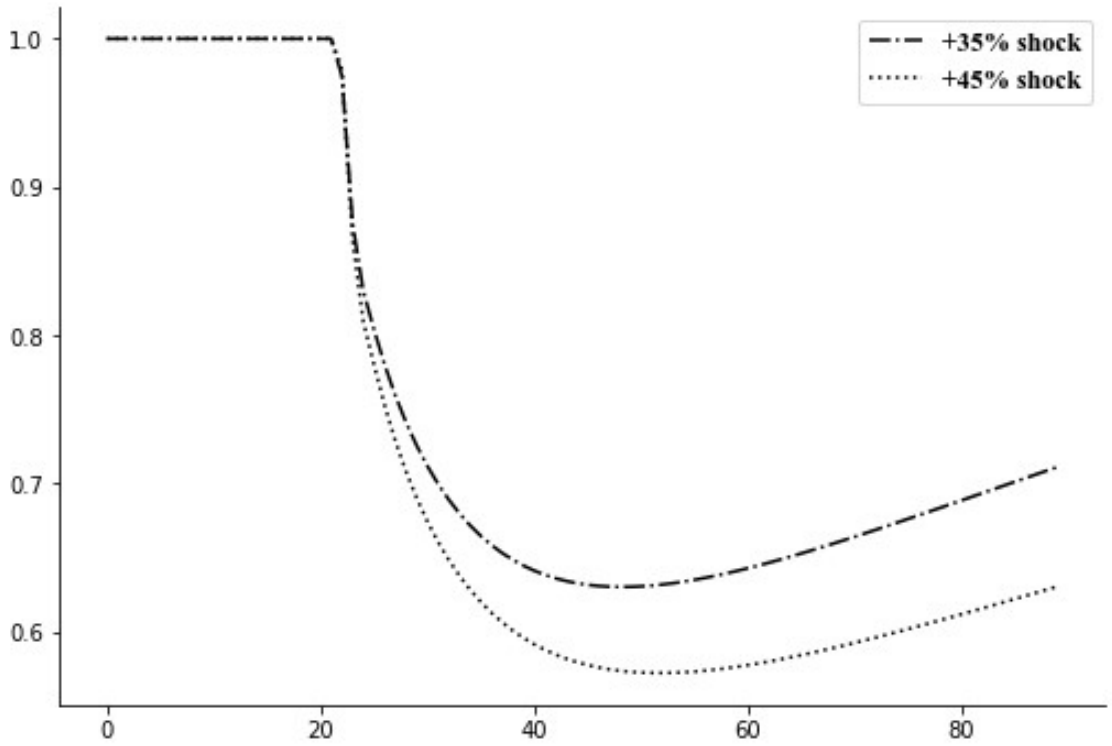

Figure 16. Evolution of the net values of investing households, relative to the scenario without any activation of coco bonds, following a decrease in preferences for firm equities.

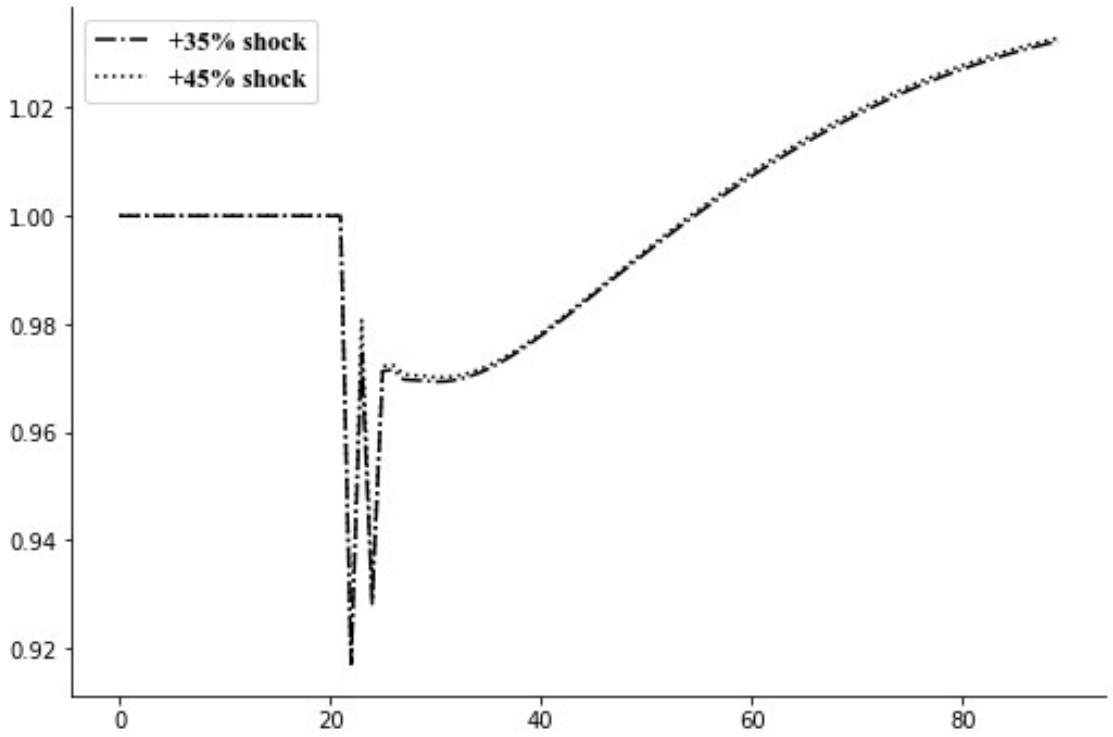

Figure 17. Evolution of the disposable income of investing households, relative to the scenario without any activation of coco bonds, following a decrease in preferences for firm equities.

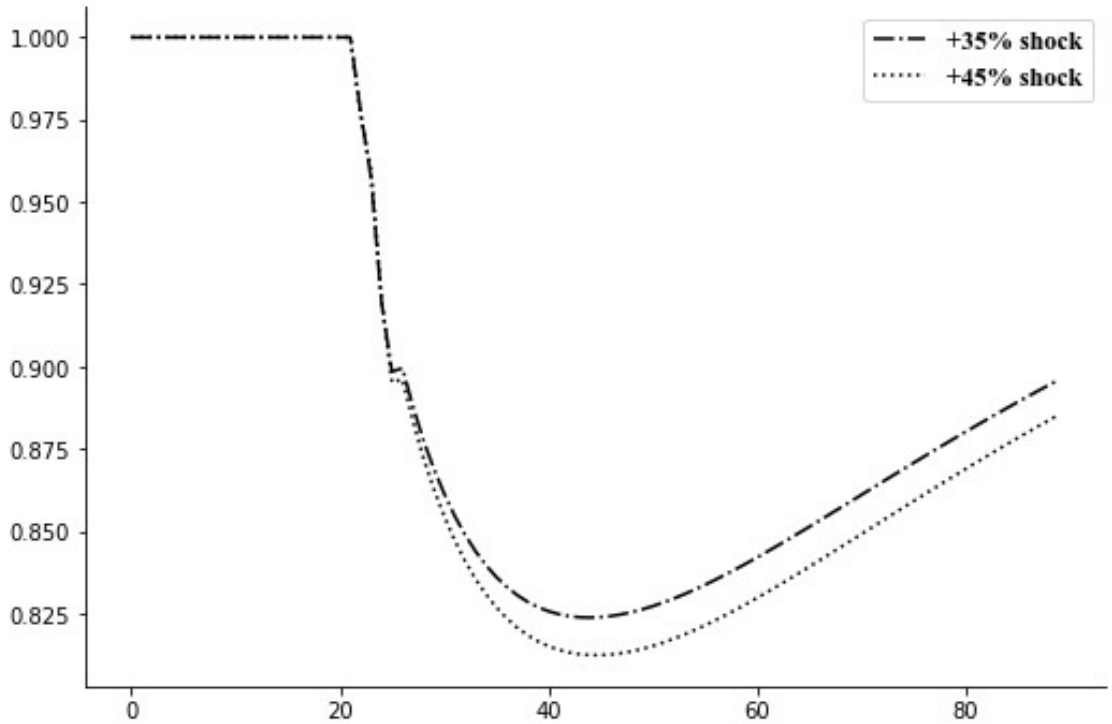

Figure 18. Evolution of the consumption of investing households, relative to the scenario without any activation of coco bonds, following a decrease in preferences for firm equities.

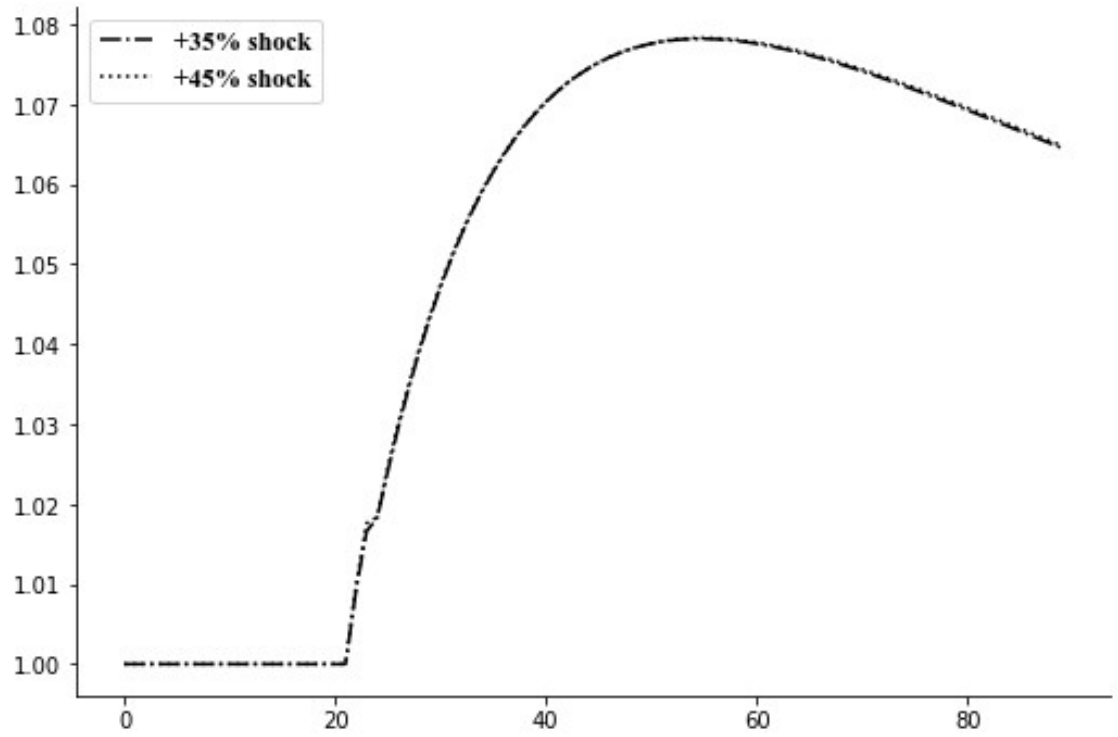

Figure 19. Evolution of the net value of investment banks, relative to the scenario without any activation of coco bonds, following a decrease in preferences for firm equities

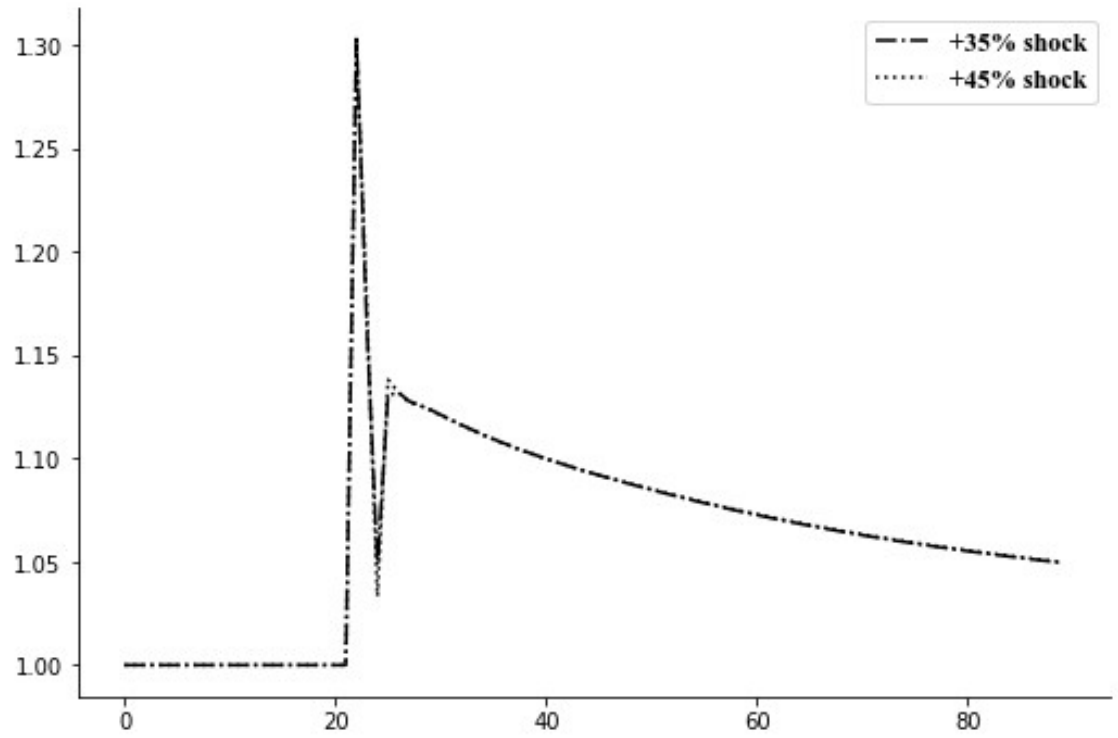

Figure 20. Evolution of the profits of investment banks, relative to the scenario without any activation of coco bonds, following a decrease in preferences for firm equities