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CoPS Working Paper No. G-261, May 2016

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ISSN 1 031 9034

ISBN 978-1-921654-69-5

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The economy-wide impacts of a rise in commercial bank capital adequacy ratios

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Abstract

Financial regulators are requiring banks to raise additional equity capital to finance their acquisition of physical assets (e.g. buildings) and financial assets (e.g. loans). 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. We find that the macroeconomic consequences of the policy are small. Our results suggest 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.

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JEL classification: E17, E44, G21, C68

Keywords: Capital adequacy ratio, financial stability, macroeconomic disruption

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1 Introduction

Following the events of 2008 and their aftermath, regulators have 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 of slow growth among developed economies and growing concerns about U.S. mortgage markets, the Lehman Brothers default in late 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 public 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 then 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 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. Sharp falls in household wealth compounded the pain of declining real incomes and employment.[1]

Atkinson et al. (2013) argue that the benefits of avoiding financial crises can be understood in terms of avoiding their deep and long-lasting impacts on employment and national income. They estimate the losses for the U.S. economy of the 2007-09 crisis at between 40 per cent and 90 per cent of one year's worth of output, or approximately $50,000-$120,000 per household. Similar loss magnitudes were forecast by Dixon and Rimmer (2011) (59% of one year's worth of private consumption) and Dixon and Rimmer (2013) (44% of one year's worth of employment). Atkinson et al. argue that estimates like these are helpful to policy makers because they provide a measure of the potential benefits against which the costs of policies aimed at avoiding future financial crisis 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

[1] 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.

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 banks were approximately 200 basis points short of levels necessary to place them in the top quartile of their international 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 equity capital. Modelling by the Institute of International Finance (IIF) (2011) anticipated large GDP losses from implementation of Basel III capital requirements and regulatory standards, of the order of -3.2% relative to baseline. However modelling coordinated 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, found more modest impacts, with a range of GDP troughs of between 0.05 per cent and 0.3 per cent at the end of the implementation periods.

Both the IIF and BIS results were generated by a two-step process: first, the effects of higher capital requirements on bank spreads and lending volumes were estimated; second, these were input as exogenous shocks to macroeconomic models. In the modelling we present in this paper, we combine these two steps. We construct a model of the financial sector in which the banking sector is one of a number of financial agents, and integrate the model of the financial sector within a comprehensive model of the Australian economy. In this way, the capital adequacy ratio is just one of many exogenous variables in a large economy-wide model. When we shock this variable, the impact on bank lending costs and credit volumes is determined endogenously along with outcomes for policy-relevant variables like employment and GDP. We find GDP impacts that are lower than those reported by IIF, and lower even than approximately 85% of the results found by BIS. As we shall argue, the integrated approach, as opposed to the two-stage approach, provides opportunities for damage-mitigating economic mechanisms (like substitution away from bank finance) to take effect.

To explore the economy-wide effects of higher bank capital requirements we raise the banking sector's capital adequacy ratio by 100 basis points. Our simulation is undertaken using a version of the financial computable general equilibrium (FCGE) model described in Dixon et al. (2015). In particular, building on the Dixon et al. (2015) model, we: (i) develop the manner in which the banking sector is modelled (particularly as it relates to the capital adequacy ratio and risk weights on financial assets held by commercial banks); and (ii) describe central bank setting of the policy rate via a Taylor rule. In the remainder of this paper we summarize the underlying FCGE model (Section 2). We explain that the model's treatment of the financial sector is constructed in a bottom-up way; that is, we identify individual financial agents and the financial instruments with which they are concerned, and assume that financial agents act in an optimising behaviour subject to constraints. Without explicitly modelling specific policy channels, this bottom-up structure produces a model that carries many of the financial policy transmission mechanisms familiar to monetary economists. Indeed, as we discuss in Section 2.1, we can identify interest rate, exchange rate, asset price and bank lending channels. In Section 2.2 we expand on developments to the FCGE model that are relevant to the current study before proceeding in Section 3 to describe the simulations we have undertaken with the model and what we learn from them.

2 The financial computable general equilibrium (FCGE) model

In this section we provide a summary of the 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). As we shall describe, the FCGE model is based on identification of many agents and the optimising behaviour governing their actions. Out of this framework emerge a number of transmission mechanisms via which a change in commercial bank capital requirements can affect activity in the real economy. We go on to describe the developments to the FCGE model that are 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 domestic and imported intermediate inputs, labour, capital and land, in a cost-minimising fashion, to produce 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 private consumption. Households 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.
5. A foreign sector, purchasing units of domestic production to be sold in foreign markets subject to price-sensitive constant elasticity export demand curves, and supplying imports to Australia at exogenous foreign currency prices.
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. Zero pure profit conditions in current production and capital formation determine basic prices (prices at the factory door) for domestically produced output. 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 policy questions (Dixon and Rimmer 2016). 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 (PSBR)? 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 model identifies 5 financial instruments and 11 financial agents.[2] Each financial agent is concerned with both the asset and the liability/equity sides of its balance sheet. Hereafter, we refer to financial agents as "asset agents" in matters concerned with the asset sides of their balances sheets, and as "liability agents" in matters concerned with the liability and equity sides of their balance sheets. 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 power of the rate of return (i.e. one plus the rate) on financial instrument *f*, issued by liability agent *s*, and held as an asset by agent *d*.

Financial agents are assumed to be constrained optimisers. Broadly, in their capacity as liability agents, financial agents are assumed to issue the mix of financial instruments that minimises the cost of servicing the total liabilities they require, subject to a constraint that prevents them moving to corner solutions in the issuance of particular financial instruments to particular asset agents. Similarly, in their capacity as asset agents, financial agents are assumed to hold the mix of financial instruments that maximises the return from their

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[2] The financial instruments are: Cash, Deposits/loans, Bonds, Equity, Gold and SDRs. The financial agents are: Commercial banks, the Central Bank, Foreigners, Government, Households, Industries, NBFIs, Superannuation, Life insurance, Non-reproducible housing, Reproducible housing. We divide the housing sector into "reproducible" and "non-reproducible" housing in anticipation of future model applications concerned with property price bubbles. For non-reproducible housing (established inner-city dwellings) it is conceivable that asset prices can depart from construction costs. For reproducible housing (apartments, units, and houses outside the inner city) construction costs should anchor asset prices.

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 are 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 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 with the financial side) 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 with the model's real side) exert an important influence on outcomes in the model's real side. For example:

- the PSBR 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;
- pension fund contributions determine new liability issuance by the pension fund sector;
- changes in the weighted average cost of financial capital influences the desirability of undertaking gross fixed capital formation.

At the same time, linkages within the financial sector are modelled. For example, the 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 prospects for one financial agent have consequences for the costs of funds to other agents.

2.2 Monetary and regulatory transmission mechanisms in the FCGE model

Mishkin (1995) outlines four mechanisms via which financial policy shocks can affect the economy: the interest rate channel, the exchange rate channel, the asset price channel, and the credit channel. While these channels are not modelled explicitly within our FCGE model, they nevertheless emerge from the identification of the financial agents and instruments, optimising behaviour, and financial / real economy links discussed in Section 2.1.

The *interest rate channel* describes the relationship between financial policy changes and real activity via the impact of interest rate movements on investment and other interest-sensitive expenditures (Mishkin 1995: 4). This mechanism is present in our FCGE model because investors are assumed to undertake capital formation up to the point where the expected rate of return on new units of physical capital is equal to the weighted average cost of the financial capital that they issue to finance the activity (see Dixon et al. 2015: 17). Because the weighted average cost of financial capital is potentially sensitive to changes in bank lending rates (and indeed, via changes in the cost of other forms of financial capital), the interest rate channel is a potentially relevant mechanism in understanding how a change in commercial bank capital requirements can affect real activity within the FCGE model.

The *exchange rate channel* describes the capacity of monetary policy to influence real activity via interest rate induced movements in the exchange rate. Mishkin (1995: 5) summarizes the chain of causation thus: $i\uparrow\Rightarrow E\uparrow\Rightarrow NX\downarrow\Rightarrow Y\downarrow$. That is, a policy induced rise in interest rates ($i\uparrow$) encourages capital inflow and thus exchange rate appreciation ($E\uparrow$

). The exchange rate appreciation damps net exports ($NX \downarrow$), and with it, real GDP ($Y \downarrow$). The exchange rate channel is an important short-run mechanism in the FCGE model, however we describe the sequence of transmission steps differently to Mishkin. While Mishkin's chain of causation emphasizes a demand-led connection between net exports and real GDP, our explanation emphasizes the neo-classical mechanism connecting employment (and thus output) to the real producer wage. That is, within the FCGE model, the chain of causation between a policy-induced rise in interest rates and real-side variables like GDP and net exports is: $i \uparrow \Rightarrow E \uparrow \Rightarrow P \downarrow \Rightarrow (W/P) \uparrow \Rightarrow L \downarrow \Rightarrow Y \downarrow \Rightarrow NX \downarrow$. Consistent with Mishkin, the first two steps in the chain link nominal appreciation with the rise in the interest rate. In the FCGE model, nominal appreciation causes a fall in the domestic price level ($P \downarrow$) due to a fall in the domestic price of traded goods. With the nominal wage sticky in the short-run, this causes the real producer wage to rise ($(W/P) \uparrow$), and hence the demand for labour to fall ($L \downarrow$). With employment lower, real GDP must fall ($Y \downarrow$). With stickiness in public consumption spending, real GNE is likely to fall by less than the fall in real GDP. Hence the balance of trade is likely to move towards deficit ($NX \downarrow$). Hence the FCGE model's exchange rate channel mechanism anticipates similar impacts on real side variables as those outlined by Mishkin, but places more emphasis on the role of short-run wage stickiness in generating a temporary fall in employment via a rise in the real producer wage.

Mishkin outlines two *asset price channel* effects: one via a Tobin's *q* mechanism, and the second via wealth effects on consumption. A mechanism like the first is present in the FCGE model. As Mishkin describes, monetary policy can affect the valuation of equities, and as such, affect investment via a Tobin *q* mechanism. Tobin's *q* is defined as the market price of firm equity divided by the replacement cost of firm physical capital. As Mishkin describes, when the value of q rises, investment should rise because firms can issue new equities at a price that is high relative to the construction cost of capital. Mishkin describes the Tobin q channel linking monetary policy with real activity via: $i \uparrow \Rightarrow P_e \downarrow \Rightarrow q \downarrow \Rightarrow I \downarrow \Rightarrow Y \downarrow$. At the beginning of this chain, a rise in interest rates reduces equity prices because the resulting fall in bond prices causes equity prices (P_e) to fall as investors switch from equities to bonds. This causes Tobin's q to fall, thereby reducing investment as firms find it relatively more attractive to purchase capital by acquiring the equities of existing firms rather than by constructing new physical capital. A similar mechanism operates within the FCGE model. In our model, a rise in interest rates, including a rise in bank lending rates induced by a rise in mandated bank capital, causes the cost of equity finance to rise because firms must offer competitive rates of return when issuing new equity finance. Hence, a tightening of industry credit conditions, whether via tight monetary policy or a mandated rise in bank capital, raises the weighted average cost of financial capital faced by industries not only because it pushes up the cost of debt finance, but also because the portfolio-switching behavior of asset agents forces issuers of new equity to offer higher rates of return on new equity. As discussed in Dixon et al. (2015: 17), with investors undertaking physical capital formation up to the point where the expected return on physical capital is equal to the weighted average cost of financial capital, a rise in the weighted average cost of financial capital will lower real investment in the FCGE model. The second asset price channel outlined by Mishkin relies on changes in equity values affecting household wealth, and with it, real consumption and real GDP. The FCGE model does not yet contain a direct link between household financial wealth and household consumption. This is a link we plan to explore in future work.

Mishkin identifies two broad credit channels: the *balance sheet channel* and the *bank lending channel*. The balance sheet channel rests on monetary and financial policy's capacity to affect lending behavior via its impact on firm balance sheets and perceptions of lending risk. For example, as Mishkin argues, a tightening of monetary policy can adversely affect the net worth of firms by lowering their equity prices. The fall in firm net worth can then adversely affect bank lending by raising bank perceptions of adverse selection and moral hazard risks. The bank lending channel emphasizes the particular role that banks play as intermediaries for certain firms and sectors. As Kashyap and Stein (1994) note, summarizing Bernanke and Blinder (1988), three conditions must hold for a model to possess a distinct lending channel for monetary policy transmission: (i) liability agents must view as imperfect substitutes financial capital raised by loans from banks and bonds sold to the general public; (ii) banks must view deposit finance and other forms of short-term finance as imperfect substitutes; and (iii) there must be a nominal rigidity that prevents monetary shocks from having no impact on the real economy. All three conditions hold in the FCGE model. Condition (i) ensures that borrowers cannot entirely offset a rise in the cost of bank funds by shifting to other sources of financial capital. Condition (ii) renders the cost of funds to commercial banks sensitive to changes in the costs of particular finance sources (like deposits) by ensuring that they cannot make costless switches between alternative funding sources. Condition (iii) ensures that changes in monetary policy are not immediately neutralized by costless price adjustment. These three conditions hold in the FCGE model, thus allowing a shock directed at commercial banks (like a rise in the capital adequacy ratio) to exert an influence on the cost of financial capital to agents reliant on bank finance (like housing construction).

2.3 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). First, the theory describing bank decision making over asset ownership must 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. We expand below.

2.3.1 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 assume that commercial banks (ComB) choose their end-of-year asset portfolio, $A1_{(s,f,ComB)}$ for all *s* and *f* to maximize

$$U(R_{(s,f,ComB)} \times A1_{(s,f,ComB)}, \text{ for all s and f}) \tag{1}$$

subject to

$$\sum_{s,f} A1_{(s,f,ComB)} = BB_{(ComB)} \tag{2}$$

and

$$\begin{aligned} &\sum_{d} A1_{(ComB,equity,d)} = \\ &MAX\left[\sum_{d} A1zero_{(ComB,equity,d)}, KAR \times \sum_{s,f} W_{(s,f,ComB)} \times A1_{(s,f,ComB)}\right] \end{aligned} \tag{3}$$

where

KAR is the capital adequacy ratio, $W_{(s,f,ComB)}$ is the risk weight that the financial regulator assigns to $A1_{(s,f,ComB)}$, $A1zero_{(ComB,equity,d)}$ is the value of equity the commercial banks would have on issue in the absence of capital adequacy requirements, $BB_{(ComB)}$ is the total value of commercial bank assets, and U is a constant elasticity of substitution function. We assume that the KAR constraint is binding so $\sum_{d} A1_{(ComB,equity,d)} = KAR \times \sum_{s,f} W_{(s,f,ComB)} \times A1_{(s,f,ComB)}$.

Equity liabilities are relatively expensive. Consequently, we approximate problem (1) through (3) as:

Choose $A1_{(s,f,ComB)}$ for all s and f

to maximize

$$U(NR_{(s,f,ComB)} \times A1_{(s,f,ComB)},\ \text{for all s and f}) \tag{4}$$

subject to

$$\sum_{s,f} A1_{(s,f,ComB)} = BB_{(ComB)} \tag{5}$$

where

$$NR_{(s,f,ComB)} = R_{(s,f,ComB)} - \Psi \times KAR \times W_{(s,f,ComB)} \tag{6}$$

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 liabilities. 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 (80 basis points). This is because the acquisition of an additional $1 of the risky asset requires that the bank raise $0.1 of additional equity finance, costing 800 basis points more than non-equity finance. 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.

2.3.2 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 paper 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) $$\begin{aligned}&\text{RABANK} \times \text{prabank} = \\ &\sum_{s\in LA}\sum_{f\in FI}[\text{RISKWGT}_{(s,f)} \times \text{A1}_{(s,f,\text{ComB})}] \times (\text{priskwgt}_{(s,f)} + \text{a1}_{(s,f,\text{ComB})})\end{aligned}$$

(8) $$\text{EQBANK} \times \text{peqbank} = \sum_{d\in AA} \text{A1}_{(\text{ComB},\text{Equity},d)} \times \text{a1}_{(\text{ComB},\text{Equity},d)}$$

(9) $$\text{pratio} = \text{peqbank} - \text{prabank}$$

(10) $$\begin{aligned}&\text{BBNEQ}_{(\text{ComB})} \times \text{pbblneq}_{(\text{ComB})} = \\ &\text{BBL}_{(\text{ComB})} \times \text{pbbl}_{(\text{ComB})} - \sum_{d\in AA} \text{A1}_{(\text{ComB},\text{Equity},d)} \times \text{a1}_{(\text{ComB},\text{Equity},d)}\end{aligned}$$

$$(11)\qquad \text{averorne}_{(\text{ComB})} = \sum_{d\in AA}\sum_{f\in FINEQ}[\text{A1}_{(\text{ComB,f,d})} / \text{BBNEQ}_{(\text{ComB})}]\times \text{rpow}_{(\text{ComB,f,d})}$$

$$(12)\qquad \text{a1d}_{(\text{ComB,f})} = \text{pbblneq}_{(\text{ComB})} + \text{TAU}\times[\text{rpowd}_{(\text{ComB,f})} - \text{averorne}_{(\text{ComB})}]\ (\text{f} \in \text{FINEQ})$$

where:

$BBL_{(ComB)}$ is the level of total end-of-year commercial bank liabilities (including equity);

$BBNEQ_{(ComB)}$ is the level of the equity-exclusive value of end-of-year commercial bank liabilities;

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

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

$A1_{(s,f,d)}$ 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;

EQBANK is the value of bank equity;

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

$priskwgt_{(s,f)}$ 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*;

$a1_{(s,f,d)}$ are the percentage changes in end-of-year holdings by agent *d* of asset type *f* issued by agent *s*;

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

pratio is the percentage change in the capital adequacy ratio;

$pbblneq_{(ComB)}$ is the percentage change in the equity-exclusive value of commercial bank liabilities;

$pbbl_{(ComB)}$ is the percentage change in end-of-year (equity-inclusive) commercial bank liabilities;

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

$rpow_{(ComB,f,d)}$ 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;

$a1d_{(ComB,f)}$ 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;

$rpowd_{(s,f)}$ is the percentage change in the power of the rate of interest 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 values for the risk weights in (7). In choosing values for $RISKWGT_{(s,f)}$, we were guided by values reported in Attachments A and D of APRA (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 pratio 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 ($pbblneq_{(ComB)}$) as the difference between total (equity-inclusive) bank financing needs ($pbbl_{(ComB)}$) 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).		

2.4 The central bank policy rate and the Taylor rule

In Section 2.1 we introduced the data arrays describing stocks of financial instruments ($A_{(s,f,d)}$) and the rates of return on those stocks ($R_{(s,f,d)}$). These data include two instruments relevant to the relationship between the central bank and commercial banks as it pertains to the operations of monetary policy within the FCGE model, namely:

1. $A_{(CenB,DeposLoans,ComB)}$ and $R_{(CenB,DeposLoans,ComB)}$, describing commercial bank holdings of clearing balances with the central bank, and the rate of return paid by the central bank on those balances.

2. $A_{(ComB,DeposLoans,CenB)}$ and $R_{(ComB,DeposLoans,CenB)}$, describing commercial bank borrowings of clearing balances from the central bank, and the rate of interest charged by the central bank on those balances.
3. $F_{(Govt,Bonds,ComB)}$, describing purchases and sales of domestic government bonds by the central bank.

Consistent with the channel system operated by the Australian central bank (e.g. Otto 2007, Woodford 2001), we begin with the idea that both $R_{(CenB,DeposLoans,Com)}$ and $R_{(Com,DeposLoans,CenB)}$ are policy variables, with $R_{(ComB,DeposLoans,CenB)} = R_{(CenB,DeposLoans,ComB)} + 0.005$.[3] We assume that the central bank maintains a given supply of commercial bank exchange settlement balances ($A_{(CenB,DeposLoans,ComB)}$) at the rate $R_{(CenB,DeposLoans,ComB)}$ via open market operations in the domestic government bond market ($F_{(Govt,Bonds,CenB)}$).[4]

Under the closure described above, $R_{(ComB,DeposLoans,CenB)}$ is exogenous, with $R_{(CenB,DeposLoans,ComB)}$ formally endogenous but uniquely determined by the exogenous status of $R_{(ComB,DeposLoans,CenB)}$ via the relationship $R_{(ComB,DeposLoans,CenB)} = R_{(CenB,DeposLoans,ComB)} + 0.005$. We endogenise $R_{(ComB,DeposLoans,CenB)}$ by introducing a Taylor rule linking movements in the policy rate to deviations of inflation from target and the employment rate from the natural rate. As Orphanides (2007) describes, Taylor rules are simple prescriptive policy rules

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[3] $R_{(s,f,d)}$ is defined as the power of the rate of return (i.e. 1 plus the rate) earned by asset agent *d* on financial instrument *f* issued by liability agent *s*. Hence, if the deposit rate for settlement balances with the central bank is 3%, then $R_{(CB,DeposLoans,Banks)} = 1.03$ and the power of the borrowing rate for settlement balances ($R_{(Banks,DeposLoans,CB)}$) is 1.035.

[4] This is consistent, for example, with the channel system description in Woodford (2003). He describes a channel system as one in which the central bank supplies a given level of clearing balances at a given policy interest rate, in addition to standing ready to lend clearing balances at a fixed spread over the policy rate (Woodford 2003: 27). This is also 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”.

describing how a central bank should adjust its policy interest rate in response to movements in inflation and economic activity. The "classic Taylor rule" proposed by Taylor (1993) is:

(13) $$r = (2 + p) + 0.5(p - 2) + 0.5y$$

where *r* is the federal funds rate, *p* is the rate of inflation over the previous four quarters, "2" denotes an assumed natural real rate for the policy rate of 2 per cent per annum (in the first bracketed term) and a target inflation rate of 2 per cent per annum (in the second bracketed term), and *y* is an output gap measure calculated as the percent deviation of real GDP from potential (Y^*), i.e., y = 100(Y-Y^*)/Y^*.

Within the FCGE model, we link movements in the policy interest rate to deviations in the price level from target and output from potential via the following adjustment process:

(14) $$\left(\frac{R_{(CenB,DeposLoans,ComB)t}}{R_{(CenB,DeposLoans,ComB)t-1}}\right) = FR\left(\frac{P_t}{P_t^{(T)}}\right)^{\alpha}\left(\frac{ER_t}{ER_t^{(T)}}\right)^{(1-\alpha)}$$

where $R_{(CenB,DeposLoans,ComB)t}$ and $R_{(CenB,DeposLoans,ComB)t-1}$ are the current and lagged powers of the interest rate offered by the central bank on settlement balances, P_t and $P_t^{(T)}$ are the actual and target levels for the consumer price index in year *t*, ER_t and $ER_t^{(T)}$ are the actual and target levels of the employment rate (1-the unemployment rate) in year *t*, *FR* is an exogenous shift variable, and α is a parameter (set at 0.5) governing the sensitivity of interest rate movements to deviations in prices and employment from target. Converting (14) to a percentage rate of change form, we have:

(15) $$r_{(CenB,DeposLoans,ComB)t} = r_{(CenB,DeposLoans,ComB)t-1} + 0.5\left(p_t - p_t^{(T)}\right) + 0.5\left(er_t - er_t^{(T)}\right) + fr$$

where $r_{(CenB,DeposLoans,ComB)t}$ and $r_{(CenB,DeposLoans,ComB)t-1}$ are the current and lagged percentage changes in the power of the interest rate offered by the central bank on settlement balances, p_t and $p_t^{(T)}$ are the actual and target rates of consumer price inflation in year *t*, er_t and $er_t^{(T)}$ are the actual and target percentage changes in the employment rate (1-the unemployment rate) in year *t*, and *fr* is a shift variable that is endogenous when the policy rule is inactive and exogenous (and typically unshocked) when the rule is activated.

3 Simulations

3.1 Background

In July 2015 APRA released the results of its comparative study of the capital ratios of Australian banks and their international peers. They noted 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 capital adequacy ratio by 100 basis points.

3.2 Model closure

We make the following closure assumptions:

i) 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 returns to its natural rate.

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

iii) The policy interest rate in year *t* adjusts relative to its *t*-1 level in response to movements in the consumer price inflation rate away from target, and movements in the employment rate (an output gap measure) away from target.

3.3 Results

The shock is a 100 basis point increase in the capital adequacy ratio of commercial banks (Figure 1). Via the mechanisms described in Section 2.3, 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 2). 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 in Figure 3 and Figure 4. In Figure 3, we see a decline in risk-weighted assets relative to total bank assets. In Figure 4, we see the composition of bank asset holdings shifting away from assets with comparatively high risk weightings (foreign loans, loans to reproducible housing, foreign equity, industry equity) towards those with lower risk weightings (domestic government bonds, loans to non-reproducible housing).

As discussed above, the rise in the capital adequacy ratio causes commercial banks to raise additional equity finance, and to reduce their demands for deposit and loan finance (Figure 2). To attract asset agents to acquire the new equity, rates of return on bank equity must rise (Figure 5). At the same time, commercial banks reduce their demand for loan and deposit finance, allowing them to secure loan and deposit financing at slightly lower rates of return relative to baseline (Figure 5). Figure 6 reports the deviation in the weighted average cost of capital to commercial banks, which rises relative to baseline as banks increase the equity share of their financing needs.

Figure 7 reports the deviations in the financial assets and liabilities of commercial banks.[5] As discussed in Dixon *et al*. (2015), banks are assumed to operate under an environment of a fixed margin on the return they earn on financial assets and the 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 6) to the agents to whom they lend. This reduces demand for loans from commercial banks, that is, it leads to a contraction in commercial bank ownership of financial assets (Figure 7). 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 7).

Figure 8 reports the movement in the interest rates that the central bank offers on settlement balance deposits by commercial banks, and charges commercial banks for settlement balance loans. As discussed in Section 2.4, the settlement balance deposit rate is determined by a policy rule in which the central bank policy rate responds to deviations in prices and unemployment from target. The movements in the policy rate reported in Figure 8 are small: a 0.6 basis point reduction in the year the policy is implemented, with this rising to a +0.1 basis point positive deviation by the end of the simulation period. This is very close to the central bank simply maintaining its baseline path for the policy rate. Figure 9 reports the movements in the price level and the employment rate that are driving, via the policy adjustment rule, the movements in the policy rate reported in Figure 8. In the year the capital

[5] We assume that commercial bank physical assets (primarily bank branches) are unaffected. Hence, in Figure 7, the percentage deviation in financial assets lies below the percentage deviation in liabilities.

adequacy ratio is increased, both the employment rate and the consumption price deflator fall relative to baseline (Figure 9). This accounts for the initial negative deviation in the policy rate (Figure 8). Thereafter, both the consumption deflator and the employment rate return to baseline. This accounts for the return of the policy rate towards baseline. By the end of the simulation period, the employment rate has returned to baseline, and the consumption price deflator is slightly above baseline. This accounts for the small positive deviation in the policy rate at the end of the simulation period. To put these numbers in context, typical RBA adjustments in the policy rate are articulated in terms of 25 basis point movements. The deviation in the policy rate at the end of the period is 0.1 basis points. The positive deviation in the consumption price index at the end of the simulation period is approximately 0.002 per cent. This is like a realized inflation outcome of 2.502 per cent when the target is 2.5 per cent.

As discussed in reference to Figure 4, the rise in the capital adequacy ratio induces commercial banks to reduce lending to reproducible and non-reproducible housing and industry. These agents can substitute towards other sources of financial capital, however their ability to do so is constrained, and as such, the reductions in bank lending have consequences for their capacity to finance physical capital formation. This is clear from Figure 10, which reports gross fixed capital formation for housing and non-housing investment. Turning to Table 1, the risk weight on lending to reproducible housing is slightly higher than that on lending to industry. This explains part of the deeper negative deviation in gross fixed capital formation in housing investment relative to non-housing investment in Figure 10. However another important factor is the ability of housing and non-housing liability agents to substitute away from bank finance. For housing investment, opportunities in this regard are limited: approximately one half of the sector’s capital formation is financed by bank lending, with another one third financed via household equity. Outside of housing, bank financing accounts for approximately one quarter of the capital required to finance investment, with other sources like foreign markets and domestic superannuation satisfying, respectively, approximately one third and one tenth of non-housing investment financing needs. As is clear from Figure 10, with both components of aggregate investment (i.e., both housing and non-housing investment) below baseline, so too is aggregate investment.

Figure 11 reports deviations in real GDP, employment, capital, and investment. In the simulation's first year, the physical capital stock cannot change from baseline. However a small negative employment deviation in the simulation's first year generates a small negative deviation in real GDP in that year. Thereafter, employment gradually returns to baseline. However, the negative deviation in real investment causes the aggregate capital stock to fall relative to baseline (Figure 11). This causes a negative deviation in GDP in the medium to longer-term of the order of -0.005 per cent, despite the return of employment to baseline.

Figure 12 reports real GDP, real GNE, and the components of real GNE (private and public consumption spending, and investment). As is clear from Figure 12, the deviation in real GNE lies below the deviation in real GDP. This is due to the negative deviations in private consumption and real aggregate investment. As discussed above, the increase in the capital adequacy ratio causes bank lending to industry and housing to fall relative to baseline. As can be seen in Figure 12, the resulting falls in dwelling and non-dwelling investment cause the aggregate investment deviation to lie below the real GDP deviation. This contributes to the GNE deviation lying below the real GDP deviation. Similarly, we see in Figure 12 that the deviation in real private consumption spending lies below the real GDP deviation, thus also contributing to the GNE deviation lying below the real GDP deviation. While real public consumption spending is assumed to remain unchanged from baseline, this is not enough to offset the contributions to the gap between the GNE and GDP deviations made by the declines in real investment and real private consumption spending.

With the real GNE deviation lying below the real GDP deviation, we expect the real balance of trade to move towards surplus. This is confirmed by Figure 13, where we see a positive deviation in export volumes and a negative deviation in import volumes. The positive deviation in export volumes generates a negative deviation in the terms of trade because exporters must lower the foreign currency prices of their commodities to support the expansion in export volumes. The negative deviation in the terms of trade has consequences for real private consumption. In discussing Figure 12, we noted that the deviation in real private consumption was below the deviation in real GDP. This is because of the decline in the terms of trade. In modelling consumption, we assume that nominal private consumption spending is a fixed proportion of nominal national income. Under this specification, a decline in the terms of trade damps private consumption spending relative to real GDP.

Figure 14 explores the implications of reduced bank lending for the composition of the liability side of the model's two capital creating agents: industry and reproducible housing. As is clear from Figure 14, the balance sheets of both sectors shift away from loan finance towards equity and (in the case of industry) bond 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 encouraged to finance a greater proportion of their stake in the reproducible housing sector via equity, and industries are encouraged to finance a greater proportion of their gross fixed capital formation via equity and bonds.

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 adverse macroeconomic 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, a rise in household equity financing of home ownership, and a rise in equity and bond financing of capital formation by industry.

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 the relationship between central bank announcements and the behavior of financial market participants. In the current model, the central bank affects changes in the policy rate through open market operations. This is consistent with descriptions of central bank activity that give open market operations a central place in maintaining the policy rate near target. However, another possibility is that central bank rate announcements induce market participants to take actions that adjust rates in the direction desired by the central bank, thus reducing the short-run need for open market operations.

Acknowledgements

This research was supported by the Centre for International Finance and Regulation (project number E003), which is a Centre of Excellence for research and education in the financial sector, funded by the Commonwealth and NSW Governments and supported by other consortium members (see www.cifr.edu.au). We are also grateful for financial support from the Australian Research Council via DP140100476. We have benefited from discussions with our research colleagues and feedback at a number of presentations. Without implication, we thank in particular Peter Docherty, Rod Maddock, Gordon Menzies, Deborah Ralston and Rod Tyers for their helpful comments and valuable suggestions.

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Figure 15: Capital adequacy ratio of commercial banks (basis point change relative to baseline)

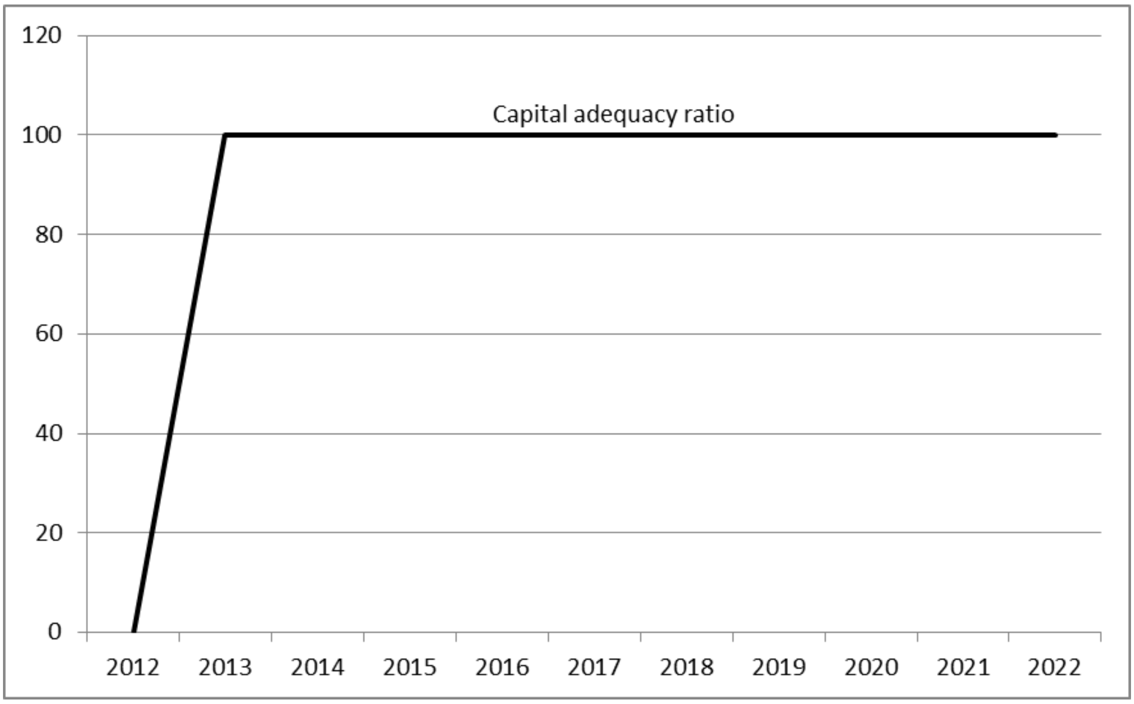

Figure 16: Outstanding financing instruments of the commercial banks (% deviation from baseline)

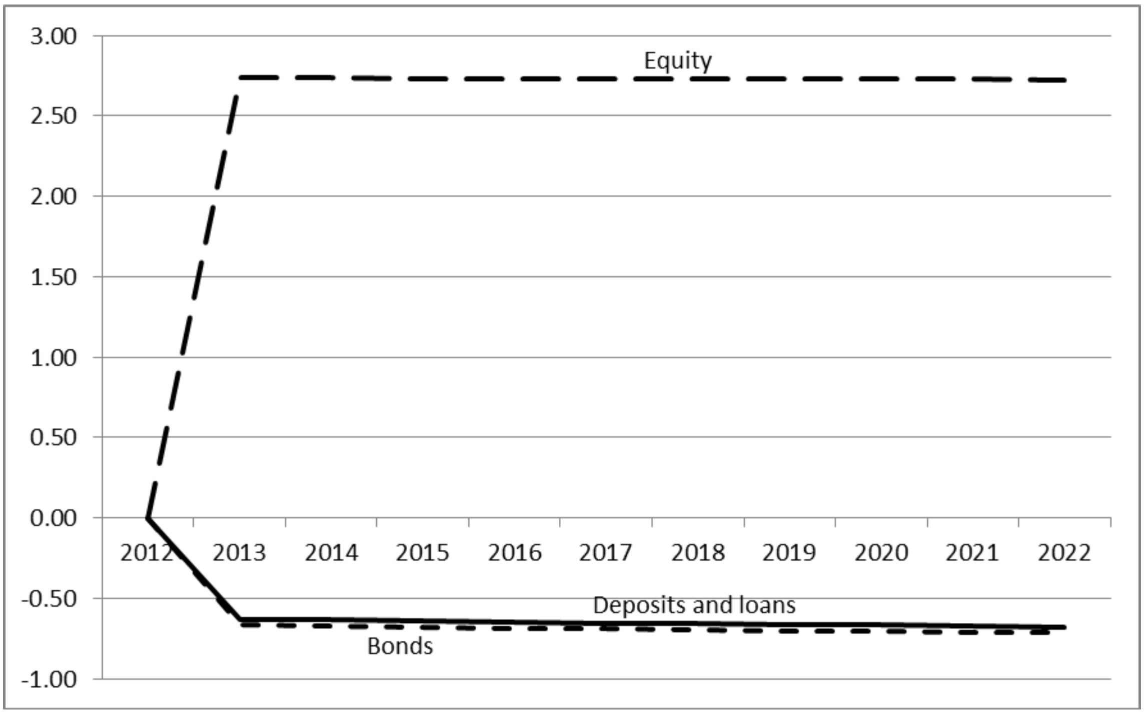

Figure 17: Bank equity, total financial assets, and risk weighted assets (% deviation from baseline)

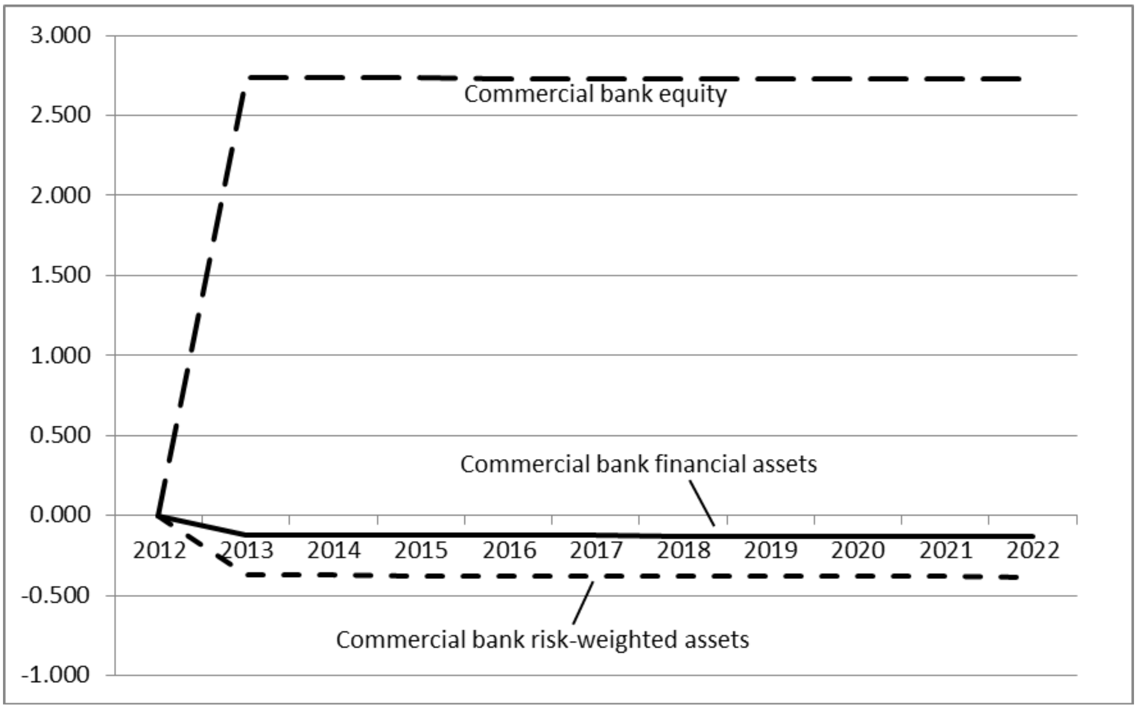

Figure 18: Major asset holdings of the commercial banks (% deviation from baseline)

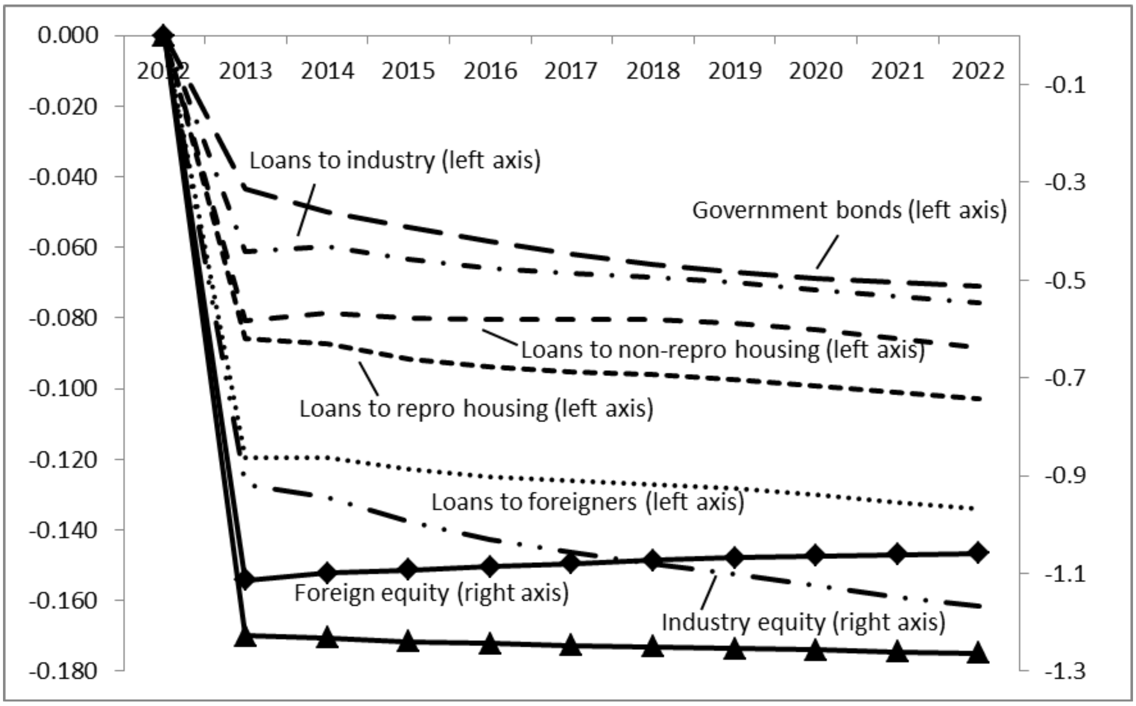

Figure 19: Rates of return (powers thereof) on bank financing instruments (% deviation from baseline)

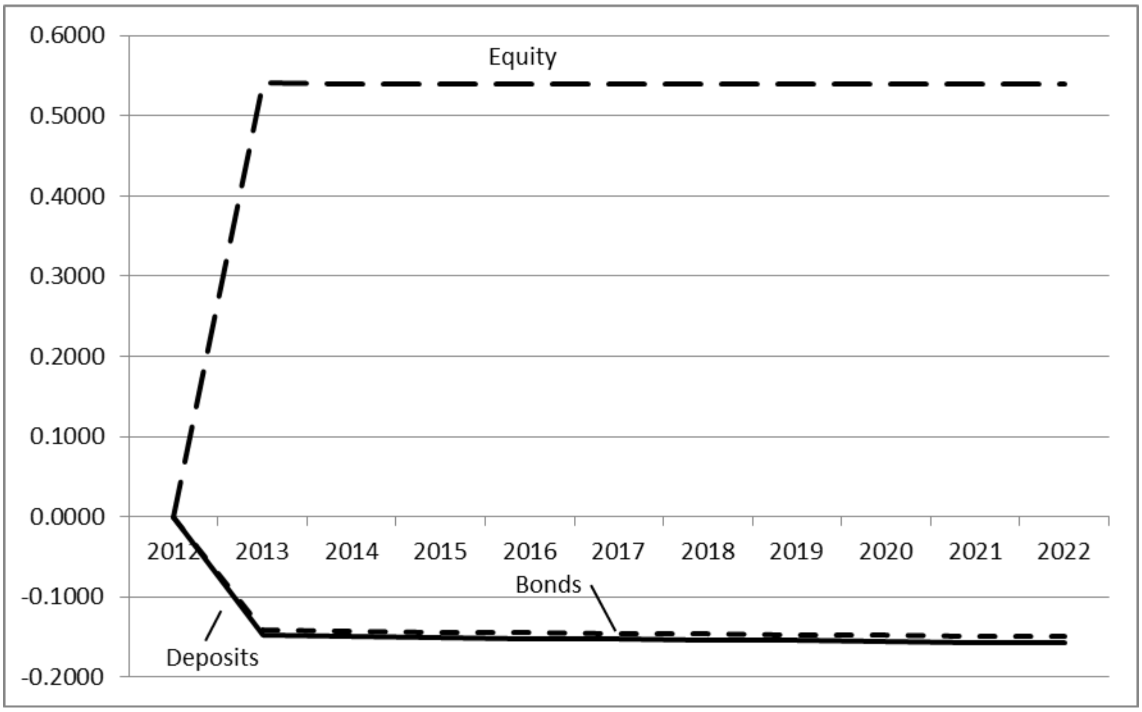

Figure 20: Weighted average cost of bank capital (basis point change from baseline)

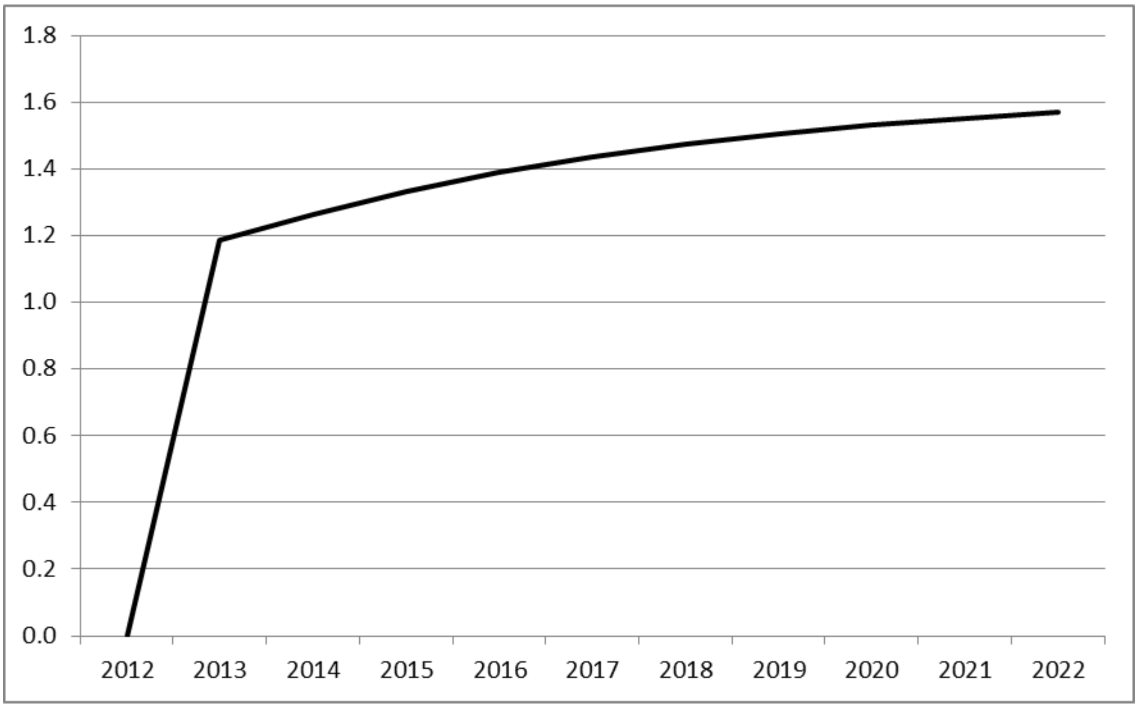

Figure 21: Financial assets and liabilities of the commercial banks (% deviation from baseline)

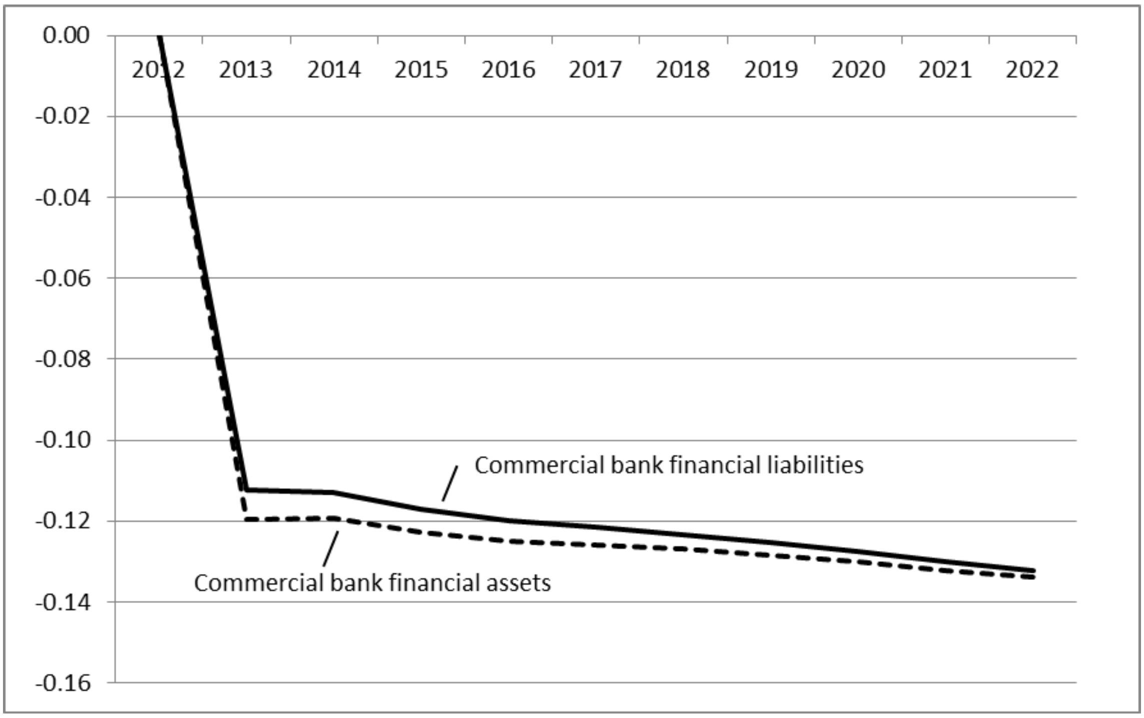

Figure 22: Movement in the central bank deposit and lending rates for settlement balances (basis point change from baseline)

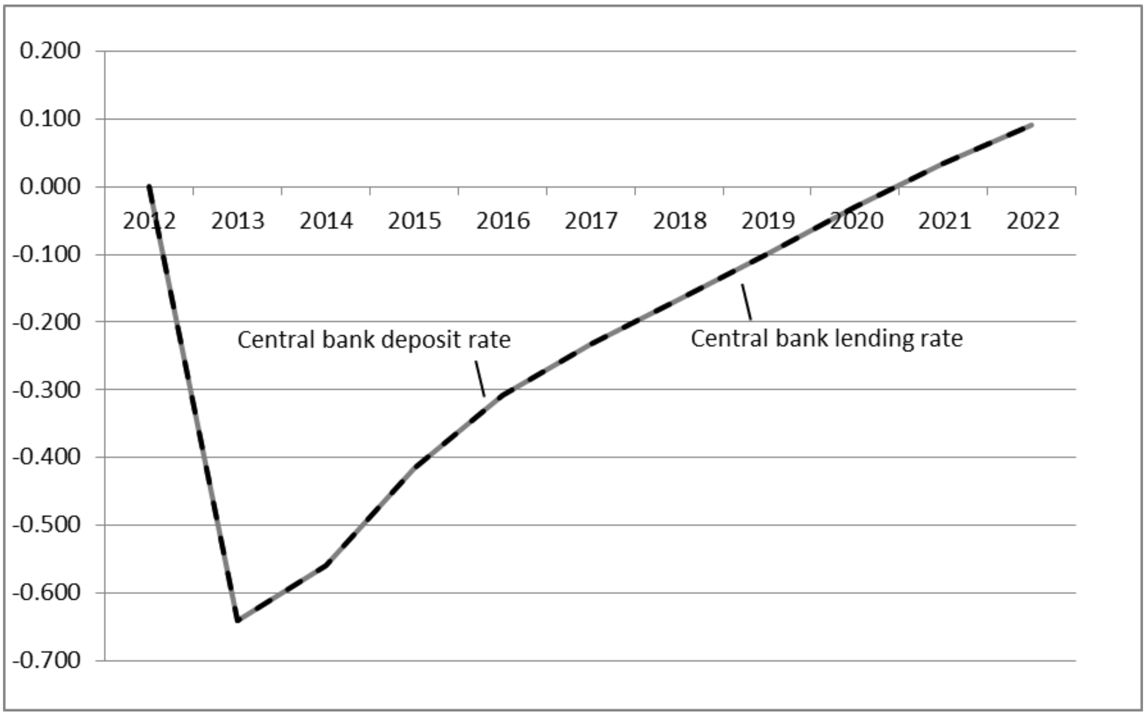

Figure 23: Employment rate and private consumption deflator (percentage deviation from baseline)

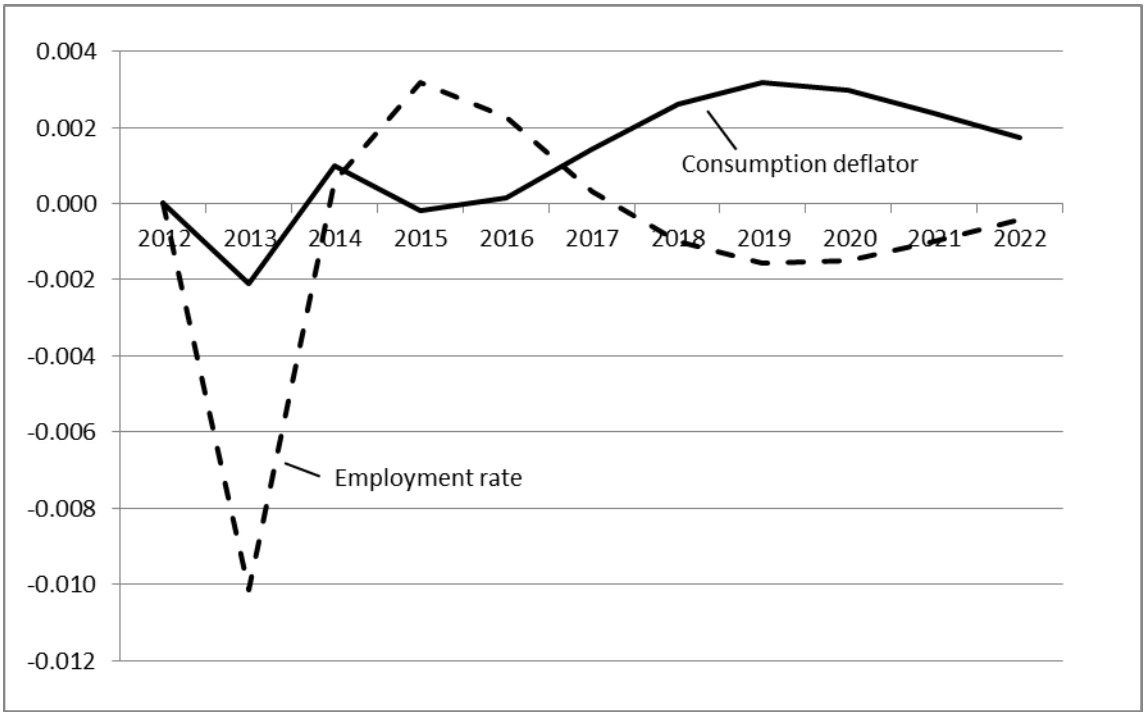

Figure 24: Housing and non-housing investment, and economy-wide investment (% deviation from baseline)

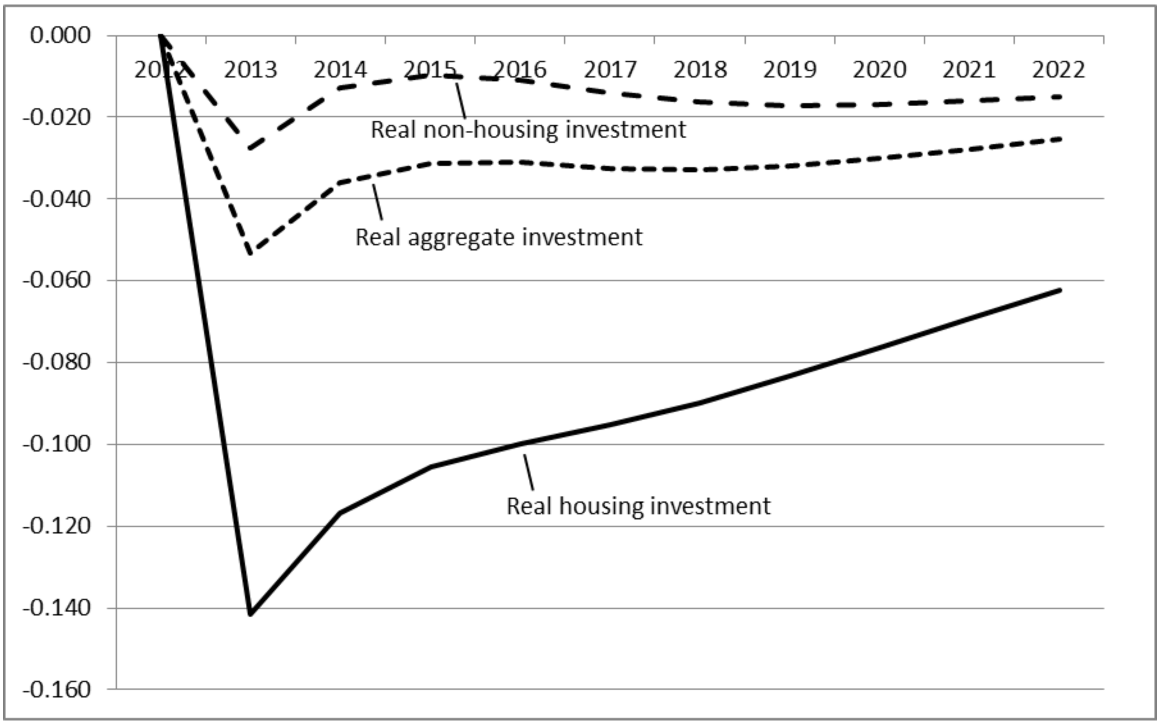

Figure 25: Real GDP, employment, capital stock and real investment (% deviation from baseline)

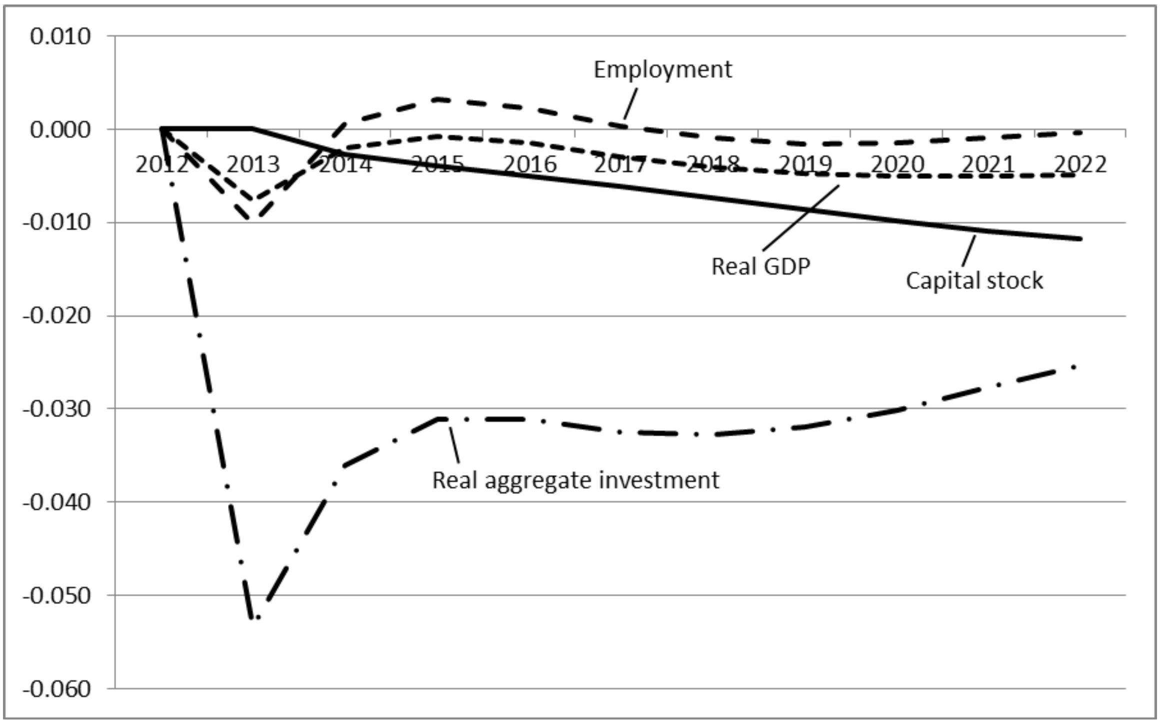

Figure 26: Real GDP, real GNE, and the components of real GNE (% deviation from baseline)

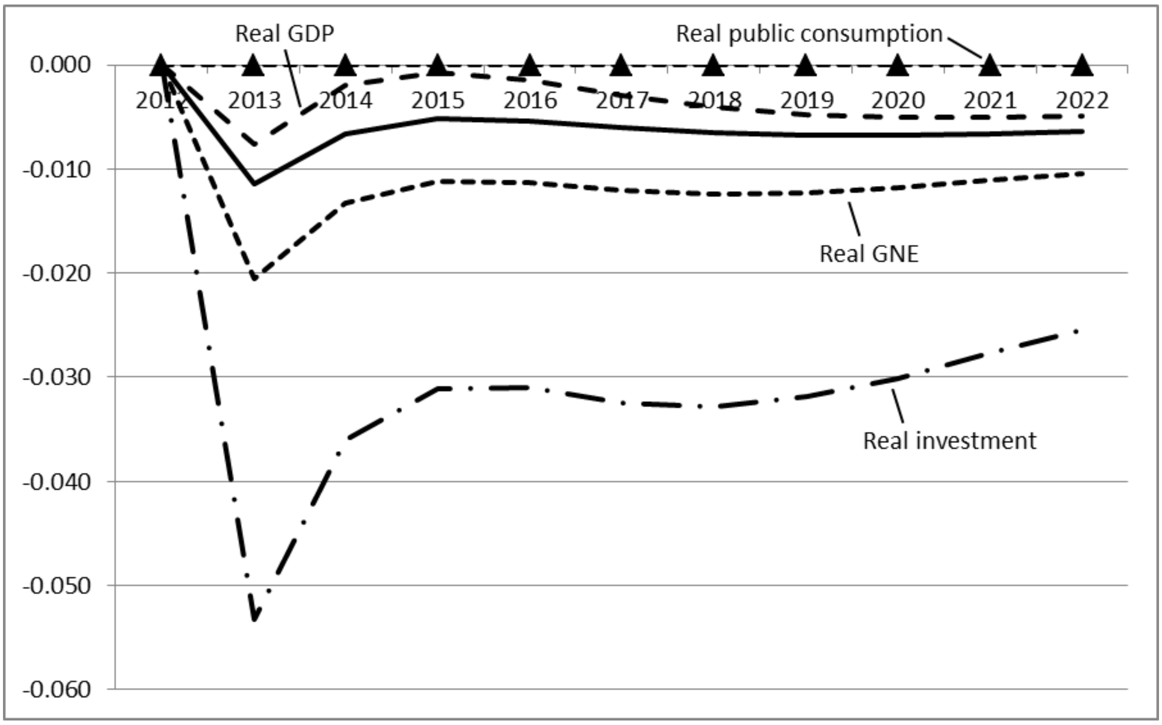

Figure 27: Export volumes, import volumes and the terms of trade (% deviation from baseline)

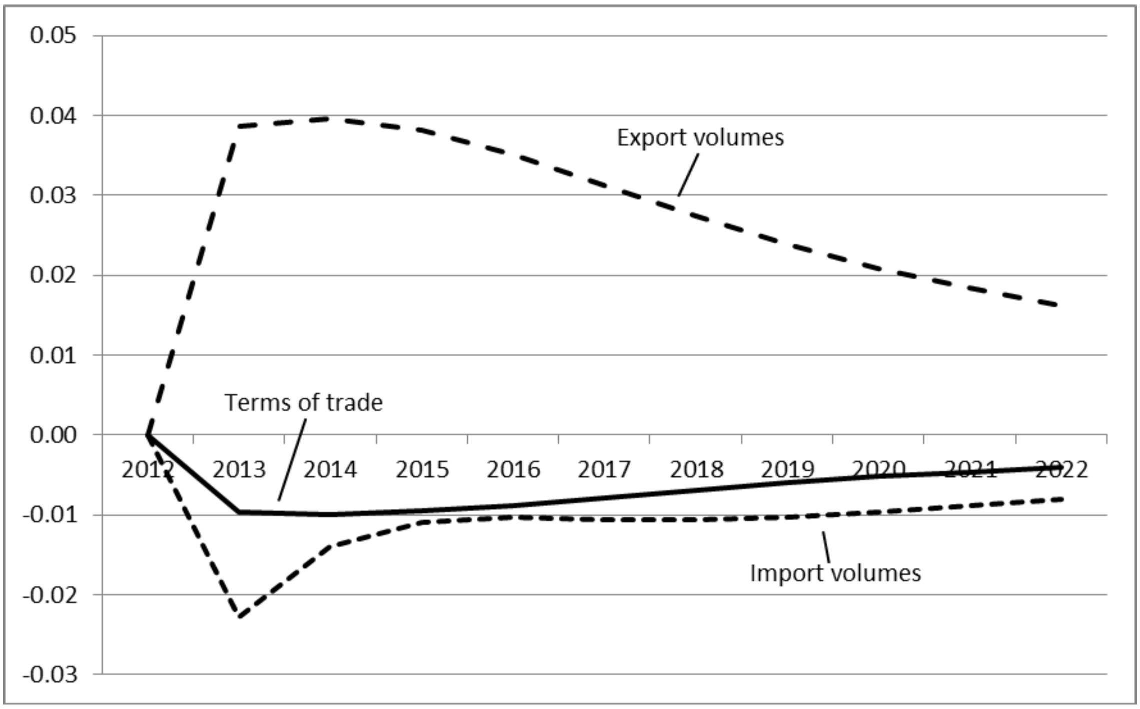

Figure 28: Equity and debt of industry and reproducible housing (% deviation from baseline)