A financial CGE assessment of the impact of a rise in commercial bank capital adequacy ratios.

Abstract

Financial regulators in Australia and overseas are requiring banks to raise additional capital. The benefits of this are understood in terms of reducing the risk of incurring the significant costs of another financial crisis. But there are potential costs from securing these benefits, in the form of unanticipated macroeconomic impacts as banks reduce leverage ratios. In this paper, we explore the economic consequences of a 100 basis point increase in commercial bank capital adequacy ratios using a financial computable general equilibrium model of the Australian economy. Chiefly for expository purposes, we investigate this under two scenarios: one in which the central bank tolerates a departure from maintenance of the policy rate (simulation 1), and one in which the central bank maintains the policy rate (simulation 2). In simulation 1, the economic cost of the increase in the capital adequacy ratio is high, with employment falling by about one third of a percent relative to baseline in the year that the capital adequacy ratio is increased. But there is every reason to expect that the central bank will maintain a given policy rate as the capital adequacy ratio is increased. In simulation 2, with the central bank policy rate maintained at baseline, there is little deviation in employment from baseline. This suggests that prudential regulators can move forward to secure the financial system stability benefits that they expect from higher capital adequacy requirements, without concern that significant costs will be imposed on the wider economy in the form of macroeconomic disruption.

1 Introduction

Following the events of 2008 and their aftermath, regulators are focused on reducing risks of another financial crisis. Policies affecting commercial bank leverage are important instruments in this regard. This follows from the role played by counterparty risk perceptions in the 2008 crisis. As described in IMF (2009), after approximately a year in which developed economy growth was slow due to U.S. mortgage market concerns, the default of Lehman Brothers in September 2008 precipitated a swift deterioration in financial market conditions. Counterparty risk perceptions peaked as bank asset values were written down, the U.S. Federal government underwrote short-falls in AIG's capacity to honour its insurance obligations, a number of prominent investment banks received emergency lines of credit from the Federal Reserve, and other private and semi-private institutions in the U.S. and Europe deemed systemically important were provided with government financial support (IMF 2009).

The crisis in financial markets quickly spilled to the real economy. A measure of the early assessments of the extent of the economic damage caused by the financial crisis can be seen in the IMF's April 2009 forecast for global real GDP growth, which they put at -1.3% (IMF 2009: xii). The realised growth rate for the year was ultimately lower, at -1.7% (UN 2015). These global figures obscure the severe impacts in those countries most directly affected by the financial crisis. Edey (2014) notes that U.S. output fell by approximately 4 per cent in the year to June 2009, and that the peak-to-trough falls in output in the U.K. and the euro area were approximately 7 per cent and 6 per cent respectively. Falls in household wealth compounded the pain of declining real incomes and employment. As reported by IMF (2009), in the first three quarters of 2008, the value of household financial assets fell in the U.S., the euro area, the U.K., and Japan by 8 per cent, 6 per cent, 8 per cent, and 5 per cent respectively. Losses continued into the fourth quarter of 2008 with further falls in the value of financial assets. Real asset prices also fell, with falls in house prices in the U.S., the U.K., and many other developed economies.

The IMF forecasts shed some light on the magnitude of the departure of actual output from potential output. However Ball (2014) raises the possibility that the financial crisis might have generated a persistent reduction in potential output relative to its pre-crisis trend. While details differ across the 23 OECD countries studied by Ball, in general he finds that the fall in potential output relative to the level it would otherwise have attained in the absence of the financial crisis is of approximately the same magnitude as the reduction in actual output relative to potential. Aggregating across the 23 countries of his sample, he finds an average reduction in potential output relative to its pre-crisis trend of approximately 8.4% in 2015. To put this in context, Ball notes that this is approximately equal to the share of the annual GDP of Germany in the sample.

Atkinson et al. (2013) argue that the benefits of avoiding financial crises can be understood in terms of avoiding the deep and long-lasting impacts on employment and national income that they cause. They estimate the losses for the U.S. economy at between 40 per cent and 90 per cent of one year's worth of output, or approximately $50,000-$120,000 per household. As they put it, estimates like this are helpful to policy makers, because they provide a measure of the potential benefits against which the costs of policies aimed at avoiding such financial crisis in the future can be weighed.

While Australia was spared economic damage of the magnitudes visited on the U.S. and many countries in Europe, it was not immune. Real GDP fell -0.8% in the September quarter of 2008, but then grew slowly in the following three quarters, providing a low but positive growth rate of 1.1 per cent in the year to September 2009. The unemployment rate increased by approximately one and one-half percentage points, rising from 4.3 per cent in September 2008, to 5.7 per cent by September 2009, with a peak in the intervening quarters at 5.9 per cent in June. Edey (2014) argues that one of the factors that insulated Australia from the worst effects of the financial crisis, in addition to fortuitous strength in the terms of trade, was effective leadership by the Australian Prudential Regulatory Authority (APRA). This saw Australian banks enter the crisis with reasonable capital buffers and sound asset positions that were not subject to material price impairments.

Consistent with its statutory purpose to promote financial system stability, APRA continues to monitor and regulate the proportion of commercial bank activities financed by equity. In July 2015 APRA released the results of its comparative study of the capital ratios of Australian and international banks. They noted that the capital ratios of Australia's major commercial banks were approximately 200 basis points short of the level necessary to place them in the top quartile of their international banking peers. This has generated policy action in the form of mandating increased risk weights on residential mortgages from July 2016, and a signal of intention over the next several years to see capital adequacy ratios rise by about 200 basis points.

While regulators understand the consequences of alternative capital adequacy ratios for financial sector resilience under various stress test scenarios, and understand the potential wider economic benefits in terms of avoiding economic damage of the scale experienced during the financial crisis, policy makers are less certain about the economic costs of mandating rises in bank capital. Modelling by the Bank for International Settlements (BIS 2010a, 2010b) of a 1 percentage point increase in the capital adequacy ratio, phased over four to eight years, suggests a range of potential GDP troughs of between approximately -0.05 per cent and -0.3 per cent at the end of the implementation periods. In this paper, we undertake simulations with a financial CGE model of the Australian economy to explore the economic consequences of a 100 basis point increase in commercial bank capital adequacy ratios. In undertaking these simulations, we build on the financial CGE model described in

Dixon *et al*. (2015). In particular, we develop the manner in which the commercial banking sector is modelled (particularly as it relates to the modelling of the capital adequacy ratio and risk weights on financial assets held by commercial banks). In the remainder of this paper we summarize the underlying financial CGE model (Section 2), expand on developments to the financial CGE model that are relevant to the current study (Section 2.2), and describe the simulations we have undertaken with the model and what we learn from them (Section 3).

2 The financial CGE model

In this section we provide a summary of the financial CGE (FCGE) model used in the simulations described in Section 3. For a detailed discussion of the model, we refer the reader to Dixon *et al*. (2015). We then go on to describe the developments to the financial CGE model specific to the simulations describing a rise in capital adequacy ratios.

2.1 Overview of the financial CGE model

While fully integrated, the FCGE model can nevertheless be broadly conceived as being comprised of two parts:

(i) A traditional CGE model describing the real side of the economy; and

(ii) A model of the interactions between financial agents and their links with the real side of the economy.

We expand on these two parts, and the important links between them, below.

The real side of the FCGE model is largely as described in Dixon and Rimmer (2002). It identifies:

1. A large number of industries, using inputs to produce commodities for use in current production, capital formation, private consumption, public consumption, and export. Each industry is modelled as an optimiser, using intermediate inputs (sourced domestically, and from overseas), labour, capital and land, in a cost-minimising fashion, to produce a given level of output. In choosing cost-minimising input combinations, each industry adjusts its input ratios in response to changes in the relative prices of intermediate inputs and primary factors.
2. Investors, producing physical capital for installation in each industry. Like the current producers identified above, investors act in an optimising fashion, adjusting their use of source-

specific inputs in response to changes in relative prices in order to produce given quantities of new units of industry-specific physical capital in a cost-minimising way. In determining how many new units of physical capital to install in each industry, investors are guided by movements in expected rates of return on physical capital.

3. A representative household, purchasing domestic and imported commodities for current consumption purposes. Households are also assumed to act as optimisers, maximising utility by choosing between alternative source-specific commodities subject to an aggregate consumption constraint.
4. A government sector, purchasing domestic and imported commodities for public consumption purposes.
5. An export sector, purchasing units of domestic production, and sensitive to the prices of that production via commodity-specific constant elasticity demand equations.
6. Providers of margin services (trade, transport, insurance and other margins), required to facilitate flows of commodities between producers, importers, households, government, investors and foreign agents in export markets.

Movements in relative prices reconcile the demand and supply sides of most commodity and factor markets through market clearing conditions. An important exception is the labour market, which is assumed to experience sticky wages in the short-run, but transition in the long run to an environment of wage flexibility and a given natural rate of unemployment. As we shall see, the sticky wage assumption has important consequences in the short-run, because it allows movements in the domestic price level to affect the real producer wage, and thus affect short-run employment. Foreign currency import prices by commodity are determined exogenously. Zero pure profit conditions in current production and capital formation determine basic prices for domestically produced commodities. Purchases prices differ from basic prices by the value of margin services and indirect taxes. In addition to indirect taxes, government revenue from direct taxes is identified, as are a variety of government outlays beyond public consumption spending (such as personal benefit payments and public investment). Together with variables describing foreign transfer payments, this provides sufficient detail for the identification of the government borrowing requirement, household disposable income, and household savings.

Real-side CGE models with characteristics such as those described above have been used for many decades to answer diverse and important policy questions. They are however silent on, or treat implicitly, the question of how a number of important transactions are financed. For example, how is investment spending financed? How does the cost of financial capital affect the decision to invest in physical capital? Who is financing the public sector borrowing requirement? How is the current account deficit financed? Who decides on how household savings are allocated? An important role of the financial part of the FCGE model is to answer these and related questions.

The core of the FCGE model is three arrays and the equations describing how the values in these arrays change through time. The three arrays are:

$A_{(s,f,d)}$ which describes the holdings by asset agent *d* (e.g. households, the banking sector) of financial instrument *f* (e.g. equity, loans, bonds) issued by liability agent *s* (e.g. households, government, industry).

$F_{(s,f,d)}$ which describes the flow of net new holdings by asset agent *d*, of financial instrument *f*, issued by liability agent *s*.

$R_{(s,f,d)}$ which describes the rate of return on financial instrument *f*, issued by liability agent *s*, and held as an asset by agent *d*.

Both asset agents and liability agents are assumed to be constrained optimisers. Broadly, liability agents are assumed to minimise the cost of servicing the liabilities they have issued, subject to a constraint that prevents them moving to corner solutions in the issuance of particular financial instruments to particular asset agents. Similarly, asset agents are assumed to maximise the return from their portfolio of financial assets, subject to a constraint that prevents them moving to corner solutions in the holding of particular financial instruments issued by particular liability agents. The solutions to these optimisation problems generate a set of return-sensitive supply equations (governing the issuance of financial instruments by liability agents) and return-sensitive demand equations (governing the demand for financial instruments by asset agents). In general, the joint solution to these supply and demand equations determines rates of return across financial instruments ($R_{(s,f,d)}$).

Results from the real side of the FCGE model (while determined endogenously and jointly with the financial side of the FCGE model) can be viewed as providing important constraints on the financial side of the model. Similarly, results for certain variables in the financial side of the FCGE model (while again, determined endogenously and jointly with the model's real side) exert an important influence on outcomes in the model's real side. For example:

- the public sector borrowing requirement determines new liability issuance by government;
- gross fixed capital formation by industry determines new liability issuance by industry;
- household savings determines new asset acquisitions by households;
- the current account deficit determines new asset acquisitions by foreigners;
- superannuation contributions determine new liability issuance by the superannuation sector;

- changes in the weighted average cost of financial capital influences the desirability of undertaking gross fixed capital formation.

At the same time, important linkages within the financial sector are modelled. For example, the commercial banking sector's roles as both a liability agent and as an asset agent are modelled, allowing detailed representation of the sector's activities in raising local and foreign deposit, bond and equity financing, and deploying the funds thus raised in the purchases of financial instruments such as loans to domestic industry for capital formation, and household mortgages for the purchase of new and existing dwellings. In this system, changes in the prospects for one financial agent can flow through to consequences for the costs of funds to other agents.

2.2 Modelling the capital adequacy ratio

Modelling of the capital adequacy ratio requires us to depart, for commercial banks, from the default modelling of asset and liability optimization on the part of financial agents as described in Dixon *et al*. (2015). In particular, the theory describing bank decision making over asset ownership must be changed to recognize differences in capital requirements across risky assets. Second, we must activate theory that allows movements in the capital adequacy ratio to affect the amount of equity that banks hold on the liability side of their balance sheets. These two matters are expanded upon below.

2.2.1 Asset demand by commercial banks

To model the effects of the capital adequacy ratio and risk weights on commercial bank behavior, we begin by modifying the standard theory in the FCGE model governing decision making by asset agents. We begin by assuming that the commercial banks (ComB) choose their end-of-year asset portfolio, AT1(s,f,ComB) for all s and f to maximize

$$\mathrm{U(R(s,f,ComB)*AT1(s,f,ComB),\ for\ \ all\ s\ and\ f\,)} \qquad (1)$$

subject to

$$\sum_{\mathrm{s,f}} \mathrm{AT1(s,f,ComB) = BB(ComB)} \qquad (2)$$

and

$$\sum_{d} AT1(ComB, equity, d) =$$

$$MAX\left[\sum_{d} AT1zero(ComB, equity, d), KAR * \sum_{s,f} W(s, f, ComB) * AT1(s, f, ComB)\right] \quad (3)$$

where

KAR is the capital adequacy ratio, $W(s, f, ComB)$ is the risk weight that the financial regulator assigns to AT1(s,f,ComB) and $AT1zero(ComB, equity, d)$ is the value of equity the commercial banks would sell in the absence of capital adequacy requirements. We assume that the KAR constraint is binding so $\sum_{d} AT1(ComB, equity, d) = KAR * \sum_{s,f} W(s, f, ComB) * AT1(s, f, ComB)$.

We assume that equity liabilities are expensive. Consequently we approximate problem (1) through (3) as:

Choose AT1(s,f,ComB) for all s and f

to maximize

$$U(NR(s, f, ComB) * AT1(s, f, ComB), \text{ for all s and f}) \quad (4)$$

subject to

$$\sum_{s,f} AT1(s, f, ComB) = BB(ComB) \quad (5)$$

where

$$NR(s, f, ComB) = R(s, f, ComB) - \Psi * KAR * W(s, f, ComB) \quad (6)$$

and

Ψ is a positive parameter.

In (6) we recognize that the commercial banks face a penalty when they expand their holding of asset (s,f,ComB). The penalty is that they have to increase expensive equity liability. We model the penalty as proportional to the capital adequacy ratio times the risk weight. The factor of proportionality, Ψ, reflects the difference between the cost of equity finance to the commercial banks and the cost of other liabilities. For example, with Ψ at 0.08, and KAR = 0.1, the penalty for a risky asset with weight 1 (W = 1) would be 0.008. If the capital adequacy ratio were increased to 0.125 then the penalty for risky assets would increase to 0.01 (an increase of 20 basis points), whereas the penalty for a less risky asset (W = 0.1, say) would barely move, from 0.0008 to 0.001 (an increase of

2 basis points). By changing the capital adequacy ratio and/or the risk weights the regulator can influence the asset choices of the commercial banks.

2.2.2 Commercial bank liabilities and equity

For details on the modelling of the liability side of commercial bank balance sheets, we refer the reader to Dixon *et al*. (2015), particularly pp. 9-10, 12-13 and 17-19. Here, we draw out the key parts of the discussion in that document that are relevant to the current simulation. In particular, we begin by reproducing the following four percentage change equations from Dixon *et al*. (2015):

(7)
$$\begin{aligned}&\text{RA\_BANK1} \times \text{p\_ra\_bank1} = \\ &\sum_{s\in LA}\sum_{f\in FI}[\text{RISKWGT}_{(s,f)} \times \text{AT1}_{(s,f,Banks)}]\times(\text{p\_riskwgt}_{(s,f)} + \text{a\_t\_1}_{(s,f,Banks)})\end{aligned}$$

(8)
$$\text{EQ\_BANK1}\times\text{p\_eq\_bank1} = \sum_{d\in AA}\text{AT1}_{(Banks,Equity,d)} \times \text{a\_t\_1}_{(Banks,Equity,d)}$$

(9)
$$\text{p\_ratio\_t1} = \text{p\_eq\_bank1} - \text{p\_ra\_bank1}$$

(10)
$$\begin{aligned}&\text{BIGBUDNEQ}_{(Banks)} \times \text{big\_budl\_neq}_{(Banks)} = \\ &\text{BIGBUDGETL}_{(Banks)}\times\text{big\_budl}_{(Banks)} - \sum_{d\in AA}\text{AT1}_{(Banks,Equity,d)}\times\text{a\_t\_1}_{(Banks,Equity,d)}\end{aligned}$$

(11)
$$\text{ave\_ror\_sne}_{(Banks)} = \sum_{d\in AA}\sum_{f\in FINEQ}[\text{AT1}_{(Banks,f,d)} / \text{BIGBUDNEQ}_{(Banks)}]\times\text{roipowl}_{(Banks,f,d)}$$

(12)
$$\begin{aligned}&\text{a\_t\_1\_d}_{(Banks,f)} = \text{big\_budl\_neq}_{(Banks)} + \\ &(\text{TAU-1})\times[\text{roipowl\_d}_{(Banks,f)} - \text{ave\_ror\_sne}_{(Banks)}]\end{aligned} \qquad (f \in \text{FINEQ})$$

where:

$\text{BIGBUDGETL}_{(Banks)}$ is the level of total end-of-year commercial bank liabilities (including equity);

$\text{BIGBUDNEQ}_{(Banks)}$ is the level of the equity-exclusive value of end-of-year commercial bank liabilities;

RA_BANK1 is the level of the value of end-of-year risk-weighted bank assets;

$\text{RISKWGT}_{(s,f)}$ is the level of the risk weights attaching to financial instrument *f* issued by liability agent *s*;

$AT1_{(s,f,d)}$ is the level of end-of-year holdings by agent *d* of asset type *f* issued by agent *s*;

TAU is a parameter governing the sensitivity of the composition of commercial bank liabilities to changes in the relative costs of financial instruments issued to particular asset agents;

p_ra_bank1 is the percentage change in risk-weighted bank assets;

$p\_riskwgt_{(s,f)}$ is the percentage change in the value of the risk weight attached to commercial bank holdings of financial instrument *f* issued by liability agent *s*;

$a\_t\_1_{(s,f,d)}$ are the end-of-year holdings by agent *d* of asset type *f* issued by agent *s*;

p_eq_bank1 is the percentage change in end-of-year bank equity;

p_ratio_t1 is the percentage change in the capital adequacy ratio;

$big\_budl\_neq_{(Banks)}$ is the percentage change in the equity-exclusive value of commercial bank liabilities;

$big\_budl_{(Banks)}$ is the percentage change in end-of-year (equity-inclusive) commercial bank liabilities;

$ave\_ror\_sne_{(Banks)}$ is the percentage change in the average rate of return on non-equity financial instruments issued by commercial banks as liability agents;

$roipowl_{(Banks,f,d)}$ is the percentage change in the power (1 plus the rate) of the rate of interest / return paid to asset agent *d* on financial instrument *f* issued by commercial banks as liability agents;

$a\_t\_1\_d_{(Banks,f)}$ is the percentage change in end-of-year non-equity liabilities ($f \in FINEQ$ i.e., deposits, loans, and bonds) issued by commercial banks as liability agents;

$roipowl\_d_{(s,f)}$ is the percentage change in the average power of the rate of interest / return paid by commercial banks on non-equity financing instrument *f*.

Equation (7) calculates the percentage change in the risk-weighted value of end-of-year commercial bank assets. The risk weight on financial instrument *f* issued by liability agent *s* and held as an asset by commercial banks is given by $RISKWGT_{(s,f)}$. Table 1 reports initial values for the risk weights in Equation (7). In choosing values for $RISKWGT_{(s,f)}$, we were guided by values reported in Attachments A and D of (Australian Prudential Regulatory Authority, 2013). Equation (8) calculates the percentage change in end-of-year bank equity as the share weighted sum of the percentage changes in bank equity held by all asset agents. Equation (9) calculates the percentage change in the capital adequacy ratio, defined as the ratio of end-of-year bank equity to risk-weighted assets.

With equation (9) activated, in the sense that *p_ratio_t1* is determined exogenously, thus enforcing a given ratio of equity to risk-weighted assets, we must provide for the non-equity component of bank financing to be determined outside of the standard liability optimisation mechanisms summarised in Section 2 above and detailed in Section 3.8 of Dixon *et al*. (2015). This is provided by equations (10), (11) and (12). Equation (10) calculates the non-equity financing needs of commercial banks ($big\_budl\_neq_{(Banks)}$) as the difference between total (equity-inclusive) bank financing needs ($big\_budl_{(Banks)}$) and that part of bank financing needs satisfied by equity. Equation (11) calculates the weighted average value of the cost of non-equity finance to agent (s). Equation (12) establishes bank liability optimising behaviour over the issuance of non-equity financing instruments.

Table 1: Risk weights on commercial bank assets

Parameter	**Description**	**Value**[(a)]
$RISKWGT_{(CB,f)}$ $(\forall\ f \in FI)$	Liabilities issued by the Central Bank.	0
$RISKWGT_{(Govt,f)}$ $(\forall\ f \in FI)$	Liabilities issued by the domestic government.	0
$RISKWGT_{(s,Cash)}$ $(\forall\ s \in LA)$	Cash.	0
$RISKWGT_{(s,Equity)}$ $(\forall\ s \in LA)$	Equity.	3.0
$RISKWGT_{(Foreigners,DeposLoans)}$	Loans to foreign agents.	0.4
$RISKWGT_{(Inds,DeposLoans)}$	Loans to domestic industry.	0.4
$RISKWGT_{(NonBankFinIn,DeposLoans)}$	Loans to non-bank financial intermediaries.	0.4
$RISKWGT_{(NRH,DeposLoans)}$	Loans to the non-reproducible housing sector.	0.35
$RISKWGT_{(RH,DeposLoans)}$	Loans to the reproducible housing sector.	0.5
$RISKWGT_{(NonBankFinIn,Bonds)}$	Bonds issued by non-bank financial institutions.	0.4
$RISKWGT_{(Foreigners,Bonds)}$	Foreign bonds.	0.4
(a) In choosing values for RISKWGT, we were guided by Attachments A and D of Prudential Standard APS 112 (APRA 2013).		

3 Simulations

3.1 Backround

In July 2015 the Australian Prudential Regulatory Authority released the results of its comparative study of the capital ratios of Australian banks and their international peers. In this they indicated that the capital ratios of Australia's major commercial banks were approximately 200 basis points short of the level necessary to place the banks in the top quartile of their international banking peers on this measure (APRA 2015). In the simulations below, we raise the average capital adequacy ratio by 100 basis points.

3.2 Model closure

In Sections 3.3 and 3.4 we undertake simulations in which we raise the capital adequacy ratio by 100 basis points. The two simulations are identical in respect to certain closure assumptions relating to the labour market and the public sector, but differ in respect to the modelling of monetary policy. With respect to the latter, to aid exposition, we begin in Section 3.3 with a simulation in which the central bank does not take action to maintain its policy interest rate. The purpose of this assumption is to isolate effects and advance the discussion, not to represent a likely monetary policy response, so we move on in Section 3.4 to the case where the central bank maintains its policy interest rate as the capital adequacy ratio is increased. As we shall see, this largely mitigates the macroeconomic consequences of the increase in the capital adequacy ratio, while leaving in place its effects on bank lending and financing behavior.

While Simulations 1 and 2 differ in terms of closure assumptions describing the response of the central bank, they share common closure assumptions in all other respects. Two important closure assumptions that have a bearing on the simulation relate to:

i) Wage determination. We assume that the nominal wage is sticky in the short run, but sufficiently flexible over the medium term to ensure that the unemployment rate is returned to its natural rate.

ii) The public sector. We assume that real public consumption spending is unaffected by the movement in the capital adequacy ratio. At the same time, we assume that the ratio of the public sector borrowing requirement to GDP is exogenous. The exogenous status of both the PSBR / GDP ratio and public consumption spending requires the flexible determination of at least one government revenue raising instrument. To this end, we endogenously determine a direct tax on household income.

3.3 Simulation 1: Effects of a rise in the capital adequacy ratio, with no central bank action to maintain the policy interest rate.

We begin by investigating the effects of a 100 basis point increase in the capital adequacy ratio under an environment in which the central bank takes no action to maintain a given level for the policy interest rate. This allows us to isolate the effects of one shock (the increase in the capital adequacy ratio). In Section 3.4 we move to a more realistic description of central bank behavior, implementing the same increase in the capital adequacy ratio, but in an environment in which the central bank maintains a given level for the policy interest rate.

The shock is a 100 basis point increase in the capital adequacy ratio of commercial banks (Figure 3). Via the theory and mechanisms described in Section 2.2, this causes banks to undertake adjustments to the composition of both the liability and asset sides of their balance sheets. On the liability side, the increase in the capital adequacy ratio causes commercial banks to increase their issuance of equity instruments, and decrease their reliance on deposit and bond financing (Figure 4). On the asset side of bank balance sheets, the rise in the capital adequacy ratio induces commercial banks to reduce their holdings of risky assets. We see this expressed in Figure 5 and Figure 6. In Figure 5, we see a decline in risk-weighted assets relative to total bank assets. In Figure 6, we see the composition of bank asset holdings shifting away from assets with comparatively high risk weightings (loans to reproducible housing, foreign equity, loans to industry) towards those with lower risk weightings (domestic government bonds, loans to non-reproducible housing).

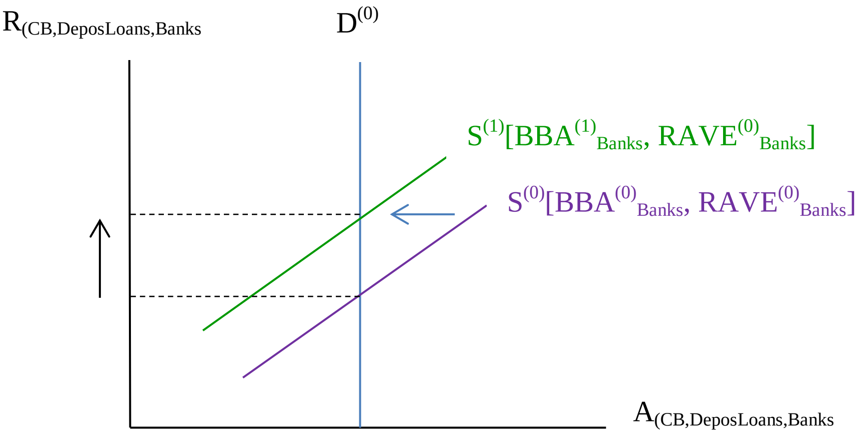
In Figure 4, we see commercial banks raising additional equity finance, and reducing their demands for deposit and loan finance. To attract asset agents to acquire the new equity, rates of return on bank equity must rise (Figure 7). At the same time, commercial banks reduce their demand for loan finance, allowing them to secure loan and deposit financing at slightly lower rates of return relative to baseline (Figure 7).

Figure 8 reports the deviation in the weighted average cost of capital to commercial banks. The increase in the capital adequacy ratio causes the average cost of bank funds to rise relative to baseline by about 2 basis points.

Figure 9 reports the deviations in the financial assets and liabilities of commercial banks. As discussed in Dixon *et al*. (2015), commercial banks are assumed to operate under an environment of a fixed difference between the aggregate return they earn on financial assets and the aggregate return they must pay on their financial liabilities. This has the effect of requiring the commercial banks to pass on the increase in the cost of their financial capital (Figure 8) to the agents to whom they are lending. This reduces demand for loans from commercial banks, that is, it leads to a contraction in commercial bank ownership of financial assets (Figure 9). Hence, commercial banks need to raise less financial capital to acquire this smaller pool of financial assets. That is, it leads to a contraction in commercial bank financial liabilities (Figure 9).

Figure 10 reports the movement in the interest rates that the central bank offers on deposits by commercial banks, and charges commercial banks for loans. We model the market for commercial bank deposits with the central bank, for a given level of open market operations by the central bank, as being in equilibrium at an endogenous interest rate in the presence of an exogenous level of deposit demand by the central bank. The interest rate at which the central bank provides loans to commercial banks is endogenously determined as a fixed mark-up (at 50 basis points) over this rate. In Figure 10 the cash rate rises because, as we have already discussed in the context of Figure 9, bank balance sheets contract when the capital adequacy ratio is increased. This causes commercial banks to wish to hold fewer deposits with the central bank at any given level of the central bank deposit rate. Because the central bank wishes to leave commercial bank deposits with it unchanged at a level consistent with their function in facilitating exchange settlement activities, and because for the moment we have assumed no change in central bank open market operations, the central bank must raise the deposit rate it offers commercial banks. This is described in Figure 1.

Figure 1: Market for commercial bank deposits with the central bank



The *x*-axis plots commercial bank deposits with the central bank. That is, in terms of the nomenclature introduced in Section 2.1, $A_{(CB,\ DeposLoans,\ Banks)}$ describes deposits by commercial banks with the central bank. The S-schedule plots desired deposits by commercial banks with the central bank at different levels of the interest rate offered by the central bank on commercial bank deposits. Note that the S-schedule is drawn for a given level of commercial bank assets (BBA) and a given average rate of return on commercial bank assets in general ($RAVE^{(0)}_{Banks}$). The D-schedule plots the central bank's desire for deposits from commercial banks. It is vertical because we assume that the central bank requires commercial banks to hold a given level of deposits with it for exchange settlement purposes. As discussed in the context of Figure 9, the simulation causes bank balance sheets to contract. In terms of Figure 1, this causes the S-schedule to shift from $S^{(0)}$ to $S^{(1)}$ as bank assets contract from $BBA^{(0)}$ to $BBA^{(1)}$. With bank assets smaller, the central bank must increase the deposit rate it offers commercial banks ($R_{(CB,DeposLoans,Banks)}$) in order to maintain a given level of commercial bank deposits. This accounts for the increase in the policy rate reported in Figure 10.

An interesting element of the simulation is that, while the average cost of bank funds rises by about 2 basis points in the simulation's first year, the cost of funds to government rises by more, at about 9 basis points (Figure 11). This reflects a fall in demand for government bonds by asset agents, relative to the supply of government bonds by government. With regard to the supply of government bonds, the public sector financing requirement changes little relative to baseline, because we assume that the ratio of the public sector borrowing requirement to GDP remains at its baseline level (see discussion in Section 3.2). This suggests that the rise in rates of return on government bonds arises from a decline in demand for government bonds for any given level of the government bond rate. To identify the source of this decline, it is helpful to begin by considering which agents are the major holders of government bonds. Examining the model database for 2013, we see that the largest holders of government bonds are commercial banks (holding 21% of government bonds), the central bank (holding 4.9%), foreigners (holding 54%), non-bank financial intermediaries (holding 8.4%), superannuation (holding 7.6%) and life insurance (holding 3.7%). This suggests three sources of decline in demand for government bonds for any given level of their rate of return:

(i) A reduction in household savings. As will be discussed below, the rise in the capital adequacy ratio, in the absence of effort by the central bank to maintain the policy rate, results in a short-run fall in employment, and thus national income. This reduces savings relative to baseline. This reduces fund flow to asset agents that purchase government bonds, such as commercial banks, and superannuation.

(ii) The contraction in the asset side of bank balance sheets. This reduces demand for financial instruments in general by commercial banks. Because commercial banks are an important holder of government bonds, ceteris paribus, this reduces demand for government bonds. Nevertheless, in Figure 6, we see little change, in the simulation's first year, in commercial bank holdings of government bonds. This reflects two things. First, despite the activity effect of the reduction in the size of asset demand in general by commercial banks, the low risk weight on government bonds sees a rise in their relative post-financing rate of return as perceived by the commercial banks (see equation 6). This induces substitution on the part of commercial banks towards government bonds. Second, this effect is reinforced by the fact that the pre-financing rate of return on bonds rises (Figure 11).

(iii) Bank lending to non-bank financial institutions and life insurance firms carry positive risk weights. The rise in the capital adequacy ratio reduces the post-financing return available to commercial banks on financial instruments issued by NBFIs and life insurance. Banks thus reduce their holdings of the liabilities issued by NBFIs and life insurance. Both sectors are important holders of government bonds. As such, the rise in the capital adequacy ratio creates an indirect reduction in demand for government bonds via reduced commercial bank financing of NBFI and life insurance activity.

(iv) Foreigners are an important source of demand for government bonds. But foreigners are also an important source of demand for commercial bank equity. For a given level of foreign demand for Australian financial assets, the rise in the rate of return on bank equity induces substitution on the part of foreign agents away from other Australian financial instruments, including government bonds.

Government bonds issued by Australian governments are an important component of the portfolios of foreign asset agents (54% of government bonds are owned by foreign asset agents, and government bonds represent approximately 9% of the Australian asset holdings of foreign agents). The initial peak in the government bond rate (Figure 11) causes a short-run positive deviation in the average rate of return that foreign asset agents receive on their holdings of Australian assets (Figure 12).

Approximately 12% of commercial bank assets are offshore, largely in the form of loans. These carry positive risk weights, leading to a substitution out of these assets when the capital adequacy ratio is increased. This is apparent in Figure 13, where we see foreign asset holdings by Australian commercial banks contracting by slightly more than risk weighted assets in general, and by significantly more than commercial bank assets in total.

For any given level of the current account deficit financing requirement, the factors described in the above two paragraphs introduce two sources of pressure for nominal appreciation. First, the rise in the government bond rate raises demand by foreigners for domestic government bonds. However, for a given level of the current account deficit, the additional capital inflow is in excess of that required. The resulting nominal appreciation raises the foreign currency value of foreign holdings of domestic assets, attenuating the foreign agent's desire for capital inflow. Second, a reduction in demand by Australian commercial banks for foreign assets has the effect, ceteris paribus, of moving the country to a position of net capital inflow. However, in the absence of a rise in the current account deficit financing requirement, this requires a matching reduction in foreign capital inflow to Australia. For a given ratio of domestic returns on financial assets to foreign returns on financial assets, this is achieved by nominal appreciation (Figure 14).

The appreciation of the nominal exchange rate generates a negative deviation in the domestic price level by damping the prices of imports and domestically produced traded goods relative to baseline (Figure 14). As discussed in Section 3.2, the nominal wage is sticky in the short-run. Hence, in the simulation's first year, the decline in the domestic price level causes the real producer wage to rise relative to baseline, causing a negative deviation in employment (Figure 15). Thereafter, the wage gradually adjusts to return the employment rate (and thus employment) back to its baseline level. This process is lagged, with the wage in year *t* adjusting gradually to year *t*-1 employment conditions. This generates a negative deviation in the real producer wage in the simulation's third and fourth years that is in excess of that required to return the employment rate back to its natural rate, leading to a positive deviation in employment in these years.

The initial negative deviation in employment generates a negative real GDP deviation in the simulation's first year (Figure 16). Real GDP is higher than baseline in the simulation's third and fourth years, due to the positive deviation in employment in these years, although damped somewhat by a negative deviation in the short-run capital stock (Figure 16).

The short-run negative deviation in the capital stock has two sources:

(i) a short-run negative investment deviation, arising from the short-run negative deviation in the marginal product of capital caused by the short-run negative deviation in employment; and,

(ii) a reduction in bank lending, particularly to housing investment.

Figure 17 reports the deviations in the average rental price of capital and the investment price deflator. In the simulation's first year, the deviation in the average capital rental price is significantly lower than that of the investment price deflator, signaling a decline in the rate of return on physical capital. The relatively large decline in the average capital rental price in the simulation's first year is due to the negative deviation in employment in that year (see Figure 15) which causes the labour / capital ratio to fall relative to baseline, and thus lowers the marginal product of capital relative to baseline. The decline in the rate of return on physical capital apparent in Figure 17 contributes to the negative deviation in real investment in the simulation's first year (Figure 18). However as is clear from Figure 18, the magnitude of the initial negative deviation in housing investment is more than twice that of non-housing investment. This reflects the importance of bank finance in housing investment relative to non-housing investment.[1] This is the second of the sources of decline in real investment in the simulation's first year: the rise in the capital adequacy ratio causes a rise in the cost of funds borrowed from banks. The resulting increase in the cost of financial capital to industry and the reproducible housing sector causes a reduction in capital formation for any given level of the marginal product of capital in these sectors. This effect is more important for reproducible housing than it is for industry, because the former sector sources approximately twice as much of its financial capital from the banking sector.

3.4 Simulation 2: Effects of a rise in the capital adequacy ratio, with central bank action to maintain the policy interest rate.

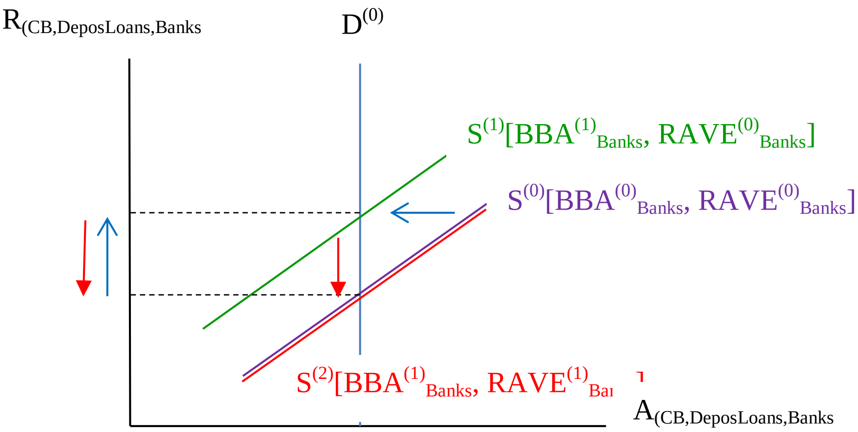
In Simulation 1 the central bank takes no action in the face of the macroeconomic consequences of the rise in the capital adequacy ratio. As discussed in reference to Figure 10, this inaction is reflected in a rise in the interest rate on commercial bank deposits with the central bank. In Simulation 2 we assume that the central bank takes action to leave this rate unchanged. This is reported in Figure 19, where we see the central bank deposit rate unchanged from baseline in Simulation 2. We assume that the central bank maintains the policy rate by supplying sufficient exchange settlement balances via open market operations.[2] This is described in Figure 2, where we see central bank open market operations moving the average return on bank assets from $RAVE^{(0)}_{Banks}$ to $RAVE^{(1)}_{Banks}$, inducing banks to hold the required level of exchange settlement balances at the old cash rate. In Simulation 1, the weighted average cost of government borrowed funds rose by almost 10 basis points in the simulation's first year (Figure 11). In Figure 20 we see that the effect of maintaining a constant level of the policy rate is to leave the cost of government funds largely unchanged from baseline. This is in part due to open market operations, but is also due to the fact that the magnitude of the real GDP deviation in

[1] Approximately 24 cents in the dollar of non-housing investment is financed by banking lending. For housing investment, this figure is approximately 50 cents in the dollar.

[2] This is consistent with early descriptions of how the Reserve Bank affects changes in the policy rate. For example, Lowe (1995, p.3): "Monetary policy operates via the Bank influencing the interest rate paid on overnight funds (the "cash rate")…The Bank's influence over the cash rate comes from its ability to control the availability of funds used to settle transactions between financial institutions. By undertaking open market operations, principally in government securities with less than one year to maturity, the Bank controls the availability of settlement funds and hence the interest rate paid on overnight deposits". However the mechanism is less consistent with more recent descriptions that downplay the need for the central bank, to achieve its desired change in the cash rate, to undertake additional action beyond its announcement of a change in the policy rate corridor. We expect to develop the monetary policy mechanism in the model further in this direction in future work. This development work is unlikely to change the conclusions in this section, as they largely follow from the idea that market interest rates remain little changed in line with the absence of change in the cash rate, rather than the details of the mechanism that link the desired policy rate and the actual cash rate.

Simulation 2 is much reduced relative to simulation 1. This leaves domestic savings, and by extension, demand for government bonds by domestic savers, little changed in Simulation 1 relative to Simulation 2.

Figure 2: Central bank actions to leave the deposit rate unchanged



With the government bond rate lower in Simulation 2 than in Simulation 1, substitution by asset agents pushes down rates of return across financial instruments and liability agents in general. As such, while in Simulation 1 we saw a positive deviation in the average rate of return on domestic assets (Figure 12), in Simulation 2 we see little change from baseline in the average return on domestic financial assets (Figure 21).

As is clear from Figure 21, the effect of maintenance of the policy rate at its baseline level is to lower the rate of return on Australian financial assets in Simulation 2 relative to Simulation 1. Relative to Simulation 1, this reduces the desire on the part of foreign financial agents to increase their holdings of Australian financial assets. Hence, we would expect to find a lesser movement towards nominal appreciation in Simulation 2 relative to Simulation 1. This is confirmed in Figure 22, where we see little deviation in the nominal exchange rate from baseline. With the nominal exchange rate little changed from baseline, we also see little deviation in the GDP deflator in Figure 22.

Figure 23 reports the deviations in the nominal wage rate, the GDP deflator, and employment, under Simulations 1 and 2. With the nominal wage sticky, the fact that there is little impetus for movement in the GDP deflator in Simulation 2 means that there is little impetus for movement in the real producer wage. As such, we see little change in employment in Simulation 2 relative to baseline (Figure 23). With the employment deviation in Simulation 2 much reduced relative to Simulation 1, so too is the real GDP deviation (Figure 24).

So far, we have focused on macroeconomic outcomes. These suggest that standard central bank practice (i.e. maintenance of a given policy rate at target) allows the rise in the capital adequacy ratio to be accommodated with little impact on the macro economy. That is, as discussed above, by keeping the central bank deposit rate unchanged from baseline, the central bank reduces the impetus for movement in the nominal exchange rate, and with it, the real wage and employment. We now turn our attention from macroeconomic effects to the behavior of commercial banks.

In Figure 25, we see that, just as in Simulation 1, the rise in the capital adequacy ratio continues to generate a positive deviation in the weighted average cost of bank capital. However, particularly in the short-run, the deviation is lower than under Simulation 1. This reflects the outcomes in Figure 20 and Figure 21, which show that maintenance of the central bank's policy rate keeps returns on government liabilities (Figure 20) and Australian financial assets in general (Figure 21) close to baseline. For banks, government bonds and other domestic financial assets represent competing destinations for the financial capital from which they might otherwise finance their operations at the margin. With rates of return on other financial assets lower in Simulation 2 relative to Simulation 1, commercial banks can attract funds at slightly lower rates of return in Simulation 2 relative to Simulation 1. This accounts for the smaller deviation in the weighted average cost of bank capital in Simulation 2 relative to Simulation 1 (Figure 25).

Turning to the liability side of bank balance sheets, we see in Figure 26 that the strength of the change in the composition of bank funding towards equity finance is as strong in Simulation 2 as it is in Simulation 1. Note that while the magnitude of the substitution away from deposit/bond finance and towards equity finance is very similar to Simulation 1, all curves are displaced upwards under Simulation 2 in Figure 26. This reflects the fact that bank balance sheets contract by less in Simulation 2 than in Simulation 1 (Figure 27). This is consistent with the smaller rise in the weighted average cost of commercial bank capital in Simulation 1 relative to Simulation 2, which has the effect of restricting commercial bank lending by less in Simulation 2 than in Simulation 1.

Figure 28 reports the deviations in bank lending to key liability agents (reproducible and non-reproducible housing, industry, and foreigners). Consistent with the discussion above describing the smaller contraction in commercial bank balance sheets under Simulation 2 relative to Simulation 1, we see in Figure 28 that the magnitude of the contractions in bank lending to key liability agents is smaller under Simulation 2. However the relative contractions are very similar, with lending to foreigners and reproducible housing declining by more than lending to non-reproducible housing. One difference is that lending to industry experiences a smaller relative contraction in Simulation 2. This reflects the absence in Simulation 2 of the short-run general contraction in economic activity that characterized Simulation 1, and which damped industry investment in that simulation for any given level of willingness by commercial banks to lend for business investment purposes.

Figure 29 reports deviations in gross fixed capital formation in the housing sector and the broader economy. As discussed above, because the employment trough is greatly mitigated in Simulation 2 relative to Simulation 1, so too is the initial trough in real investment. However, like Simulation 1, the rise in the capital adequacy ratio reduces bank lending to housing investment relative to non-housing investment. This accounts for the reduction in housing investment relative to non-housing investment in Figure 29.

Figure 30 explores the implications of reduced bank lending to housing for the composition of the liability side of housing balance sheets. As is clear from Figure 30, the financing of reproducible housing shifts towards equity and away from loan finance. This suggests a second avenue via which the rise in the capital adequacy ratio potentially improves financial stability. Not only are commercial banks encouraged to finance a greater proportion of their operations by equity, but by raising the cost of bank debt finance, households are also encouraged to finance a greater proportion of their stake in the reproducible housing sector via equity.

4 Conclusions and future work

Prudential regulators in Australia and many other countries monitor and regulate the proportion of commercial bank activities financed by equity. Their concern is to ensure that banks have sufficient loss-absorbing capital to maintain financial system resilience in the event of adverse shocks to individual banks or the banking system as a whole, with the aim of avoiding in the future economic damage of the magnitudes experienced by advanced economies following the 2008 financial crisis. But can the raising of commercial bank capital adequacy impose its own economic costs? We investigate this by examining the effects of a 100 basis point increase in the capital adequacy ratio of commercial banks. We find that this has modest macroeconomic impacts while securing a rise in bank capital, a shift in bank lending away from residential housing investment, and a rise in household equity financing of home ownership. This result is contingent on a policy environment in which the central bank maintains a given policy rate at the same time that capital adequacy ratios are increased. But this is a reasonable expectation: not only does the Reserve Bank act to avoid short-run volatility in the policy rate, it is concerned that its policy rate choices are consistent with macroeconomic stability.

In future work, we plan to extend the modelling reported in this paper in two main directions. First, in this paper our simulations are concerned with investigating the economic costs of raising capital adequacy ratios, while taking as given the idea that financial regulators have a considered view on the benefits, in terms of financial stability, of a given increase in capital requirements. In future work, we expect to investigate the impact on financial stability of changes in the share of equity in commercial bank financing. To do this, we will need to develop the model further, embedding theory explaining how financial stability is affected by changes in equity / debt financing ratios in both commercial banking and housing finance. The aim will be to model factors that can quickly affect financial stability, such as bank runs, or rapid house price deflation. Modelling of the former is likely to require explicit modelling of how the willingness of asset agents to hold commercial bank deposits is a function of perceived bank stability, with one input to these perceptions being the margin of remaining loss absorbing capital. Modelling of the latter is likely to require explicit modelling of real estate bubbles, with a link between asset price growth and commercial bank lending activity.

The second direction of model development will be in the description of central bank behavior. In the current model, the central bank affects changes in the policy rate through open market operations. While consistent with descriptions of central bank activity that give open market operations a central place in maintenance of the policy rate near target, it is less consistent with descriptions of central bank activity that give more prominence to the role of central bank rate announcements in moving market participants to adjust interest rates in the desired direction, without the need for open market operations.

Acknowledgements

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Figure 3: Capital adequacy ratio of commercial banks (basis point change relative to baseline)

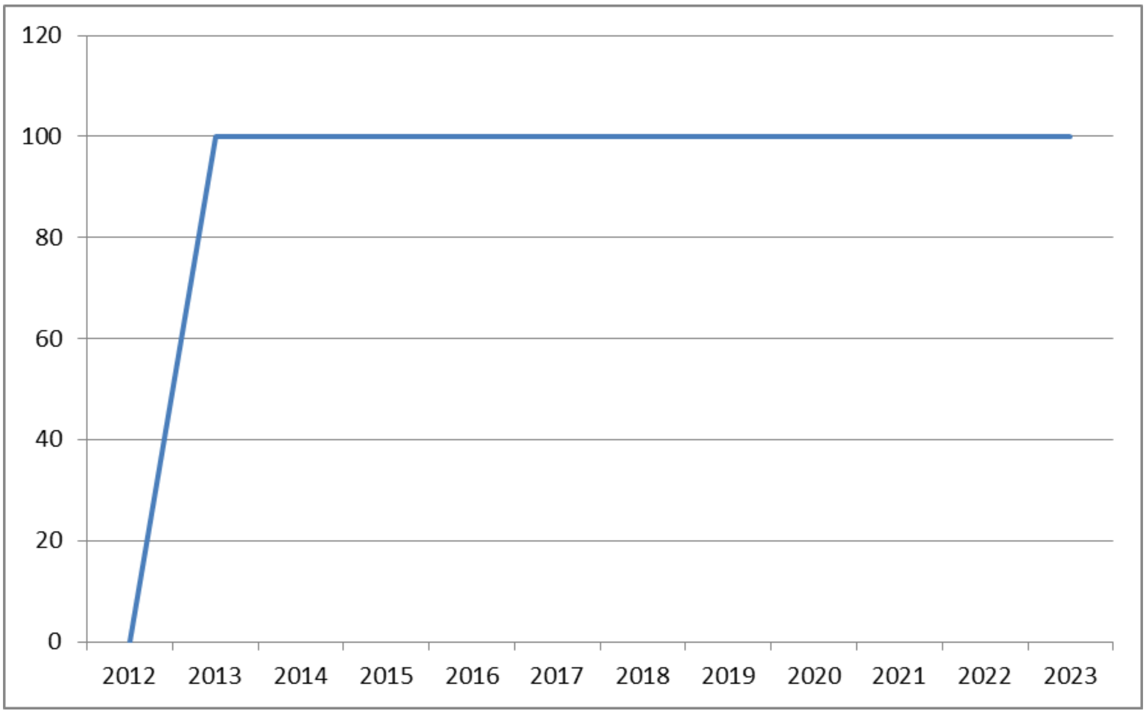

Figure 4: Outstanding financing instruments of the commercial banks (% deviation from baseline)

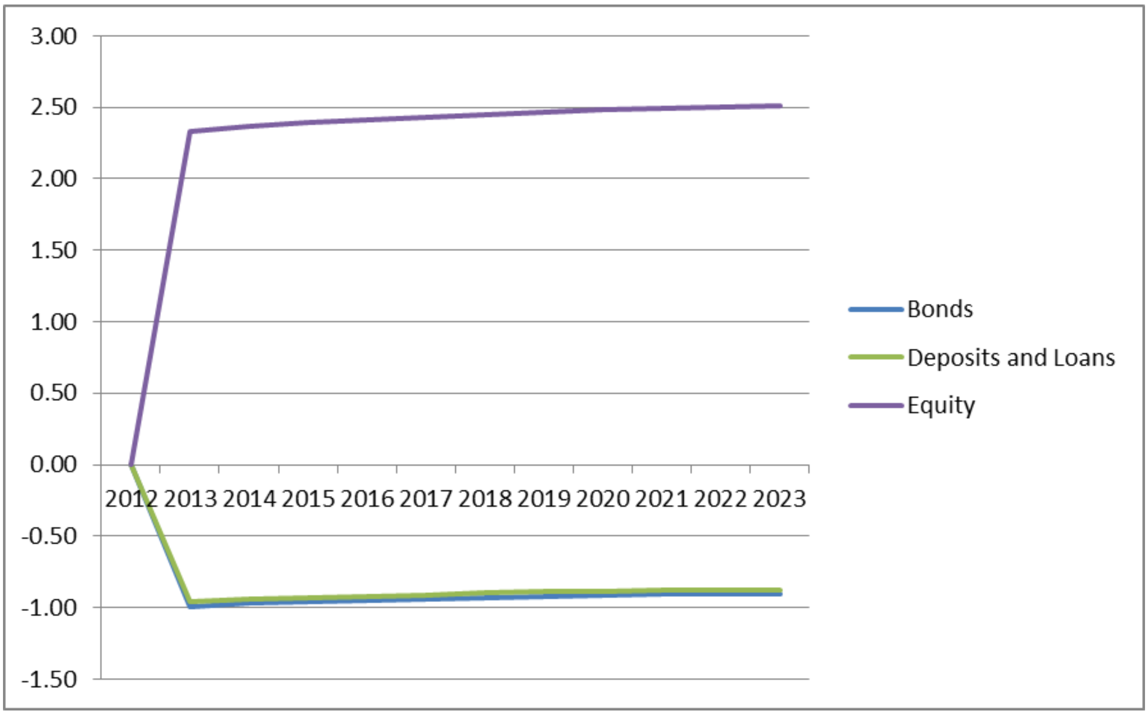

Figure 5: Bank equity and risk weighted assets (% deviation from baseline)

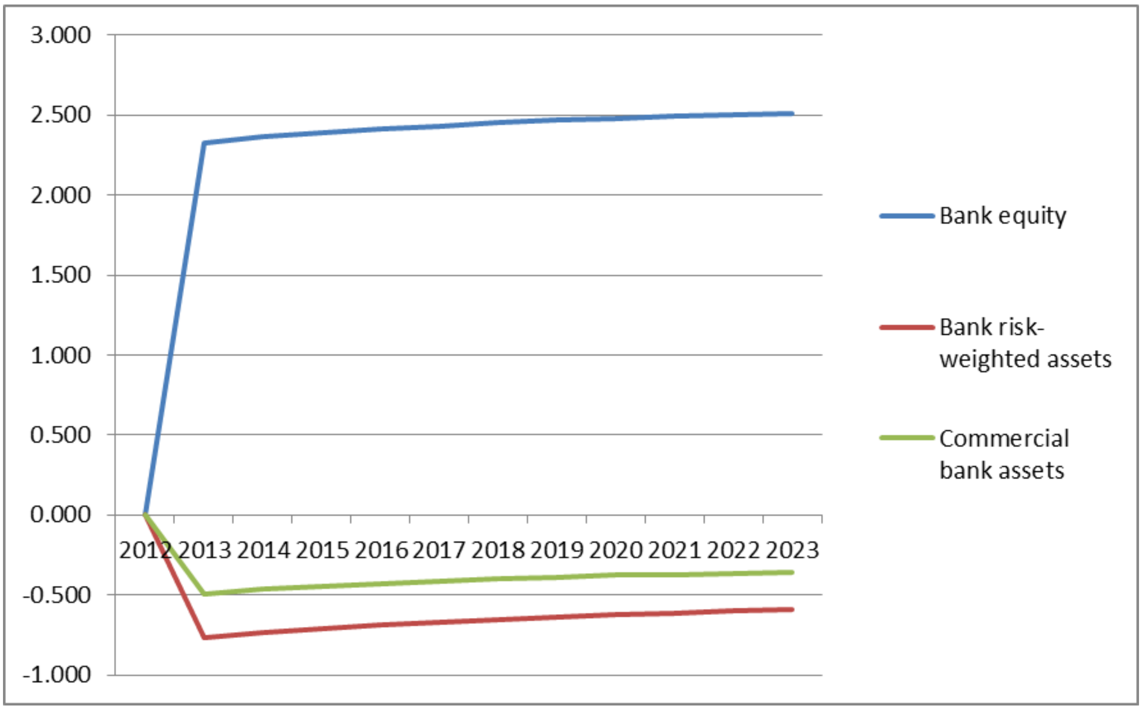

Figure 6: Major asset holdings of the commercial banks (% deviation from baseline)

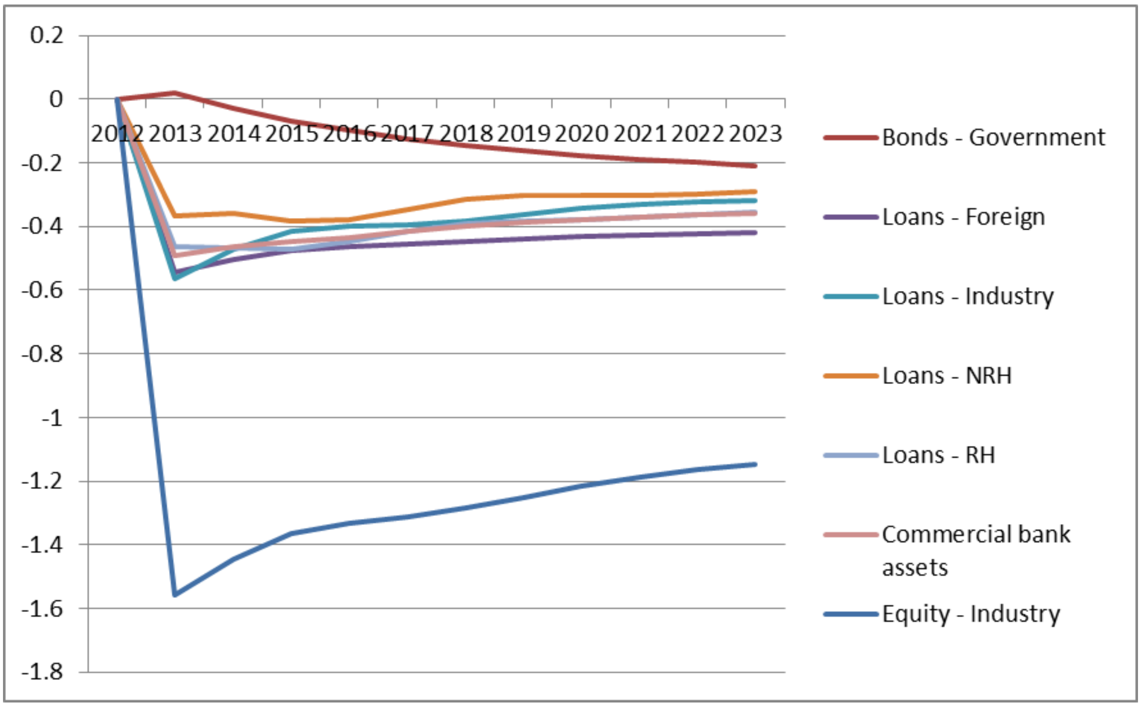

Figure 7: Rates of return (powers thereof) on bank financing instruments (% deviation from baseline)

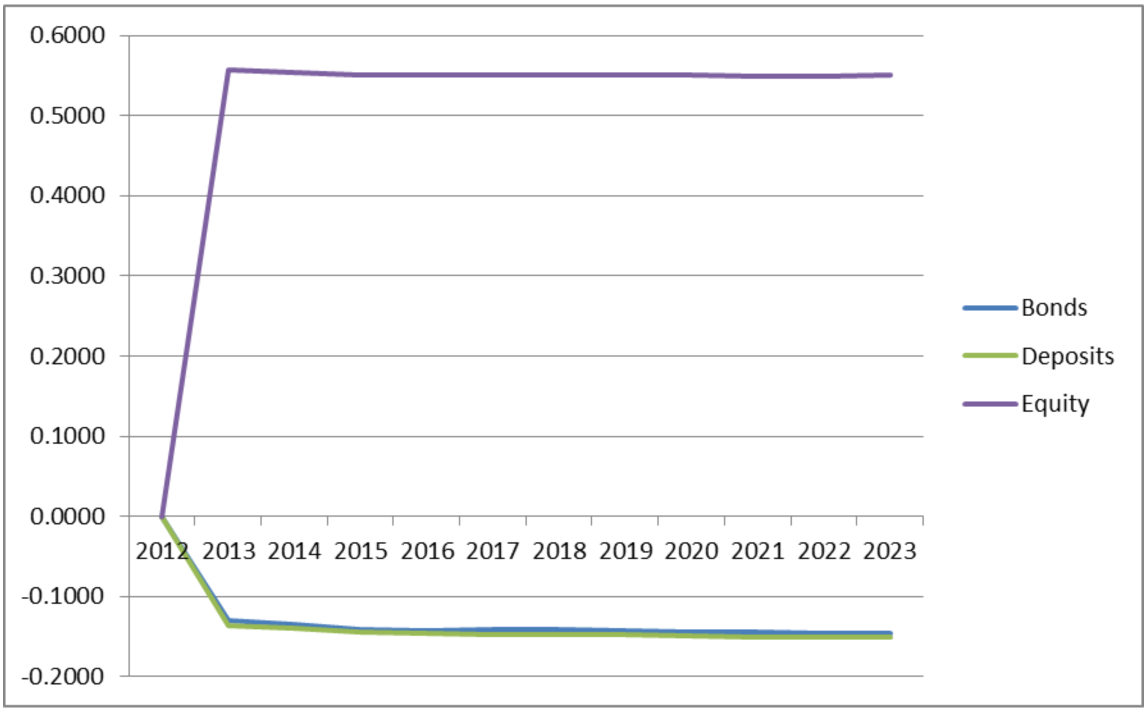

Figure 8: Weighted average cost of bank capital (basis point change from baseline)

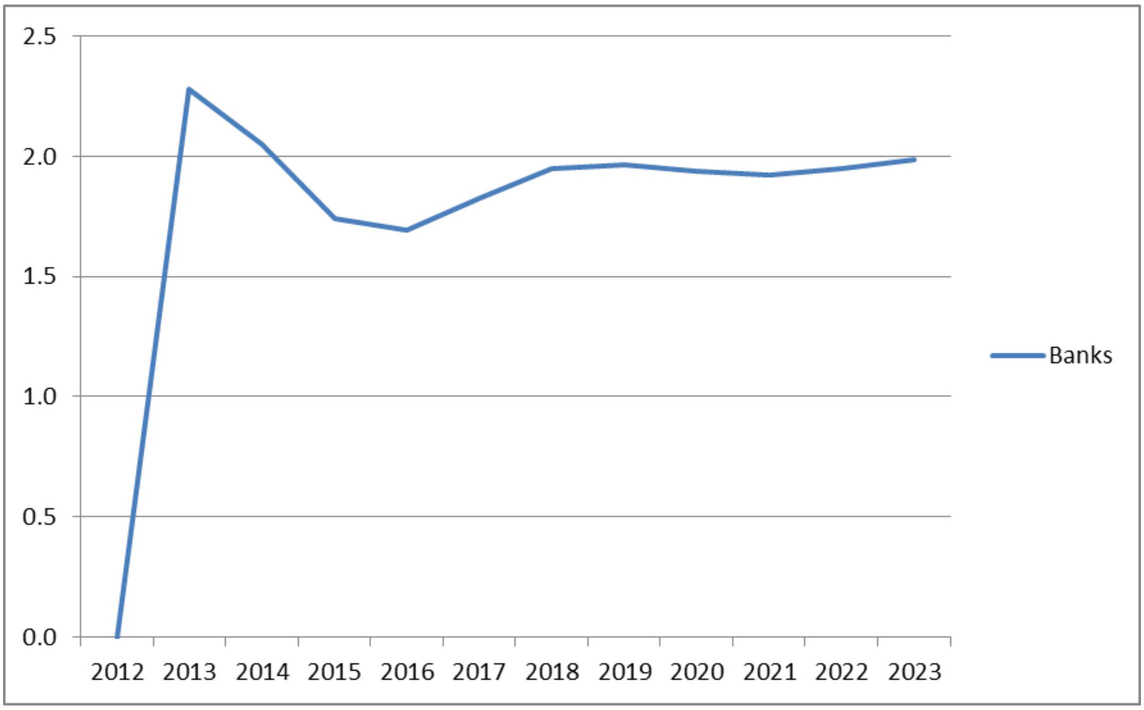

Figure 9: Financial assets and liabilities of the commercial banks (% deviation from baseline)

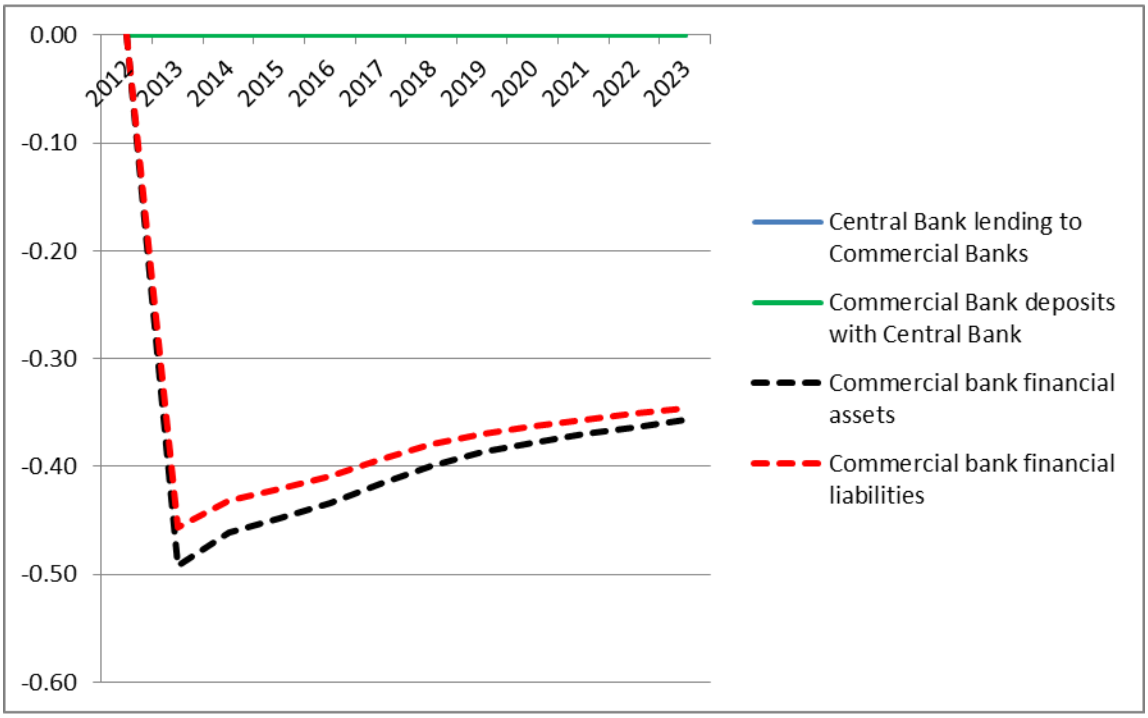

Figure 10: Movement in the borrowing and lending rates that the central bank offers the commercial banks (basis point change from baseline)

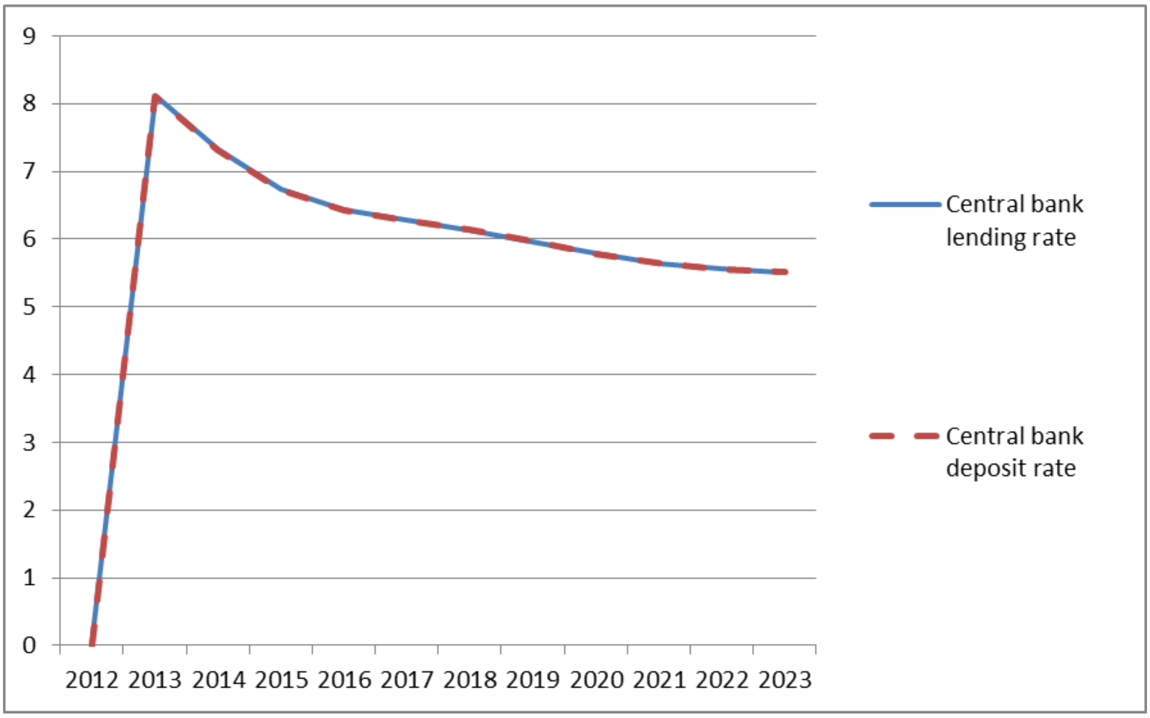

Figure 11: Weighted average cost of government borrowing (basis point change from baseline)

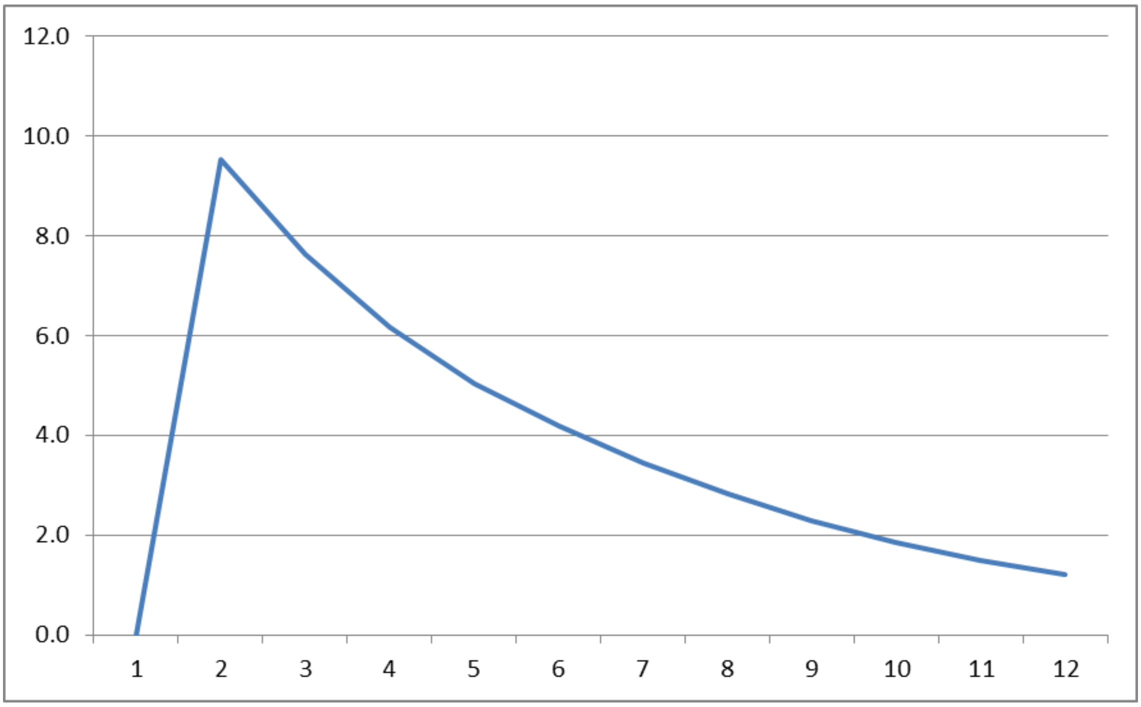

Figure 12: Average rates of return (powers thereof) on domestic and foreign assets (% deviation from baseline)

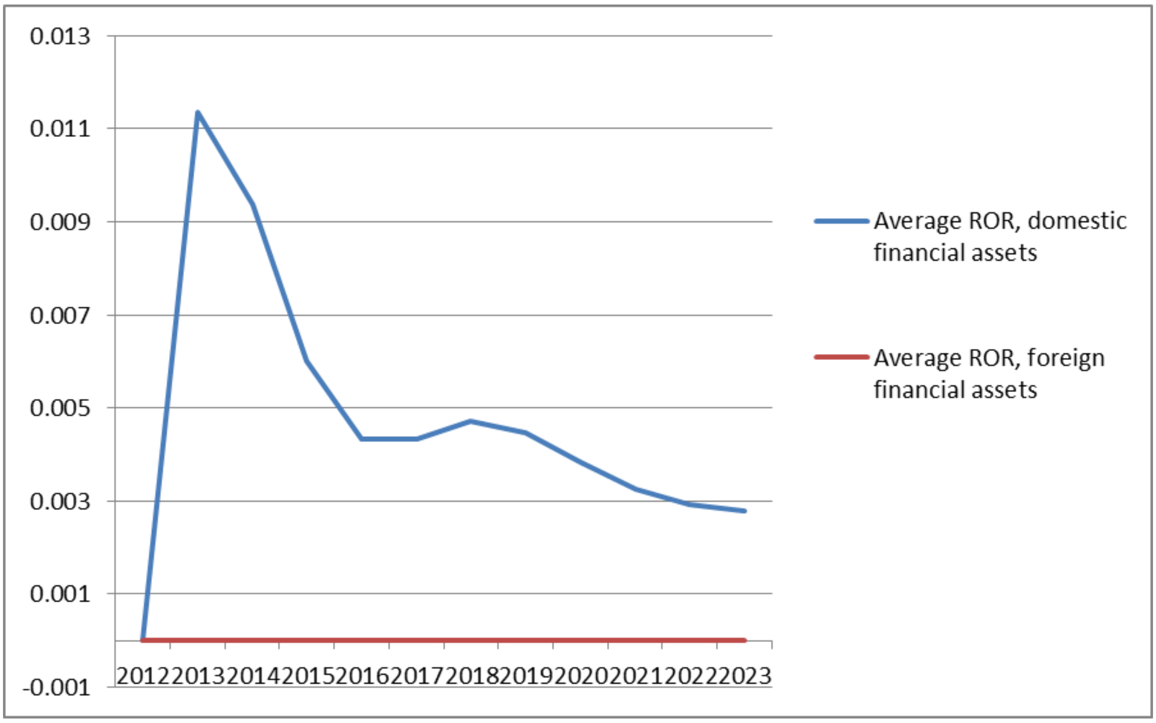

Figure 13: Foreign assets of commercial banks (% deviation from baseline)

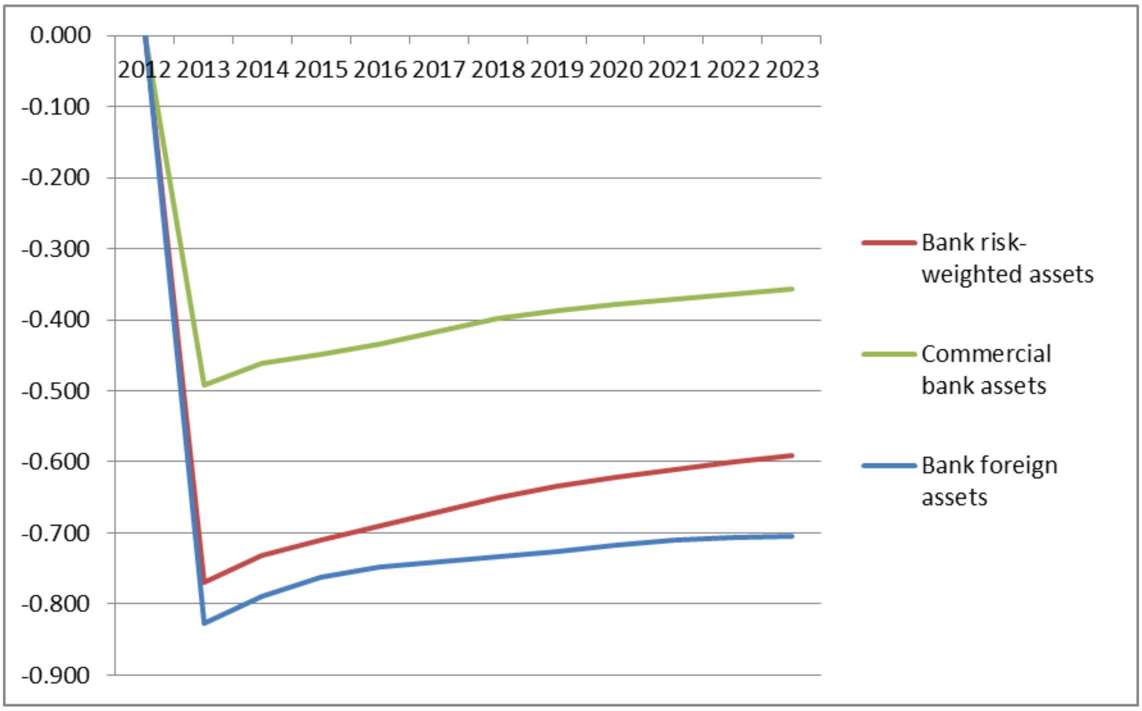

Figure 14: Nominal exchange rate, GDP deflator, CPI (% deviation from baseline)

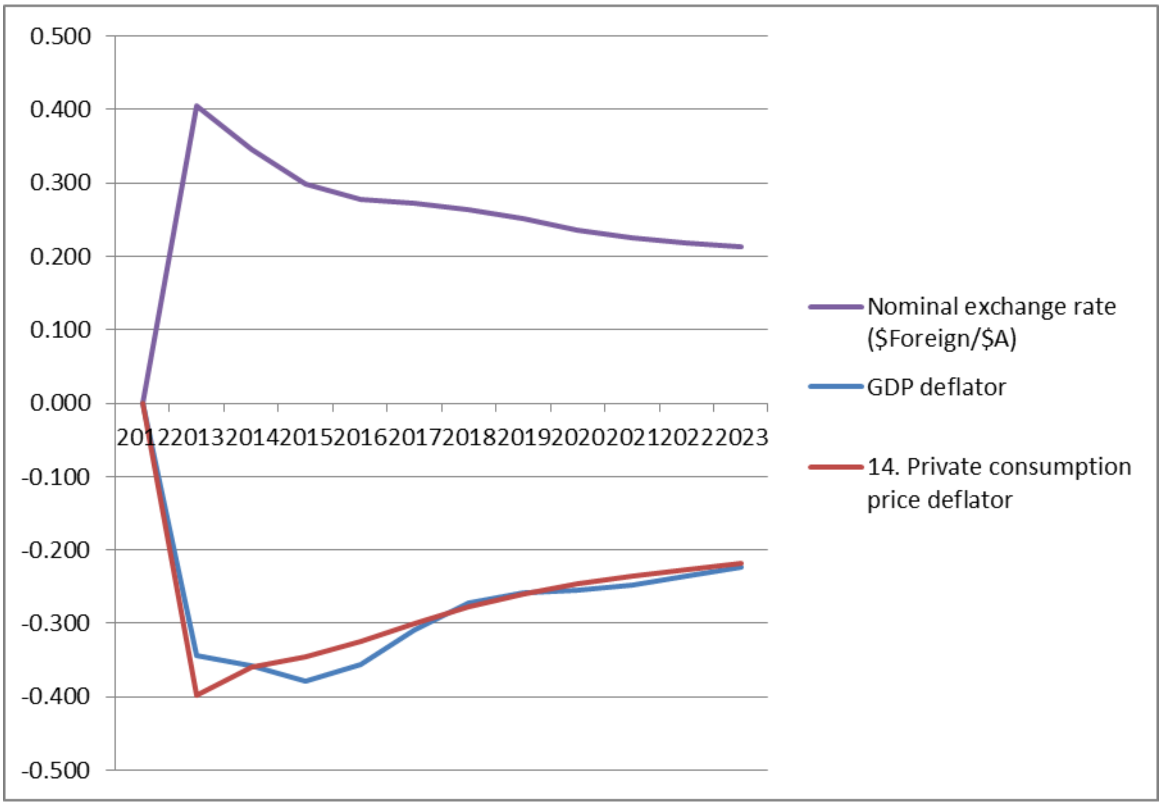

Figure 15: Employment, nominal wage, real producer wage (% deviation from baseline)

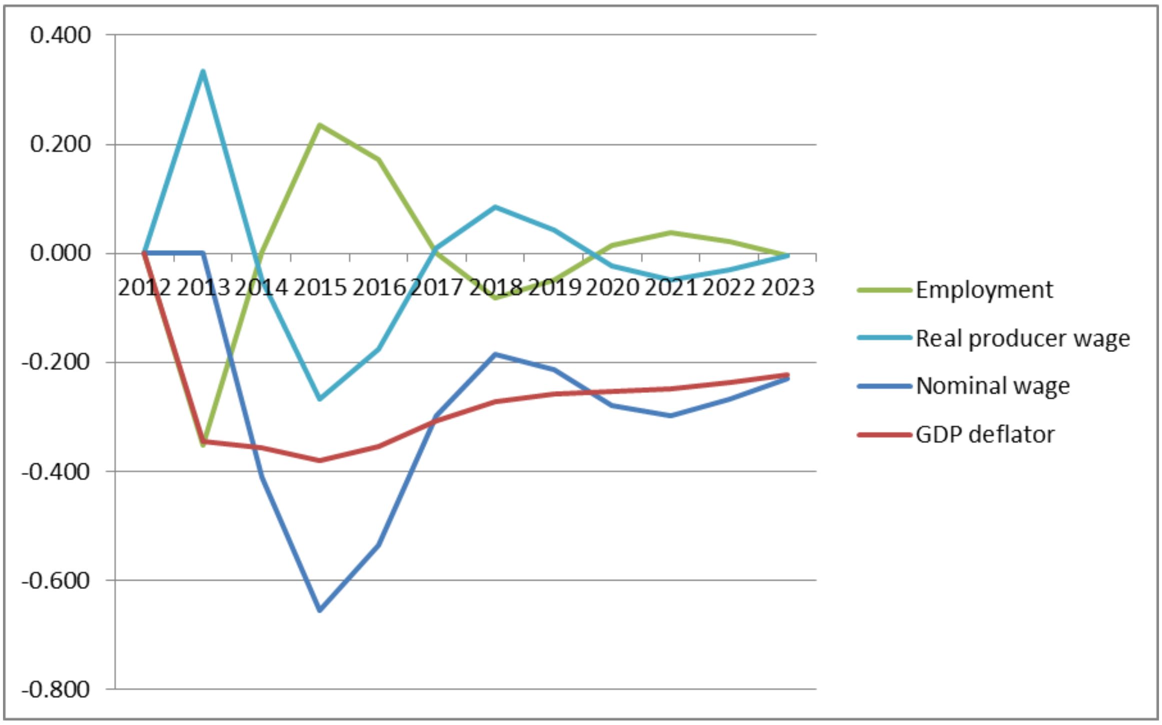

Figure 16: Employment, capital stock, real GDP (% deviation from baseline)

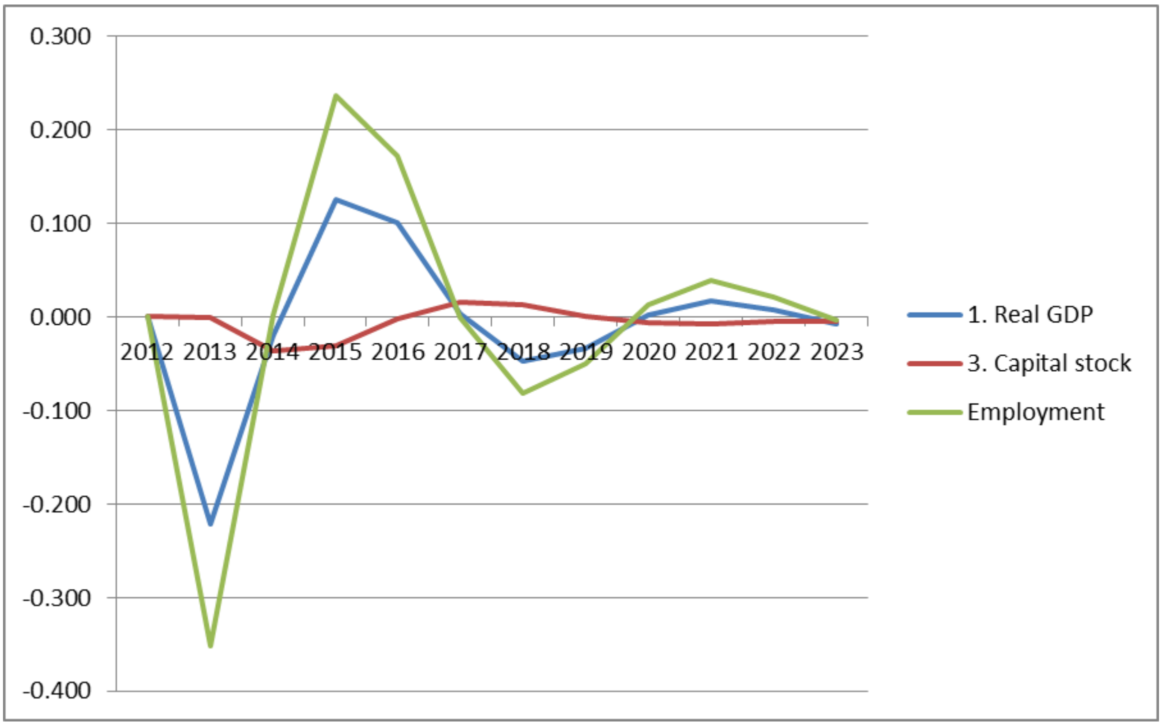

Figure 17: Average capital rental price and investment price deflator (% deviation from baseline)

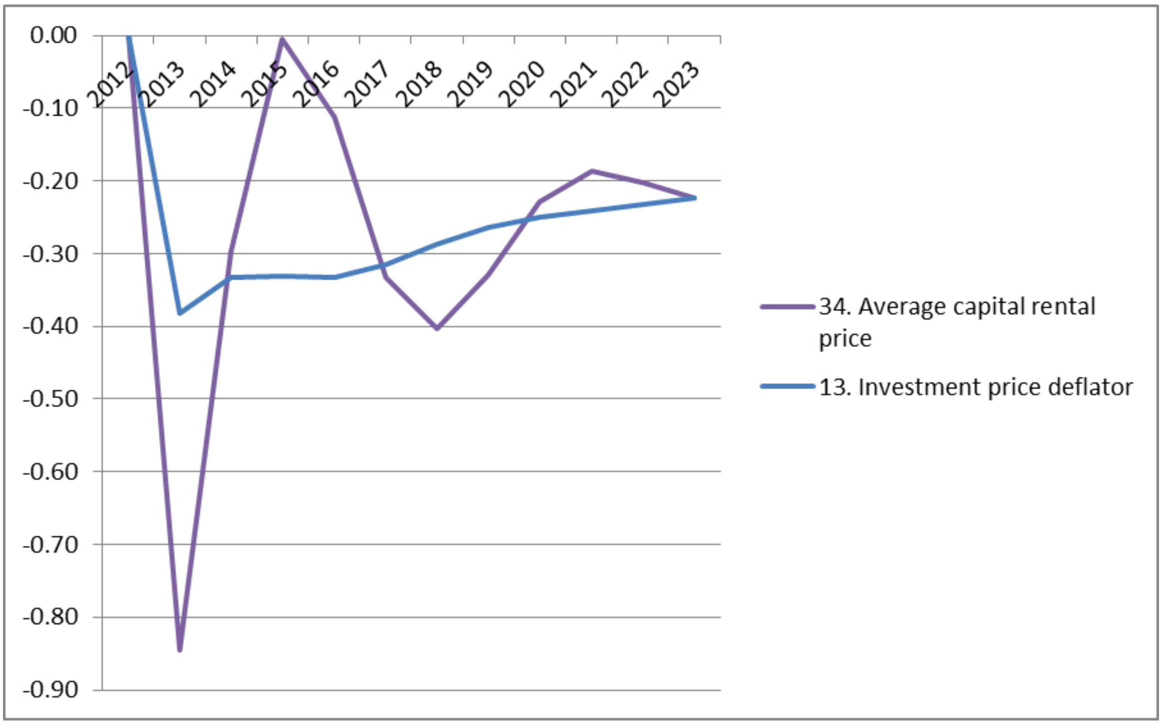

Figure 18: Real dwelling and non-dwelling investment (% deviation from baseline)

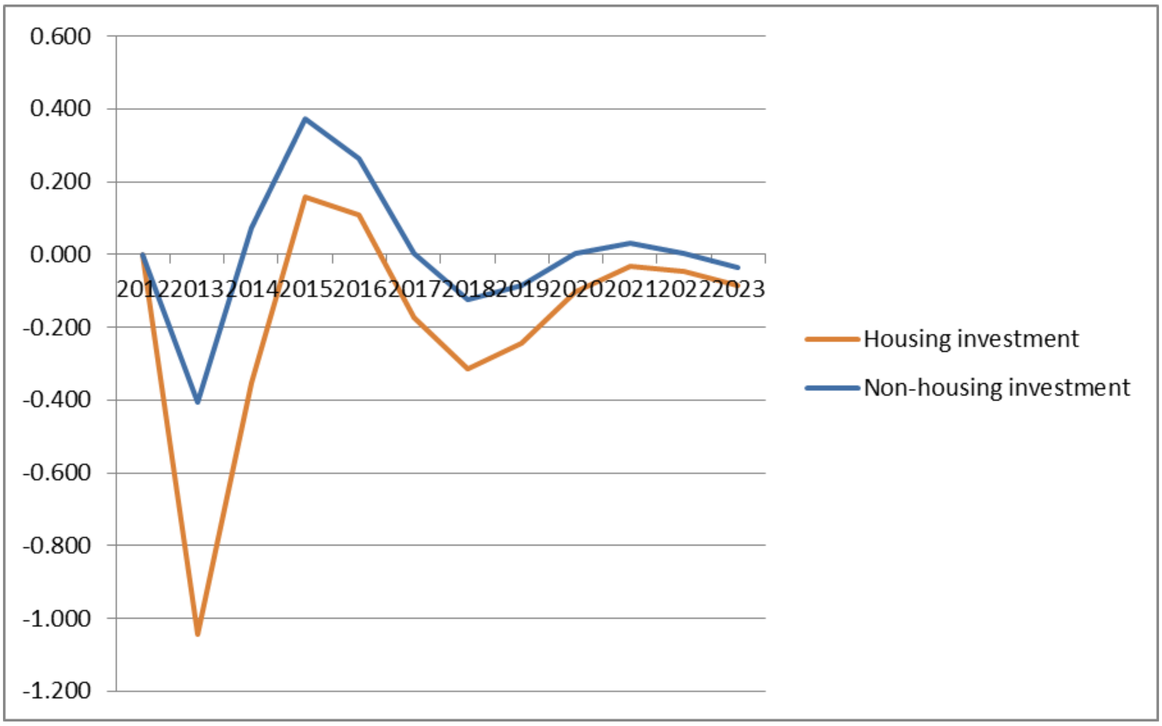

Figure 19: Central bank deposit rate (basis point change from baseline)

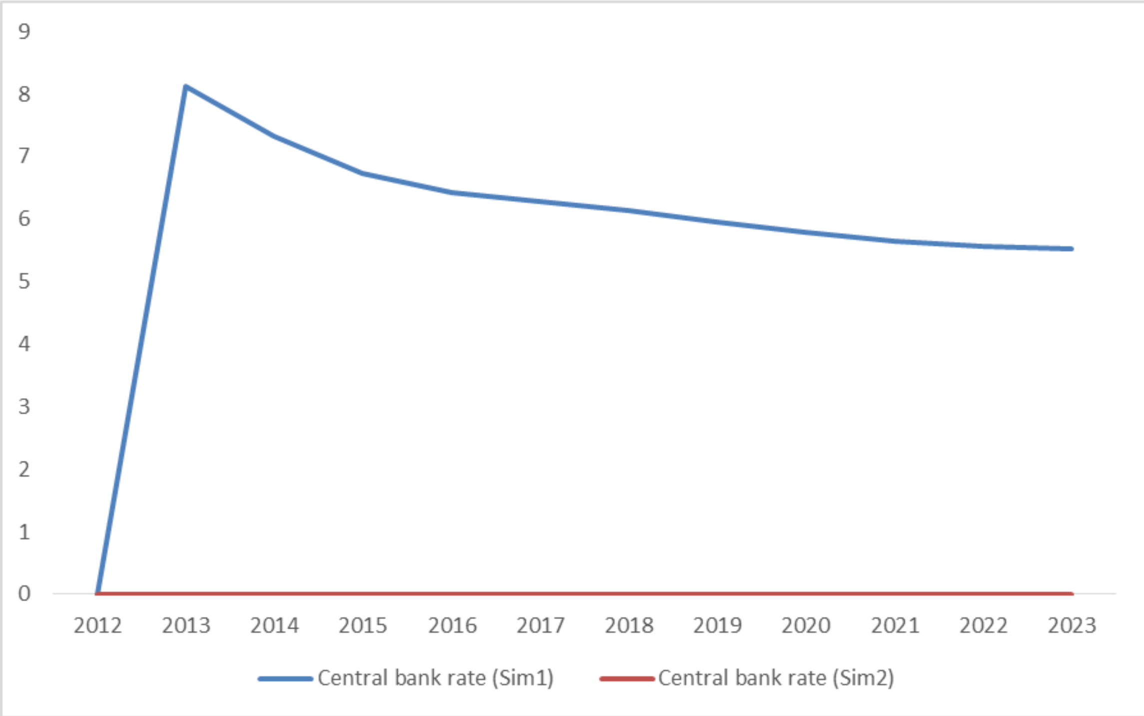

Figure 20: Weighted average cost of government borrowing (basis point change from baseline).

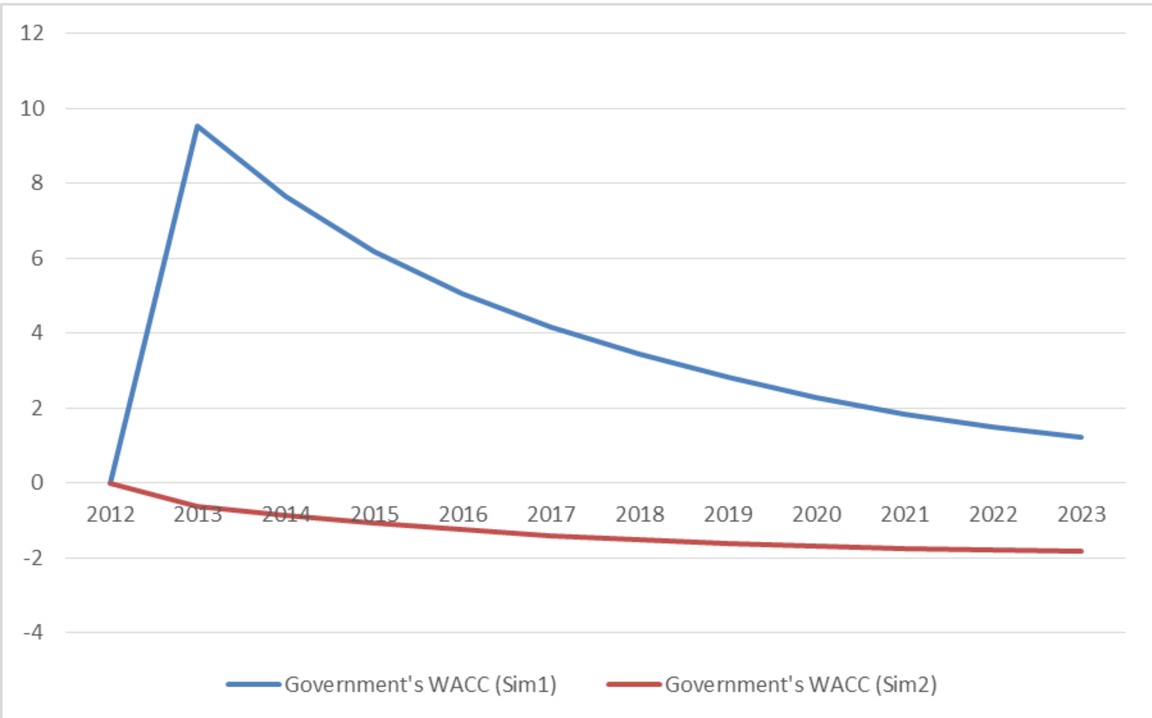

Figure 21: Average rates of return on domestic and foreign financial assets (% deviation in powers of rates of return).

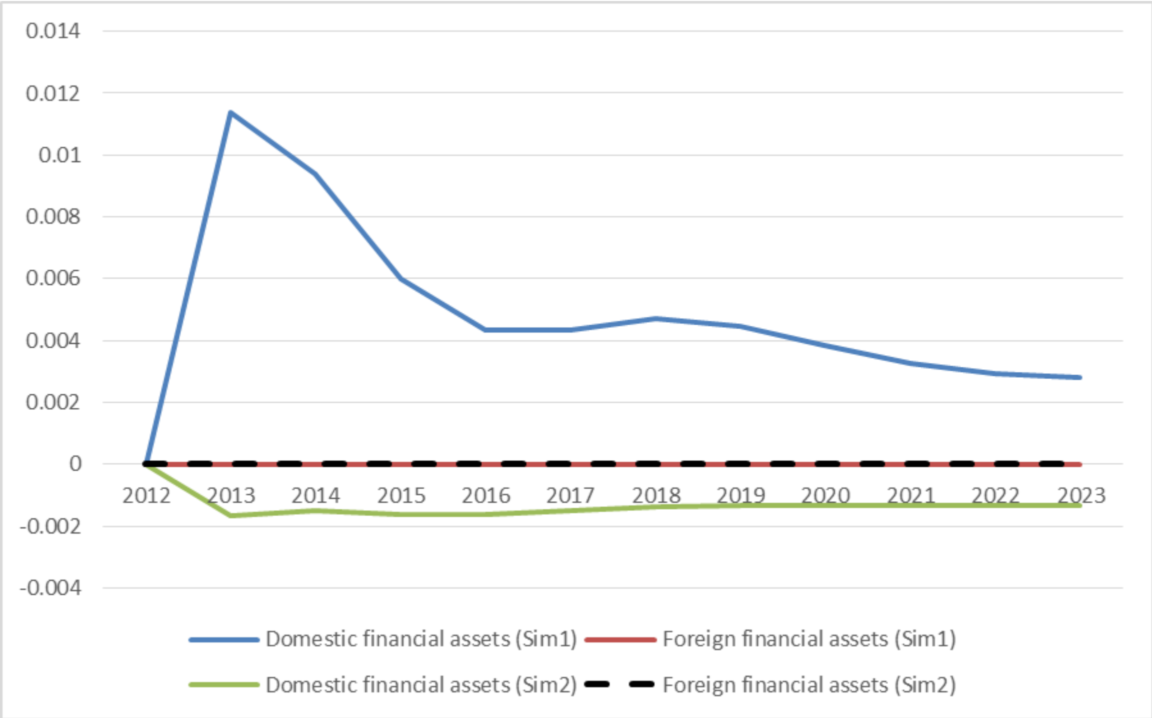

Figure 22: Nominal exchange rate and GDP deflator (% deviation from baseline).

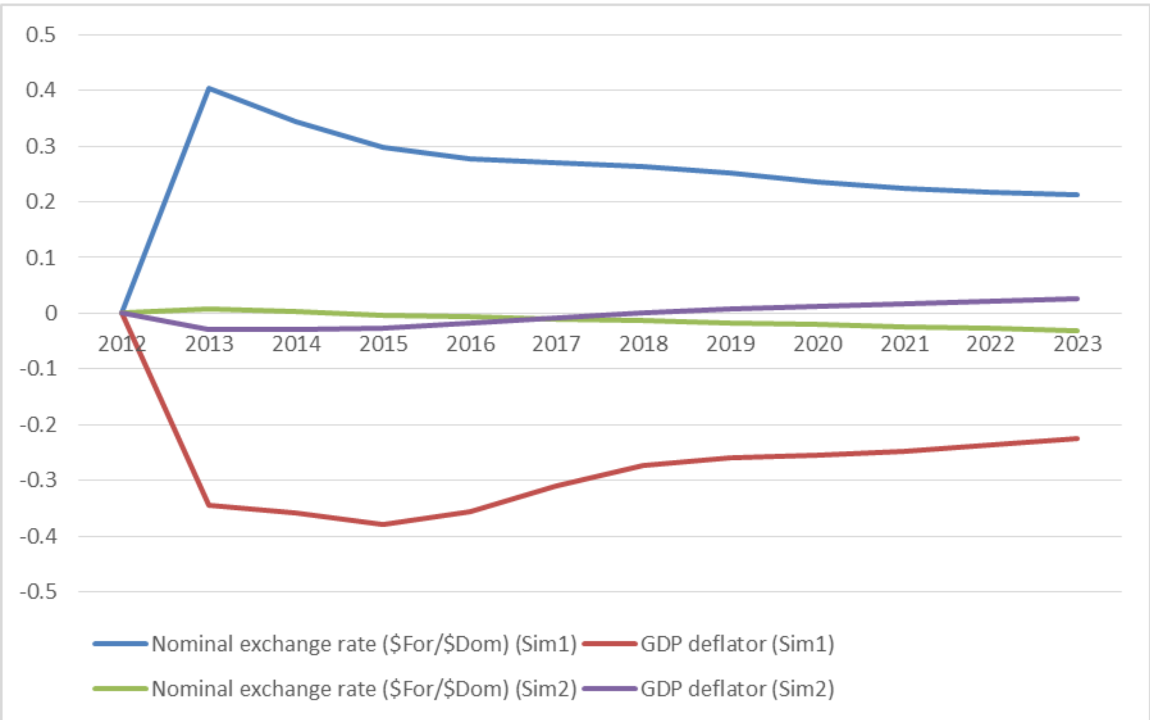

Figure 23: Employment, nominal wage, GDP deflator (% deviation from baseline).

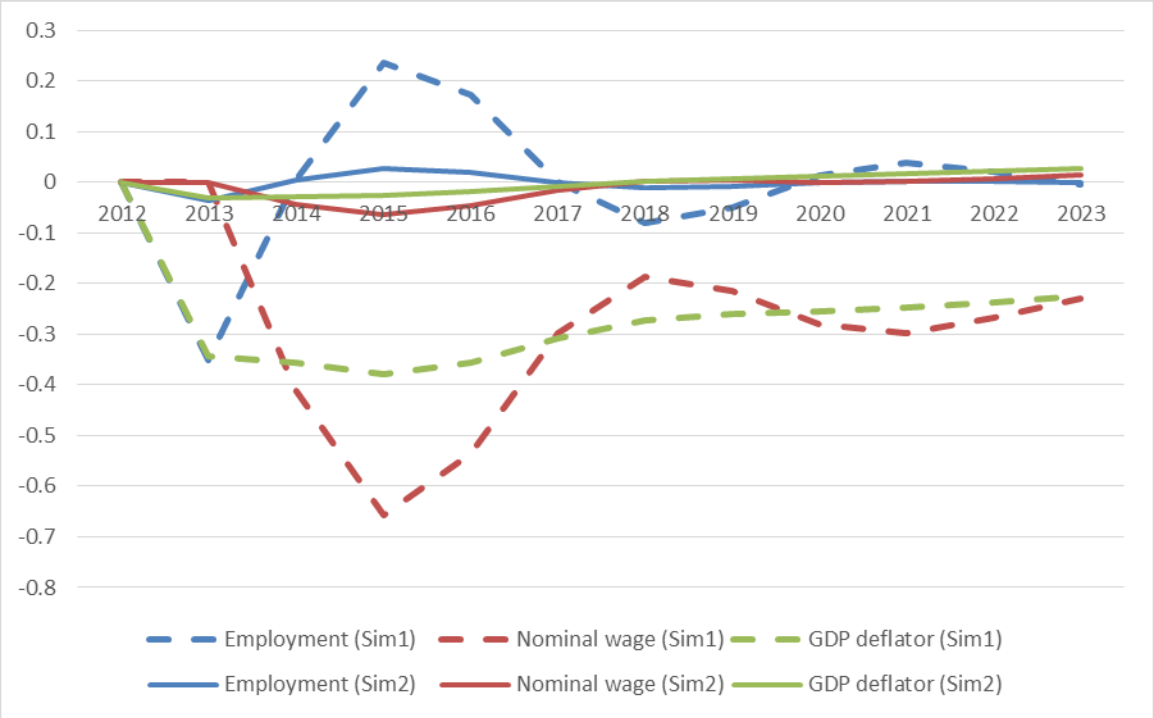

Figure 24: Real GDP (% deviation from baseline).

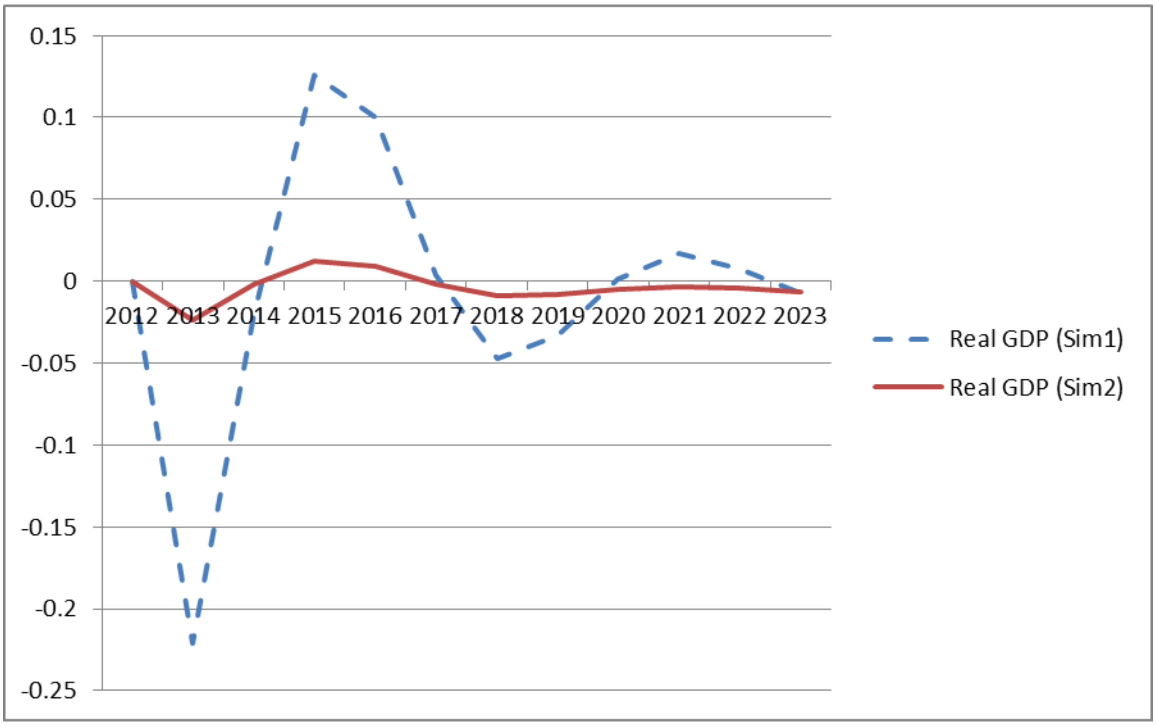

Figure 25: Weighted average cost of capital (basis point change from baseline).

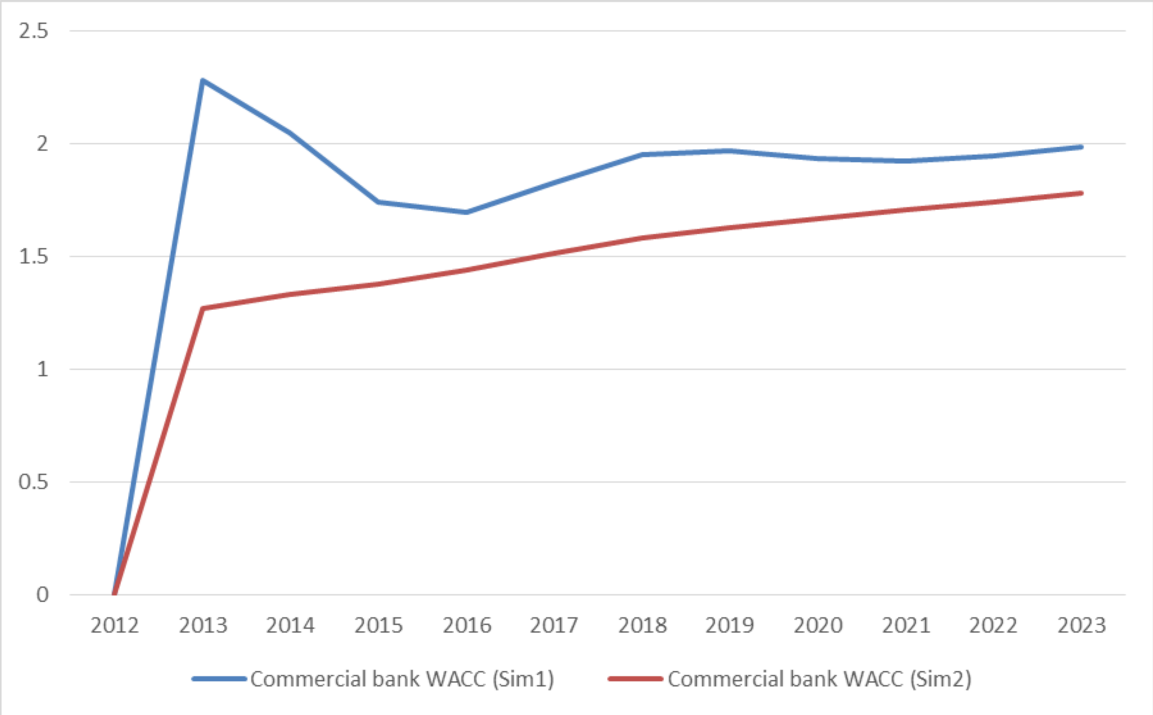

Figure 26: Outstanding financial instruments of the commercial banks (% deviation from baseline).

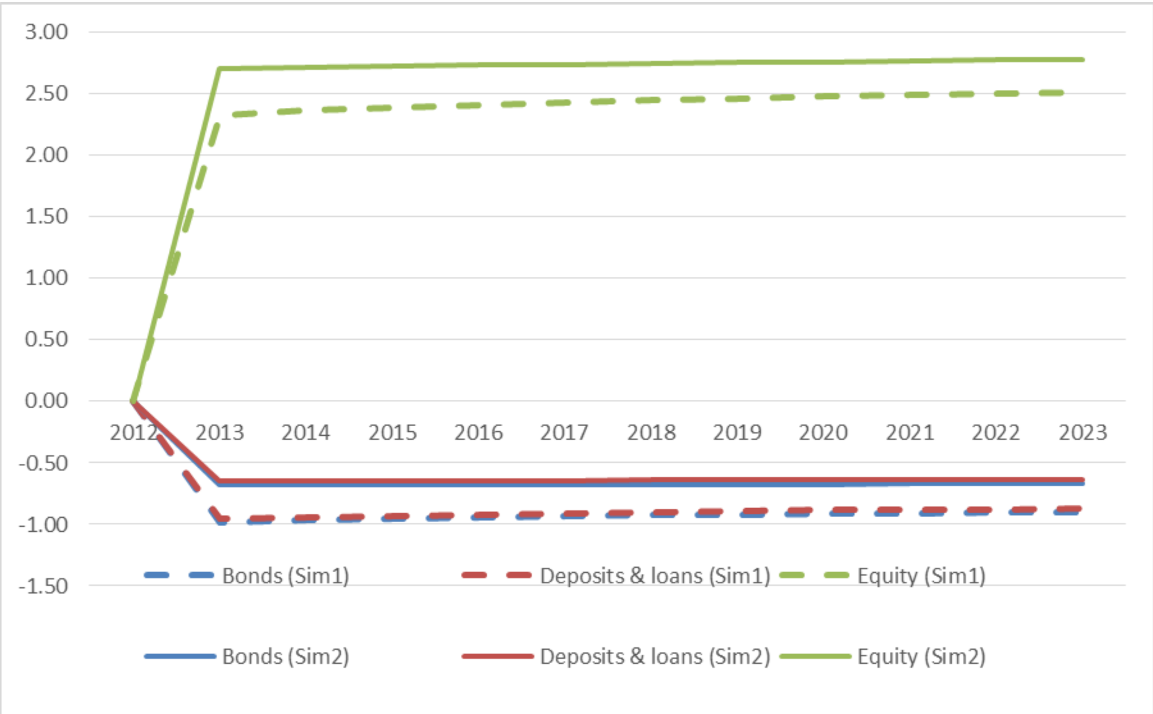

Figure 27: Financial assets and liabilities of the commercial banks (% deviation from baseline).

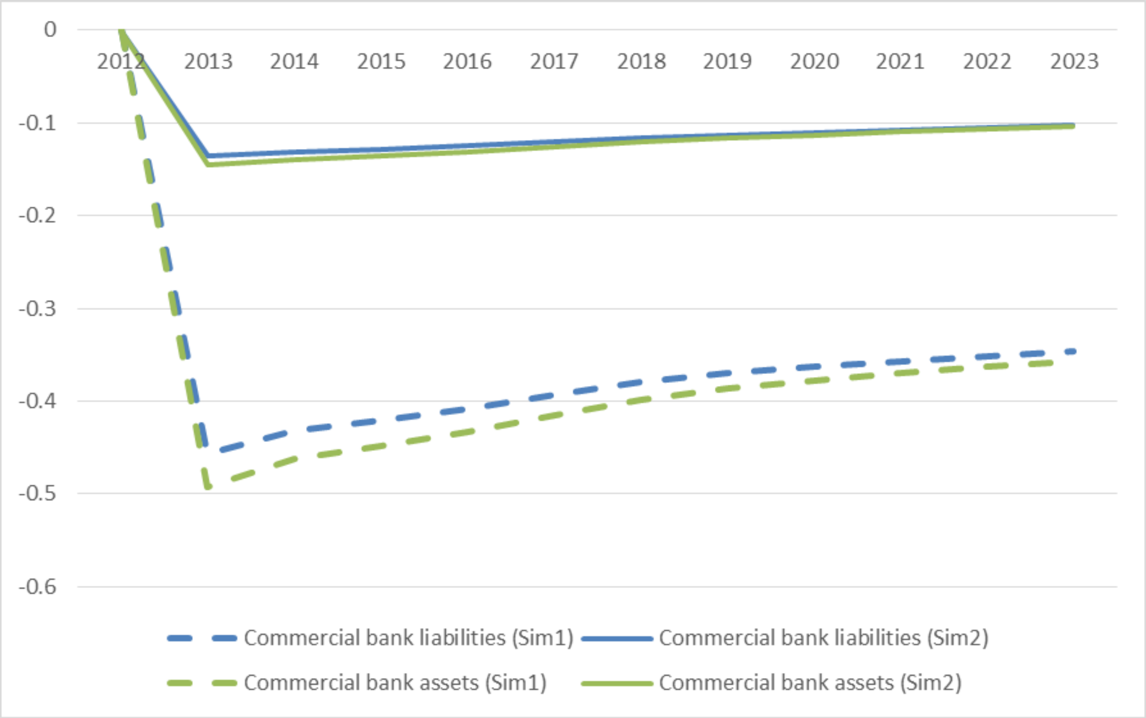

Figure 28: Bank lending to selected liability agents, Simulation 1 and 2 compared (% deviation from baseline).

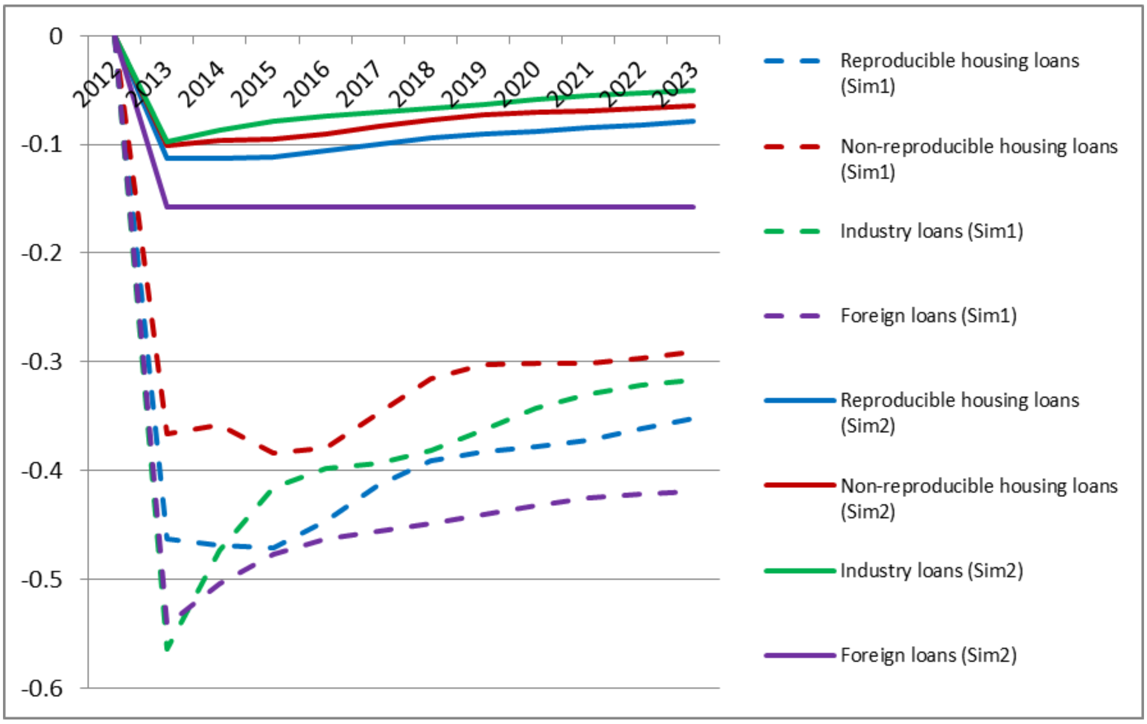

Figure 29: Housing and non-housing investment (% deviation from baseline).

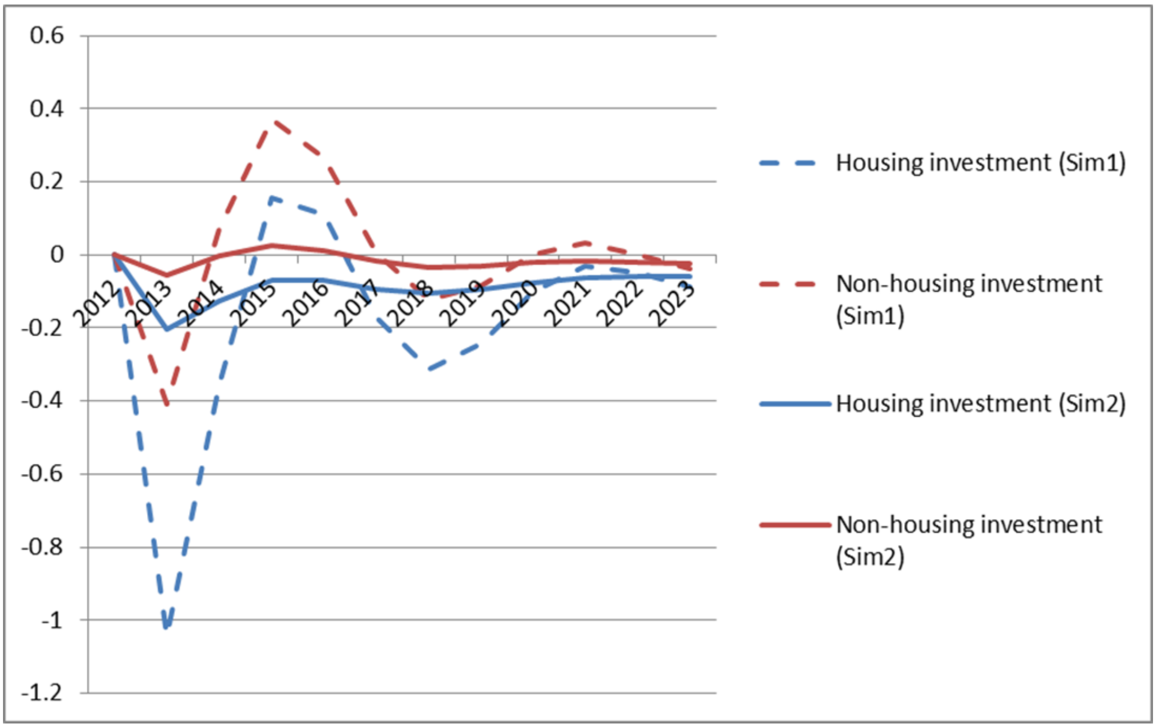

Figure 30: Equity and debt of the reproducible housing sector (% deviation from baseline).