General Equilibrium Consequences of Indonesian Bank Regulatory Reform:

Theory, Data, and Application of a Financial Computable General Equilibrium Model of The Indonesian Economy

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Abstract

Over the last thirty years, Indonesia has undertaken a series of financial reforms to unlock the potential of financial development for economic growth. Before the 1997 Asian Financial Crisis (AFC), three major financial reforms were highlighted. The first was the June 1983 banking deregulation package, known as Pakjun 83, which modernised banking operations by liberalising commercial bank decisions on interest rates and credit provision. The second reform was the October 1988 (Pakto 88) policy package which significantly relaxed new bank licencing and scope of business, with particular focus on liberalising the banking sector's ability to manage their foreign liabilities. The third reform was the enactment of the 1992 Indonesian banking law (Law No.7 1992) to strengthen the bank prudential framework. Despite efforts to develop and implement a prudential framework, the collapse of the Indonesian banking system during the AFC was one of the worst in the history of banking in emerging economies. In the global financial crisis (GFC) in 2008, Indonesia experienced a substantial capital outflow from its financial system. However, the overall financial system remained intact.

This thesis uses a financial computable general equilibrium (FCGE) model, AMELIA-F, to evaluate the impacts of Indonesian financial reforms on the economy and financial stability. AMELIA-F is composed of two major parts: First, the real-side of the model, representing the real dynamic CGE model. This part contains equations that outline how traditional economic agents, like households, industries, investors and the public sector, adjust their consumption bundles, and set production structures. Second, the financial-side of the model. This part describes how financial agents in Indonesia set both their capital structures and financial asset allocations. The real- and financial-sides of the model are connected via multiple channels. When these channels are activated, the real- and financial-sides constrain and influence each other in a general equilibrium framework.

Using AMELIA-F, this thesis investigates two important financial reforms in Indonesia. First, it evaluates a 100 basis point increase in bank capital adequacy ratios (CAR). The results show that the reform has small, negative consequences for the economy. The commercial banks experience a balance sheet reduction as they move away from riskier assets and finance more of their activity by equity rather than debt. This negatively impacts the capacity of industry and housing developers to invest in physical capital formation and economic growth. However, the reforms aids financial stability via: (i) a fall of bank debt-to-equity ratios; (ii) attenuated bank risk-taking behaviour; and (iii) lower economy-wide private debt to income ratio. Second, this thesis assesses a 100 basis point increase in bank net open position (NOP), to represent a capital account relaxation policy. The results suggest small gains for the Indonesian real economy, measured as increases in real investment and GDP relative to baseline forecasts. Net foreign capital inflows in each case cause exchange rate appreciation, which causes small reductions in the central bank policy rate.

Declaration

I, Arief A. Rasyid, declare that the PhD thesis entitled *General Equilibrium Consequences of Indonesian Bank Regulatory Reform: Theory, Data, and Application of a Financial Computable General Equilibrium Model of The Indonesian Economy* is no more than 80,000 words in length including quotes and exclusive of tables, figures, appendices, bibliography, references and footnotes. This thesis contains no material that has been submitted previously, in whole or in part, for the award of any other academic degree or diploma. Except where otherwise indicated, this thesis is my own work. I have conducted my research in alignment with the Australian Code for the Responsible Conduct of Research and Victoria University's Higher Degree by Research Policy and Procedures.

Signature: [redacted]

Date: December 2nd 2022

Dedications

This thesis is dedicated to:

My beloved wife: Lia Amelia Sulistyodewi, for your supports, patience, and sacrifices.

My dearest daughters: Zaradine Rasyid and Magnolia Rasyid, for your understanding.

My Parents: Nunuh Rasyid and Endang Aridianti, Alm. R. Utomo Suyanto, Usriyati Utomo for your kindness and sincere prayers.

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Publications and Conferences

Publication

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Conferences

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CHAPTER 1
Background and Thesis Overview

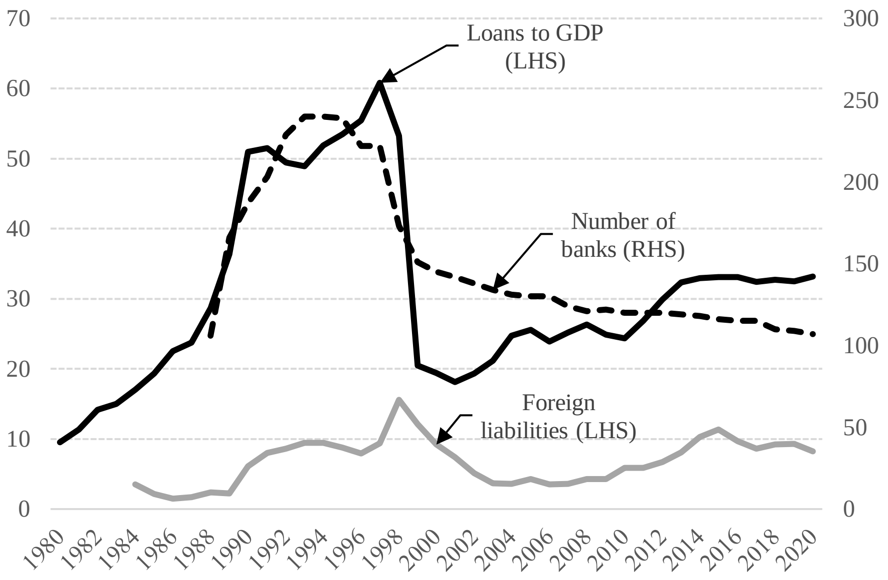
1.1 Background

Financial development has been advanced in many studies as a significant driver of development of the real economy. A common thread to the arguments in these studies is that financial development facilitates the efficient allocation of savings to industries, thus supporting technological advancement and entrepreneurial innovation [Bagehot (1873); Schumpeter (1912); Hicks (1969); Goldsmith (1969); McKinnon (1973); Shaw (1973); and Pagano (1993); and Miller (1999)]. There are several dissenting arguments to the leading role of financial development in economic development, such as Robinson (1952) who said "where enterprise leads finance follows", and Lucas (1988) who did not find a role for financial development in landmark literatures of economic development [such as in Meier and Seers (1984) and Stern (1989)]. The more recent empirical research from Estrada et al. (2010), Popov et al. (2012), and Cecchetti and Kharroubi (2012) suggest an important role for regulatory reform in mitigating risks of crisis from financial development and in sustaining the benefits of the financial sector to the real economy.

Over the last thirty years, Indonesia has undertaken a series of reforms to unlock the potential of financial development to support real economic performance. There were three milestones before the 1997 Asian financial crisis (hereafter, AFC) which notably determined the course of financial development in Indonesia.

The first milestone was the June 1983 banking deregulation package, known as Pakjun 83. This reform modernised banking operations by abolishing financial repression that curtailed the Indonesian banking industry's capacity to work optimally (Nasution, 1994). Pakjun 83 removed government controls on interest rates and credit allocation. Previous government interventions on bank interest rates had caused negative real interest rates, leaving bank saving products unattractive for depositors [Permono (2004); Hamada (2003)].

The second milestone came from the deregulation package promulgated in October 1988 (Pakto 88). The key points of this reform were a massive relaxation of new bank licencing (including for opening new branches) and expansion of banking businesses, especially in foreign exchange related activities. Pakto 88 also installed several prudential regulations such as: minimum (nominal) capital requirements; legal lending limits;[1] loan to deposit ratio; capital adequacy ratio (CAR);[2] and, net open position (NOP).[3] Rapid approval of new licences caused the number of commercial banks to expand significantly. This was followed by a significant increase in bank intermediation (measured as loans to GDP) and foreign liabilities (see Figure 1.1).



Source: CEIC, Bank Indonesia, and World Bank

Figure 1.1 Bank Loans to GDP (%), Number of Banks, and Foreign Liabilities (% of total liabilities)

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[1] The legal lending limit is a regulatory limit on banks' capacity to lend to affiliated firms. This cap is enforced to mitigate the risk of concentrated bank lending.
2 The CAR is defined as the ratio of equity capital raised as a liability by a bank, to the risk-weighted assets of the bank. In PAKTO 88, the CAR was set to gradually rise to 5 per cent by March 1992, 7 per cent by March 1993, and 8 per cent by December 1993.
[3] The NOP is calculated as the ratio of net foreign liabilities raised by a bank, to its equity capital liabilities. The regulatory NOP in PAKTO 88 was set to 25 per cent, meaning that the banks have to provide Rp 4 equity capital for each Rp 1 expansion of their net foreign liabilities. This prudential measure was introduced when limitations on bank foreign borrowing were abolished. The NOP was tightened to 20 per cent in 2000 to limit the use of foreign debt to finance bank liabilities (Jayasuriya and Leu, 2012).

The third milestone was the enactment of the Indonesian banking law 1992 (Law No.7 1992). This law was a response by Indonesian policy makers to the rapid expansion of the banking sector in the 1980s. Banking reforms undertaken in the 1980s were deemed too lax, with policymakers concerned they may trigger macroprudential problems (Bennett, 1995). The spirit of the Indonesian banking law 1992 reforms was to provide legal certainty of the continuation of banking reforms (i.e., the curtailment of government intervention and confirmation of the scope of private bank business). The law also reinforced prudential measures in relation to minimum capital provisions and legal lending limits. These prudential measures encouraged the consolidation of the banking industry and reduced concentrated risk amidst a concern of conglomeration between private banks and the manufacturing industry.

Despite these efforts to build a prudential framework, the collapse of the Indonesian banking system in the AFC was one of the worst in the history of banking in emerging economies. Non-performing loans (NPL) sharply increased, rising to 63 per cent of total loans in 1998 (Nasution, 2000). The Bank CAR fell far below regulatory requirements, with many turning negative due to large accumulated losses. The authorities forced 67 banks to cease operations in 1998-1999 due to severe insolvency (Hamada, 2003). This action however triggered a wide-scale panic among depositors and immediately led to a bank-run (Djiwandono, 2005).

The costs of the AFC on the Indonesian economy were significant and called for stronger and more effective reforms in the financial system. The costs of bank restructuring amounted to more than Rp 600 trillion (US$ 80 billion) at the end of 1999 (Enoch et al. 2003). Fane and Mcleod (2002) estimated that the cost of Indonesian bank recapitalisation in 1998, required in order to reach a minimum 8 percent CAR, was approximately 15 per cent of GDP. Hamada (2003) calculated that US$24 billion of capital was divested from the Indonesian economy in the period between 1997 and 1999. By 1998, annual real investment and real GDP growth in Indonesia had contracted 33 per cent and 13 per cent peak-to-trough, respectively. Within the IMF crisis resolution program, the Indonesian government commissioned further reforms in the banking sector, including recapitalisation, establishment of the Indonesian Deposit Insurance Corporation (IDIC), and an independent central bank (Hamada, 2003).

Since the AFC, the Indonesian financial system has been relatively sound and resilient. Figure 1.1 reports that while bank intermediation has grown between 2000-2020, the pace has been modest when considered relative to the rate of expansion in the lead up to the AFC. The number of banks has gradually reduced, as a result of bank consolidation. The use of foreign liabilities was comparatively low and stable over 2000-2010, while it steadily increased over 2011-2015 as major foreign central banks enacted policies of quantitative easing in response to the global financial crisis (GFC).

The Indonesian economy and financial system performed relatively well during the GFC compared to other ASEAN countries (Basri and Rahardja, 2010). The Indonesian economy grew 6.1 per cent in 2008, higher than both the global economy (3 per cent) and the ASEAN-5[4] economies (5.4 per cent). The smaller impact of the GFC on the Indonesian economy compared with other peer countries has been attributed to the country's weaker exposure to transmission channels via global trade [Estrada et al. (2010); Claessens et al., (2012); Baur (2012)]. In the financial sector, the Indonesian banking system remained well capitalised during the GFC. The bank sector-wide CAR was 16.8 per cent, far above the minimum Basel II regulatory standards of 8 per cent (Basri and Siregar, 2009). The NOP was 5.2 per cent, well below the maximum domestic regulatory standard of 20 per cent. The Indonesian authorities supported economic resilience by running expansionary monetary and fiscal policies (Basri and Rahardja, 2010).

Importantly, since the GFC the Indonesian economy and financial system have become more exposed to movements in capital flows and global financial markets (Mara et al., 2021). As described in Warjiyo (2017), these developments motivate a better understanding of the macro-financial linkages and the use of a mixture of policies to achieve financial stability and sustainable economic growth.

As discussed above, the Indonesian economy has been subject to substantial financial shocks over the past three decades. At the same time, Indonesian policy makers have pursued financial sector reform to strengthen the resilient to financial shocks. While Indonesia has a long tradition in the development and application of real-side economic models to investigate the effects of government policies and economic shocks, there has

[4] The ASEAN-5 refers to Indonesia, Malaysia, Singapore, Thailand, and the Philippines.

been far less work done in the area of building and using economic models with financial sector detail. This is despite financial shocks and financial regulatory reforms playing important roles in the recent history of Indonesia's economic development. The central aim of this thesis is to address this analytical capability gap by developing a detailed model of the Indonesian economy that integrates modelling of both the real- and financial-sides of the economy.

To this end, herein I develop a financial computable general equilibrium (FCGE) model of the Indonesian economy, called AMELIA-F (A Model of Economic Linkages of Indonesia-FCGE). Having developed AMELIA-F, I then investigate two financial policies relevant to both the recent history of Indonesian policy development and prospects for future policy change. First, I simulate the impact of a 100 basis point increase in the bank capital adequacy requirement (bank CAR) in Indonesia. As I outline herein, AMELIA-F carries within its core database and model theory the capacity to trace transmission of this shock through the financial system to the real economy, under a general equilibrium framework. The results of the simulation suggest that this type of prudential policy has relatively small negative consequences for the Indonesian real economy, while it strengthens indicators of Indonesian financial stability. Second, I evaluate the impacts of relaxation in Indonesian capital controls on the banking industry by simulating a 100 basis point increase in bank net open position (bank NOP). In studying this shock, I identify a series of accommodation modes by the commercial banking sector, specifically through liability- or asset-side adjustments. I study the general equilibrium consequences of the policy reform on the wider financial sector and the real economy under each mode. The findings of these simulations will contribute to a better understanding among Indonesian academics and policy makers about the role of financial regulation in aiding financial and macroeconomic stability, and balancing the real economic costs and benefits of financial policy intervention.

In addition to the policy applications with the new FCGE model, another major contribution of this thesis is the development of the Indonesian FCGE model itself, which provides an enduring capacity for future forecasting and policy work. The FCGE model contains detailed modelling of financial instruments and agents, with data aligning to the

2010 Indonesian input-output table[5] and Bank Indonesia's 2018 financial account and balance sheet database (FABSI). On the financial side, the model describes financial agents as constrained optimising managers of the asset and liability sides of their respective balance sheets. Financial decision making takes place in a general equilibrium framework with rates of return across financial instruments and agents equilibrating to ensure constancy across both financial agent decision making and financing constraints connected to the real economy. Institutional arrangements related to wage setting and policy interest rates are modelled, with the wage-employment relationship described by a Phillips curve (Phillips, 1958), and central bank responses described by a Taylor rule [Taylor (1993); Orphanides (2007)]. In future work, the development of the model could be directed to improve the granularity of financial agents by disaggregating insurance and pension fund agents. These agents in the present model are combined within the NBFI (Non-bank Financial Institutions) sector as a single representative financial agent. Another potential area of development is extending the model's regional detail and adding detailed taxation policy attributes, particularly as these relate to financial decision making.

1.2 Achievements of the Thesis

As documented in the body of this thesis, my thesis research produced six achievements:

(1) Development of a traditional real side comparative-static CGE model of the Indonesian economy.

(2) Development of a traditional real side dynamic CGE model of the Indonesian economy.

(3) Development of a dynamic financial CGE model of the Indonesian economy.

(4) Investigation of the economic effects of capital adequacy regulation using a financial CGE model of the Indonesian economy.

(5) Investigation of the economic effects of regulations on Indonesian bank lending to, and borrowing from, foreign financial markets, using a financial CGE model of the Indonesian economy.

[5] Updated to 2018 using Horridge (2009) input output table "Adjuster Program".

(6) Insights into consistency problems with Indonesian official statistics on financial flows and stocks, which will prove helpful in improving future official data releases.

Achievements (1) and (2) were by-products of my progress towards (3). I started with the development of an Indonesian version of the ORANI-G comparative static CGE model of the real side of the economy (achievement 1 above). I then converted this static model into a MONASH-style dynamic CGE model of the real side of the economy, by incorporating stock/flow dynamics and wage-employment dynamics (achievement 2 above). I then extended the dynamic real CGE model to a financial CGE model by introducing theories governing financial agent behaviour determining asset and liability decisions, together with links connecting asset and liability decisions to the real economy via relevant financing linkages. Supporting this financial theory were substantial additions to the database describing disaggregated financial stocks and flows (achievement 3 above). At all stages of achievements 1 – 3, the modelling process required extensive database work covering data collection, processing, integration with theory, consistency checking across data sources and with model theory, and revision. These tasks included hundreds of experiments and iterative testing processes to ensure the synchronisation of the database with the model theory and the identification and correction of inconsistencies in official statistics. In undertaking these tasks, I identified a significant inconsistency between financial statistical data and traditional national accounts data prepared by two different Indonesian agencies (achievement 6 above). I alerted these agencies to the inconsistency and as a result, future data releases should be improved. I applied the financial CGE model to the investigation of two Indonesian financial regulatory issues: capital adequacy regulation (achievement 4 above) and regulation of bank borrowing from foreigners and lending to foreigners (achievement 5 above). The remainder of this thesis provides details of these research achievements.

1.3 Thesis Overview

The thesis comprises 10 chapters, organised in the following manner. Chapter 1 provides a brief background to Indonesian financial and economic developments that motivate the work undertaken for this thesis. Chapter 2 discusses the literature on the nexus between the financial system and the real economy and outlines the research gaps that this thesis aims to fill. Chapter 3 contains detailed explanations of the theoretical structure of the real-side economic elements of AMELIA-F. Chapter 4 goes on to explain the financial side of AMELIA-F and the connecting channels through which the real and financial sides interact with each other within the FCGE model. Chapters 5 and 6 describe the real and financial databases that underlie the theories in the real-side and financial-side of AMELIA-F respectively. Chapter 7 presents the baseline simulation with AMELIA-F. Chapter 8 is a policy simulation describing a 100 basis point increase in bank CAR. Chapter 9 is a policy simulation describing a 100 basis point increase in bank NOP. Chapter 10 concludes the thesis. In the following subsections, I provide an expanded summary of each chapter.

1.3.1 Chapter 2: Literature review

Since this thesis uses economic modelling as a platform to evaluate the impacts of financial policy reform, the literature review focusses on discussions of modelling approaches. I limit the discussion to large-scale economic models, because small-scale and partial-equilibrium models cannot appropriately capture feedbacks between the real economy and the financial system, and also lack the policy-relevant detail of large models. The modelling approaches are categorised into themes: macroeconometric, dynamic stochastic general equilibrium (DSGE), and financial computable general equilibrium (FCGE). In the macroeconometric section, I explain the key equations and major characteristics of macroeconometric models used by various public and private agencies. I provide an overview of the MARTIN model as an example of current macroeconometric models used by monetary authorities. At the end of the section, I discuss the major criticisms of macroeconometric models (which predominantly came from the school of rational expectations and the Lucas critique (Lucas, 1976)) and some counter arguments of those criticisms. DSGE models appear as the immediate successors of macroeconometric models. The equations explaining agents' behaviours are mostly derived from micro-foundations. However, the complexity required for accommodating forward-looking expectations and uncertainty to address the Lucas critique constrains the flexibility of these models, particularly with regard to the theoretical behaviours of financial agents, e.g., the optimal behaviour of disaggregated economic agents in the financial sector. Turning to FCGE models, I elucidate the various FCGE models that have been developed and how the recent FCGE models have great potential in modelling the detailed behaviour of financial agents and their explicit connections to the real economy. At the end of the chapter, I describe the modelling practices within Indonesian economic agencies i.e., National Development Planning, Ministry of Finance, Central Bank of Indonesia (BI). I discuss some key aspects on how improvements in economic modelling capabilities could be made to benefit Indonesian agencies in policy formulations.

1.3.2 Chapter 3: The theoretical structure of the real-side elements of the model

The real-side elements of AMELIA-F comprise a dynamic CGE model closely following the MONASH model theory of Dixon and Rimmer (2002). The real-side elements of the model follow a neoclassical framework that assumes the agents behave as optimisers of their objective functions subject to specific constraints. It applies a zero pure profit condition for production, investment, imports, exports, and distribution activities. Markets clear such that the price of commodities and factors are determined by the equalisation of supply and demand. In current production, the model is specified as a multi-level nesting system. The industries have four different nest layers, namely: primary factors, intermediate inputs, activity level (production capacity), and supply of commodities. The household agent maximises a Klein-Rubin utility function (Klein and Rubin, 1947) subject to a budget constraint by choosing a combination of commodities to consume. CES optimisation governs choices across source-specific consumption of commodities. Commodity-specific export demands are determined as negative functions of foreign currency export prices. Government demand is naturally exogenous but can be set to follow household consumption using appropriate closure swap arrangements.

1.3.3 Chapter 4: The theoretical structure of the financial-side elements of the model.

The financial elements of AMELIA-F govern financial agent behaviour toward financial instruments (financial assets and liabilities) and counterparty agents. The financial theory describes the function of financial markets in facilitating intermediation of financial flows and real-side activities like investment, current account financing, and funding of government activity. The financial side of AMELIA-F has eight financial agents comprising: industries, the central bank, commercial banks, NBFIs, government, households, housing, and the rest of the world (ROW); and five financial instruments comprising: bonds, cash, deposit/loans, equity, and Gold and IMF Special Drawing Rights (SDRs). When a financial agent is concerned about the assets it is holding, it is defined as an asset agent. When the financial agent is concerned with the composition of its equity and debt liabilities, it is defined as a liability agent. Financial agent behaviour is derived from asset and liability constrained optimisation. Subject to an overall asset holding constraint, asset agents seek to maximise a function of the returns from their asset holdings by choosing between financial assets, with the function describing the maximand structured in a way that encourages diversification of asset holdings. Liability agents are also modelled as constrained optimisers. Subject to a need to maintain and raise a given level of financial capital, liability agents seek to minimise a function of the weighted average cost of financial capital, with the structure of the minimand configured in a way that encourages diversification of sources of financial capital. The commercial banking sector is modelled in further detail, as it has a significant role in expressing the effects of financial regulations and monetary transmission. In this thesis, commercial banks are designed to be impacted by financial policies like CAR and NOP. The commercial banks are also connected to the central bank via exchange settlement accounts when the central bank performs open market operations. Within the Taylor rule framework, the central bank maintains inflation and GDP growth stability around the targets by setting its policy rate (cash rate).

1.3.4 Chapter 5: Building the database for the real-side elements of the model

The main source for the traditional real-side CGE database is the 2010 Indonesian input out table (IOT) provided by Indonesian Statistics Bureau (BPS, 2015b). To convert the original IOT into the required from for AMELIA-F, I undertake three key adjustment steps: (i) preparing essential matrices which comprise basic values by user, margins, indirect taxes, and value-added; (ii) balancing the value of sales and costs in the database structure; (iii) converting all essential matrices into the structures required to conform to ORANI-G and MONASH model conventions. The real-side CGE database also includes behavioural and other parameters, values for which are adapted from previous CGE studies of Indonesia e.g., the studies of Horridge and Yusuf (2017), Abimanyu (2000), and Wittwer (1999). To ensure validity of the database and traditional real-side CGE model, the database and model are tested using methods recommended by Horridge (2013). The test results suggest that the traditional CGE model and its database possess the nominal and real homogeneity characteristics implicit in the model's neoclassical theory. A further test of model implementation is provided in baseline forecasting mode, where I find that the balance between industry-specific sales and costs holds throughout a 10 year forecasting run. In addition, the test ensures that GDP results in initial run hits the value of nominal GDP in official statistics, and the equality of expenditure-side and income-side measures of GDP hold throughout all simulations.

A contribution arising from my work on the database for the traditional real-side CGE model relates to revision of the dwelling sector. The original database provided by BPS (2015) describes only a small (3 per cent) share of total investment represented by investment in residential buildings. I suspected this did not reflect the actual share of investment flowing to residential dwellings. According to BKPM (2019), in 2018 the dwelling sector accounted for 15 per cent of total investment. To fix this issue, I rearranged the dwellings industry in the data to have 15 per cent of total investment. In the final step, I update the database to target the expenditure-side components of 2018 Indonesian GDP using the adjuster program developed by Horridge (2009). The update is necessary to match the base year of the traditional real-side CGE database with the financial database which has a base year of 2018.

1.3.5 Chapter 6: Building the database for the financial elements of the model

The financial elements of the AMELIA-F database are sourced from 2018 Financial Account and Balance Sheet Indonesia (FABSI) data produced by Bank Indonesia. The original database records stocks and flows of particular financial instruments issued by each agent and held by each counterparty agent. The detailed structure and data methodology of FABSI is explained in full in Karyawan (2017) and Karyawan et al. (2015). The configuration of financial agents and instruments in the financial database are designed to follow the structure of financial elements of AMELIA-F i.e., 8 agents and 5 instruments. The work on the financial database is dominated by data aggregation and the calibration of financial instruments and agents. The original financial database has 8 financial agents and 8 financial instruments. The financial agents comprise: non-financial corporation (NFCs), the central bank, Other Depository Corporations (i.e., Commercial Banks), Other Financial Corporations (NBFIs), Local Government, General Government, households, and the rest of the world (ROW). The financial instruments include: Gold and IMF SDR, Currency and Deposits, Debt Securities, Loans, Equity, Insurance and Pension Funds, Financial Derivative, and Other Receivables and Payables. This configuration is aggregated to 8 financial agents (i.e., Industries, Central bank, Commercial banks, NBFIs, Government, Households, Foreigners, and Housing) and 5 instruments as explained in previous section (i.e., Bonds, Cash, Monetary gold and SDRs, Deposits and loans, and Equity). The financial database is then calibrated to match the financing and saving requirements in the traditional real-side database. There are four channels that bind the financial- and real-side databases. First, the public sector borrowing requirement is financed by the net liability issuance of the government financial agent. Second, the current account deficit is financed by net foreign acquisition of domestic assets. Third, aggregate investment is financed by industry and housing (capital creator agents) net liability issuance. Fourth, household savings is equal to the asset acquisitions of the household financial agent. I then rerun the validity tests encouraged by Horridge (2013) i.e., homogeneity, balance of sales and costs, and income-expenditure GDP discrepancies.

1.3.6 Chapter 7: Baseline simulation

I create a baseline simulation which represents the Indonesian economy under a business as usual (BAU) scenario between 2019 to 2028. Because my focus is on policy deviation results, not baseline forecasting, I exclude the effects of COVID-19 from the baseline. With limited data sources for the baseline, and with the baseline not being a focus of the thesis, I limit the baseline shocks to inputs for: real GDP, real investment, and the terms of trade. Real GDP and real investment are set to grow at 5 per cent per annum, which represents trend GDP and investment growth for Indonesia over 2019-2028. The primary source of the forecast data is the IMF World Economic Outlook 2019 (IMF, 2019). To accommodate the imposed 5 per cent GDP growth rate, the model endogenously finds the required growth in primary-factor augmenting technical change. Following the same principle, I set investment to grow at 5 per cent while letting the model calculate the required shift in required rates of return. Throughout the baseline simulation, the terms of trade is exogenised by endogenising a general shifter on the positions of export demand schedules. On the financial side, I set the baseline forecast of the central banks' CPI inflation target at 3 per cent, which represents the official long-run inflation target of the central bank.

1.3.7 Chapter 8: Economy-wide impacts of strengthened bank CAR

This chapter uses AMELIA-F to investigate the consequences of raising bank capital adequacy requirements (CAR) by 100 basis points in a financial general equilibrium framework. The results show that a 100 basis point increase in bank CAR has small negative consequences for the economy. The commercial banks experience a balance sheet reduction as they move away from riskier assets and finance more of their activity by equity rather than debt. This negatively impacts the industry and housing agents' capacity to invest in physical capital formation. Real investment falls by 0.02 per cent relative to baseline in the year the policy is implemented and returns gradually to baseline in the long run. Real GDP decreases by 0.01 per cent from baseline in the year the policy is implemented and gradually returns to baseline thereafter. The central bank initially reduces its policy rates to counter the negative impacts on employment and consumer prices. Falling real investment decreases the external financing requirement, as indicated by a fall in the current account deficit. The simulation identifies three channels via which bank CAR aids macro stability: (i) bank debt-to-equity ratios fall, and so too do those of the housing and non-housing sectors; (ii) bank risk-taking behaviour is attenuated, as partial accommodation of higher CARs sees them tilt away from high risk-weight assets; and (iii) the economy-wide private debt to income ratio (a leading indicator of macro stability) falls.

1.3.8 Chapter 9: Impacts of relaxation of bank NOP

This chapter simulates the economy-wide impact of changes in financial regulation on capital flows: specifically, via an increase of 100 basis points in the level of the bank net open position (bank NOP) in Indonesia. The simulation facilitates an analysis of policy implications for the broader financial system and the Indonesian real economy. The chapter examines two possible channels through which banks accommodate the rise of NOP: (i) banks accommodate higher NOP by increasing their foreign liabilities, i.e., by borrowing more in foreign markets; and (ii) banks accommodate the rise by reducing foreign lending. In each case, small gains materialise for the Indonesian real economy, measured by increases in real GDP relative to baseline forecasts. Net foreign capital inflows in each case cause exchange rate appreciation, which drives small reductions in the central bank policy rate.

1.3.9 Chapter 10: Conclusions and issues for future research

The final chapter concludes with an overview of the contributions of this thesis and provides directions for future research in the development and application of models like AMELIA-F. I argue that the AMELIA-F applications in this thesis demonstrate the model's flexibility and capability in analysing a potentially wide range of financial policy initiatives and tracing their comprehensive effects. The ability to perform ex-ante analysis using a structural model like AMELIA-F is very useful for Indonesian policy makers faced with the difficult task of anticipating the economic consequences of new policies for which there might not be historical equivalents in the Indonesian context. I outline potential avenues for future research. These include: expanding the granularity of financial agent representation (for example, by disaggregating insurance and pension funds from the NBFI agent); transforming the AMELIA-F model into a regional model, to allow for the investigation of the regional economic effects of monetary policy and financial regulation; and the inclusion of taxation detail, particularly as it relates to decision making by financial agents.

CHAPTER 2
Modelling Integration of the Real Economy and the Financial Sector: A Literature Review

2.1 Introduction

This chapter discusses the body of relevant literature on economic models that integrate the real economy and the financial sector. The discussion is focussed on large-scale models specified to address cross-cutting issues related to both the real and financial sectors. Small-scale models are excluded from the discussion as they cannot appropriately capture feedback loops between the real economy and the financial system, while also lacking the policy-relevant detail of large models. The large-scale models discussed herein are divided into three categories: (i) macroeconometric models; (ii) dynamic stochastic general equilibrium (DSGE) models; and financial computable general equilibrium (FCGE) models.

As an introduction to macroeconometric models, I start with the early business cycle Tinbergen macroeconometric model, built by Jan Tinbergen at the end of World War II to explain U.S. economic fluctuations in depression conditions. The advancement of econometric techniques and computational capabilities benefited the further developments of macroeconometric models. There were various types of macroeconometric models built by agencies in the U.S., such as MIT-PENN-SSRC for the U.S. Federal Reserve, and Fair's Models for commercial institutions. The internationalisation of macroeconometric models was accelerated via development of multi-country models in the 1970s. In other parts of the world, macroeconometric models emerged from internal government policy needs, such as the recent MARTIN model of the Reserve Bank of Australia (RBA). Despite its popularity, macroeconometric models attracted some criticisms, predominantly by the school of rational expectations and via the Lucas critique (Lucas, 1976). These criticisms generated rebuttal arguments from the proponent of macroeconometric models to justify the absence of rational expectation properties and explain the instability of estimated parameters.

DSGE models are the immediate successor to macroeconometric models. These models try to fix the shortcomings claimed of macroeconometric models. Unlike macroeconometric models, DSGE models have strong microeconomic foundations and include forward-looking expectations in many parts of the model. The parameters are estimated via calibration and rigorous estimation methods to account for the presence of uncertainties, using Bayesian methods. Most of this is to accommodate the Lucas critique. However, the complexity of estimation limits the flexibility of the model to apply deep theoretical foundations in all parts of the model, especially in the financial sector. DSGE models also typically have low levels of sectoral disaggregation. From a helicopter view, and setting aside the complexity of the estimation methods and rational expectations, the general connections between equation blocks within DSGE models are rather similar to those in macroeconometric models.

FCGE takes a different approach to macroeconometric and DSGE models. FCGE models are typically built by combining a well-established real-side computable general equilibrium (CGE) model with a financial-side model. Given the deterministic nature of FCGE models, where the parameters are typically fixed over time, FCGE models are more flexible in applying a wide-range of theoretical foundations. While not immune to the Lucas critique, the rebuttal arguments of macroeconometric proponents could potentially be applied to justify the use of FCGE models as well. In the discussion, I describe how the ability of FCGE models in modelling the detail of financial sector, including the linkages to the real economy, could benefit policy authorities by facilitating deep economy-wide analysis.

The remainder of this chapter is set out as follows. Section 2.2 describes the macroeconometric models. This section outlines the key macroeconometric models used by selected agencies around the world, criticisms, and rebuttal arguments. Section 2.3 presents the real business cycle DSGE model and New-Keynesian DSGE model. It also discusses the shortcomings of DSGE models. Section 2.4 explains the variety of FCGE models, issues, and room for improvements. Section 2.5 provides a general overview of modelling practices in Indonesian government agencies. Section 2.6 concludes the chapter.

2.2 Macroeconometric Models

Macroeconometric models are built primarily with macroeconomic foundations. The parameters of the models are estimated using econometric methodologies. Academically, they have been used to test the empirical efficacy of macroeconomic theories. Practically, they have widely employed for forecasting and policy simulations in commercial and public institutions (Welfe, 2013).

2.2.1 Early business cycles models (Tinbergen's models)

Tinbergen (1939) was recognised as the pioneer of the U.S. macroeconometric models. He built the early macroeconometric model known as the U.S. business cycle model. The model aimed to explain fluctuations in U.S. macro-aggregates over 1919-1932. It was known as a mid-size model with a few equations explaining: (i) prices, (ii) wages, (iii) final demand, (iv) income distribution, and (v) financial sector. It was arranged as 32 linear regression equations with 17 identities. The parameters were estimated by ordinary least square (OLS) methods. In the financial sector, the model defined four types of assets: equity, bonds, short-term debt, and cash and specified the demand and supply of those assets (Wolff and van der Linden, 1988). Tinbergen's model was mainly used for experimenting the role of economic policies in business cycles such as countercyclical monetary policy, price stabilisation policy, and policies to avoid speculation (Koopmans, 1949).

2.2.2 MIT-PENN-SSRC[6] (Stylised Public Agency Model)

With the progression of econometric techniques, computational ability, and data availability, the development of macroeconometric models flourished following Tinbergen's work. Some types of modelling were designed specifically for public institution. For example, MIT-PENN-SSRC (MPS) was a key macroeconometric model built for public institutions. The model was the joint work of two academics (James Ando and Franco Modigliani) and one practitioner (Frank De Leeuw) from the U.S. Federal Reserve System in 1966 (De Leeuw and Gramlich, 1968). The model was also known as the Fed Model.

[6] SSRC stands for the U.S. Social Science Research Council

The MPS system had 170 equations and was estimated by the OLS methodology (Ando et al., 1972). The linkages between the real and financial systems were mainly explained by interest rate channels: (i) interest rates define the user cost investment; (ii) interest rates affect the value of household financial assets (wealth effect); and (iii) residential investment is a function of interest rates. The model was predominantly used for evaluating the impacts of U.S. monetary policies over the 1970-1980s. By incorporating energy and food prices, it was also used for assessing the economy-wide impacts of the 1974 oil shock on the U.S. Over the 1980-1990s, the model incorporated a broad money definition (M2) to analyse the role of the demand for money. In the academic field, the MPS model was frequently used for validation of monetary theories (Ando et al., 1972).

2.2.3 Fair's Model (Stylised Private Agency Model)

Fair's model was a macroeconometric model which highlighted the importance of financial markets in the economy. Unlike users of MPS, the users of Fair's model were mostly private institutions. It was designed to produce accurate short-term forecasting outcomes. In practice, the parameters in Fair's model were frequently re-estimated to improve forecast accuracy (Fair, 1974, 1976). In its early development in the 1970s, Fair's model comprised 19 equations with 4 stochastic equations. By 1984, the equations had increased to 128 with 30 in stochastic forms.

Fair's model was characterised by three principles. First, macroeconomic equations must have microeconomic foundations. This principle was manifested in the households' and firms' optimal decisions. Second, the acknowledgement of disequilibrium in some markets. The main source of disequilibria were the forecast errors which justified the non-rational expectations of economic agents and manifested in some holding of inventories. Third, the imposition of some restrictions (predominantly by monetary theory of demand for money) in the balance sheets of financial agents.

In the financial sector, the key equations of Fair's model were specified as follows:

$$\mathrm{MH} = F_1\left(\mathrm{Yd}_{(+)}, \mathrm{RS}_{(-)}, \mathrm{MH}_{\mathrm{t-1}_{(+)}}\right), \tag{2.1}$$

$$\mathrm{MF} = F_2\left(\mathrm{SF}_{(+)}, \mathrm{RS}_{(-)}, \mathrm{MF}_{\mathrm{t-1}_{(+)}}\right), \tag{2.2}$$

$$\mathrm{CU} = F_3\left(\mathrm{CU}_{\mathrm{t-1}_{(+)}}, \mathrm{SF}_{(+)}, \mathrm{RS}_{(-)}\right), \tag{2.3}$$

$$\mathrm{RS} = F_4\left(\mathrm{RS}_{\mathrm{t-1}_{(+)}}, \Delta\mathrm{RS}_{\mathrm{t-1}_{(+)}}, \Delta\mathrm{RS}_{\mathrm{t-2}_{(+)}}, \%\mathrm{PD}_{(+)}, \mathrm{UR}_{(-)}, \Delta\mathrm{UR}_{(-)}, \%\mathrm{M1}_{\mathrm{t-1}_{(-)}}\right), \qquad (2.4)$$

where MH and MF denote households' and firms' demand for narrow money (currency and demand deposits) respectively. Yd denotes disposable income. RS is the risk-free interest rate. SF represents firms' sales. CU is currency in circulation. %PD is the percentage change in the GDP deflator. UR is the unemployment rate. $\%\mathrm{M1}_{\mathrm{t-1}}$ is the lagged percentage change in M1. Subscript signs declare the functional (positive/negative) relationships to the LHS of the equations.

Equation (2.1) describes the demand for money by households. MH is a positive function of real transactions (Yd), but is negatively related to interest rates (RS). $\mathrm{MH}_{\mathrm{t-1}}$ was used for empirical testing of the nominal money adjustment hypothesis in the Fair model. The hypothesis is also known as "neutrality of money" in macroeconomic theory. Under the neutrality of money hypothesis, the long-run money balance only affects economic variables in nominal terms but not in real terms. Fair (2004) confirmed the existence of money neutrality in the model. Demand for money by firms in Equation (2.2) was specified following similar principles to Equation (2.1), except the transaction variable is represented by firms' sales (SF) instead of disposable income (Yd).

Equation (2.3) explains the demand for money (CU) in other institutions (beyond firms and households). It is a positive function of lagged CU and firms' transactions, but negatively related to the interest rate. Equation (2.4) is the policy rate (cash-rate) rule. The risk-free interest rate is a function of the lagged risk-free interest rate, the GDP deflator, the unemployment rate, and M1 (narrow money definition including currency and demand deposits). Equation (2.4) had a strong influence on the financial and real-sides of the model. RS appears as an explanatory variable in all financial equations. In the real-side, RS influences household consumption and investment decisions. The Fair model structures were adapted for core specifications in multi-country models in the late 1990s through to the early 2000s (Fair, 2004).

2.2.4 Internationalisation of Macroeconometric models via Project LINK

The internationalisation of macroeconomic models was accelerated via Project LINK, organised by the LINK Centre at the University of Pennsylvania in the 1970s. The project was motivated by rapid development of macroeconomic models in advanced countries in the 1960s and by the need to assess global transmission of economic shocks from particular countries. In 1971, Project LINK reached its first milestone by standardising macroeconometric models of the U.S., Canada, Japan, and major European countries, and interlinked the models in one closed system via a trade matrix (Bodkin et al., 1991). The Project LINK models for advanced countries were typically larger and more complicated than those of developing countries (Ball, 1973). The standard models were adjusted to medium-scale for the case of developing countries (Waelbroeck, 1976).

The financial block was mainly governed by the financial equations that appeared in the Fair model i.e., including money demand and a policy rule of the central bank. In the financial side, the multi-country Project LINK models defined the exchange rate as a function of its expected value, the gap between foreign and domestic interest rates (interest rate differential), and a risk premium (Welfe, 2012). The interactions between interest rates, the exchange rate, and capital flows were arranged by the Mundell-Flemming (MF) policy trilemma (Whitley, 1994). In the MF policy trilemma, the flexible exchange rate regime with perfect capital mobility causes uncontrollable movements of interest rates, thus undermining the independency of the central bank.

In the 1980s, Project LINK models became popular policy tools to estimate global impacts of the changes in exchange rate policy and capital regimes (Hickman and Klein, 1985). In 2003, Project LINK had more than 250 members around the world and produced 80 national macroeconometric models. Project LINK was recognised as a major driving force for national macroeconomic models of developing countries in South America, Africa, and Asia (Welfe, 2013). The early Indonesian macroeconometric model was built by the National Development Planning Agency (Bappenas) and central bank of Indonesia (Bank Indonesia) in the 1980s, as part of Asian Link (Kobayashi et al., 1985). This model was ready to join the Project LINK multi-country models at the end of the 1980s (Welfe, 2013).

2.2.5 MARTIN Model of Reserve Bank of Australia (RBA)[7]

Development of the MARTIN macroeconometric model of the RBA had a different impetus. Instead of accommodating an external driving force to reshape a domestic model, MARTIN was born from internal business processes within the RBA. MARTIN

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[7] MARTIN stands for Macroeconomic Relationship for Targeting Inflation.

represents how the RBA staff perceive the mechanisms of the Australian macroeconomy to operate. It is an extended version of RBA staff empirical work, which used to be in single-equation forms (Ballantyne et al., 2019). Single-equation forms are simple and flexible, but fail to catch the feedback loops between parts of the economy (Cusbert and Kendall, 2018).

In the RBA taxonomy, MARTIN occupies an intermediate position between theoretical and empirical approaches. In the RBA, the full-theoretical model is ruled by the dynamic stochastic general equilibrium model (DSGE). The results of DSGE models are highly regarded by the RBA in the theoretical sense. However, they sometimes do not fit empirical data. In the more empirical approach, the RBA uses some econometric models such as Vector Autoregression (VAR), Structural Vector Autoregression (SVAR), and Vector Error Correction Model (VECM). In contrast to DSGE, these models typically result in good empirical fitness, however due to highly data dependent parameters, they are sometimes theoretically inconsistent (Cusbert and Kendall, 2018).

The latest version of the MARTIN model has 33 behavioural equations (Cusbert and Kendall, 2018, Ballantyne et al., 2019). The equations are specified as Error Correction Models (ECM). This specification is chosen for capturing the short-run dynamics of economic variables while determining the stable long-run levels of these variables. The movements of variables are designed to converge to the long-run levels via error correction mechanisms (Cusbert and Kendall, 2018).

In what follows, I summarise the key equations of the MARTIN model according to Ballantyne et al., (2019). On the supply side, GDP potential is a function of trends in labour productivity, population, and labour hours. Household consumption is a function of disposable income, net wealth (household assets minus liabilities), and the real interest rate. Owner-dwelling investment depends on the allocation of household expenditures and real interest rates. Non-mining investment is determined by cost of capital and domestic output (GNE). Mining investment is primarily driven by mining output and domestic prices. Export volumes are affected by world GDP and relative prices (foreign/domestic price). Import volumes are determined by GNE and relative prices. Movement of wages with respect to employment is governed by a Phillips curve (Phillips, 1958). The cash-rate is governed by a policy rule on inflation and unemployment gaps. Macro-aggregates are arranged in the common national account identity. The MARTIN model has no specific arrangements on the optimal behaviour of financial agents or how the financial sector interacts with the real economy.

The MARTIN model has been used for explaining monetary transmission in the Australian economy. Referring to Cusbert and Kendall (2018), the lower cash rate stimulates the economy via three channels. First, depreciation of the exchange rate raises export volumes and reduces import volumes. The higher import prices are passed through to domestic prices thus causing inflation. Second, the lower cash rate reduces mortgage rates, boosting housing prices and thus net wealth. This causes a positive wealth effect on household consumption. Third, the lower cash rate causes borrowing cost to be cheaper, hence stimulating housing and non-housing investments.

2.2.6 Criticisms of macroeconometric models

Up to this point, I have highlighted the key points of macroeconomic models. In what follows, I describe the major criticisms addressed at these models. Referring to Pesaran (1995), I highlight a few relevant issues in macroeconometric worthy of note. First, the theoretical inconsistency to rational expectations. In rational expectations, economic agents make reasonable predictions of the future. These predictions then affect the current behaviour of the agents. Second, model instability as outlined in the Lucas critique. Lucas (1976) argued that economic agents alter their behaviour in response to policy changes. The change in agents' behaviours causes instability of the parameters in macroeconometric models. Third, lack of theoretical foundations in determining the endogenous/exogenous division of variables. Fourth, problems with diagnostic tests. These problems are predominantly related to data issues (e.g., data non-stationarity). For readers who are interested in seeing the structure of macroeconometric models, I provide a description of the stylised structure of a macroeconometric model in the appendix of this thesis.

2.2.7 Counter Arguments of Macroeconometric Modellers

There were several rebuttal arguments offered by the proponent of macroeconometric models. Related to rational expectations, Bodkin and Marwah (1988) argued that the concept of rational expectations was unrealistic. Given the limited access to the required data and information, agents cannot predict the future accurately. This argument was supported by Fair (2004) who found that in most empirical cases the rational expectations hypothesis was rejected. While admitting the Lucas critique, Klein (1989) argued that change in economic structure does not necessarily destabilise parameters. He believed the change of the parameter values happens because of the introduction of exogenous variables or random errors.

Sims (1980) came with atheoretical vector autoregressions (VARs), which do not require a strong theoretical basis for the division of exogenous/endogenous variables. In response to the Lucas critique, Leamer (1983) advocated the Bayesian approach to estimation of parameters. In this approach, the estimation of parameters is conditional on the probability of a parameter value which is not a subject of the Lucas critique i.e., the pure stable exogenous variables. Hendry (2000) promoted the Autoregressive distributed lag (ARDL) method in determining the nature of the relationship of explanatory variables, hence data would determine the theory (data-driven approach).

2.3 Dynamic Stochastic General Equilibrium (DSGE)

Dynamic Stochastic General Equilibrium (DSGE) models are the immediate successor of macroeconometric models. The models try to fix the shortcomings highlighted in macroeconometric models. The standard DSGE models include behavioural equations derived from microeconomic foundations and forward-looking expectations (Hurtado, 2014). As explained in Cusbert and Kendall (2018), DSGE is more theoretical-driven relative to macroeconometric models and other econometric approaches such as VAR, SVAR, and VECM which are highly data-driven.

Accommodation of the Lucas critique (Lucas, 1976) resulted in a few alterative estimation methods on the DSGE parameters. For example, Monte-Carlo calibrations were used for capturing the uncertainties illustrated in a confidence interval. The confidence interval was implemented both in parameter values and the exogenous variables [e.g., Canova (1994, 1995)]. Maximum likelihood estimation (MLE) was adopted as the traditional method approach in DSGE. In MLE, the values of parameters are chosen to maximise the likelihood of model's results fitting empirical data. The drawback of MLE is the strong assumption that the model (including its parameters) is the true data generating process (DGP) which is against the essence of the Lucas-critique (Kremer et al., 2006). Bayesian estimation combines calibration and some weighting techniques. Bayesian estimation starts with determination of prior values of the parameter. It could come from calibration or empirical estimation of other studies. This prior is then weighted on the likelihood of empirical data (Kremer et al., 2006).

2.3.1 Real Business Cycle (RBC) DSGE Models

The point of departure of DSGE models was the introduction of real business cycle (RBC) models by Kydland and Prescott (1982). The origins of business cycles in RBC models differs from Tinbergen's business cycle model in which the economic fluctuations are perceived as a constant phenomenon of capitalism, resulting predominantly from investment dynamics (see Section 2.2.1). Kydland and Prescott (1982) criticised the old specifications of investment decisions which did not incorporate investment shadow prices such as Tobin's q and resulted in theoretical inconsistency between real investment and (investment) price (Welfe, 2013). Kydland and Prescott (1982) argued that economic fluctuations were caused by stochastic shocks which could cause repetitive events, instead of counting only on investment cycles.

Referring to Christiano et al. (2018), the early RBC DSGE model of Kydland and Prescott (1982) resulted in non-Keynesian policy implications. Within general equilibrium settings, the households engage in perfect competition over commodities, factors, and asset markets. Economic fluctuations are the effective responses of economic agents to uncertainty and technology shocks. The model suggested that government interventions to smooth the fluctuations negatively impacted on welfare. The RBC DSGE model was criticised for three issues. First, the specification of the fixed labour supply. Second, the difficulty of quantifying some key parameters (e.g., equity premium). Third, the absence of a role of monetary policy.

2.3.2 DSGE Models for Monetary Policy (New Keynesian DSGE models)

Today, DSGE models are used in many central banks for policy formulation and communication. These activities include showing the banks' economic outlook and policy stance to the general public. Since these models involve a policy role, they are categorised as New Keynesian DSGE Models (Gürkaynak and Tille, 2017). For readers who are interested to see the structure for these models, I provide a stylised structure of the New Keynesian DSGE model in the appendix of this thesis.

Sbordone et al. (2010) categorise the main body of New Keynesian DSGE models into three divisions: (i) a demand block, (ii) a supply block, and (iii) a monetary policy block. In the demand block, real GDP is a function of the real interest rate (nominal interest rate minus expected inflation) and expected future GDP. When the real interest rate is high, households incline more to saving than consumption and investors are constrained by higher borrowing costs.

The current GDP that emerges from the demand block is fed to the supply block. Via inversion of the production function, the current GDP determines inflation and also expected future inflation. In good times, acceleration of GDP induces an increase in wages to attract the labour force into employment. The higher wages raise the firms' marginal costs and put pressure on current and expected future inflation. Determination of GDP and prices in the demand and supply blocks are channelled through to the reaction function of the central bank. To reduce the pressure of inflation arising from accelerated economic activity, the central bank raises the nominal interest rate.

As embedded in their design, the DSGE models for monetary policy incorporate stochastic processes to account for uncertainty. The stochastic random shocks are imposed in many parts of the model to capture uncertainty and the resulting economic fluctuations. In the demand block, the stochastic shocks affect the willingness of households to consume and firms to invest. In the supply block, mark-up pricing and technical progress shocks affect pricing and firms' production decisions. Monetary policy shocks can affect all agents in the demand and supply blocks.

Sbordone et al. (2010) used a New Keynesian DSGE model to analyse the anomaly of the U.S. persistent inflation between 2004-2008. While the inflation rate was low (around 2 per cent), the U.S. inflation rate increased from 1 per cent in 2003 to 1.5 per cent in 2004, then around 2 per cent up to 2008. This trend could not be explained by unaccelerated domestic GDP at that period. The DSGE modelling concluded that the rise of inflation was caused by inflation expectations. U.S. households and firms made their own calculation of expected inflation due to a high implicit inflation target of the U.S. Federal Reserve System. The loose monetary policy stance during 2003-2004 was responsible for higher inflation expectations in the future. This policy stance was captured by the economic agents as a high inflation tolerance that could bring high inflation pressure in the future.

2.3.3 The Shortcomings of DSGE Models

Blanchard (2017) did a review of the New-Keynesian models and highlighted three points of weaknesses as follows. First, the specification of household optimal behaviour that consumption depends on expected future prices and economic prospects is exaggerated.

In this case, Blanchard (2017) opinion seems to break down the rational expectations backbone in the DSGE model. However, this is rather consistent with the rebuttal arguments of the macroeconometric models on the implausibility of rational expectations that came from Bodkin and Marwah (1988) and Fair (2004).

Second, the estimation of parameters, which heavily rely on the calibration technique and Bayesian methods, are unconvincing. The parameters are the result of the full model calibration and estimation techniques, instead of via empirical estimation outside the DSGE model. According to Blanchard, ideally, the calibration is done if the theoretical or empirical values of parameters are observed. The calibration for the whole large system would be hard to be theoretically consistent taken altogether. In addition, Blanchard (2017) found that the application of a standard set of cross-country parameters such as the “Calvo standard parameters” may be inconsistent to country specific evidence.

Third, the normative results from specific modelling tasks are doubtful. Here, Blanchard (2017) points to the welfare analysis of monetary policy. Unlike, in neoclassical models, treatments in DSGE models cause a non-uniform response on the part of economic agents to changes in prices. This is caused by a specification of agent behaviour whereby the agents do not respond to price changes at the same time. Therefore, it is difficult to quantify welfare effects of an economic policy in an economy-wide context.

Fourth, the outcomes of the DSGE models are hard to communicate to the general public. The motivation to capture uncertainty causes the modeller to incorporate stochastic shocks in many parts of the model. However, these mechanisms are not easy to explain to general audiences without prior academic economic backgrounds.

2.4 Financial Computable General Equilibrium (FCGE)

Another class of economic model which combine the real economy and financial sectoral mechanisms is Financial Computable General Equilibrium (FCGE). FCGE takes a different approach in relation to macroeconometric and DSGE models. FCGE models are typically a combination of a well-established real-side computable general equilibrium (CGE) model and a financial-side model. The real-side CGE models commonly follow a neoclassical framework where all economic agents behave optimally, subject to their specific constraints, within a general equilibrium system. The financial-side model represents the optimal behaviour of financial agents in choosing the pair of financial instrument and counterparty agents and the explicit linkages to the real-side model). The deterministic nature of FCGE models, where the parameters are fixed overtime, makes FCGE models more flexible in applying a wide-range of theoretical foundations.

The first attempt to connect the financial sector to a real-side CGE model was Adelman and Robinson (1989). They introduced loanable funds to a real CGE model to assess the impact of financial developments on income distribution. The IMF and the World Bank promoted the FCGE models to analyse international development issues. For example, the institutions evaluated the impacts of stabilisation policies on poverty and income distributions in selected developing countries. To do this task, they developed a template FCGE model which could be applied to many developing countries (Robinson, 1991).

With the passage of time, there are a few single country FCGE models that have been developed in some part of the worlds. Yeldan (1997) developed an FCGE model for the Turkish economy. He defined the balance sheets of financial agents and the connections to the real economy. However, the asset and liability decisions were not determined via optimal behavioural assumptions of financial agents. The model was limited to comparative static tasks. Liu et al. (2015) created an FCGE for the Chinese economy to analyse the response of the Chinese central bank to oil price shocks. The FCGE model of Liu et al. (2015) closely followed the International Food Policy Research Institute (IFPRI) CGE model framework. Similar to Yeldan (1997), the FCGE model of Liu et al. (2015) model was comparative static and did not specify details of financial agents' optimal behaviour.

More recently, more sophisticated FCGE models have been developed with the introduction of new features such as optimal behaviour of financial agents, time-dynamics, and a variety of financial policies. Dixon et al. (2015) developed an Australian FCGE model by extending an Australian real-side CGE model (MONASH) with a financial module. The model was used for analysing the economy-wide impacts of a change in superannuation contributions in Australia. The study found that the increase in superannuation contributions raises long-run real GDP via an increase in the savings rate. In the FCGE model of Dixon et al. (2015), financial agents are constrained optimisers. Financial assets are allocated to maximise a function of portfolio returns while the distribution of liability issuance is arranged to minimise a function of the cost of liabilities.

The real- and financial-sides of the model are connected via five channels: (i) the public sector borrowing requirement (PBSR) from the real-side of the model, is financed in the financial-side of the model by net government liability issuance; (ii) investment from the real-side of the model, is financed in the financial-side of the model by net liability issuance of the industry and housing agents; (iii) the current account deficit is financed by net domestic asset purchases by the foreign investor; (iv) aggregate household savings from the real-side of the model, is linked to the acquisition of financial assets by households in the financial-side of the model, and thus too to the funding of gross fixed capital formation, public debts, and foreign assets; and, (v) changes in the weighted average cost of capital (WACC) of the capital creating agents in the financial side of the model (industry and housing) are linked to changes in required rates of return of investment in the real-side of the model. When these channels are activated, the real- and financial-sides constrain each other in a general equilibrium framework.

Giesecke et al. (2016) extended the Australian FCGE model with integration of banking regulatory reforms. They found that a 100 basis point increase in bank capital requirement resulted in small negative consequences for the economy. Nassios et al. (2020) developed a U.S. FCGE model and compared the regulatory shock in the Giesecke et al. (2016) study to the U.S. case. Nassios et al. (2020) showed that the different structure of the financial sector in the U.S. relative to Australia contributed to an opposite directional impact on economic activity in the U.S. compared to Australian from an increase in bank regulatory capital. An increase in regulatory bank capital in the U.S. causes a substitution away from bank intermediation within capital markets. The more expensive bank credit caused by a larger share of bank equity financing induces borrowers to find financing alternatives to bank lending. As non-bank sources of finance are a significant share of the U.S. financial market, financial intermediation from non-bank capital sources results in a stimulatory effect on the economy.

Dixon et al. (2021) integrated a dynamic GTAP model with a financial module to calculate the consequences of financial decoupling between the U.S. and China as a continuation of the trade war between the two countries. The study found that a reduction in U.S. investment in China favours the U.S. domestic investment. In contrast, a decline of Chinese investment in the U.S. favours China's domestic investment. In term of magnitude, China wins this trade war as China has a larger amount of investment in the U.S.

2.5 The Use of Economic Models in Indonesian Agencies

According to Budhiasa (2012), there are three Indonesian economic agencies recognised for increasing use of large-scale economic models in their policy formulations. These agencies are: (i) National Development Planning Agency (Bappenas); (ii) Ministry of Finance (MoF); and (iii) Bank Indonesia (BI). In what follows, I discuss the development and use of large-scale economic models in these institutions. The discussions are limited to the three classes of model that have been explained in the previous section i.e., macroeconometric, DSGE, and CGE/FCGE.

2.5.1 Bappenas

As a development planning institution, Bappenas is responsible for designing the long-term trajectory of Indonesian economic development. The first economic model developed by this institution was a macroeconometric model called A-Medium-Term-Macro-Econometric model. The model was introduced by Kuribayashi (1987) as part of the Asian Link System of econometric models. The modelling process later intended to join the early development of Pennsylvania's LINK project (Welfe, 2013). Ichimura (1994) mentioned that the model was internally used and updated, however it has never been publicly disclosed. In the 1990s, Bappenas developed a macroeconometric model by adopting IS (goods market equilibrium) -LM (financial market equilibrium) framework and Mundell-Flemming balance of payment curve (Mundell et al. 1963, Fleming, 1962). The model was called Bappenas Quarterly Macroeconometric Model for the Indonesian Economy (BTQM97). BTQM97 was used to estimate the course of economic development under various settings of fiscal and monetary policies (Budhiasa, 2012).

Bappenas also used CGE models for analysing development strategies for long-term planning. In 2010, the organisation released the masterplan for acceleration and expansion of Indonesia's Economic Development 2011-2025 (MP3EI) (Kementerian Koordinator Bidang Perekonomian, 2011). The document reported the structural issues faced by the Indonesian economy from regional perspectives predominantly related to growth deceleration, poverty alleviation, and disparities across regions. Together with the Centre of Policy Studies (CoPS) Victoria University, Asian Development Bank, and Padjajaran University, Bappenas studied the impacts of multiple investment scenarios in MP3EI using a regional dynamic CGE model of Indonesia i.e., INDOTERM. The study found that the general infrastructure and regional comparative advantage investment strategy is in line with MP3EI's goals i.e., accelerating growth and poverty alleviation, and reducing disparities across regions. However, the study revealed that the broad-based investment strategy is superior to the sector specific investment strategy in terms of employment creation and poverty reduction.

2.5.2 Ministry of Finance (MoF)

Along with Bappenas, MoF also developed large-scale macroeconometric and CGE models focusing on the use of fiscal instruments. According to Budhiasa (2012), the MoF created a macroeconometric model called MODFI to elucidate the impacts of state budgets on economic growth. MODFI is a macroeconometric model with three large equation blocks covering: (i) government (fiscal policy); (ii) real sector; (iii) prices. In the government equation block, taxes/subsidies could directly affect aggregate expenditures, and thus GDP. The government equation block is linked to the real sector equation block via equalisation of expenditure and income GDP. In the real sector equation block, GDP determines production and employment. Employment and GDP define labour productivity in the prices equation block. Given a fixed long-run labour supply, labour productivity determines wages and production costs.

Recently, Sitepu et al. (2022) built a new version of the macroeconometric model of the MoF. The model was run to generate forecasts under COVID-19 scenarios. It found a significant pressure from COVID-19 on the state budget. The study explained that the realised fiscal deficit was likely to breach the fiscal rule of 3 per cent of GDP. The study recommended financing the deficit via domestic sources to avoid exchange rate volatility.

MoF also used FCGE models for performing benefit-cost analysis of infrastructure project financing in several regions of Indonesia. For example, Kim et al. (2017) performed a comparative study of toll road developments in Jakarta and East Kalimantan. The financial sector was arranged as follows. Financial institutions included rural low, rural high, urban low, urban high, corporations, financial institutions (including the central bank), government, and the rest of the world. Financial instruments comprised real wealth, government bonds, composite financial assets including private bonds, equity, and deposits (money).

Liability decisions were determined by minimisation of a CET function. Asset allocations were simply tied to the accumulated wealth of the agents. The study found that the toll road near the capital city (Jakarta) had a larger effect in reducing income disparities between rural and urban areas. Financing the toll road construction via a tax is superior to bond and private financing. The study described that bond financing causes crowding-out of private investment. In another FCGE work, Kim and Samudro (2021) used an FCGE model to study the reallocation of the fuel subsidy into more productive expenditures such as infrastructure financing. They found that increasing tax for infrastructure financing resulted less distortionary effects on consumption than removing the fuel-subsidy.

To some extent, the crowding-out effect of private investment could be attributable to the specification of asset allocation in the financial side of the model. Without agent optimising behaviour over asset allocations, the liability issuance by the government agent could cause an exaggerated increase in liability interest rates. The increase in interest rates however does not induce more asset allocation towards government liabilities to off-set the rise in interest rates, as no asset allocation substitution effects take place in the model. In the second-order, as interest rates equilibrate, this drives the rise in overall interest rates in both the financial- and real-sides of the economy which is harmful to real investment.

2.5.3 Bank Indonesia (BI)

Like other central banks around the world, BI mostly uses macroeconometric and DSGE models as the core toolkits for policy formulation. The first macroeconometric model built by BI was called MODBI (Model of Bank Indonesia). It was developed in 1986 in an inter-agency collaboration between Bank Indonesia and Bappenas. MODBI is characterised as a static macroeconometric model and is designed to perform short-run (1 year) monetary policy analysis (Joseph et al., 2003). In MODBI, the policy rate (cash rate) and the exchange rate are the main policy instruments of the central bank. The interest rate is specified as having a direct effect on domestic consumption and production. The excess of domestic production is exported while production shortage leads to more imports. Exchange rate determination can be set by the central bank to manage the external balance (current account deficit).

In 2000, BI started development of a DSGE model. The BI's first generation DSGE model was called General Equilibrium Model of Bank Indonesia (GEMBI). The impetus of GEMBI was motivated by a desire to explain the policy implications of uncertainty in a general equilibrium context. The model theory in GEMBI was adapted from short-run macroeconomic dynamic model developed by Agénor and Montiel (2015). The model was developed with the following characteristics: (i) the behaviours of economic agents (households, producers, government, and central bank) are derived from optimisation processes; (ii) forward-looking expectations; (iii) dynamics; (iv) top-down approach in model aggregation; and (v) use of a Taylor rule as the monetary policy rule. In the early period of the introduction of an inflation targeting framework (ITF), BI used GEMBI for projecting the period when the realised inflation rate hits the 3 per cent target.

With the expansion of BI's mandate to include maintenance of financial stability, BI's DSGE models were required to include some macroprudential policies. There have been auxiliary DSGE models built by BI staff to explain the impacts of implementation of macroprudential policies. For example, Simorangkir and Purwanto (2015) found an increase in loan-to-value (LTV) improves economic growth with a small inflationary pressure. Harmanta et al. (2014) explained a mix of LTV and CAR policies could enhance BI's ability to maintain financial stability. Sahminan et al. (2017) explained that government spending on infrastructure is superior in improving the country's welfare relative to non-infrastructure spending. Chawwa (2021) simulated combined macroprudential policies of reserve requirement (RR) and liquidity coverage ratio (LCR) and found that the interactions between RR and LCR have consequences for bank purchases of government bonds, raising a concern on policy coordination between macroprudential and fiscal authorities. Until recently, CGE models have not been included as the BI's core models for policy formulation.

Once in 2011, BI's staff built an FCGE model to analyse monetary and fiscal policy coordination to combat growth deceleration caused by the global financial crisis (GFC) (Simorangkir and Adamanti, 2012). As an FCGE model however, this model does not align the financial rate of return with the rate of return in the real-side economy as should have been included (see Dixon et al., 2015; Giesecke et al. (2016); and Nassios et al., 2020). As a result, the monetary shock has a minor impact on real investment decisions and thus on the wider real economy. The monetary policy shock (i.e., lower policy rate) is transmitted through the real economy via an increase in aggregate saving that causes a rise in the supply of loanable funds for investment.

2.6 Conclusions

This chapter discusses three economic model classes that are commonly used for analysing financial issues. The models are macroeconometric, dynamic stochastic general equilibrium (DSGE), and financial general equilibrium (FCGE). Macroeconometric models are recognised as the pioneers of large-scale economic models across the globe. Their influence spread through development of multi-country models, particularly Project LINK led by the University of Pennsylvania in 1970s. Since then, the variety of macroeconometric models has expanded. For example, MIT-PENN-SSRC model was identified as a model used by public institutions, like the Fed. Fair's models were mostly used by private agencies to produce forecasting for their clients. Recently, the Reserve Bank of Australia (RBA) built a macroeconometric model called MARTIN used as the core model of its policy formulation.

While they vary in some details, macroeconometric models retain similarities in theoretical structure. The models are characterised by major economic agents such as households, firms, and governments. The behaviours of these agents are specified in econometric equations, predominantly via linear regressions. Household consumptions is a function of GDP and interest rates. Firms' investment decisions also depend on GDP and interest rates. On the production side, demand for labour is determined by inversion of the production function. Behaviour of the government agent is normally exogenised. The financial sector is mainly represented by money demand equations. On the monetary policy side, the policy rate is governed by a policy rule such as Taylor rule [Taylor (1993); and Orphanides (2007)]. Policy rate shock are designed to affect both the financial- and real-sides of the model.

Some criticisms are addressed to macroeconometric models, predominantly related to the absence of a role for expectations, and parameter instability as noted in the well-known Lucas critique (Lucas, 1976). The rational expectations school argued that without forward-looking expectations the specifications of agents' current behaviours is wrong. Lucas (1976) stated that economic agents alter their behaviour in response to the policy changes. The change in agents' behaviours can cause instability of the parameters in models. In counter arguments, Bodkin and Marwah (1988) argued that rational expectations were unrealistic given agents' limited access to data and information. This argument was supported by Fair (2004) who found that in most empirical cases the rational expectation hypothesis was rejected. Klein (1989) argued that the change in economic structure does not necessarily destabilise parameters. He believed that the change in the parameters happens because of the introduction of exogenous variables or random errors.

DSGE models try to fix shortcomings highlighted in macroeconometric models. The behaviour of economic agents in DSGE models are formally derived from optimisation processes, mainly grounded in microeconomic foundations. The major breakthrough of DSGE models lies in the estimation method for parameters. The estimation of parameters must capture the uncertainties resulting from change in policies, technologies, or demands. This setting is initially approached by calibration and sophisticated estimation techniques e.g., by Monte-Carlo simulations and Bayesian methods. While different in functional forms, mainly due to forward-looking expectations, the implicit relationships within the equation blocks of DSGE models are rather similar to those in macroeconometric models. In demand equations, current GDP is determined by expected GDP and real interest rates. This GDP is fed into inversion of production function in supply-side economy to determine demand for labour, and thus wages and prices. The emerged GDP and prices are used in policy rule (Taylor rule) to define interest rates. The interest rates are then transmitted everywhere, mainly in demand equations.

FCGE models take a different approach in integrating real economy and financial sector. Using deterministic approach where the parameters are fixed overtime, FCGE models are more flexible in applying theoretical foundations for formulating behaviours of economic agents. The rebuttal arguments against rational expectations and Lucas critique on macroeconometric models could potentially be applied to justify the use of FCGE models. The FCGE are usually built from the well-established real CGE models. The financial-side shows the flow of financial assets between financial agents and some behaviours of financial agents and financial authorities (policy rule). The detailed mechanisms of financial sectors and the explicit linkages to the real economy are the major advantages of FCGE models relative to macroeconometric and DSGE models. This provides transparency and tractability of financial-real economy transmission could improve policy communication for general public.

In Indonesia, so far there are three FCGE models that have been developed. Two models were developed by the Ministry of Finance (MoF) staff and one by the central bank staff (BI). I highlighted some issues in order to improve these FCGEs. One of two MoF's model indicated asymmetric specification between financial agents' liability issuance and asset allocations. Liability issuance is based on CET optimisation, while the asset allocation is simply tied to wealth accumulation by agent. This specification could cause an exaggerated increase of interest rate in the rise of liabilities and thus too harmful for the real investments. The FCGE created by BI staff did not link the formulation of financial rate of return to the rate of return in real economy. This potentially undermines the role of financial sector on the investment decisions, hence lower the impact of monetary policy on the real economy.

The central aim of this thesis is to address this analytical capability gap by developing a detailed model of the Indonesian economy that integrates modelling of both the real and financial sides of the economy. After reviewing the bodies of relevant literature on the large-scale economic models, I conclude that I could approach this thesis objective by developing an FCGE model for Indonesia. The model is a complete dynamic general equilibrium structure of real-side CGE models and financial-side. The financial-side describes optimal behaviour of financial agents. Financial assets are allocated to maximise portfolios' returns while the distribution of liability issuance is arranged to minimise repayment of the liabilities. Both asset allocations are liability distributions, and are constrained from choosing corner solutions. The financial-side is connected to real-side model via multiple channels. When the channels are activated, the financial and real economy constrain each other in general equilibrium framework.

CHAPTER 3
The Theoretical Structure of The Real-Side Model

3.1 Introduction

AMELIA-F is constructed from two major theoretical frameworks. The first framework, hereafter the real-side model, constitutes a traditional real CGE model. The theory applied in the real-side model closely follows the theory in the MONASH model (Dixon and Rimmer, 2002), which is a well-known single country dynamic CGE model of Australia. The second framework, hereafter the financial-side of the model, constitutes financial markets modelling that explains the mechanisms inside financial markets and links these mechanisms to decision making in the real-side model. The theory in the financial-side of the model is adapted from the model theory of VU-Nat-F and USAGE2F financial CGE models [Giesecke et al. (2017); Nassios et al. (2019a); and Nassios et al. (2020)].

This chapter discusses the details of the real-side model. The discussion comprises the model overview, major elements of the model, model assumptions, important macroeconomic accounts (e.g., governments, national, and current accounts), and technical notes on derivation of equations and computation. At the end of this chapter, I discuss the links to connect the real-side model and financial-side of the model. The details of the financial-side of the model will be discussed further in Chapter 4.

3.2 Overview of the Real-side Model

The real-side model is a **real dynamic CGE** model representing an economy without explicit financial markets. In this model, the financial provisions to the real economy are determined by several assumptions. For example, the current account deficit is assumed to be unlimitedly financed by flows of foreign liabilities which accumulate foreign debts. The real-side model allows to have unlimited increase in the current account deficit in the long run, as it is automatically financed by capital inflows that accumulate the stock of foreign debts. This accumulation of foreign debt has no impacts on the domestic expected rate of return, hence does not affect investment.

In reality, this assumption might not be true, especially for a small country like Indonesia. In a small country, capital flows from foreigners' asset purchases are scarce. A long run increase in the current account deficit might cause a higher required rate of return of foreign liabilities, hence impacting negatively on real investment. This is one of the shortcomings of a real CGE model that will be addressed by integrating the financial-side of the model.

The '**dynamic'** term describes the capability of the model to perform multi-period simulations e.g., multi-year. The MONASH model is an example of a single country real dynamic CGE model (Dixon and Rimmer, 2002) which is an extension of a Johansen-style static comparative CGE model, ORANI-G (Dixon et al. 1982). The major distinctions between ORANI-G and MONASH lie in the dynamic elements i.e., capital accumulation and sticky-wage adjustment mechanism included in the MONASH theory. These dynamic mechanisms are discussed further in Section 3.2.2.

The '**computable'** term explains that the model is numerically computable and provides quantitative outcomes (Lkhanaajav, 2016). Both real-side and financial-side of the model in AMELIA-F are numerical models which are implemented as a large and non-linear equation system. The explanations of computation methods will be discussed in a more detail in Section 3.2.3.

The '**general equilibrium'** refers to the condition where economic agents e.g., industries, investors, households, governments, and exporters are systematically interconnected (Dixon et al. 1992). General equilibrium models can be contrasted with partial equilibrium models, which focus on changes in a single market or subset of markets, assuming ceteris paribus in all other markets (Perloff, 2014). General equilibrium requires that the equilibrium in any given single market is also influenced by the equilibriums in all other markets.

The real-side model in AMELIA-F by nature is a **neoclassical** economic model which adopts competitive market mechanisms (Johansen, 1960). The model assumes that the economy operates in competitive markets. That is any changes from the state of equilibrium are determined by the movement of relative prices, change of a commodity relative to average price of commodities (Forsund et al. 1985). A Neoclassical model is characterised by the following properties:

(1) economic agents behave as **optimisers** of their objective functions, subject to specific constraints;
(2) **zero pure profit conditions** apply for production, import, export, and distribution activities;
(3) **markets clear** via the prices of commodities and factors being determined by the equalisation of supply and demand;
(4) a single price is set as a **numerairé.** Relative movements in all other prices are measured in term of the numerairé (Dixon et al. 1992).

3.2.1 Notational Conventions

There are several notational conventions implemented in the real-side model. These conventions closely follow those used in the ORANI-G and MONASH models and are designed to simplify the recognition of the types of economic agents and flows in the model code.

3.2.1.1 Economic agents and type of flows

There are six economic agents defined in the real-side model. The agents are labelled consistently throughout the model in via the following numbering system:

(1) Industries (Producers);
(2) Investors;
(3) Households;
(4) Exporters;
(5) Governments; and
(6) Allocation for inventories.

Each of these agents undertake economic activities according to their specific objectives. For example, industries use intermediate inputs and primary factors in cost-minimising combinations in order to produce and sell output in a revenue-maximising fashion to commodity users (industries, investors, households, governments, inventories and foreign markets).

There are three types of flows of commodities used by agents: basic flows, indirect taxes, and margins. When the commodities are valued by the producer, it is defined as "basic flows". The basic flows are conventionally written as V<*agent's number*>BAS. Hence, the basic value of intermediate input purchases by industry is written as V1BAS.

Indirect taxes can be levied on the use of commodities. This is denoted as V<*agent's number*>TAX. For example, the value of indirect taxes on commodities used by industry is written as V1TAX. To deliver the commodities to final users, agents require transportation and trade services. These are valued in "Margin Flows" matrices recorded via the naming convention (V<*agent's number*>MAR). For example, the margin commodities required to facilitate purchases of intermediate inputs by industry are written as V1MAR.

The sum of the basic value, indirect taxes, and margins yields the purchasers value, denoted via (V<*agent's number*>PUR). For instance, the purchaser's value of commodities used by industry is written as V1PUR, where V1PUR is the sum of V1BAS, V1TAX, and V1MAR.

There are another two additional inputs to be considered for the industries. The first is the flows of primary factor inputs. This comprises rental of capital (V1CAP), rental of land (V1LND), and labour costs (V1LAB). The second is production taxes (V1PTX). The sum of V1PUR, V1CAP, V1LND, V1LAB, and V1PTX represents total cost of production (V1TOT). The initial values for these flows are provided by the initial database taken from the 2010 Input-Output Table of Indonesia (BPS, 2015b). The real-side model's database will be explained in detail in Chapter 5.

3.2.1.2 Flow dimensions

Set	Description	Index	Element
IND	Set of industries	i	51
COM	Set of commodities	c	51
SRC	Set of sources	s	2 (domestic and imported)
MAR	Set of margin commodities	m	6 (Sales and maintenance, Retail, Land transportation, Water transportation, Air transportation, and Other).
FAC	Set of Primary Factor	f	3 (Labour, Capital, and Land.)
USERS	Set of User Agents	u	7 (industries, investors, households, governments, foreign (exports), and inventory)

Table 3.1 Set of Dimensions

There are several dimensions that can explain the directions of the flows. Table 3.1 reports the set descriptions, corresponding indices, and the number of elements in each set. The sets of industries (IND) and commodities (COM) are represented in indices (i) and (c) respectively. Both sets contain 51 elements. These are an aggregation of the 185 elements in the original database (BPS, 2015b). The source set (SRC) contains the element of domestic and import sources. This set is to explain from where the input commodities are obtained. The margin set (MAR) contains margin commodities that facilitate the flow of commodities from source (s) to the users. The margin commodities are produced domestically. The set of factors (FAC) is the factor used for the current production by industries.

The dimensions are denoted in subscripts after a flow coefficient. For example, $\mathrm{V1BAS}_{(\mathrm{c,s,i})}$ shows the basic value of commodity (c), sourced from (s), used as production input in industry (i), valued at basic price. The subscript (c,s,i) refers to the member elements of COM, SRC, and IND respectively. $\mathrm{V1TAX}_{(\mathrm{c,s,i})}$ and $\mathrm{V1MAR}_{(\mathrm{c,s,i})}$ are values of indirect tax and margin of the commodity (c) sourced from (s) used by industry (i).

3.2.1.3 Coefficients and variables

Coefficients and variables are coded according the conventions of GEMPACK software (Harrison et al., 2016). For convenience, upper-case code represents the coefficients, while lower-case code represents the variables.[8] For example, in the levels, the value of a transaction is defined as the product of quantity and price $(\mathrm{V} = \mathrm{X} \cdot \mathrm{P})$. The corresponding relationship in percentage-change terms is coded in lower-case letters $(\mathrm{w} = \mathrm{x} + \mathrm{p})$. Technology coefficients are commonly denoted by upper case (A), with the corresponding lower-case percentage-change variable (a).

3.2.2 Dynamic Mechanisms

There are two essential elements that run dynamic mechanism in the real-side model, namely stock accumulation relationships (e.g. accumulation of industry-specific capital stocks) and sticky-wage adjustment. However, the sticky-wage adjustment mechanism will be deactivated and replaced by the Phillip curve (Phillips, 1958) when the financial-

[8] While GEMPACK does not distinguish between upper and lower case. This notation is intended to benefit the modeller to differentiate between coefficient and variable in the model code.

side of the model is introduced later. This replacement is necessary to accommodate the role of the central bank as a significant financial agent.

3.2.2.1 Capital stock accumulation

Capital stock accumulations in the real-side model follows the standard capital-investment accumulation equation. In this equation, capital stock accumulations at the end-of-year (t+1) is determined by post-depreciation capital stock at the start-of-year (t), supplemented by new (flow) investments within-year (t). Algebraically, this relationship can be written as follow:

$$K_{(t+1,i)} = \left(1 - \delta_{(i)}\right) \cdot K_{(t,i)} + I_{(t,i)}, \tag{3.1}$$

where,

- $K_{(t+1,i)}$ is end-of year capital stock in industry (i);
- $K_{(t,i)}$ is start-of-year capital stock in industry (i);
- $\delta_{(i)}$ is constant depreciation rate in industry (i);
- $I_{(t,i)}$ is within-year flow of investment in industry (i).

The percentage change form of Equation (3.1) is given as follow:

$$K_{(t+1,i)} \cdot k_{(t+1,i)} = \left(1 - \delta_{(i)}\right) \cdot K_{(t,i)} \cdot k_{(t,i)} + I_{(t,i)} \cdot x^{(2)}_{(t,i)}, \tag{3.2}$$

where,

- $k_{(t+1,i)}$ is end-of-year percentage-change of capital stock in industry (i);
- $k_{(t,i)}$ is start-of-year percentage-change of capital stock in industry (i);
- $x^{(2)}_{(t,i)}$ is percentage-change of real investment in industry in industry (i).

Equation (3.1) and (3.2) describe that if a new stream of investment cannot replace capital depletion due to depreciation $[\left(1 - \delta_{(i)}\right) \cdot K_{(t,i)}]$, the end-of-year capital stock would decline.

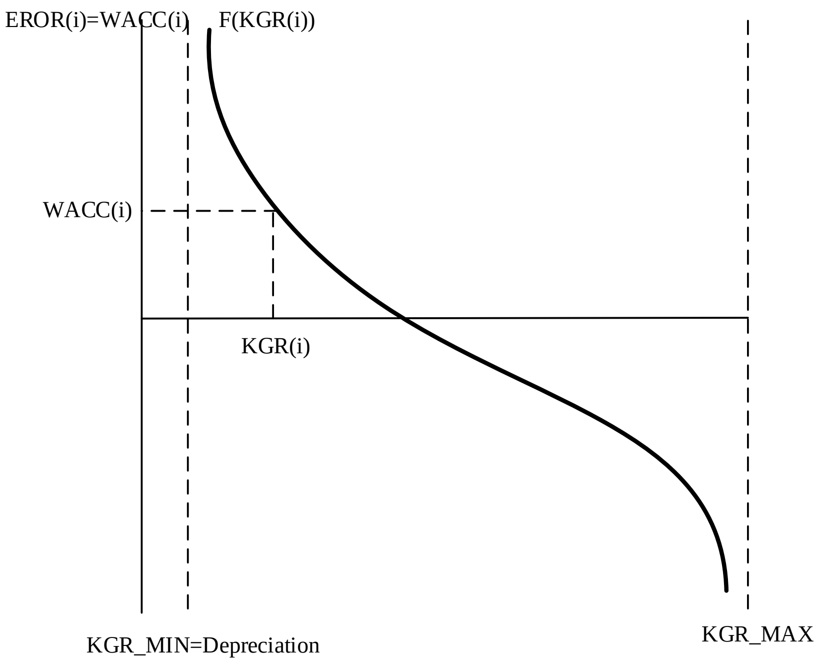
The supply of capital is determined by a logistic function, as illustrated by Figure 3.1. Under this function, investors invest up to the point where the weighted average cost of financial capital ($WACC_{(i)}$) is equal to the expected rate of growth on capital. Investors expect that higher rates of capital growth will be associated with lower expected rates of return on capital. Hence, when the weighted average cost of capital falls, investors are willing to fund a higher capital growth rate. At the same time, actual rates of return act as a vertical shift on the logistic function, such that an increase in current rates of return will raise the capital growth rate for any given level of the expected rate of return. When the financial theory is linked to this real side theory, I set the expected rate of return equal to the weighted average cost of financial capital. In a simplified expression, the capital supply function can be described in the following equation:

$$\mathrm{EROR}_{(\mathrm{i})} = \mathbf{F}\left(\mathrm{K}_{(\mathrm{i})}\right) \cdot \mathrm{ROR}_{(\mathrm{i})}, \tag{3.3}$$

where,

- $\mathrm{EROR}_{(\mathrm{i})}$ is expected and actual rate of return in industry (i);
- $\mathrm{ROR}_{(\mathrm{i})}$ is actual rate of return in industry (i);
- $\mathbf{F}\left(\mathrm{K}_{(\mathrm{i})}\right)$ is a negative function of capital growth in industry (i).

Equation (3.3) implies that investors are assumed to be conservative toward expected rates of return. They expect a lower rate of return in the future as they add a new investment.



Source: Giesecke et al. (2015)

Figure 3.1 Inverse Logistic Function

Equation (3.3) is illustrated in a schematic representation by the Figure 3.4. Parameterisation of the function is anchored around values for trend capital growth, normal rates of return, the elasticity of investment to rates of return, and minimum and maximum rates of annual capital growth. In the vicinity of the point on the curve defining normal rates of return and historical trend of capital growth. At the outer ends of the function, capital growth is limited by values for maximum and minimum permissible rates. The maximum capital growth can be determined by adding to the trend ($\mathrm{kgr\_trend}_{(i)}$) *plus* a deviation (diff). The minimum rate is determined by the depreciation rate $\left(\delta_{(i)}\right)$.

3.2.2.2 Sticky-wage adjustment

In a static CGE model such as ORANI-G, the relationship between employment and real wages is determined by setting the labour market closure. In a typical short-run closure, the real wage is exogenous, and is thus unaffected by employment. A typical long run closure is configured to define a period of time over which the labour market has had sufficient time to adapt, and as such, the real wage is endogenous and employment is exogenous.

In a dynamic CGE model such as MONASH, the real wage is not totally unchanged in the short-run as it is in ORANI. Instead, a limited movement of the real wage is possible in response to changes in short-run labour market conditions. Over time, the real wage continues to adjust as employment moves toward full-employment over the long run. This framework is called the **sticky-wage adjustment**.

Following Dixon and Rimmer (2002: 205), the sticky-wage adjustment equation can be written as follow:

$$\left\{\frac{W^{p}_{(t)}}{W^{f}_{(t)}}-1\right\}=\left\{\frac{W^{p}_{(t-1)}}{W^{f}_{(t-1)}}-1\right\}+\alpha\cdot\left\{\frac{E^{p}_{(t)}}{E^{f}_{(t)}}-1\right\}, \tag{3.4}$$

where,

- $W^{p}_{(t)}$ and $W^{f}_{(t)}$ are the end-of-year policy and forecast of real wage respectively;
- $W^{p}_{(t-1)}$ and $W^{f}_{(t-1)}$ are lagged-year policy and forecast of real wage respectively;
- $E^{p}_{(t)}$ and $E^{f}_{(t)}$ are the end-of-year policy and forecast of employment respectively;
- α is an adjustment parameter $(\alpha > 0)$.

The term $\left\{\frac{W^p_{(t)}}{W^f_{(t)}} - 1\right\}$ represents deviation of real wage from the equilibrium at year t, i.e., policy simulation compared to baseline forecast. This term depends on the last year real wage deviation $\left\{\frac{W^p_{(t-1)}}{W^f_{(t-1)}} - 1\right\}$ and current year employment deviation $\left[\alpha \cdot \left\{\frac{E^p_{(t)}}{E^f_{(t)}} - 1\right\}\right]$. Overall, Equation (3.4) explains that real wage and employment can change from the equilibrium in the short-run and gradually adjust (return) to full-employment equilibrium in the long run.

3.2.3 Computation Methods

To explain how to solve the AMELIA-F equation system, I use Johansen/Euler methods (Johansen, 1960) as implemented in GEMPACK software. This can be explained as follows:

$$\mathbf{F}(\mathbf{Y}, \mathbf{X}) = 0, \tag{3.5}$$

where,

- $\mathbf{Y}$ is a vector that consists of endogenous variables;
- $\mathbf{X}$ is a vector that consists of exogenous variables; and
- $\mathbf{F}$ is a differentiable non-linear vector function representing a large non-linear equation system.

Equation (3.5) constitutes the implicit function of equation systems in AMELIA-F. This contains the vectors of endogenous and exogenous variables. Our objective here is to solve the system using the Johansen/Euler methods.

Taking total derivative of Equation (3.5), I obtain the following expression:

$$\mathbf{F_Y}(\mathbf{Y}, \mathbf{X}) \cdot \mathbf{dY} + \mathbf{F_X}(\mathbf{Y}, \mathbf{X}) \cdot \mathbf{dX} = 0. \tag{3.6}$$

Transforming $\mathbf{dY}$ and $\mathbf{dX}$ into percentage-changes forms, Equation (3.6) becomes:

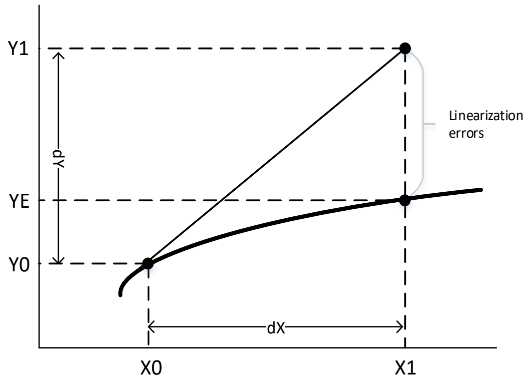
$$\mathbf{G_Y}(\mathbf{Y}, \mathbf{X}) \cdot \mathbf{y} + \mathbf{G_X}(\mathbf{Y}, \mathbf{X}) \cdot \mathbf{x} = 0, \tag{3.7}$$

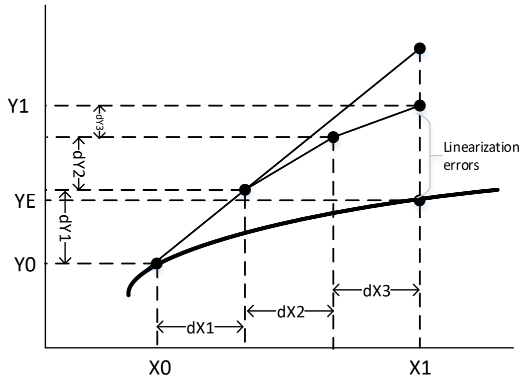
where,

- $\mathbf{y}$ is vector of percentage-change of endogenous variables ($\mathbf{y} = \mathbf{dY}/\mathbf{Y} \cdot 100$);
- $\mathbf{x}$ is vector of percentage-change of endogenous variables ($\mathbf{x} = \mathbf{dX}/\mathbf{X} \cdot 100$);
- $\mathbf{G_Y}(\mathbf{Y}, \mathbf{X}) = \mathbf{F_Y}(\mathbf{Y}, \mathbf{X}) \cdot \mathbf{Y} \cdot 0.01$;
- $\mathbf{G_X}(\mathbf{Y}, \mathbf{X}) = \mathbf{F_X}(\mathbf{Y}, \mathbf{X}) \cdot \mathbf{X} \cdot 0.01$.

Therefore,

$$\mathbf{y} = -\mathbf{G_Y}(\mathbf{Y}, \mathbf{X})^{-1} \cdot \mathbf{G_X}(\mathbf{Y}, \mathbf{X}) \cdot \mathbf{x}. \tag{3.8}$$



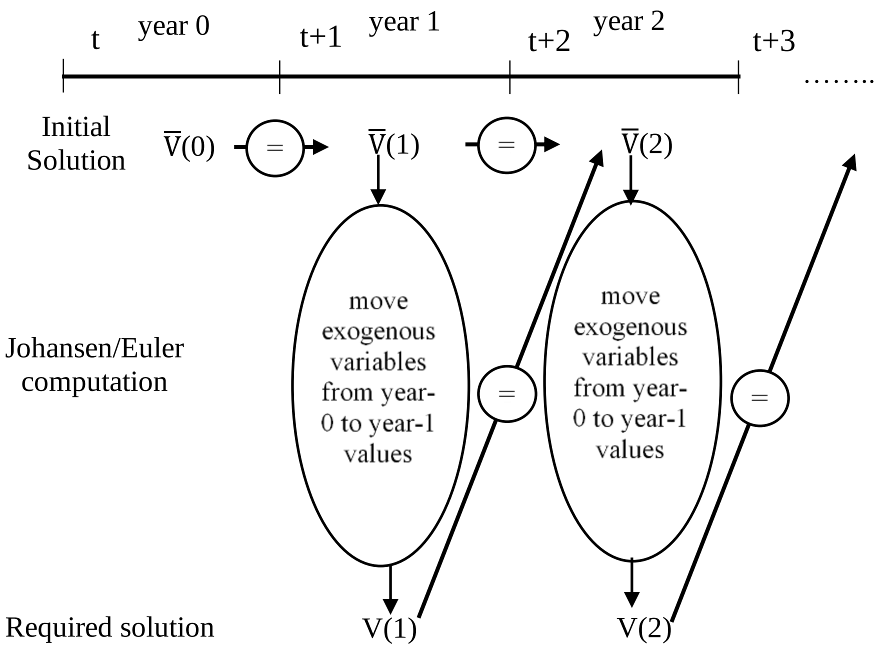


Source: Adapted from Horridge (2013).

Figure 3.2 One-step Solution Method (Johansen)

Figure 3.3 Multi-step Solution Method (Euler)

Equation (3.8) describes how the equation system is solved with Johansen/Euler methods. The vector of percentage-changes in endogenous variables ($\mathbf{y}$) now becomes a function of the vector of percentage-changes in exogenous variable ($\mathbf{x}$). However, as $\mathbf{G_Y}(\mathbf{Y}, \mathbf{X})^{-1} \cdot \mathbf{G_X} \cdot (\mathbf{Y}, \mathbf{X})$ is evaluated using the non-linear functions of the underlying levels model (3.5), the results of $\mathbf{y}$ may suffer from linearisation errors when $\mathbf{x}$ is large. Figure 3.2 and Figure 3.3 illustrate how Equation (3.8) is solved using Johansen and Euler methods respectively. The horizontal axis represents the level term X variable (exogenous variable), while the vertical axis represents the level term Y variable (endogenous variable).



Source: Adopted from Dixon and Rimmer (2002)

Figure 3.4 A Sequence of Solutions

Figure 3.2 explains how the one-step Johansen method solves the equation system. In the initial point the equilibrium is at X0 and Y0. Then, there is a policy shock that causes X0 to move to X1. The difference between X0 and X1 is denoted by dX. The one-step Johansen method is based on a linearisation process that generates elasticities of Y with respect to X based on the slope of the function at the initial solution (X0, Y0). Using the one-step Johansen method causes Y0 to change to Y1 (dY), instead of YE which lies on the actual non-linear equation system. The solution thus generates linearisation error of Y1-YE.

Figure 3.3 explains how the multi-step Johansen method (i.e. the Euler method) solves the equation system. This method offers an approach to reduce the linearisation errors by breaking the solution into multiple steps. In this particular example, the change in X (dX) is broken into three steps (dX1, dX2, and dX3). As a result, Y divides into three steps (dY1, dY2, and dY3). At each point in the sequence, elasticities of Y with respect to X are recomputed and the new computations used for the next step in the sequence. The computed values for Y are thus more likely to follow the actual non-linear function under this multi-step approach. This makes for less linearisation error than in the Johansen method.

AMELIA-F is a recursive dynamic CGE model which computes solutions at the end of period (t+1) based on information provided at the beginning of the period (t). The solutions at the end of period (t+1) are carried over as information at the beginning period (t+2). Based on this information the model computes the solutions for the end period (t+3). The process continues perpetually, thus making a sequence of solutions.

Figure 3.4 illustrates this process for making a sequence of solutions. $\overline{\mathrm{V}}(0)$ is the initial solution as represented by the original database used in the model. In the first year, $\overline{\mathrm{V}}(0)$ is the initial solution of period 1, therefore $\overline{\mathrm{V}}(0) = \overline{\mathrm{V}}(1)$. After specifying the shocks of exogenous variables, the $\overline{\mathrm{V}}(1)$ is solved with Johansen or Euler computation methods (Horridge, 2013). Both methods generate the required solution of $\mathrm{V}(1)$. The $\mathrm{V}(1)$ updates the database for the second year, thus preparing $\overline{\mathrm{V}}(2)$, then running the $\overline{\mathrm{V}}(2)$ to generate $\mathrm{V}(2)$. This process creates a sequence of solutions that represent the dynamic results of the CGE model.

3.3 The Real-side Model

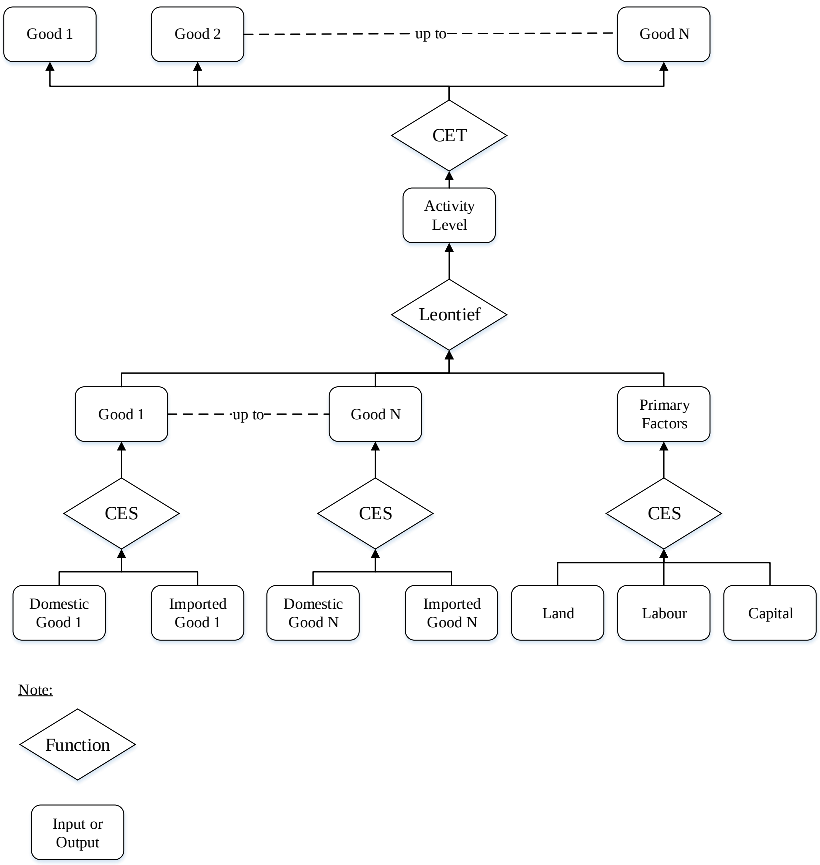
This section briefly explains the general theory of the real-side model. For detailed explanations please see Dixon and Rimmer (2002), Dixon et al. (1982), and (Horridge, 2013). This section covers the behaviours of economic agents, key assumptions, and essential macroeconomic accounts.

The behaviour of each agent is derived under specific optimisation processes. Each agent tries to achieve its objective function e.g., maximum revenue or minimum cost, by choosing a combination of inputs or outputs, subject to a particular constraint. First, the optimisation problem will be stated in an explicit mathematical expression. Second, the solutions of the optimisation problem are declared in percentage-change terms, representing the formulae to be coded in the GEMPACK software. Only real-side behaviour equations, those that are essential to help understanding of the overall skeleton of the real-side model, will be presented in this part.

The rest of this section will describe the underlying model assumptions and important macroeconomic accounts. As a neoclassical model, the real-side model assumes zero pure profit (ZPP) and market clearing conditions. The important macroeconomic accounts to be discussed include government accounts, the current account, national account, and aggregate households' consumption.

3.3.1 Optimal Behaviour in Current Production

This section describes the theory of current production by industry agents. The current production in the real-side model is approached by a multi-level nesting system, as illustrated in Figure 3.5. In each nest, industries choose a combination of inputs and outputs to achieve their objective function. For example, at the lower nests, industries choose the optimal inputs of intermediate commodities and primary factors that minimise costs. In the upper nest, industries choose a combination of output to maximise revenue. In short, the nesting system in Figure 3.5 shows the structure of demand for inputs and supply of outputs of the industries. The optimisation process is performed in four different nests, namely primary factor, intermediate inputs, inputs for current production, and commodities produced by industries.



Source: adapted from Horridge (2003)

Figure 3.5 Structure of Production

3.3.1.1 Demand for primary factors

In Figure 3.5, the primary factor nest is illustrated in the bottom right-hand corner. In this nest, each industry chooses a combination of primary factors (labour, capital, and land) by minimising the composite costs of primary factors subject to a constant elasticity of substitution (CES) production function. Algebraically, the optimisation problem of primary factors is expressed as follow:

Choose: $X^{(1)}_{(f,i)}$ by,

$$\text{Minimise:} \quad \sum_{f \in FAC} X^{(1)}_{(f,i)} \cdot P^{(1)}_{(f,i)}, \tag{3.9}$$

$$\text{Subject to} \quad X^{(1)}_{(prim,i)} = \sum_{f \in FAC} \left\{ \delta^{(1)}_{(f)} \left(\frac{X^{(1)}_{(f,i)}}{A^{(1)}_{(f,i)}} \right)^{-\rho^{(1)}_{(f,i)}} \right\}^{-\frac{1}{\rho^{(1)}_{(f,i)}}}, \tag{3.10}$$

$$f \in FAC, i \in IND.$$

where,

- superscript (1) refers to inputs used for current production;
- $X^{(1)}_{(prim,i)}$ is demand for composite primary factor used in industry (i);
- $X^{(1)}_{(f,i)}$ and $P^{(1)}_{(f,i)}$ are quantity and price of primary factor (f) used in industry (i);
- $A^{(1)}_{(f,i)}$ is technical change of primary factor (f) used in industry (i);
- $\delta^{(1)}_{(f)}$ is value share of factor (f) cost in relative to the total primary factor costs;
- $\rho^{(1)}_{(f,i)}$ is elasticity substitution of primary factor (f) used in industry (i) ($\rho^{(1)}_{(f,i)} > -1$ and $\rho^{(1)}_{(f,i)} \neq 0$). In the real-side model, $\rho^{(1)}_{(f,i)}$ is set to be equal across primary factors and industries.

The solution of the optimisation problem of Equation (3.9) and (3.10) in percentage change is given as follow:

$$x^{(1)}_{(f,i)} = x^{(1)}_{(prim,i)} - \sigma prim^{(1)}_{(i)} \left(p^{(1)}_{(f,i)} - p^{(1)}_{(prim,i)} \right) + a^{(1)}_{(f,i)} - \sigma prim^{(1)}_{(i)} \left(a^{(1)}_{(f,i)} - alk^{(1)}_{(i)} \right), \tag{3.11}$$

where,

$$p^{(1)}_{(prim,i)} = \sum_{f \in FAC} \delta^{(1)}_{(f)} \cdot p^{(1)}_{(f,i)}; \tag{3.12}$$

and,

$$alk^{(1)}_{(i)} = \sum_{f} \delta^{(1)}_{(f)} \cdot a^{(1)}_{(f,i)}, \tag{3.13}$$

$f \in LK(\text{Labour and Capital})$ and $LK \in FAC$.

where,

- $x^{(1)}_{(prim,i)}$ and $p^{(1)}_{(prim,i)}$ are percentage-changes of quantity and price of composite primary factor used in industry (i);
- $x^{(1)}_{(f,i)}$ and $p^{(1)}_{(f,i)}$ are percentage-changes of quantity and price of primary factor (f) used in industry (i);
- $a^{(1)}_{(f,i)}$ is percentage-change of technical improvement of primary factor (f) used in industry (i);
- $alk^{(1)}_{(i)}$ is percentage-change of weighted average technical improvement of labour and capital used in industry (i); and
- $\sigma prim^{(1)}_{(i)}$ is elasticity of substitution that governs demand substitution across factors due to change in factors' prices;

Equation (3.11) represents the demand for factor (f) used in industry (i). To understand the equation, I begin by assuming no change in the price and technical variables. The equation now states that, in the absence of price and technical change, a change in the demand for the composite primary factor, leads to a proportional change in the demand for all types of factor inputs in industry (i). For example, a 1 per cent rise in demand for composite primary factor causes 1 per cent increase in demand for each specific factor.

The second term represents substitution effects in factor demand due to relative changes in factor prices. With unchanged primary factor demand and technology, an increase in the price of a specific factor relative to the average factor price induces lower demand for the corresponding factor, while inducing a higher demand for other factors. The sensitivity of the substitution effect is governed by $\sigma prim^{(1)}_{(i)}$.

The third term represents the effect of technical change on factor demand. With unchanged primary factor demand and factor prices, subject to value of elasticity of substitution and demand of the product, an improvement in factor-specific technology would induce lower demands for the corresponding factor, while inducing lower demand for other factors. The sensitivity of impact of technology improvement is also governed by $\sigma prim^{(1)}_{(i)}$. Equation (3.12) represents the weighted average price of primary factor used by industry (i). Equation (3.13) shows the weighted average of technical change in using labour and capital by industry (i).

3.3.1.2 Demand for intermediate inputs

Besides primary factors, industries require commodities as intermediate inputs to produce goods and services. These commodities are sourced locally or imported. In Figure 3.5, production capacity is determined in the upper nest: industries choose a combination of source-specific commodities to minimise the cost of intermediate goods. Algebraically, the optimisation problem can be written as follow:

Choose $X^{(1)}_{(c,s,i)}$, by

$$\text{Minimise:} \quad \sum_{s \in SRC} X^{(1)}_{(c,s,i)} \cdot P^{(1)}_{(c,s,i)}, \tag{3.14}$$

$$\text{Subject to} \quad X\_S^{(1)}_{(c,i)} = \sum_{s \in SRC} \left\{ \delta^{(1)}_{(c,s,i)} \left(\frac{X^{(1)}_{(c,s,i)}}{A^{(1)}_{(c,s,i)}} \right)^{-\rho^{(1)}_{(c)}} \right\}^{-\frac{1}{\rho^{(1)}_{(c)}}}, \tag{3.15}$$

$$c \in COM, s \in SRC, \text{and } i \in IND.$$

where,

- $X\_S^{(1)}_{(c,i)}$ is source-composite commodity (c) used in industry (i);
- $X^{(1)}_{(c,s,i)}$ and $P^{(1)}_{(c,s,i)}$ are quantity and price of commodity (c) from source (s) used in industry;
- $A^{(1)}_{(c,s,i)}$ is the technical change of commodity (c) from source (s) used in industry (i);
- $\delta^{(1)}_{(c,s,i)}$ is the value share of commodity (c) from source (s) used in industry (i);

- $\rho^{(1)}_{(c)}$ is the elasticity of substitution of commodity (c) used in industry (i). The elasticity is set to equal across industries.

In choosing source-specific intermediate commodity, the real-side model assumes imperfect substitution between domestically-produced and imported inputs (Armington, 1969; 1970). In this assumption, the lower price commodity will induce a higher demand without eliminating one of the commodities from the local market (Dixon et al., 1982: 69).

The solution of Equation (3.14) and (3.15) in percentage-change form is given as follows:

$$x^{(1)}_{(c,s,i)} = x\_s^{(1)}_{(c,i)} - \sigma^{(1)}_{(c)}\left(p^{(1)}_{(c,s,i)} - p\_s^{(1)}_{(c,i)}\right) + a^{(1)}_{(c,s,i)} - \sigma^{(1)}_{(c)}\left(a^{(1)}_{(c,s,i)} - a\_s^{(1)}_{(c,i)}\right), \tag{3.16}$$

where,

$$p\_s^{(1)}_{(c,i)} = \sum_{s \in SRC} S^{(1)}_{(c,s,i)} \cdot p^{(1)}_{(c,s,i)}; \tag{3.17}$$

and,

$$a\_s^{(1)}_{(c,i)} = \sum_{s \in SRC} S^{(1)}_{(c,s,i)} \cdot a^{(1)}_{(c,s,i)}. \tag{3.18}$$

where,

- $x^{(1)}_{(c,s,i)}, x\_s^{(1)}_{(c,i)}, p^{(1)}_{(c,s,i)}, a^{(1)}_{(c,s,i)}$ are percentage-changes in quantity, price, and technical change variables of corresponding level variables written in upper-case notations in Equation (3.14) and (3.15);
- $p\_s^{(1)}_{(c,i)}$ and $a\_s^{(1)}_{(c,i)}$ are price and technical change of source-composite commodity (c) used in industry (i);
- $\sigma^{(1)}_{(c)}$ is Armington elasticity which governs the substitution between domestic and imported commodities; and
- $S^{(1)}_{(c,s,i)}$ is the value share of source-specific commodity (c) to the total costs of intermediate inputs used in industry (i).

The first term in the RHS of Equation (3.16) explains the capacity effect (size effect) on source-specific demand for intermediate inputs. In the absence of price and technical change, the demand for source-specific intermediate commodity is equal to the percentage change in demand for the composite commodity (c) in industry (i). This composite commodity is determined in the different nest (upper nest), which is related to the industry's production capacity (activity level). The terms in brackets explain the price substitution effect on demand for source-specific inputs. For example, if capacity and technology are fixed, an increase in the price of domestically-produced commodities relative to the average price, induces lower demand for the domestically-produced commodity, while inducing higher demand for the imported commodities. The sensitivity of the substitution effect is governed by $\sigma^{(1)}_{(c)}$.

The third term explains the technological impact on the demand for source-specific inputs. When capacity and prices remain unchanged, subject to value of elasticity of substitution and demand of specific product, an improvement in technology (negative growth in technical change) in the use of commodity induces lower demand for corresponding commodity. The sensitivity of the technological impact is also governed by $\sigma^{(1)}_{(c)}$. Equation (3.17) is the weighted average of source-composite use of commodity (c) by industry (i). Equation (3.18) is the weighted average of technical-change in the use of commodity (c) by industry (i).

3.3.1.3 Demand for composite inputs for current production

In current production, industries demand a combination of primary and intermediate inputs, subject to a constraint to minimise input costs, and subject to a given activity level (production capacity). The combination of primary and intermediate inputs is chosen subject to a Leontief function specification, reflecting a non-substitutable nature between intermediate inputs and primary factors. Algebraically, the optimisation problem faced by the industries can be expressed as follows:

Choose $X\_S^{(1)}_{(c,i)}$ and $X^{(1)}_{(prim,i)}$, to

Minimise costs: $$X\_S^{(1)}_{(c,i)} \cdot P\_S^{(1)}_{(c,i)} + X^{(1)}_{(prim,i)} \cdot P^{(1)}_{(prim,i)}, \tag{3.19}$$

Subject to $$Z_{(i)} = \min\left\{\frac{X\_S^{(1)}_{(1,i)}}{A\_S^{(1)}_{(1,i)}}, \cdots, \frac{X\_S^{(1)}_{(1,c)}}{A\_S^{(1)}_{(1,c)}}, \frac{X^{(1)}_{(prim,i)}}{A^{(1)}_{(prim,i)}}\right\}, \tag{3.20}$$

$c \in \mathrm{COM}$ and $i \in \mathrm{IND}$,

where,

- $\mathrm{P\_S}_{(c,i)}^{(1)}$ is the source-composite price of composite commodity (c) used in industry (i);
- $\mathrm{Z}_{(i)}$ is the activity level or production capacity of industry (i);
- $\mathrm{A\_S}_{(c,i)}^{(1)}$ is the technical change of source-composite commodity (c) used in industry (i);
- $\mathrm{A}_{(prim,i)}^{(1)}$ is the primary factor composite technical change used in industry (i).

Supposedly, the technical changes are set to 1, the RHS of Equation (3.20) shows the minimum effective inputs needed to support one unit activity level of in a particular industry. Therefore, a reduction in technical change variables causes proportional rise of activity level (fixed proportion) (Dixon et al., 1982: 69).

In level terms, the demand functions of source-composite and primary factor composite inputs are given as follow:

$$\mathrm{X\_S}_{(c,i)}^{(1)} = \mathrm{Z}_{(i)} \cdot \mathrm{A\_S}_{(c,i)}^{(1)}, \tag{3.21}$$

$$\mathrm{X}_{(prim,i)}^{(1)} = \mathrm{Z}_{(i)} \cdot \mathrm{A}_{(prim,i)}^{(1)}, \tag{3.22}$$

In percentage-change terms, the solutions represented in Equation (3.21) and (3.22), of all corresponding variables, can be written as follow:

$$\mathrm{x\_s}_{(c,i)}^{(1)} = \mathrm{z}_{(i)} + \mathrm{a\_s}_{(c,i)}^{(1)}, \tag{3.23}$$

$$\mathrm{x}_{(prim,i)}^{(1)} = \mathrm{z}_{(i)} + \mathrm{a}_{(prim,i)}^{(1)}. \tag{3.24}$$

In Equation (3.23) and (3.24), if the technology variables remain unchanged, demand for source and primary factor-composite inputs are determined proportionately by the activity level. For example, a 1 per cent increase in production capacity causes a 1 per cent increase in industry demand for both source-composite intermediate inputs and primary factor composite primary input.

If the desired production capacity is unchanged, an improvement in technology in source-composite intermediate input or primary factor-composite input causes less demand for the corresponding intermediate or primary factor input. There are no relative prices shown on the RHS of the equations, as no substitution can occur between intermediate and primary factor inputs. This is a property of the underlying Leontief production function.

3.3.1.4 Commodities produced by industries

With a given production possibility frontier (production capacity), industries have to decide on the combination of commodity outputs they want to produce to maximise revenue. Formally, the optimisation problem can be expressed as follow:

Choose $X^{(0)}_{(c,i)}$, to

Maximise revenue: $$\sum_{c \in COM} P^{(0)}_{(c)} \cdot X^{(0)}_{(c)}, \tag{3.25}$$

Subject to $$Z^{(0)}_{(i)} = \sum_{c} \left\{ \delta^{(0)}_{(c,i)} \left(\frac{X^{(0)}_{(c,i)}}{A^{(0)}_{(c,i)}} \right)^{\rho^{(0)}_{(c)}} \right\}^{\frac{1}{\rho^{(0)}_{(c)}}}, \tag{3.26}$$

$c \in COM,$

where,

- Superscript (0) represents the commodity is consumed by all users;
- $P^{(0)}_{(c)}$ and $X^{(0)}_{(c)}$ are price and output of commodity (c) for all users;
- $Z^{(0)}_{(i)}$ is production capacity (activity level) of industry (i);
- $\delta^{(0)}_{(c,i)}$ is the share of commodity (c) produced by industry (i) $\left(\sum_{c \in COM} \delta^{(0)}_{(c,i)} = 1\right)$;
- $\rho^{(0)}_{(c)}$ is the elasticity of transformation across commodities values ≤ -1, and equals for all industries;
- $A^{(0)}_{(c,i)}$ is the technical changes in production.

Equation (3.25) expresses total revenue from sales of commodity (c) by industry (i). Equation (3.26) is the production capacity specified in an elasticity of transformation (CET) function. The CET is a concave function representing the production possibility frontier (PPF) faced by each industry.

The solution to the optimisation problem in percentage-change terms is given as follows:

$$x^{(0)}_{(c,i)} + a^{(0)}_{(c,i)} = z_{(i)} + \sigma out^{(0)}_{(i)} \left(p^{(0)}_{(c,\text{"dom"})} - p\_e^{(0)}_{(i)} - a^{(0)}_{(c,i)} \right), \tag{3.27}$$

where,

$$p\_e^{(0)}_{(i)} = \sum_{c \in COM} S^{(0)}_{(c,i)} \left(p^{(0)}_{(c,\text{"dom"})} - a^{(0)}_{(c,i)} \right), \tag{3.28}$$

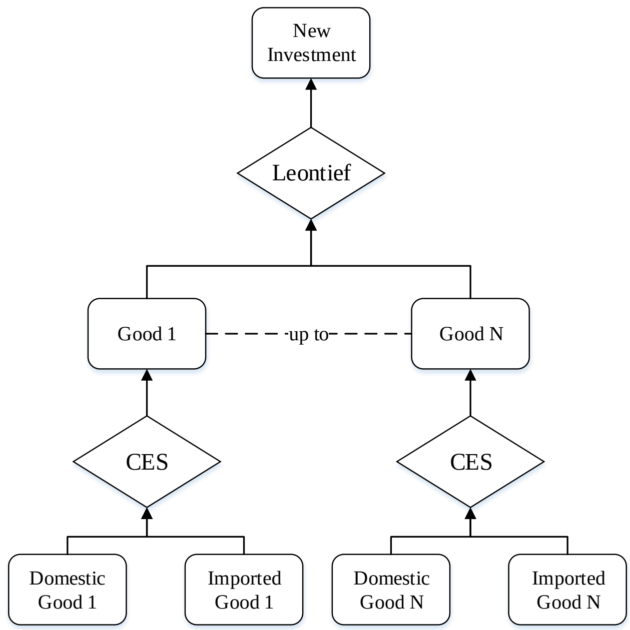
where,

- $x_{(c,i)}^{(0)}$ and $p_{(c,dom)}^{(0)}$ are percentage-changes in quantity and price of output commodity (c) in the domestic market;
- $p\_e_{(i)}^{(0)}$ is percentage-change weighted average price of output produced by industry (i);
- $a_{(c,i)}^{(0)}$ is percentage-change in technical change in producing output commodity (c) by industry (i); and
- $S_{(c,i)}^{(0)}$ is the value share of output of commodity (c) in the total value of commodity sales by industry (i).

In Equation (3.27), commodity output by industry is determined by production capacity, relative prices, and technical change. In the absence of price and technical change, subject to value of elasticity substitution and demand of the product, the output of each commodity is proportionately determined by the industry's level of output capacity. Hence, a 1 per cent increase in productive capacity increases all commodity outputs produced by the industry by 1 per cent. A rise in the price of a specific commodity relative to the weighted average prices of commodities produced by the industry induces an increase of supply in favour of the corresponding commodity and away from producing other commodities (transformation effect). The sensitivity of the output transformation is governed by the parameter $\sigma out_{(i)}^{(0)}$. Equation (3.28) is the weighted average price of output commodities produced by industry (i).

3.3.2 Creation of New Capital

As aforementioned in Section 3.2.2.1, investment is a process of creation of new capital that replaces depreciation of existing capital and potentially adds net new capital. If net investment exceeds depreciation, the end-of-year capital stock rises. The physical creation of new units of capital is modelled in a similar fashion to production activities outlined earlier. Figure 3.6 illustrates the structure of production of capital inputs for investment.



Source: adapted from Horridge (2003)

Figure 3.6 Structure of Production of New Capital

The creation of new capital does not require primary factors directly. The new capital is produced from a combination of outputs produced by industries e.g., manufactured machinery, equipment, and buildings. The primary factors are only used as inputs to current production. Effectively, primary factor inputs into capital formation are embedded in the commodities (like construction services) that are used directly to create new units of capital.

For the production of new capital, it is easier to discuss the theoretical structure from the top to the bottom. Given the required level of investment in industry (i) $\left(\mathrm{I}_{(\mathrm{i})}\right)$, which is tied to Equation (3.1),[9] an industry (i) needs to choose the source-composite commodities that,

Choose $\mathrm{X\_S}^{(2)}_{(\mathrm{c,i})}$ by,

$$\text{Minimise:} \quad \mathrm{X\_S}^{(2)}_{(\mathrm{c,i})} \cdot \mathrm{P\_S}^{(2)}_{(\mathrm{c,i})}, \tag{3.29}$$

[9] As the investment variable in this section accounts for the flow within-year, the time dimension can be omitted.

Subject to $$\mathrm{I}_{(i)} = \min\left\{\frac{X\_S^{(2)}_{(c,1)}}{A\_S^{(2)}_{(c,1)}}, \cdots, \frac{X\_S^{(2)}_{(c,1)}}{A\_S^{(2)}_{(c,1)}}\right\}, \tag{3.30}$$

$c \in \mathrm{COM}$ and $i \in \mathrm{IND}$.

where,

- superscript (2) indicates that the variables are related to capital creation;
- $X\_S^{(2)}_{(c,i)}$ and $P\_S^{(2)}_{(c,i)}$ are the source-composite commodity and price of investment input (c) used in industry (i), therefore $X\_S^{(2)}_{(c,i)} \cdot P\_S^{(2)}_{(c,i)}$ represents the input costs to capital creation;
- $\mathrm{I}_{(i)}$ is new capital units in industry (i);
- $A\_S^{(2)}_{(c,i)}$ is technical change in using input (c) in industry (i).

Since the optimisation problem in Equation (3.29) and (3.30) is similar to the optimisation in Section 3.3.1.3, the solution and the interpretation are similar. In percentage-change terms, the solution gives demand functions for source-composite inputs to capital formation as follow:

$$x\_s^{(2)}_{(c,i)} = x^{(2)}_{tot} + a\_s^{(2)}_{(c,i)}, \tag{3.31}$$

Without technical change, the percentage-change in demand for source-composite capital input (c) in industry (i) is determined by aggregate units of capital created. There is no price substitution effect in Equation (3.31), reflecting the demand function is derived from the Leontief fixed proportion form.

The next task in capital creation is to define the source-specific inputs for capital formation, given the demand for source-composite capital inputs. The optimisation problem in this nest is to define a combination of source-specific inputs to minimise costs subject to CES production functions. Herein, the CES specification is similar to that outlined in Section 3.3.1.1, therefore the simplified form of the optimisation problem can be written as follow:

Choosing $X^{(2)}_{(c,s,i)}$ by,

Minimise cost: $$\sum_{s} X^{(2)}_{(c,s,i)} \cdot P^{(2)}_{(c,s,i)}, \tag{3.32}$$

Subject to $$X\_S^{(2)}_{(c,i)} = \mathrm{CES}\left(\frac{X^{(2)}_{(c,s,i)}}{A^{(2)}_{(c,s,i)}}\right), \tag{3.33}$$

$$c \in \mathrm{COM}, s \in \mathrm{SRC}, \text{and } i \in \mathrm{IND}.$$

where,

- $X^{(2)}_{(c,s,i)}$ and $P^{(2)}_{(c,s,i)}$ are the source-specific commodity and price of capital input (c) used in industry (i), therefore $\sum_s X^{(2)}_{(c,s,i)} \cdot P^{(2)}_{(c,s,i)}$ represents the input costs of capital creation;
- $A^{(2)}_{(c,s,i)}$ is source-specific technical change of commodity (c) used in industry (i) in relation to capital creation.

The solution in percentage-change can be given as follows:

$$x^{(2)}_{(c,s,i)} = x\_s^{(2)}_{(c,i)} - \sigma^{(2)}_{(c)}\left(p^{(2)}_{(c,s,i)} - p\_s^{(2)}_{(c,i)}\right) + a^{(2)}_{(c,s,i)} - \sigma^{(2)}_{(c)}\left(a^{(2)}_{(c,s,i)} - a\_s^{(2)}_{(c,i)}\right), \tag{3.34}$$

where,

$$p\_s^{(2)}_{(c,i)} = \sum_{s \in SRC} S^{(2)}_{(c,s,i)} \cdot p^{(2)}_{(c,s,i)}; \tag{3.35}$$

and,

$$a\_s^{(2)}_{(c,i)} = \sum_{s \in SRC} S^{(2)}_{(c,s,i)} \cdot a^{(2)}_{(c,s,i)}. \tag{3.36}$$

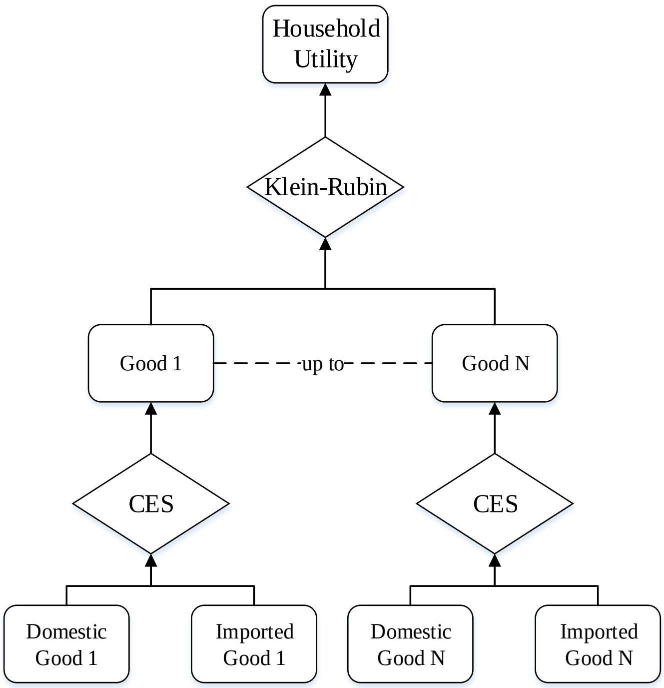
where,

- $x^{(2)}_{(c,s,i)}, x\_s^{(2)}_{(c,i)}, p^{(2)}_{(c,s,i)}, a^{(2)}_{(c,s,i)}$ are percentage-changes in the quantity, price, and technical change variables of the corresponding level variables written in upper-case notations in Equation (3.32) and (3.33);
- $p\_s^{(2)}_{(c,i)}$ and $a\_s^{(2)}_{(c,i)}$ are price and technical change of source-composite commodity (c) used in industry (i);
- $\sigma^{(2)}_{(c)}$ is the Armington elasticity which governs the substitution between domestic and imported commodities; and
- $S^{(2)}_{(c,s,i)}$ is the value share of source-specific commodity (c) in the total costs of capital creation for industry (i).

Equation (3.34), (3.35), and (3.36) represent the demand functions, average price, and technical change for source-specific inputs for capital creation. The pattern of these equations is similar to Equation (3.16), (3.17), and (3.18). Hence, the interpretation of the equations is similar too. The demand function depends on the size of source-composite demand (size effect), relative input prices (substitution effect), and the technological effect (technical change). In the absence of price and technological effects, the demand for source-specific inputs follows the source-composite input demand determined in the upper-nest. A rise in the relative price of a commodity induces the capital creator to move away from the corresponding commodity while favouring other commodities. The technological improvement in specific commodity causes a, subject to value of elasticity of substitution, decrease in use of corresponding commodity. The substitution effects are governed by a constant elasticity across industries, $\sigma_{(c)}^{(2)}$.

3.3.3 Households Consumption

The structure of household demand in the real-side model can be illustrated by Figure 3.7. The optimisation problem for the households is divided into two nests. In the top nest, households consume a combination of commodities to maximise utility, subject to a budget constraint. The utility function used in this optimisation process is specified as Klein-Rubin (L. R. Klein & Rubin, 1947). On the lower nest, the households choose the source-specific commodities to minimise the cost of acquiring utility-maximising composite commodities.



Source: adapted from Horridge (2003)

Figure 3.7 Structure of Household Demand

3.3.3.1 Demand for source-composite commodities

The optimisation problem of the households at the top of the nest can be written as follow:

Choose $X\_S^{(3)}_{(c)}$ by,

Maximise: $$U = U\left(\frac{X\_S^{(3)}_{(1)}}{A\_S^{(3)}_{(1)}}, \dots, \frac{X\_S^{(3)}_{(n)}}{A\_S^{(3)}_{(n)}}\right), \tag{3.37}$$

Subject to $$Y = \frac{1}{Q}\sum_{c \in COM} X\_S^{(3)}_{(c)} \cdot P\_S^{(3)}_{(c)} = \frac{V^{(3)}_{(tot)}}{Q}, \tag{3.38}$$

$c \in COM$.

where,

- superscript (3) represents that the variables are related to households;
- U is the household's utility function;
- $X\_S^{(3)}_{(c)}$ and $P\_S^{(3)}_{(c)}$ are the quantity and price of source-composite commodity (c) consumed by households;

- $A\_S^{(3)}_{(c)}$ is a taste variable such that an increase in $A\_S^{(3)}_{(c)}$ induces the households to consume more of commodity (c);
- Y is household expenditure per household;
- $V^{(3)}_{(tot)}$ is aggregate household expenditure, economy-wide;
- Q is number of the households in the economy.

With the homothetic property of the Klein-Rubin utility function, the household's budget depends on relative prices and income. This specification is written in an implicit function as follow:

$$X\_S_{(c)} = F\big(P\_S_{(1)}, \dots, P\_S_{(k)}, Y\big), \tag{3.39}$$

The total differential of Equation (3.39) can be expressed as:

$$\begin{aligned} dX\_S_{(c)} &= \frac{\partial}{\partial P\_S_{(1)}} dP\_S_{(1)} +, \dots, + \frac{\partial}{\partial P\_S_{(n)}} dP\_S_{(n)} + \frac{\partial}{\partial Y} \\ &= \sum_{k \in COM} \frac{\partial}{\partial P\_S_{(1)}} dP\_S_{(1)} + \frac{\partial}{\partial Y} dY, \end{aligned} \tag{3.40}$$

Dividing both sides of equation by $X\_S^{(3)}_{(c)}$, I obtain:

$$\frac{dX\_S_{(c)}}{X\_S_{(c)}} = \sum_{k \in COM} \frac{\partial}{\partial P\_S_{(1)}} \frac{P\_S_{(k)}}{X\_S_{(c)}} \frac{dP\_S_{(k)}}{P\_S_{(k)}} + \frac{\partial}{\partial Y} \frac{Y}{X\_S_{(c)}} \frac{dY}{Y}, \tag{3.41}$$

In percentage-change Equation (3.41) can be modified as follow:

$$x\_s_{(c)} = \sum_{k \in COM} \eta_{(k,c)} \cdot p\_s_{(k)} + EPS_{(c)} \cdot y, \tag{3.42}$$

where,

- $x\_s_{(c)}$ is the percentage-change in demand for source-composite commodity (c) consumed by households;
- $\eta_{(k,c)}$ is the cross-price elasticity of demand for commodity (c) with respect to the price of k;
- $p\_s_{(k)}$ is percentage change in the price of source-composite commodity (k) paid by households.
- $EPS_{(c)}$ is the expenditure elasticity of demand for commodity (c);
- y is the percentage change in household expenditure.

Equation (3.42) represents the general form of the equations for household demand for source-composite commodities. Household demands for each commodity are a negative function of price and a positive function of income. To apply Equation (3.42) in effective form, the following terms need to be introduced:

$$
\begin{aligned}
&X\_S_{(c)} = \frac{1}{Q} \cdot \frac{X\_S^{(3)}_{(c)}}{A\_S^{(3)}_{(1)}};\\
&P\_S_{(c)} = P\_S^{(3)}_{(c)} \cdot A\_S^{(3)}_{(c)};\\
&Y = \frac{V^{(3)}_{(tot)}}{Q},\\
&c \in COM,
\end{aligned}
\qquad (3.43)
$$

In percentage-change form, the terms in Equation (3.43) become:

$$
\begin{aligned}
&x\_s_{(c)} = x\_s^{(3)}_{(c)} - a\_s^{(3)}_{(c)} - q;\\
&p\_s_{(c)} = p\_s^{(3)}_{(c)} + a\_s^{(3)}_{(c)};\\
&y = v^{(3)}_{(tot)} - q.
\end{aligned}
\qquad (3.44)
$$

Substituting the terms in Equation (3.44) into (3.42) and modifying the demand equation yields percentage-change demand equations as follow:

$$
x\_s^{(3)}_{(c)} - q = \sum_{k \in COM} \eta_{(k,c)}\left(p\_s^{(3)}_{(c)} + a\_s^{(3)}_{(c)}\right) + E_{(c)}\left(v^{(3)}_{(tot)} - q\right) + ave\_a3com, \qquad (3.45)
$$

where,

- $ave\_a3com = \sum_{c \in COM} S^{(3)}_{(c)} \cdot a\_s^{(3)}_{(c)}$.

To implement Equation (3.45), the parameters $\eta_{(k,c)}$ and $E_{(c)}$ must be determined by introducing the following arrangements:

- elasticity of household expenditures $\left(E_{(c)}\right)$ or the marginal budget $\left(\Delta_{(c)}\right)$;
- budget share (budget to income ratio),

  $$S^{(3)}_{(c)} = \frac{P\_S^{(3)}_{(c)} \cdot X\_S^{(3)}_{(c)}}{Y};$$

Frisch parameter (F); [10]

- The cross-price elasticities are defined as follow:

$$\eta_{(k,c)} = KD_{(k,c)} \cdot \frac{\Delta_{(c)}}{S^{(3)}_{(c)}}\frac{1}{F} - \frac{\Delta_{(c)}}{S^{(3)}_{(c)}}\left(S^{(3)}_{(c)} + \frac{\Delta_{(k)}}{F}\right),$$
$$= KD_{(k,c)} \cdot \frac{E_{(c)}}{F} - EPS_{(c)}\left(S^{(3)}_{(c)} + \frac{\Delta_{(k)}}{F}\right). \tag{3.46}$$

where,

- $KD_{(k,c)}$ is the Kronecker delta, whose elements equal 1 for $k = c$, and 0 for $k \neq c$.
- F is the Frisch parameter, expressed as the negative inverse of the share of the luxury budget, i.e.,

  $$\frac{-1}{\left(Y - \sum_{k \in COM} P_{(k)} \cdot X_{(subk)}\right)},$$

  where, $\sum_{k \in COM} P_{(k)} \cdot X_{(sub,k)}$ is the budget for subsistence consumptions.

The marginal budget share is determined as follow:

$$\Delta_{(c)} = EPS_{(c)} \cdot S^{(3)}_{(c)}, \tag{3.47}$$

$c \in COM$,

where,

- $$\Delta_{(c)} = \frac{\partial\, P\_S^{(3)}_{(c)} \cdot X\_S^{(3)}_{(c)}}{\partial Y}.$$

3.3.3.2 Demand for source-specific commodities

On the lower nest, households choose a combination of commodities sourced from domestic or imported sources to minimise costs, subject to CES function of given source-composite consumption. Algebraically, the optimisation problem can be written as follow:

Choose $X^{(3)}_{(c,s)}$ by,

$$\text{Minimise:} \quad \sum_{s \in SRC} P^{(3)}_{(c,s)} \cdot X^{(3)}_{(c,s)}, \tag{3.48}$$

[10] The value of Frisch parameter is taken from literature (Horridge, 2013)

Subject to $$X\_S^{(3)}_{(c)} = \text{CES}\left(\sum_{s \in SRC} X^{(3)}_{(c,s)}\right), \tag{3.49}$$

$s \in SRC$ and $c \in COM$,

where,

- $P^{(3)}_{(c,s)}$ and $X^{(3)}_{(c,s)}$ are the price and quantity of source-specific commodity (c) consumed by households respectively;

The solution of the optimisation problem in percentage-change terms is:

$$x^{(3)}_{(c,s)} = x\_s^{(3)}_{(c)} - \sigma^{(3)}_{(c)}\left(p^{(3)}_{(c,s)} - p\_s^{(3)}_{(c)}\right) + a^{(3)}_{(c,s)} - \sigma^{(3)}_{(c)}\left(a^{(3)}_{(c,s)} - a\_s^{(3)}_{(c)}\right), \tag{3.50}$$

where,

$$p\_s^{(3)}_{(c)} = \sum_{s \in SRC} S^{(3)}_{(c,s)} \cdot p^{(3)}_{(c,s)}; \tag{3.51}$$

and,

$$a\_s^{(3)}_{(c)} = \sum_{s \in SRC} S^{(3)}_{(c,s)} \cdot a^{(3)}_{(c,s)}. \tag{3.52}$$

where,

- $x^{(3)}_{(c,s)}$, $p^{(3)}_{(c,s)}$, and $a^{(3)}_{(c,s)}$ are the percentage-changes in the corresponding levels for source-specific variables of quantity, price, and taste;
- $p\_s^{(3)}_{(c)}$, $x\_s^{(3)}_{(c)}$, and $a\_s^{(3)}_{(c)}$ are the percentage-changes in the corresponding levels for the source-composite variables of quantity, price, and taste;
- $\sigma^{(3)}_{(c)}$ is the substitution elasticity between domestic and imported commodities (Armington elasticity); and
- $S^{(3)}_{(c,s)}$ is share of the cost of source-specific commodity (c) in the total cost of commodity (c) from all sources consumed by households.

The solution to Equation (3.50) has a similar form as Equation (3.34), hence resulting in a similar interpretation for all equation elements.

3.3.4 Export Demand

Export determination in the real-side model is characterised by downward sloping demand functions. The specification of the export demand function in level terms is given as follow:

$$X_{(c)}^{(4)} = \left[\frac{P_{(c)}^{(4)} \cdot \phi}{PF_{(c)}^{(4)} \cdot F_{(gen)}^{(4)}}\right]^{\varepsilon_{(c)}} \cdot FQ_{(c)}^{(4)}, \tag{3.53}$$

$c \in COM.$

where,

- $X_{(c)}^{(4)}$ and $P_{(c)}^{(4)}$ are the quantity and price of export commodity (c);
- $\varepsilon_{(c)}$ is export elasticity where $\varepsilon_{(c)} < 0$;
- Φ is the nominal exchange rate, defined as foreign currency units per Rp;
- $FQ_{(c)}^{(4)}$ is a horizontal shifter in the commodity-specific export demand curve;
- $PF_{(c)}^{(4)}$ is a vertical shifter in the commodity-specific export demand curve;
- $F_{(gen)}^{(4)}$ is a vertical shifter uniformly for all commodities.

In percentage change terms, Equation (3.53) can be rewritten as follow:

$$x_{(c)}^{(4)} = fq_{(c)}^{(4)} + \varepsilon_{(c)} \cdot \left(p_{(c)}^{(4)} + phi - pf_{(c)}^{(4)} - f_{(gen)}^{(4)}\right), \tag{3.54}$$

If all shifters are unchanged, the demand for export commodity (c) is a negative function of price and appreciation of the nominal exchange rate. An increase in the domestic price and appreciation of nominal exchange rate causes the domestic commodity to be more expensive from a foreigner's perspective, thus inducing a decline in export demand. $fq_{(c)}^{(4)}$ can be used to implement an autonomous change in foreign demand for commodity (c) for any given level of foreign price for (c) (that is, a horizontal shift in the export demand schedule for (c)). In like fashion, $pf_{(c)}^{(4)}$ can be used to implement a vertical shift in the export demand schedule for commodity (c).

3.3.5 Government Demand

The government demand for commodities is exogenously determined. It is a function of several shifter variables. However, by implementing an appropriate swap in model closure, government demands can be made to follow household demands. The government demand function equation is written as follows:

$$x^{(5)}_{(c,s)} = \mathrm{SDOM}_{(s)} \cdot f^{(5)}_{(c)} + f^{(5)}_{(gen)} + fx^{(5)}_{(tot)}, \qquad (3.55)$$

$c \in \mathrm{COM}.$ a

and,

$$fx^{(5)}_{(tot)} = x^{(3)}_{(tot)} + fx^{(5)}_{(tot2)}, \qquad (3.56)$$

where,

- $x^{(5)}_{(c,s)}$ is the percentage-change in source-specific government demand for commodity (c);
- $\mathrm{SDOM}_{(s)}$ is a coefficient valued 1 if s = "dom" and 0 if s = "imp";
- $f^{(5)}_{(c)}$ is a commodity-specific shifter of government demand;
- $f^{(5)}_{(gen)}$ is a uniform shifter of government demand;
- $fx^{(5)}_{(tot)}$ and $fx^{(5)}_{(tot2)}$ are shifter variables to link government demand to household demand.

Typically, $fx^{(5)}_{(tot)}$ is exogenous and $fx^{(5)}_{(tot2)}$ is endogenous. Swapping the closure status of these variables, i.e., endogenizing $fx^{(5)}_{(tot)}$ while exogenising $fx^{(5)}_{(tot2)}$, results in $x^{(5)}_{(c,s)}$ being tied to movements in $x^{(3)}_{(tot)}$. Implementing these swaps, government consumption will exactly follow household consumption.

3.3.6 Allocation for change in inventory

Changes in inventories are part of final demands. The sign of the value for changes in inventories can be positive (additions to inventories) or negative (withdrawals from inventories). The change in inventory is important in the market clearing assumption implemented in the real-side model. This means that the domestic supply of commodities must be equal to the sum up of domestic demands for commodities. This includes the commodities allocated to or removed from inventories.

To accommodate the values (negative or positive), the change in inventory is written as an ordinary change variable, as follow:

$$100 \cdot \Delta X^{(6)}_{(c,s)} = V6BAS_{(c,s)} \cdot xdom^{(0)}_{(c)} + fx^{(6)}_{(c,s)}, \tag{3.57}$$

$c \in COM.$

where,

- $\Delta X^{(6)}_{(c,s)}$ is ordinary change in inventory of commodity (c);
- $X6BAS_{(c,s)}$ is the level term of change in inventory of commodity (c);
- $xdom^{(0)}_{(c)}$ is percentage-change in total domestic output of commodity (c);
- $fx^{(6)}_{(c,s)}$ is a shifter variable.

3.3.7 Demand for margin commodity

Margins are used to facilitate the domestic flow of commodities within Indonesia. There are six types of margin commodities provided in the real-side model: Sales and Maintenance, Retail, Land transportation, Water transportation, Air transportation, and Other (please see Table 3.1). The demand for margin (m) is specified as a fixed proportion of the demand for source-specific commodity (c) used by user agent (u). The demand equation can be written as follow:

$$X^{(u)}_{(c,s,m)} = X^{(u)}_{(c,s)} \cdot A^{(u)}_{(c,s,m)}, \tag{3.58}$$

$c \in COM$; $s \in SRC$; $m \in MAR$; and $u \in USER$[11]

where,

- $X^{(u)}_{(c,s,m)}$ is demand for margin m to facilitate the flow of source-specific commodity (c) to agent (u);
- $X^{(u)}_{(c,s,m)}$ is the use of source-specific commodity (c) by agent (u);
- $A^{(u)}_{(c,s,m)}$ is a technology variable describing the per unit requirement of margin commodity m to facilitate the purchases of source-specific commodity (c) by agent (u);

[11] USER is the set of agents defined in Table 3.1.

The percentage-change form of Equation (3.58) is given as follows:

$$x^{(u)}_{(c,s,m)} = x^{(u)}_{(c,s)} + a^{(u)}_{(c,s,m)}, \tag{3.59}$$

3.3.8 Indirect taxes

The government can levy taxes or provide subsidies on commodities consumed by agents. When the government levies a tax, the corresponding variables will have positive values. When the government imposes subsidies, the tax variable values will be negative. The tax variable in the real-side model is expressed in a power term (one plus the tax rate) as follows:

$$T = \left(1 + \frac{\mathrm{TAXREV}}{\mathrm{TAXBASE}}\right) = (1 + \mathrm{TAXRATE}), \tag{3.60}$$

where,

- T is the variable of tax expressed in power terms (1 + rate of tax);
- $\mathrm{TAXRATE} = \mathrm{TAXREV}/\mathrm{TAXBASE}$;
- TAXREV is tax revenue; and
- TAXBASE is the transaction value upon which the tax is levied.

The Equation (3.60) can be modified to the following forms:

$$\mathrm{TAXREV} = (T - 1) \cdot \mathrm{TAXBASE}, \tag{3.61}$$

As TAXBASE typically equals the basic value, Equation (3.61) can be redefined by:

$$\mathrm{TAXREV} = (T - 1) \cdot (X \cdot P), \tag{3.62}$$

In percentage-change terms, Equation (3.62) is specified as follow:

$$\begin{aligned} &\mathrm{TAXREV}_{(u)} \cdot \mathrm{wtax}_{(u)} \\ &\qquad = \mathrm{TAX}_{(u)} \cdot \left(x_{(u)} + p_{(u)}\right) + \left(\mathrm{TAX}_{(u)} + \mathrm{BAS}_{(u)}\right) \cdot t_{(u)}, \\ &u \in \mathrm{USER}. \end{aligned} \tag{3.63}$$

where,

- $\mathrm{TAXREV}_{(u)}$ is the total indirect taxes levied on agent (u);
- $\mathrm{wtax}_{(u)}$ is percentage-change in the value of indirect taxes levied on agent (u);
- $\mathrm{TAX}_{(u)}$ is value of indirect taxes levied to agent (u);
- $x_{(u)}$ and $p_{(u)}$ are quantity and price of commodity used by agent (u);

- $\mathrm{BAS}_{(u)}$ is basic value of commodity used by agent (u);
- $\mathrm{t}_{(u)}$ is a power of tax levied to agent (u).

For example, the percentage change in the value of indirect taxes levied on the commodities consumed by households is:

$$
\begin{aligned}
&\mathrm{VTAX}^{(3)} \cdot \mathrm{wtax}^{(3)} \\
&\qquad = \sum_{s \in SRC} \sum_{c \in COM} \Big[\mathrm{VTAX}^{(3)}_{(c,s)} \cdot \left(\mathrm{p0}^{(3)}_{(c,s)} + \mathrm{x}^{(3)}_{(c,s)}\right) \\
&\qquad + \left(\mathrm{VTAX}^{(3)}_{(c,s)} + \mathrm{VBAS}^{(3)}_{(c,s)}\right) \cdot \mathrm{t}^{(3)}_{(c,s)}\Big], \\
&c \in COM \text{ and } s \in SRC.
\end{aligned}
\tag{3.64}
$$

3.3.9 Zero-pure-profit conditions (ZPP)

All markets in the real-side model are assumed to be operating under perfect competition. In this setting, agents do not earn persistent supernormal profit from performing economic activities. More precisely in terms of the CGE implementation, zero pure profits conditions are implemented as value-preservation relationships that ensure that prices reflect all input costs (which potentially might include above normal returns on fixed factors).

In current production activity, zero-pure-profit conditions mean the revenue received is equal to all costs of current production i.e., including basic price, margins, primary factors, and taxes. In import activity, the price received by importers reflects the cost of importing in foreign currency converted by the nominal exchange rates, and added together with the tariff. For the export activity, the foreigners' price for purchasing an export commodity is equal to the price of the commodity in the domestic market converted by nominal exchange rate. Overall, the prices paid by commodity users reflects the basic price plus taxes and margins to deliver the commodity from the suppliers to the users (Dixon and Rimmer, 2002: 152-153).

3.3.9.1 Zero-pure-profit in current production

The zero-pure-profit principle in current production can be started by writing the cost equations by industry as follow:

$$\mathrm{V1TOT}^{(1)}_{(i)} = \sum_{c\in COM}\sum_{s\in SRC}\mathrm{V1PUR}^{(1)}_{(c,s,i)} + \mathrm{V1LAB}^{(1)}_{(i)} + \mathrm{V1CAP}^{(1)}_{(i)} + \mathrm{V1LND}^{(1)}_{(i)} + \mathrm{V1PTX}^{(1)}_{(i)},$$

$c \in \mathrm{COM}$, $i \in \mathrm{IND}$ and $s \in \mathrm{SRC}$.

(3.65)

where,

- $\mathrm{V1TOT}^{(1)}_{(i)}$ is the total cost of current production for industry (i);
- $\sum_{c\in COM}\sum_{s\in SRC}\mathrm{V1PUR}^{(1)}_{(c,s,i)}$ is the value of commodities including margin and taxes in industry (i);
- $\mathrm{V1LAB}^{(1)}_{(i)}$, $\mathrm{V1CAP}^{(1)}_{(i)}$, and $\mathrm{V1LND}^{(1)}_{(i)}$ are the values of primary factor payments (to labour, capital, and land respectively) used in industry (i); and
- $\mathrm{V1PTX}^{(1)}_{(i)}$ is the value of production taxes levied on industry (i);

Replacing value term by price and quantity, Equation (3.65) can be rewritten to be:

$$\mathrm{P}^{(0)}_{(i,dom)} \cdot \mathrm{Z}_{(i)} = \sum_{c\in COM}\sum_{s\in SRC}\mathrm{P}^{(1)}_{(c,s,i)} \cdot \mathrm{X}^{(1)}_{(c,s,i)} + \mathrm{P1LAB}^{(1)}_{(i)} \cdot \mathrm{X1LAB}^{(1)}_{(i)} + \mathrm{P1CAP}^{(1)}_{(i)} \cdot \mathrm{X1CAP}^{(1)}_{(i)} + \mathrm{P1LND}^{(1)}_{(i)} \cdot \mathrm{X1LND}^{(1)}_{(i)} + \mathrm{P}^{(0)}_{(i,dom)} \cdot \mathrm{Z}_{(i)}\left(\mathrm{T}^{(1)}_{(i)} - 1\right),$$

$c \in \mathrm{COM}$, $i \in \mathrm{IND}$ and $s \in \mathrm{SRC}$,

(3.66)

where,

- $\mathrm{P}^{(0)}_{(i,dom)}$ and $\mathrm{Z}_{(i)}$ are the price and activity level of domestically-produced commodities in industry (i);
- $\mathrm{P}^{(1)}_{(c,s,i)}$ and $\mathrm{X}^{(1)}_{(c,s,i)}$ are price and quantity of source-specific commodity (c) used by industry (i);
- $\mathrm{P1LAB}^{(1)}_{(i)}$ and $\mathrm{X1LAB}^{(1)}_{(i)}$ are price and quantity of labour used by industry (i);
- $\mathrm{P1CAP}^{(1)}_{(i)}$ and $\mathrm{X1CAP}^{(1)}_{(i)}$ are price and quantity of capital used by industry (i);
- $\mathrm{P1LNDP}^{(1)}_{(i)}$ and $\mathrm{X1LND}^{(1)}_{(i)}$ are price and quantity of land used by industry (i);
- $\mathrm{T}^{(1)}_{(i)}$ is power of production tax levied by government to industry (i);

Transforming Equation (3.66) to percentage-change and substituting in the demand equations for current production yields:

$$\left[\mathrm{V1TOT}^{(1)}_{(i)} - \mathrm{V1PTX}^{(1)}_{(i)}\right] \cdot \left(\mathrm{p}^{(0)}_{(i)} - \mathrm{a}_{(i)}\right) = \sum_{c \in COM} \sum_{s \in SRC} \mathrm{V1PUR}^{(1)}_{(c,s,i)} \cdot \mathrm{p}^{(1)}_{(c,s,i)} + \mathrm{V1LAB}^{(1)}_{(i)} \cdot \mathrm{p1lab}^{(1)}_{(i)} + \mathrm{V1CAP}^{(1)}_{(i)} \cdot \mathrm{p1cap}^{(1)}_{(i)} + \mathrm{V1LND}^{(1)}_{(i)} \cdot \mathrm{p1lnd}^{(1)}_{(i)} + \left[\mathrm{V1PTX}^{(1)}_{(i)} + \mathrm{V1TOT}^{(1)}_{(i)}\right] \cdot \mathrm{t0}^{(1)}_{(i)},$$

$c \in COM$, $i \in IND$ and $s \in SRC$.

(3.67)

Meanwhile, the technology variable in industry (i) $\left(\mathrm{a}_{(i)}\right)$, as presented in Equation (3.67), is specified in the following equation:

$$\left[\mathrm{V1TOT}^{(1)}_{(i)} - \mathrm{V1PTX}^{(1)}_{(i)}\right] \cdot \mathrm{a}_{(i)} = \sum_{c \in COM} \mathrm{MAKE}_{(c,i)} \cdot \mathrm{a0}_{(c,i)} + \sum_{s \in SRC} \mathrm{V1PUR\_S}^{(1)}_{(c,i)} \cdot \mathrm{a\_s}^{(1)}_{(c,i)} + \sum_{c \in COM} \sum_{s \in SRC} \mathrm{V1PUR}^{(1)}_{(c,s,i)} \cdot \mathrm{a}^{(1)}_{(c,s,i)} + \mathrm{V1LAB}^{(1)}_{(i)} \cdot \mathrm{a1lab}^{(1)}_{(i)} + \mathrm{V1CAP}^{(1)}_{(i)} \cdot \mathrm{a1cap}^{(1)}_{(i)} + \mathrm{V1LND}^{(1)}_{(i)} \cdot \mathrm{a1lnd}^{(1)}_{(i)} + \mathrm{V1PRIM}^{(1)}_{(i)} \cdot \mathrm{a1prim}^{(1)}_{(i)},$$

$c \in COM$, $i \in IND$ and $s \in SRC$,

(3.68)

Equations (3.67) and (3.68) explain the price of the output produced by industry (i) as the weighted average of the combination of price of inputs i.e., intermediate at purchaser price and primary input price, taxes, and technology.

3.3.9.2 Zero-pure-profit in capital creation

In similar principle to Equation (3.67), the ZPP equation in capital creation can be given as follow:

$$\mathrm{V2TOT}^{(2)}_{(i)} \cdot \mathrm{p2tot}^{(2)}_{(i)} = \sum_{c \in COM} \sum_{s \in SRC} \mathrm{V2PUR}^{(2)}_{(c,s,i)} \cdot \left[\mathrm{p2\_s}^{(2)}_{(c,i)} + \mathrm{a2\_s}^{(2)}_{(c,i)} + \mathrm{a2}^{(2)}_{(c,s,i)}\right],$$

$c \in COM$, $i \in IND$ and $s \in SRC$,

(3.69)

where,

- $\mathrm{V2TOT}_{(i)}^{(2)}$ is the total cost of capital creation in industry (i);
- $\mathrm{p2tot}_{(i)}^{(2)}$ is the percentage-change in the cost of a unit of capital in industry (i);
- $\sum_{c \in COM} \sum_{s \in SRC} \mathrm{V2PUR}_{(c,s,i)}^{(2)}$ is the purchasers' value of commodity input for capital creation in industry (i);
- $\mathrm{p2\_s}_{(c,i)}^{(2)}$ is the price of the source-composite input for capital creation of commodity (c) used by industry (i); and
- $\mathrm{a2\_s}_{(c,i)}^{(2)}$ and $\mathrm{a2}_{(c,s,i)}^{(2)}$ are source-composite and source-specific technical change terms in capital creation using commodity (c) in industry (i).

Equation (3.69) implies that the total cost for capital creation is the weighted average cost of commodity inputs and corresponding technical change terms.

3.3.9.3 Zero-pure-profit in importing

The purchasers' price paid by importers is the cost of importing in foreign currency converted by the nominal exchange rate to domestic currency terms, and added tariff. The price reflects the basic price of the commodity imported, excluding margins and taxes. Algebraically, this assumption can be expressed as follow:

$$\mathrm{P0IMP}_{(c)} = \frac{\mathrm{PF}_{(c)}^{(\mathrm{CIF})}}{\phi} \cdot \mathrm{T0IMP}, \tag{3.70}$$

where,

- $\mathrm{P0IMP}_{(c)}$ is the basic price of imported commodity (c) valued in the domestic market;
- $\mathrm{PF}_{(c)}^{(\mathrm{CIF})}$ is the CIF price of imported commodity (c) valued in the foreign market;
- Φ is the nominal exchange rate expressed as foreign currency units per Indonesian Rp; and
- T0IMP is the power of the tariff (i.e. one plus the tariff rate).

In percentage-change terms, Equation (3.70) can be written as:

$$\mathrm{p0}_{(c)}^{(\mathrm{imp})} = \mathrm{pf0cif}_{(c)} - \mathrm{phi} + \mathrm{t0imp}, \tag{3.71}$$

3.3.9.4 Zero-pure-profit in the supply of commodities

The purchasers' price is the price paid by the users that includes the basic price of commodities, taxes, and margins. This assumption applies for all types of users. The equation describing this assumption is as follow:

$$\mathrm{VPUR}_{(c,s)}^{(u)} = \mathrm{VBAS}_{(c,s)}^{(u)} + \mathrm{VTAX}_{(c,s)}^{(u)} + \mathrm{VMAR}_{(c,s)}^{(u)}, \qquad (3.72)$$

$c \in \mathrm{COM}$ and $s \in \mathrm{SRC}$,

where,

- $\mathrm{VPUR}_{(c,s)}^{(u)}$ is the purchasers' price of source-specific commodity (c) used by user (u);
- $\mathrm{VBAS}_{(c,s)}^{(u)}$ is the basic value of source-specific commodity (c) used by user (u);
- $\mathrm{VTAX}_{(c,s)}^{(u)}$ is the value of taxes levied on source-specific commodity (c) used by user (u); and
- $\mathrm{VMAR}_{(c,s)}^{(u)}$ is the value of margins on use of source-specific commodity (c) used by user (u);

where,

- $\mathrm{VPUR}_{(c,s)}^{(u)} = \mathrm{P}_{(c,s)}^{(u)} \cdot \mathrm{X}_{(c,s)}^{(u)}$;
- $\mathrm{VBAS}_{(c,s)}^{(u)} + \mathrm{VTAX}_{(c,s)}^{(u)} = \mathrm{P}_{(c,s)}^{(0)} \cdot \mathrm{X}_{(c,s)}^{(u)} \cdot \mathrm{POWTAX}_{(c,s)}^{(u)}$; and (3.73)
- $\mathrm{VMAR}_{(c,s)}^{(u)} = \sum_{m \in \mathrm{MAR}} \mathrm{P}_{(c,dom)}^{(0)} \cdot \mathrm{A}_{(c,s,m)}^{(u)} \cdot \mathrm{X}_{(c,s,m)}^{(u)}$.

Hence,

$$\begin{aligned} \mathrm{VPUR}_{(c,s)}^{(u)} \cdot \mathrm{p}_{(c,s)}^{(u)} & \\ &= \left[\mathrm{VBAS}_{(c,s)}^{(u)} + \mathrm{VTAX}_{(c,s)}^{(u)}\right] \cdot \left(\mathrm{p}_{(c,s)}^{(0)} + \mathrm{t}_{(c,s)}^{(u)}\right) \\ &+ \sum_{m \in \mathrm{MAR}} \mathrm{VMAR}_{(c,s,m)}^{(u)} \cdot \left(\mathrm{p0}_{(m,dom)}^{(0)} + \mathrm{amar}_{(c,s,m)}^{(u)}\right), \end{aligned} \qquad (3.74)$$

$c \in \mathrm{COM}$, $s \in \mathrm{SRC}$, and $m \in \mathrm{MAR}$,

where,

- $p_{(c,s)}^{(u)}$ is the percentage-change in the purchasers' price of commodity (c) sourced from (s) used by user (u);
- $p_{(c,s)}^{(0)}$ is the percentage-change in the basic price of commodity (c) sourced from (s) used by user (u);
- $t_{(c,s)}^{(u)}$ is the percentage-change in the power of taxes levied on commodity (c) sourced from s used by user (u);
- $p0_{(m,dom)}^{(0)}$ is the percentage-change in the basic price of margin commodity (m) used by user (u); and,
- $amar_{(c,s,m)}^{(u)}$ is the percentage-change in the technical change term governing use of margin (m) for facilitating flows of commodity (c) sourced from (s) and used by user (u).

3.3.10 Market clearing conditions

Market clearing conditions ensure that supply and demand are equal for all source specific commodity markets. The market clearing for commodities can be distinguished for those categorised as non-margin commodities and margin commodities. For non-margin commodities, the equalisation of supply and demand is as follow:

$$X_{(c,s)}^{(0)} = \sum_{i \in IND} X_{(c,s,i)}^{(1)} + \sum_{i \in IND} X_{(c,s,i)}^{(2)} + X_{(c,s)}^{(3)} + X_{(c,"dom")}^{(4)} + X_{(c,s)}^{(5)} + X_{(c,s)}^{(6)}, \tag{3.75}$$

$c \in COM$, $i \in IND$ and $s \in SRC$,

where,

- $X_{(c,s)}^{(0)}$ is the supply of non-margin commodity (c) sourced from (s); and
- $X_{(c,s)}^{(u)}$ is the demand for non-margin commodity (c) sourced from (s) used by user (u);

There is no import demand for commodities used for export, as the real-side model assumes there is no re-export activities.

In percentage change terms, Equation (3.75) is written as follows:

$$X_{(c,s)}^{(0)} \cdot x0_{(c,s)}^{(0)} = \sum_{i \in IND} X_{(c,s,i)}^{(1)} \cdot x_{(c,s,i)}^{(1)} + \sum_{i \in IND} X_{(c,s,i)}^{(2)} \cdot x_{(c,s,i)}^{(2)} + X_{(c,s)}^{(3)} \cdot x_{(c,s)}^{(3)} + X_{(c,dom)}^{(4)} \cdot x_{(c,dom)}^{(2)} + X_{(c,s)}^{(5)} \cdot x_{(c,s)}^{(5)} + X_{(c,s)}^{(6)} \cdot x_{(c,s)}^{(6)}, \tag{3.76}$$

For margin commodities, the market clearing can be distinguished into two categories. First, an agent may consume a margin commodity directly, rather than as a margin (e.g., household purchase of insurance to insure a home). Secondly, an agent uses commodity as a margin which facilitates the flow of non-margin commodity (e.g. household purchase of insurance to insure a parcel). For the market clearing condition to hold, these two types of transactions must be taken into account:

$$\begin{aligned} X_{(m,dom)}^{(0)} = {} & \sum_{i \in IND} X_{(m,dom,i)}^{(1)} + \sum_{i \in IND} X_{(m,dom,i)}^{(2)} + X_{(m,dom)}^{(3)} + X_{(m,dom)}^{(4)} \\ & + X_{(m,dom)}^{(5)} + X_{(m,dom)}^{(6)} + \sum_{c \in COM} \sum_{s \in SRC} \sum_{i \in IND} X_{(c,m,s,i)}^{(1)} \\ & + \sum_{c \in COM} \sum_{s \in SRC} \sum_{i \in IND} X_{(c,m,s,i)}^{(2)} + \sum_{s \in SRC} \sum_{i \in IND} X_{(c,m,s)}^{(3)} \\ & + \sum_{c \in COM} X_{(c,m,dom)}^{(4)} + \sum_{s \in SRC} \sum_{i \in IND} X_{(c,m,s)}^{(5)}, \end{aligned} \tag{3.77}$$

$c \in COM$, $i \in IND$, $m \in MAR$, and $s \in SRC$,

where,

- $X_{(m,dom)}^{(0)}$ is the supply of the margin commodity in the domestic market; and
- $X_{(m,dom)}^{(u)}$ is the demand for margin commodity (m) used by user (u).

3.3.11 Government accounts

In the real-side model, the government agent is assumed to play a significant role in the economy. The government can raise revenue by levying direct and indirect taxes, perform transfer payments, create investment, run deficits, and accumulate public sector debt. These activities are recorded in several government accounts.

3.3.11.1 Government investment

Government investment is a subset of aggregate investment. Hence, the percentage-change in government investment is a share function of aggregate investment, as follows:

$$\text{AGGINVG} \cdot \text{agginv\_g} = \sum_{i \in \text{IND}} \left[\text{G\_INVEST}_{(i)} \cdot \left(p^{(2)}_{\text{tot}} + x^{(2)}_{\text{tot}}\right)\right], \quad (3.78)$$

$i \in \text{IND}$

where,

- AGGINVG and $\text{G\_INVEST}_{(i)}$ are aggregate government investment and industry-specific government investment respectively;
- agginv_g is the percentage-change in the value of government investment; and
- $p^{(2)}_{\text{tot}}$ and $x^{(2)}_{\text{tot}}$ are the price and quantity of aggregate investment respectively.

3.3.11.2 Transfer payments

The government can transfer money for households' benefit and net interest payments. The net interest is paid on the public debt accumulated by the government. In levels form, this is specified as follows:

$$\text{TRANS} = \text{BENEFITS} + \text{NETINT\_G}, \quad (3.79)$$

In percentage change form, Equation (3.79) can be written as:

$$\text{TRANS} \cdot \text{transfers} = \text{BENEFITS} \cdot \text{bens} + 100 \cdot \text{d\_net\_int\_g}, \quad (3.80)$$

where,

- TRANS and BENEFITS are the value of transfer payments and benefits;
- transfers and bens are the percentage-changes in transfer and benefit payments respectively; and
- d_net_int_g is the ordinary change in the net interest payments.

The percentage-change in benefits is linked to the percentage-change in population, inflation, and the real-wage:

$$\text{bens} = \text{pop} + \text{p3tot} + \text{real\_wage\_c}, \quad (3.81)$$

The value of net interest payments are computed by the following equation:

$$\text{d\_net\_int\_g} = \text{PSDATT} \cdot \text{d\_int\_psd} + \text{INT\_PSD} \cdot \text{d\_psd\_t}, \quad (3.82)$$

where,

- d_int_psd and d_psd_t are the ordinary change in nominal interest rate and domestic public debt respectively.

- PSDATT is level term for the stock of public debt; and
- $\mathrm{INT\_PSD}$ is level term for government interest payment.

3.3.11.3 Government deficit and public debt accumulation

The government deficit is defined by the difference between government expenditures and revenues. Public sector debt accumulation is modelled as follows:

$$\mathrm{PSDATT}_{(t+1)} = \mathrm{PSDATT}_{(t)} + \mathrm{GOV\_DEF}, \tag{3.83}$$

where,

- $\mathrm{PSDATT}_{(t)}$ and $\mathrm{PSDATT}_{(t+1)}$ are the stock of domestic public debt at the start-of-year and end-of-year respectively; and
- $\mathrm{GOV\_DEF}$ is the government deficit in current year.

Equation (3.83) explains the domestic debt public dynamics. If the government runs a deficit during the year, this raises the amount of public debt at the end of the year. When the government runs a surplus, the domestic public debt will fall.

3.3.12 Current account deficit and foreign debt accumulation

The current account deficit (CAD) is calculated by adding the trade deficit (the value of imports minus exports) with the interest payments on foreign debt. The CAD equation can be expressed as follow:

$$\mathrm{CADEF} = \mathrm{V0CIF\_C} - \mathrm{V4TOT} + \mathrm{INTFD}, \tag{3.84}$$

where,

- CADEF is the value of the current account deficit;
- $\mathrm{V0CIF\_C}$ is the value of total imports;
- $\mathrm{V4TOT}$ is the value of total exports; and
- INTFD is the interest payment on foreign debt valued in domestic currency (Rp).

The value for CADEF each year is used to update the value of the stock of net foreign debt at the end of each year.

In mixed percentage and ordinary-change terms, Equation (3.84) can be expressed as follow:

$$100 \cdot \mathrm{d\_CAD} = \mathrm{V0CIF\_C} \cdot \mathrm{w0cif\_c} - \mathrm{V4TOT} \cdot \mathrm{w4tot} + 100 \cdot \mathrm{d\_int\_fd}, \tag{3.85}$$

where,

- $\mathrm{d\_CAD}$ is the ordinary-change in the current account deficit;
- $\mathrm{w0cif\_c}$ is the percentage-change in the value of CIF imports;
- $\mathrm{w4tot}$ is the percentage-change in the total value of exports; and
- $\mathrm{d\_int\_fd}$ is the ordinary-change in net interest payment on foreign debt.

The net interest payment on foreign debt is determined in the following equation:

$$\mathrm{d\_int\_fd} = \mathrm{ROIFOREIGN} \cdot \mathrm{d\_fd\_t}, \tag{3.86}$$

where,

- $\mathrm{ROIFOREIGN}$ is the power of the rate of interest on foreign debt; and
- $\mathrm{d\_fd\_t}$ is the ordinary-change the stock of net foreign debt.

A current account deficit (surplus) will increase (reduce) the stock of debt at the end-of the year. The foreign debt dynamics equation is given as follow:

$$\mathrm{FDATT}_{(t+1)} = \mathrm{FDATT}_{(t)} + \mathrm{CADEF}, \tag{3.87}$$

where,

- $\mathrm{FDATT}_{(t)}$ and $\mathrm{FDATT}_{(t+1)}$ are the stock of foreign debt at the start-of-year and end-of-year respectively.

3.3.13 Gross Domestic Product (GDP)

The real-side model specifies GDP derived from both the expenditure approach and the income approach. The expenditure approach accounts for the consumption of domestically-produced commodities by final demanders. The income approach to calculating GDP accounts for all payments received by factors and indirect taxes.

3.3.13.1 Expenditure-side GDP calculation

The expenditure-side calculation of GDP is specified in the following identity equation:

$$\mathrm{GDPEXP} = \mathrm{C} + \mathrm{I} + \mathrm{G} + \mathrm{EXP} - \mathrm{IMP} + \mathrm{INV}, \tag{3.88}$$

where,

Consumption expenditure:

$$C = V3TOT = \sum_{s \in SRC} \sum_{c \in COM} X^{(3)}_{(c,s)} \cdot P^{(3)}_{(c,s)}, \tag{3.89}$$

Investment expenditure:

$$I = V2TOT\_I = \sum_{i \in IND} \sum_{s \in SRC} \sum_{c \in COM} X^{(2)}_{(c,s,i)} \cdot P^{(2)}_{(c,s,i)}, \tag{3.90}$$

Government expenditure:

$$G = V5TOT = \sum_{s \in SRC} \sum_{c \in COM} X^{(5)}_{(c,s)} \cdot P^{(5)}_{(c,s)}, \tag{3.91}$$

Export value:

$$EXP = V4TOT = \sum_{c \in COM} X^{(4)}_{(c)} \cdot P^{(4)}_{(c)}, \tag{3.92}$$

Import expenditure:

$$IMP = V0CIF = \sum_{c \in COM} X^{(imp)}_{(c)} \cdot P^{(imp)}_{(c)}, \tag{3.93}$$

Change in inventory

$$INV = V6TOT = \sum_{s \in SRC} \sum_{c \in COM} X^{(6)}_{(c,s)} \cdot P^{(6)}_{(c,s)}, \tag{3.94}$$

In percentage-change terms, aggregate expenditure is specified as the weighted average of source-specific quantity and price of commodity consumed by corresponding user agents. The equations are given as follow:

Quantity and price of consumption expenditure:

$$xtot^{(3)} = \sum_{s \in SRC} \sum_{c \in COM} S^{(3)}_{(c,s)} \cdot x^{(3)}_{(c,s)}, \tag{3.95}$$

$$ptot^{(3)} = \sum_{s \in SRC} \sum_{c \in COM} S^{(3)}_{(c,s)} \cdot p^{(3)}_{(c,s)}, \tag{3.96}$$

Quantity and price of investment expenditure:

$$xtot^{(2)} = \sum_{i \in IND} \sum_{s \in SRC} \sum_{c \in COM} S^{(2)}_{(c,s,i)} \cdot x^{(2)}_{(c,s,i)}, \tag{3.97}$$

$$\mathrm{ptot}^{(2)} = \sum_{i \in IND} \sum_{s \in SRC} \sum_{c \in COM} S^{(2)}_{(c,s,i)} \cdot p^{(2)}_{(c,s,i)}, \tag{3.98}$$

Quantity and price of government expenditure:

$$\mathrm{xtot}^{(5)} = \sum_{s \in SRC} \sum_{c \in COM} S^{(5)}_{(c,s)} \cdot x^{(5)}_{(c,s)}, \tag{3.99}$$

$$\mathrm{ptot}^{(5)} = \sum_{s \in SRC} \sum_{c \in COM} S^{(5)}_{(c,s)} \cdot p^{(5)}_{(c,s)}, \tag{3.100}$$

Quantity and price of exports:

$$\mathrm{xtot}^{(4)} = \sum_{c \in COM} S^{(4)}_{(c)} \cdot x^{(4)}_{(c)}, \tag{3.101}$$

$$\mathrm{ptot}^{(4)} = \sum_{c \in COM} S^{(4)}_{(c)} \cdot p^{(4)}_{(c)}, \tag{3.102}$$

Quantity and price of imports:

$$\mathrm{xtot}^{(cif)} = \sum_{c \in COM} S^{(cif)}_{(c)} \cdot x^{(cif)}_{(c)}, \tag{3.103}$$

$$\mathrm{ptot}^{(cif)} = \sum_{c \in COM} S^{(cif)}_{(c)} \cdot p^{(cif)}_{(c)}, \tag{3.104}$$

Quantity and price of change in inventories:

$$\mathrm{V6TOT} \cdot \mathrm{xtot}^{(6)} = 100 \cdot \sum_{s \in SRC} \sum_{c \in COM} \Delta x^{(6)}_{(c,s)}, \tag{3.105}$$

$$\mathrm{V6TOT} \cdot \mathrm{ptot}^{(6)} = \sum_{c \in COM} \mathrm{POLEV}_{(c,s)} \cdot p^{(6)}_{(c)}, \tag{3.106}$$

where,

- V6TOT is levels value of change in inventory.
- $\mathrm{POLEV}_{(c,s)}$ is producer price of commodity (c) sourced from (s).

Transforming Equation (3.95) to (3.106) into GDP identity in Equation (3.88) yields the percentage-change in real and price deflator as follows:

$$\begin{aligned} x^{(0)}_{(gdpexp)} &= S^{(3)} \cdot \mathrm{xtot}^{(3)} + S^{(2)} \cdot \mathrm{xtot}^{(2)} + S^{(5)} \cdot \mathrm{xtot}^{(5)} \\ &\quad + S^{(4)} \cdot \mathrm{xtot}^{(4)} - S^{(cif)} \cdot \mathrm{xtot}^{(cif)} + S^{(6)} \cdot \mathrm{xtot}^{(6)}, \end{aligned} \tag{3.107}$$

$$p_{(gdpexp)} = S^{(3)} \cdot ptot^{(3)} + S^{(2)} \cdot ptot^{(2)} + S^{(5)} \cdot ptot^{(5)} + S^{(4)} \cdot ptot^{(4)} - S^{(cif)} \cdot ptot^{(cif)} + S^{(6)} \cdot ptot^{(6)}, \tag{3.108}$$

where,

$S^{(u)} = V^{(u)}_{(tot)}/\text{GDP for } u \in \text{USERS}.$

3.3.13.2 Income-side GDP Calculation

The equation for income-side GDP at market prices is given as follow:

$$GDPINC = V1LAB\_I + V1CAP\_I + V1LND\_I + V0TAX, \tag{3.109}$$

The percentage-change equations in the corresponding RHS elements are as follow:

Percentage-change in wage-bill of labour and price of labour are:

$$xlab^{(1)} = \sum_{i \in IND} S^{(1)}_{(lab,i)} \cdot x^{(1)}_{(lab,i)}, \tag{3.110}$$

$$plab^{(1)} = \sum_{i \in IND} S^{(1)}_{(lab,i)} \cdot p^{(1)}_{(lab,i)}, \tag{3.111}$$

Percentage-change in capital stock and rental of capital are:

$$xcap^{(1)} = \sum_{i \in IND} S^{(1)}_{(cap,i)} \cdot x^{(1)}_{(cap,i)}, \tag{3.112}$$

$$pcap^{(1)} = \sum_{i \in IND} S^{(1)}_{(cap,i)} \cdot p^{(1)}_{(cap,i)}, \tag{3.113}$$

Percentage-change in land and rental of land are:

$$xlnd^{(1)} = \sum_{i \in IND} S^{(1)}_{(lnd,i)} \cdot x^{(1)}_{(lnd,i)}, \tag{3.114}$$

$$plnd^{(1)} = \sum_{i \in IND} S^{(1)}_{(lnd,i)} \cdot p^{(1)}_{(lnd,i)}, \tag{3.115}$$

where,

- $S^{(1)}_{(lab,i)} = V1LAB_{(i)}/V1LAB\_I;$
- $S^{(1)}_{(cap,i)} = V1CAP_{(i)}/V1CAP\_I;$ and
- $S^{(1)}_{(lnd,i)} = V1LND_{(i)}/V1LND\_I.$

Hence, the percentage-change of Equation (3.109) can be expressed by:

$$
\begin{aligned}
x^{(0)}_{(gdpexp)} = {} & S^{(1)}_{(lab)} \cdot xlab^{(1)} + S^{(1)}_{(cap)} \cdot xcap^{(1)} + S^{(1)}_{(lnd)} \cdot xlnd^{(1)} \\
& + \sum_{u \in USER} S^{(1)}_{(salesTax,u)} \cdot x^{(1)}_{(u)} \\
& + + \sum_{u \in USER} S^{(1)}_{(PrdTax,u)} \cdot z_{(i)},
\end{aligned}
\tag{3.116}
$$

3.3.14 Gross National Product and Consumption Function

3.3.14.1 Gross National Product (GNP)

Nominal GNP is the output of a jurisdiction produced by domestic factors. Hence, the value of GNP is total gross output (GDP) less the net income claims of foreigners. When the domestic economy accumulates foreign debts, the income of foreigners is represented by the interest payment of the respective foreign debts.

The equation of nominal GNP is:

$$GNP = GDP - INTFD, \tag{3.117}$$

where,

- GNP is nominal gross national product; and
- INTFD is nominal interest payment on foreign debt in domestic currency (in Rp).

In percentage and ordinary-change terms, Equation (3.117) can be expressed by:

$$GNP \cdot gnp = GDP \cdot wgdp - 100 \cdot d\_int\_fd, \tag{3.118}$$

3.3.14.2 Aggregate consumption function

The aggregate consumption function in the real-side model relates the aggregate consumption with disposable income. Hence, to construct the aggregate consumption function of households, firstly I must account for household disposable income as follows:

$$HINC = V1LAB\_I + V1CAP\_I + V1LND\_I + BENEFITS - LAB\_TAX, \tag{3.119}$$

Secondly, I have to define the average propensity to consume as follow:

$$APC = \frac{V^{(3)}_{(tot)}}{HINC}. \tag{3.120}$$

In percentage-change terms, the aggregate consumption function is given by:

$$V_{(tot)}^{(3)} \cdot w_{(tot)}^{(3)} = APC \cdot HINC \cdot (apc + hdy), \tag{3.121}$$

where,

- $w_{(tot)}^{(3)}$ is nominal aggregate household consumptions $\left(w_{(tot)}^{(3)} = x_{(tot)}^{(3)} + p_{(tot)}^{(3)}\right)$; and
- apc and hdy are the percentage changes in the average propensity to consume and household disposable income respectively.

3.3.15 Linkages to the financial-side of the model

As mentioned in the beginning of this chapter, the real-side model does not consider the development in financial markets. In the next chapter I explain the underlying theory of the financial-side of the model. This side is linked to the real side model via the following channels:

(1) The government deficit, which is defined in the real-side model, determines net liability issuance by the government agent in the financial-side of the model.
(2) Gross fixed capital formation (investment) in the real-side model determines net liability issuance by the industry and housing agents (the capital creator agents) in the financial-side of the model.
(3) Household savings in the real-side model determines net asset acquisition by the financial agent called households in the financial-side of the model.
(4) Current account deficit in the real-side model determines external borrowing needs which must be financed by net domestic asset acquisitions by foreigners in the financial-side of the model.

Once these four channels are activated, endogenous variables in the real-side model are constrained by the financial-side of the model, and vice versa. The financial-side will be discussed further in Chapter 4.

3.4 Conclusions

This chapter discusses the theoretical framework of the real-side CGE components of the AMELIA-F model. This comprises the model overview, major elements of the model, model assumptions, important macroeconomic accounts (e.g., governments, national, and current accounts), and technical notes on the derivation of equations and computation.

The real-side model of AMELIA-F constitutes a real dynamic CGE model. The theoretical frameworks closely follow the MONASH model by Dixon and Rimmer (2002). As a neoclassical model, the real-side model assumes that the agents behave as optimisers of their objective functions, subject to specific constraints. Zero pure profit conditions apply for production, imports, exports, and distribution activities. Markets clear such that, together with the zero pure profit conditions, the prices and outputs of commodities and factors are determined by the equalisation of supply and demand.

There are three essential elements that describe the dynamic mechanisms in the real-side model, namely: capital stock accumulation, net foreign debt accumulation, and sticky-wage adjustments. Capital stock and net debt accumulation accumulations in the real-side model follow standard stock/flow accumulation equations. For example, in the case of capital, end-of-year capital stock accumulation is determined by after depreciation capital stock at the start-of-year, plus new (flow) investments. Under the sticky-wage assumption, employment is not totally unchanged in the short-run, but can respond to labour market conditions. However, real wage adjustment over time forces employment to move toward full-employment over the long-run.

The behaviour of each agent is derived under agent-specific optimisation processes. The model uses multi-levels or nesting systems in describing the input choices underlying the optimisation process. Optimisation in one nest is connected by optimisation in other nests. The industries have four different types of nests, namely: primary factors, intermediate inputs, activity level (production capacity), and supply of commodities. In primary factor and intermediate input nests, the industries minimise costs subject to CES production functions. The activity level is determined by Leontief production function, as no intermediate inputs and primary factors are allowed to substitute between each other. Supply of commodities is determined by maximising revenue subject to the CET transformation function. The investor agents choose inputs to minimise the costs of assembling new units of physical capital. The CES optimisation is used to determine source-specific commodity inputs. The Leontief fixed proportion function governs the transformation of source-composite composite inputs into new units of physical capital. Households maximise utility function subject to a budget constraint by choosing a combination of commodities to be consumed. CES optimisation is used for source-specific consumption commodities, while a Klein-Rubin utility function optimisation is used for the source-composite consumption commodities (L. R. Klein & Rubin, 1947). Export demand is determined by the negative function of commodity price and nominal appreciation of the exchange rate. Government demand is naturally exogenous but can follow household consumption via appropriate closure swaps.

AMELIA-F is a CGE model with financial market detail (Financial CGE). There are four channels in the real-side model that are connected with the financial markets. First, government deficits are financed by net liability issuance by the government agent. Second, investment is financed by net liability issuance by the industry and housing agents. Third, household savings are linked to household asset acquisition. Four, current account deficits are financed by net domestic asset acquisition by foreigners. The details of the financial-side of the model are discussed further in Chapter 4.

CHAPTER 4
Financial-Side of AMELIA-F[12]

4.1 Introduction

As mentioned in previous chapters, this thesis uses a financial computable general equilibrium (FCGE) model, called AMELIA-F, to elucidate the economy-wide impacts of financial reforms in Indonesia. AMELIA-F is composed of two major parts: (i) as outlined in Chapter 3, a traditional real-side CGE model of the national economy of Indonesia; and (ii) the financial-side of the model. The real-side of the model contains equations that outline how traditional economic agents, like households, industries, investors and the public sector, adjust their consumption bundles, set their production structures, and respond to changes in expected rates of return on investment. The theory of the real-side model closely follows Dixon & Rimmer (2002). Despite the efficacy of CGE models as tools in policy analysis, key linkages between the real and financial economies are often treated implicitly; for example, the current account deficit is assumed to be financed in full by a foreign agent, e.g., via a small country assumption. In an explicit sense I may ask how the foreign investor chooses to finance a deficit, e.g., do they prefer to purchase domestic agent bonds, equity or a combination of the two instruments? What are the associated implications for relative rates-of-return across the suite of domestic financial instruments, and how do changes in relative returns affect domestic agent investment decisions, nominal exchange rates, and the real economy. These limitations preclude the study of important policy questions related to the financial sector. In this chapter, I describe the theory underpinning the financial-side of AMELIA-F that addresses these shortcomings.

Broadly, the financial theory is comprised of two parts: (i) a set of financial asset and liability agents that are assumed to be constrained optimisers; and, (ii) linkages

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[12] Several parts of this chapter was presented at the 24th Annual Conference on Global Economic Analysis in 2021 (https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=6251) and published at Applied Economics in March 2022 (see https://doi.org/10.1080/00036846.2022.2042478).

between net asset accumulation or liability accrual by these agents, and outputs from the real-side of the model. 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 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 theoretical framework outlined herein follows that explained in Dixon et al. (2015) and Giesecke et al. (2017).

With regard to linkages between the real- and financial-sides, I identify five key linkage channels: (i) the public sector borrowing requirement (PBSR) from the real-side of the model, is financed in the financial-side of the model by net government liability issuance; (ii) real investment from the real-side of the model, is financed in the financial-side of the model by net liability issuance of the industry and housing agents; (iii) the current account deficit is financed by net domestic asset purchases by the foreign investor; (iv) aggregate household savings from the real-side of the model, is linked to the acquisition of financial assets by households in the financial-side of the model, and thus to funding costs for investors and the public sector; and, (v) changes in the weighted average cost of capital (WACC) of the capital creating agents in the financial-side of the model (herein, defined as industry [non-residential capital creator] and housing [residential capital creator]) are linked to changes in required rates of return of investment in the real-side of the model. With these channels active, the real- and financial-sides constrain one another in a general equilibrium framework.

The remining sections of this chapter are arranged in as follows. As a starting point, Section 4.2 defines the financial agents and instruments involved in the financial-side of AMELIA-F. Section 4.3 describes the financial flow and stock matrices underpinning the AMELIA-F financial-side. Section 4.4 presents general optimisation equations for the models' financial agents. Section 4.5 explains the channels through which financial-side is linked to the real-side of AMELIA-F. Section 4.6 and 4.7 describe modifications to the general optimisation theory, in so far as they pertain to modelling constraints on the behaviour of the commercial and central banking agents, respectively. Section 4.8 describes the introduction of nominal rigidities in wage setting via the Phillip's curve (Phillips, 1958). Section 4.9 discusses policy rules of the central bank, following Taylor (1993); and Orphanides (2007). Concluding remarks are presented in Section 4.10.

4.2 Financial Agents and Instruments

The financial-side of AMELIA-F contains interactions between financial agents and financial instruments. Table 4.1 and Table 4.2 define the financial agents and instruments included in the financial-side of AMELIA-F. The listed financial agents and instruments represent the major actors and asset classes traded in Indonesian financial markets. When an agent issues liability financial instruments, it is called a **liability agent (LA)**. When an agent purchases financial assets, it referred to as an **asset agent (AA)**. Typically, financial agents are operating both as liability agents (when handling questions related to the liability side of their balance sheet) and as an asset agent (when handling matters related to the asset side of their balance sheet) at the same time.

No	Agent	Description
1.	Inds	Non-financial industry, excluding housing sector
2.	CB	Central bank
3.	Banks	Commercial banks
4.	NBFI	Non-bank financial institutions, including insurers and pension funds
5.	Govt	Governments
6.	HH	Single representative household financial agent
7.	ROW	Foreigners or Rest of the world
8.	Housing	Single representative housing sector

Table 4.1 Financial Agents (LA or AA)

No.	Instrument	Description
1.	GldSDRs	Gold and IMF Special Drawing Rights (SDRs)
2.	Cash	Cash
3.	DepLoans	Deposits and Loans
4.	Debt	Interest-bearing securities, e.g., bonds, of varying terms of maturity
5.	Equity	Equity

Table 4.2 Financial Instruments (FI)

4.3 Key Matrices

There are four key matrices to be parameterised in the financial-side of AMELIA-F. These matrices capture the flow and stock values of financial instruments across financial agents. They are:

(i) $\mathrm{A0}_{(\mathrm{s,f,d})}$ is the start-of-year financial stocks of financial instrument $(\mathrm{f}) \in \mathrm{FI}$ issued by liability agent $(\mathrm{s}) \in \mathrm{LA}$ and held by asset agent $(\mathrm{d}) \in \mathrm{AA}$. For example, $\mathrm{A0}_{(\mathrm{Inds,DepLoans,Banks})}$ represents the start-of-year value of the stock of loans taken out by industries and provided by commercial banks;

(ii) $\mathrm{FLOW}_{(\mathrm{s,f,d})}$ is the within-year flows of financial instrument $(\mathrm{f}) \in \mathrm{FI}$ issued by liability agent $(\mathrm{s}) \in \mathrm{LA}$ and held by asset agent $(\mathrm{d}) \in \mathrm{AA}$. For example, $\mathrm{F}_{(\mathrm{Inds,DepLoans,Banks})}$ represents within-year flow of new loans taken out by industries and provided by commercial banks;

(iii) $\mathrm{R}_{(\mathrm{s,f,d})}$ is the power (1 *plus* the rate) of the rate of return on financial instrument $(\mathrm{f}) \in \mathrm{FI}$ issued by liability agent $(\mathrm{s}) \in \mathrm{LA}$ and held by asset agent $(\mathrm{d}) \in \mathrm{AA}$. For example, $\mathrm{R}_{(\mathrm{Inds,DepLoans,Banks})} = 1.10$ would mean that the commercial banks charge 10 per cent on the loans they provide to industries;

(iv) $\mathrm{V}_{(\mathrm{s,f,d})}$ is a valuation term allowing end-of-year changes in values of financial instrument $(\mathrm{f}) \in \mathrm{FI}$ issued by liability agent $(\mathrm{s}) \in \mathrm{LA}$ and held by asset agent $(\mathrm{d}) \in \mathrm{AA}$.

4.4 Theoretical Framework

In modelling financial agent behaviour, I differentiate the behaviour between domestic and foreign agents. This is mainly because of the role of the nominal exchange rate in the valuation of the assets/liabilities from the foreign agent's perspective.

4.4.1 Optimal Behaviour of Domestic Asset Agent (AALF)

The set containing domestic asset agents is defined as all asset agents except foreigners (AALF = AA – ROW). This set includes Inds, CB, Banks, NBFI, Govt, HH, and Housing (please see Table 4.1). The optimisation problem for these agents is to choose a combination of assets that maximise a constant elasticity of substitution (CES) function of asset-weighted rates of return, subject to the constraint that the value of the portfolio of assets available for allocation is equal to the start of year assets ($\mathrm{A0}_{(\mathrm{s,f,d})}$), adjusted by revaluation effects ($V_{(s,f,d)}$) plus the value of any new assets ($\mathrm{NEWASSET}_{(d)}$). Algebraically, it can be written as follow:

$$\text{Maximise: } \mathrm{CES}\big(\mathrm{A1}_{(s,f,d)} \cdot \mathrm{R}_{(s,f,d)}, \forall s, f\big), \tag{4.1}$$

$$\text{Subject to: } \mathrm{NEWASSET}_{(d)} = \textstyle\sum_{s,f} \mathrm{FLOW}_{(s,f,d)} = \sum_{s,f} (\mathrm{A1}_{(s,f,d)} - \mathrm{A0}_{(s,f,d)} \cdot \mathrm{V}_{(s,f,d)}),$$

$$s \in \mathrm{LA}, f \in \mathrm{FA}, d \in \mathrm{LALF}.$$

where,

- $\mathrm{A1}_{(s,f,d)}$ is end-of-year value of financial instrument (f) issued by liability agent (s) held by asset agent (d);
- $\mathrm{R}_{(s,f,d)}$ is power rate of return of financial instrument (f) issued by liability agent (s) held by asset agent (d);
- $\mathrm{A0}_{(s,f,d)}$ is the start-of-the-year value of financial instrument (f) issued by liability agent (s) held by asset agent (d);
- $\mathrm{NEWASSET}_{(d)}$ is the available budget for asset agent (d) to purchase new financial assets;
- $\mathrm{V}_{(s,f,d)}$ is the power of a revaluation term (1 plus valuation rate) of financial instrument (f) issued by liability agent (s) held by asset agent (d).

The solution of optimisation problem stated in Equation (4.1) in percentage-change is given by:

$$\mathrm{at1}_{(s,f,d)} = \mathrm{assets}_{(d)} + \sigma_{(d)} \cdot \big(\mathrm{roipowa}_{(s,f,d)} - \mathrm{averor}_{(d)}\big), \tag{4.2}$$

$$s \in \mathrm{LA},\ f \in \mathrm{FI}, \text{ and } d \in \mathrm{AALF},$$

where,

- $\mathrm{at1}_{(s,f,d)}$ is the percentage-change in the end-of-year value of instrument (f) issued by liability agent (s) held by asset agent (d);
- $\mathrm{assets}_{(d)}$ is the percentage-change in the value of the total asset portfolio of agent (d);
- $\mathrm{roipowa}_{(s,f,d)}$ is the percentage-change in the power of the rate of return on instrument (f) issued by liability agent (s) and held by asset agent (d);

- $\mathrm{averor}_{(d)}$ is the weighted average rate of return received by asset agent (d);
- $\sigma_{(d)}$ is a positive parameter governing the sensitivity of asset agent (d)'s asset allocation decisions to changes in relative rates of return $\left(\mathrm{roipowa}_{(s,f,d)} - \mathrm{averor}_{(d)}\right)$ across financial assets.

Equation (4.2) operates as follows. In the absence of a change in relative rates of return, an expansion, say, in the value of agent (d)'s total budget for purchasing assets (i.e., an increase in the value of $\mathrm{assets}_{(d)}$) leads to a uniform expansion in agent (d)'s holding of all assets. Since $\sigma_{(d)} > 0$, a relative increase, say, in the interest rate on a specific financial asset, $\mathrm{roipowa}_{(s,f,d)}$, relative to the average rate of return, $\mathrm{averor}_{(d)}$, induces the asset agent (d) to adjust the composition of their portfolio towards holding more of that specific asset ($\mathrm{at1}_{(s,f,d)}$).

4.4.2 Optimal Behaviour of Domestic Liability Agent (LALF)

The optimisation problem of liability agents is expressed by Equation (4.3). A liability agent (s) chooses its capital financing structure, defined as holdings by particular asset agents of the liability instruments issued by the liability agent, to minimise a CET function of the liability-weighted value of the rates of return paid on each source of funds, subject to the constraint of a given value for total end-of-financial year liabilities on issue by agent (s).

$$\text{Minimise: } \mathrm{CET}\left(\mathrm{A1}_{(s,f,d)} \cdot \mathrm{R}_{(s,f,d)}, \forall f, d\right) \tag{4.3}$$

$$\text{Subject to: } \mathrm{NEWLIAB}_{(s)} = \textstyle\sum_{d,f} \mathrm{FLOW}_{(s,f,d)} = \sum_f \sum_d \left(\mathrm{A1}_{(s,f,d)} - \mathrm{A0}_{(s,f,d)} \cdot \mathrm{V}_{(s,f,d)}\right),$$

$$s \in \mathrm{LALF}, f \in \mathrm{FI}, d \in \mathrm{AA}.$$

The solution of the liability agent optimisation statement in Equation (4.3), in percentage-change form, is presented as follows:

$$\mathrm{at1}_{(s,f,d)} = \mathrm{liabilities}_{(s)} - \tau_{(s)} \cdot \left(\mathrm{roipowl}_{(s,f,d)} - \mathrm{wacc}_{(s)}\right), \tag{4.4}$$

$$s \in \mathrm{LALF}, f \in \mathrm{FI}, d \in \mathrm{AA}.$$

Equation (4.4) operates as follows. In the absence of any change in the relative cost of different sources of financial capital, a general expansion, say, in the financing requirement of agent (s) ($\text{liabilities}_{(s)}$) will lead to a uniform expansion in the financial instruments on offer by (s), and their holdings by asset agents, with no change in the composition of the liability side of agent s' balance sheet. However, a change in the relative cost of different sources of financial capital will change the composition of the agent's financing sources. Since $\tau_{(s)} > 0$, a positive deviation in the interest rate on a particular capital instrument purchased by a particular asset agent ($\text{roipowl}_{(s,f,d)}$) relative to the weighted average cost of capital ($\text{wacc}_{(s)}$) will induce the liability agent to move away from reliance on (f,d) as a source of funds.

4.4.3 Optimal behaviour of foreign agents

In essence, the behaviour of foreign asset and liability agents are derived similarly to those of domestic agent optimisation decisions, with the addition of the nominal exchange rate for asset valuations. The statements of optimisation problem of foreign asset and liability agent are formally expressed in Equation (4.5).

Maximise: (4.5)

$$\text{CES}\left(\Phi \cdot \text{A1}_{(s,f,RoW)} \cdot \text{R}_{(s,f,RoW)}, \forall s, f \text{ and assets in other countries}\right),$$

Subject to:

$$\textstyle\sum_{s,f} \text{AT1}_{(s,f,RoW)} = \sum_{s,f} \text{AT0}_{(s,f,RoW)} \times \text{V}_{(s,f,RoW)} + \text{FLOW}(s, f, RoW),$$

and

$$\text{NEWASSETF} = \textstyle\sum_{s,f} \Phi \cdot \text{FLOW}_{(s,f,RoW)} + \text{OFLOW},$$

$$s \in LA, f \in FA, d \in ROW.$$

where,

- Φ is nominal exchange rate valued in foreign currency units per Rupiah in level terms;

- $\mathrm{NEWASSETF}$ is the level of new funding available (in foreign currency terms) to the foreign agent for new asset purchases during the year; and
- OFLOW is the value, in foreign currency terms, of the foreigners' acquisition of new assets in other countries.

The solution of optimisation problem stated in Equation (4.5) is given in percentage change form in the following equation.

$$\phi + \mathrm{at1}_{(s,f,RoW)} = \mathrm{assetfor} + \sigma \cdot \left(\mathrm{roipowa}_{(s,f,RoW)} - \mathrm{averorf}\right), \quad (4.6)$$
$$s \in LA,\ f \in FI$$

where,

- ϕ is percentage change in the nominal exchange rate expressed as foreign currency units per Indonesian Rupiah;
- $\mathrm{averorf}$ is the percentage change the average rate of return received by foreigners on their world-wide asset holdings.
- $\mathrm{assetfor}$ is the percentage change in the foreign currency value of the worldwide portfolio of the foreign asset agent.

Equation (4.6) has a similar construction to that of Equation (4.2), except for the appearance of the nominal exchange rate in the LHS. In addition to the optimal asset agent mechanisms explained in Section 4.4.1, Equation (4.6) shows the role of the nominal exchange rate in foreign demand for domestic financial assets. Depreciation of the exchange rate ($\phi \downarrow$) has an equivalent effect to a relaxation in foreigners' budget constraint in domestic asset acquisitions ($\mathrm{assetfor}$). Since $\sigma > 0$, a rise in the rate of return on a domestic financial asset relative to the return available on foreign financial assets induces the foreigners to accumulate more of that specific asset. In a small-open economy context, both $\mathrm{assetfor}$ and $\mathrm{averorf}$ are determined as exogenous variables.

4.4.4 Equilibrium of asset and liability rates of return

In the general arrangement of AMELIA-F, the percentage movements in the powers of the rates of return on particular financial instruments are identical from the perspective of both asset and liability agent (see Equation 4.7 below). However, there are exceptions. For example, the movements in rates of return on existing equity and issues of new equity are not the same (Giesecke et al. 2015). In a tight financial condition, the rate of return offered by liability agents on new equity might need to be higher than the rate of return on the existing equity.

$$\mathrm{roipowa}_{(s,f,d)} = \mathrm{roipowl}_{(s,f,d)} + \mathrm{f\_roipow}_{(s,f,d)}, \tag{4.7}$$
$$s \in \mathrm{LA},\ f \in \mathrm{FI},\ \text{and}\ d \in \mathrm{AA},$$

where,

- $\mathrm{f\_roipow}_{(s,f,d)}$ is a specific shift variable, which, when exogenous, establishes the equality of rates of return on (s,f,d)-specific financial instruments.

The specific arrangement between asset and liability power of rates of return is undertaken by exogenising or endogenising the specific shifter variable. When the two variables are designed to move one-to-one, the shifter should be exogenised. This is the default for most financial instruments. The exception is equity, where I allow for the expected rate of return to be a weighted average of the realised return on existing equity and the rate of return on new equity issues as follows:

$$\begin{aligned}\mathrm{roipowa}_{(s,\mathrm{Equity},d)} = {} & \alpha \cdot \mathrm{roipoweqc}_{(s)} \\ & + (1-\alpha) \cdot \mathrm{roipowl}_{(s,\mathrm{Equity},d)} + \mathrm{f4\_roipow}_{(s,d)},\end{aligned} \tag{4.8}$$
$$s \in \mathrm{KAGENT},\ f \in \mathrm{FI},\ \text{and}\ d \in \mathrm{AA},$$

where,

- α is a weighting parameter with values between 0 and 1. With α close to 1, asset agents expect that rates of return on new equity will be close to rates of return realised on existing equity. With α close to 0, asset agents are willing to accept that expected rates of return on new equity can differ from realised returns on existing equity;

- $\mathrm{roipowl}_{(s,Equity,d)}$ is the rate of return on new equity issued by liability agents;
- $\mathrm{roipowa}_{(s,Equity,d)}$ is the rate of return expected by asset holders;
- $\mathrm{roipoweqc}_{(s)}$ is the realised rate of return on existing equity; and
- $\mathrm{f4\_roipow}_{(s,d)}$ is a shifter variable.

Equation (4.8) is activated if $\mathrm{f4\_roipow}_{(s,d)}$ is exogenously determined. When $\alpha = 1$, the asset agents do not follow the market rate of return, but instead look to the realised rates of return on capital investment in the real economy. There are two capital creator agents (KAGENT) in AMELIA-F, i.e., industries (Inds) and housing (Housing).

The industries and housing have their own calculation on rates of return and they link to the rates of return in the real economy. As both agents face a similar form of real economy rate of return, for explanatory purpose in this section, I only explain the industry rate of return on equity. In levels form, the power of the rate of return on liability equity issued by industries is expressed as follow:

$$\mathrm{ROI\_EQ\_D}_{(Inds)} = 1 + \frac{\left\{\begin{array}{c}\sum_{i\in NOD} \mathrm{V1CAP}_{(i)} \\ +\sum_{i\in NOD}(\mathrm{P2TOT\_INF}-1)\cdot \mathrm{VCAP}_{(i)} \\ -\sum_{i\in NOD}\left[\mathrm{DEP}_{(i)}\cdot \mathrm{VCAP}_{(i)}\right] \\ -\sum_{f\in NEQ}\sum_{d\in AA}\left[\mathrm{AT}_{(Inds,f,d)}\cdot \mathrm{VAL}_{(Inds,f,d)}\left(\mathrm{ROIL}_{(Inds,f,d}-1\right)\right]\end{array}\right\}}{\sum_{d\in AA}\mathrm{AT}_{(Inds,Equity,d)}\cdot \mathrm{VAL}_{(Inds,Equity,d)}}, \tag{4.9}$$

where,

- Set NOD = INDS – OD, where OD is the dwellings industry and NOD is the non dwelling industry;
- $\mathrm{ROI\_EQ\_D}_{(Inds)}$ is the power of the realised equity rate of return of the industry agent;
- $\sum_{i\in NOD}\mathrm{V1CAP}_{(i)}$ is the rental value of physical capital used by industries (i) excluding housing;

- $\sum_{i \in NOD}(\text{P2TOT\_INF} - 1) \cdot \text{VCAP}_{(i)}$ is the increase the price of physical capital over a one year holding period, noting that P2TOT_INV is the power of the inflation rate, and VCAP is the value of the physical capital stock;
- $\sum_{i \in NOD}\left[\text{DEP}_{(i)} \cdot \text{VCAP}_{(i)}\right]$ is current year value of depreciation to physical capital;
- $\sum_{f \in NEQ} \sum_{d \in AA}\left[\text{AT}_{(\text{Inds,f,dd})} \cdot \text{VAL}_{(\text{Inds,f,dd})}\left(\text{ROIL}_{(\text{Inds,f,dd}} - 1\right)\right]$ is the sum of payments made on non-equity (NEQ) instruments (like loans);
- $\sum_{dd \in AA} \text{AT}_{(\text{Inds,Equity,dd})} \cdot \text{VAL}_{(\text{Inds,Equity,dd})}$ is the market value of equity issued by industries.

In what follows, I describe the interpretation of Equation (4.9). As a financial agent, industry calculates its realised equity rate of return by summing up the rental values over non-owner dwelling sectors, *plus* the price gain of the physical capital, minus capital depreciation. From this value is subtracted the claims made by non-equity holders on the returns on industry capital. The later term is purposed to exclude non-equity gross operating surpluses from the equity rate of return valuation. The percentage-change in Equation (4.9) is given by:

$$\frac{\text{ROI\_EQ\_D}_{(\text{Inds})}}{\text{ROI\_EQ\_D}_{(\text{Inds})} - 1}(\text{roipoweqc} - \text{f\_roipow\_ie}) =$$

$$\left\{\frac{1}{\begin{array}{c}\sum_{i \in NOD} \text{V1CAP}_{(i)} + \sum_{i \in NOD}(\text{P2TOT\_INF} - 1) \cdot \text{VCAP}_{(i)} - \sum_{i \in NOD}\left[\text{DEP}_{(i)} \cdot \text{VCAP}_{(i)}\right] \\ - \sum_{f \in NEQ} \sum_{d \in AA}\left[\text{AT}_{(\text{Inds,f,d})} \cdot \text{VAL}_{(\text{Inds,f,d})}\left(\text{ROIL}_{(\text{Inds,f,d}} - 1\right)\right]\end{array}}\right\}$$

.

$$
\left\{\sum_{i\in NOD} V1CAP_{(i)} \cdot \left(x1cap_{(i)} + p1cap_{(i)}\right) + \left[P2TOT\_INF \cdot \sum_{i\in NOD} VCAP_{(i)}\right] \cdot p2totinf \right.
$$

$$
+ [P2TOT\_INF - 1] \cdot \sum_{i\in NOD} VCAP_{(i)} \cdot \left(x1cap_{(i)} + p2tot_{(i)}\right)
$$

$$
- \sum\nolimits_{i\in NOD} \left[DEP_{(i)} \cdot VCAP_{(i)}\right] \cdot \left(x1cap_{(i)} + p2tot_{(i)}\right)
$$

$$
- \sum_{f\in NEQ} \sum_{d\in AA} \left[AT_{(Inds,f,d)} \cdot VAL_{(Inds,f,d)} \cdot ROIL_{(Inds,f,d}\right] \cdot roipowl_{(Inds,f,d)}
$$

$$
- \sum_{f\in NEQ} \sum_{d\in AA} \left[AT_{(Inds,f,d)} \cdot VAL_{(Inds,f,d)}\left(ROIL_{(Inds,f,d} - 1\right)\right]
$$

$$
\left. \cdot \left(a\_t_{(Inds,f,d)} + v_{(Inds,f,d)}\right)\right\}
$$

$$
- \left\{\frac{1}{\sum_{dd\in AA} AT_{(Inds,Equity,d)} \cdot VAL_{(Inds,Equity,d)}}\right\}
$$

$$
\cdot \left\{\sum_{d\in AA} AT_{(Inds,Equity,d)} \cdot VAL_{(Inds,Equity,d)} \right.
$$

$$
\left. \cdot \left(a\_t_{(Inds,Equity,d)} + v_{(Inds,Equity,d)}\right)\right\}.
$$

(4.10)

where,

- roipoweqc is percentage-change of equity power of rate of return issued by industry agent; and
- f_roipow_ie is shifter variable. To activate Equation (4.10), f_roipow_ie must be exogenised.

4.5 Linkages between the Financial-Side and the Real-side of AMELIA-F

AMELIA-F has five channels connecting the financial- and real-sides of the model. Those channels represent the common financing constraints faced by real economic agents and highlight the significant role of the financial system in the macroeconomy.

4.5.1 Financing the current account deficit

The current account deficit (CAD) accounts for trade deficit and net foreign income. These are endogenously determined in the real-side of the model. When a current account deficit occurs, this must be financed to offset the excess domestic liability to rest of the world. The finance is provided by foreigners by purchasing financial instruments issued by domestic liability agents. Algebraically, the financing of the current account deficit is written as follow:

$$\mathrm{CAD} = \mathrm{NEWAACQ}_{(\mathrm{RoW})} - \sum_{\mathrm{f} \in \mathrm{FI}} \sum_{\mathrm{d} \in \mathrm{AALF}} \mathrm{FLOW}_{(\mathrm{RoW,f,d})}, \tag{4.11}$$

where,

- CAD is the value of the current account deficit;
- $\mathrm{NEWAACQ}_{(\mathrm{ROW})}$ is new foreign acquisitions of domestic financial assets; and
- $\sum_{\mathrm{f} \in \mathrm{FI}} \sum_{\mathrm{d} \in \mathrm{AALF}} \mathrm{FLOW}_{(\mathrm{RoW,f,d})}$ is the liability issuance by foreigners in domestic financial markets.

In level terms, Equation (4.11) describes that the current account deficit is financed by net asset acquisitions by foreigners. In ordinary change terms, the Equation (4.11) can be expressed as:

$$\mathrm{d\_CAD} = \mathrm{d\_new\_assacq}_{(\mathrm{ROW})} - \sum_{\mathrm{d} \in \mathrm{AALF}} \sum_{\mathrm{f} \in \mathrm{FI}} \mathrm{d\_flow}_{(\mathrm{ROW,f,d})} + \mathrm{d\_ff\_phi}. \tag{4.12}$$

where,

- d_CAD is the ordinary-change in the current account deficit;
- d_ff_phi is a shift variable;
- $\mathrm{d\_new\_assacq}_{(\mathrm{ROW})}$ is the ordinary-change in foreign acquisitions of domestic assets; and

- $\text{d\_flow}_{(\text{RoW,f,d})}$ is the ordinary-change in foreign liability issuance in the domestic market.

The LHS of Equation (4.12) represents the change in the value of the current account deficit, which is determined in the real-side model by movements in savings and investment. It is constrained by net acquisition of domestic assets by foreigners. This channel is activated when d_ff_phi is exogenised.

4.5.2 Financing the public sector borrowing requirement (PSBR)

Under a similar concept, financing the PSBR is arranged by the following equation:

$$\text{GOVDEF} = \sum_{f \in FI} \sum_{d \in AALF} \text{FLOW}_{(\text{govt,f,d})} - \text{NEWAACQ}_{(\text{govt})}, \tag{4.13}$$

where,

- GOVDEF is the public sector borrowing requirement (PSBR);
- $\sum_{f \in FI} \sum_{d \in AALF} \text{FLOW}_{(\text{govt,f,d})}$ is the liability issuance by the government agent;
- $\text{NEWAACQ}_{(\text{govt})}$ is asset acquisitions by the government agent.

The ordinary-change of Equation (4.13) is as follow:

$$\text{d\_new\_assacq}_{(\text{govt})} = \sum_{f \in FI} \sum_{d \in AA} \text{d\_flow}_{(\text{govt,f,d})} - \text{d\_gov\_def} + \text{d\_ff\_govt}, \tag{4.14}$$

where,

- $\text{d\_new\_assacq}_{(\text{govt})}$ is the ordinary-change in government financial asset acquisitions;
- $\text{d\_flow}_{(\text{govt,f,d})}$ is the ordinary-change in government liability issuance;
- d_gov_def is the ordinary-change in the government deficit; and
- d_ff_govt is a shift variable.

Equation (4.14) means that the net government liability issuance in financial markets is equal to the fiscal deficit defined in the real-side of the model. The mechanism in Equation (4.14) is activated when d_ff_govt is exogenised.

4.5.3 Aggregate saving allocation

Aggregate household savings, which is determined in the real-side of the model, is connected to the model's financial-side via net asset acquisitions by household agents. The aggregate household saving in the real-side of the model is obtained by subtracting nominal household consumption from nominal household disposable income. In this arrangement, the aggregate savings become the available budget for the household financial agent to undertake new purchases of asset instruments in financial markets. The linkage between aggregate savings and household new asset acquisitions in AMELIA-F is expressed in the following equation:

$$100 \cdot \left[\mathrm{d\_assacq}_{(\mathrm{HH})} - \sum_{\mathrm{f} \in \mathrm{FI}} \sum_{\mathrm{d} \in \mathrm{AA}} \mathrm{d\_flow}_{(\mathrm{HH,f,d})} \right] = \mathrm{HOUS\_DIS\_INC} \cdot \mathrm{hdy} - \mathrm{V3TOT} \cdot \mathrm{w3tot} + \mathrm{d\_shiftH}, \tag{4.15}$$

where,

- $\mathrm{d\_assacq}_{(\mathrm{HH})}$ is the ordinary-change in new asset acquisitions by households;
- $\sum_{\mathrm{f} \in \mathrm{FI}} \sum_{\mathrm{d} \in \mathrm{AA}} \mathrm{d\_flow}_{(\mathrm{HH,f,d})}$ is the ordinary-change in liability issued by households;
- HOUS_DIS_INC and hdy are the coefficient and percentage-change in disposable income respectively;
- V3TOT and w3tot are the level and the percentage-change of nominal household consumption respectively; and
- d_shiftH is a shift variable.

The LHS of Equation (4.15) is the ordinary change in new asset acquisitions by the household financial agent. Since AMELIA-F does not at present have underlying theory for the determination of liabilities issued by the household agent, the elements of

$\sum_{f \in FI} \sum_{d \in AA} \mathrm{d\_flow}_{(HH,f,d)}$ are valued at zero for all elements. The RHS of the equation represents the aggregate savings defined in the real-side of the economic model.

4.5.4 Financing investment

As aforementioned, AMELIA-F has two capital creating financial agents (KAGENT), i.e., Industries and Housing. The industries raise liabilities to finance their capital creation activities. The equation explaining the finance of capital creation can be expressed by:

$$\mathrm{d\_new\_liaacq}_{(Inds)} - \mathrm{d\_new\_assacq}_{(Inds)} = \mathrm{d\_invest\_ind} + \mathrm{d\_shiftind}, \tag{4.16}$$

where,

- $\mathrm{d\_new\_liaacq}_{(Inds)}$ is the ordinary change in new liabilities issuance by industries;
- $\mathrm{d\_new\_assacq}_{(Inds)}$ is the ordinary change in new asset acquisitions by industries;
- d_invest_ind is the ordinary change in nominal non-housing investment;
- d_shiftind is a shifter variable;

This channel is activated if d_shiftind is exogenously determined.

The RHS of Equation (4.17) describes the net liability issuance of financial instruments by industries. The LHS of the equation is the ordinary change in non-housing investment determined in the real-side of the model. The equation explaining the ordinary change in non-housing investment is explained in the following equation:

$$\begin{aligned} 100 \cdot \mathrm{d\_invest\_ind} = {} & \mathrm{V2TOT\_I} \cdot \mathrm{w2tot\_i} \\ & - \sum_{i \in IND} \mathrm{G\_INVEST}_{(i)} \cdot \mathrm{w2tot}_{(i)} \\ & - \sum_{i \in OD} \mathrm{V2TOT}_{(i)} \cdot \mathrm{w2tot}_{(i)} \\ & + \mathrm{V6TOT} \cdot \mathrm{w6tot}, \end{aligned} \tag{4.17}$$

where,

- V2TOT_I is aggregate investment;

- $\mathrm{G\_INVEST}_{(i)}$ is government investment in industry (i);
- $\mathrm{V2TOT}_{(i)}$ is the purchasers' value of investment in industry (i);
- $\mathrm{w2tot\_i}$ is the percentage change in aggregate nominal investment;
- $\mathrm{w2tot}_{(i)}$ is the percentage change in aggregate nominal investment in industry (i);
- $\mathrm{V6TOT}$ is the purchasers' value of aggregate inventories; and
- $\mathrm{w6tot}$ is the percentage change in nominal aggregate net additions to inventories.

Equation (4.17) describes that $\mathrm{d\_invest\_ind}$ is the ordinary change in private investment. The first part of the RHS explains the ordinary-change in aggregate investment. The second term explains government investment. The third part of the RHS is the ordinary change in housing investment. The housing sector in the real-side of the model is categorised as the dwelling sector (OD) in the real-side model. The last part is the ordinary change in inventory accumulated by all industries. This element becomes a part of private investment expenditures, as some commodities are stored as inventories as an investment. The overall Equation (4.17) explains that private investment is aggregated from non-housing investment excluding government investments.

Following the same principle, the investment in the housing sector is financed by liabilities issued by the housing financial agent. This is described in the following equation:

$$\mathrm{d\_new\_laacq}_{(\mathrm{Housing})} - \mathrm{d\_new\_assacq}_{(\mathrm{Housing})} = \mathrm{d\_invest\_H} + \mathrm{d\_shiftRH}, \tag{4.18}$$

where,

- $\mathrm{d\_new\_laacq}_{(\mathrm{Housing})}$ is the ordinary change in liability issuance by the housing financial agent;
- d_invest_H is the ordinary change in housing investment;
- $\mathrm{d\_new\_assacq}_{(\mathrm{Housing})}$ is the ordinary change in financial asset acquisitions by the housing agent; and
- d_shiftRH is a shift variable for activating Equation (4.18).

Equation (4.18) is activated when $\mathrm{d\_shiftRH}$ is exogenised. The LHS of Equation (4.18) explains the ordinary change in net financial liabilities issued by the housing agent. As the housing investment agent has no need to accumulate financial assets, the elements of $\mathrm{d\_new\_assacq}_{(\mathrm{Housing})}$ are exogenous and zero. The RHS describes the ordinary change in housing investment, which is determined as follows:

$$100 \cdot \mathrm{d\_invest\_H} = \sum_{\mathrm{i} \in \mathrm{OD}} \mathrm{V2TOT}_{(\mathrm{i})} \cdot \mathrm{w2tot}_{(\mathrm{i})} - \sum_{\mathrm{i} \in \mathrm{IND}} \mathrm{G\_INVEST}_{(\mathrm{i})} \cdot \mathrm{w2tot}_{(\mathrm{i})}. \tag{4.19}$$

The setting of housing investment in Equation (4.19) is very similar to that explained previously for non-housing investment equation. Equation (4.19) explains that the ordinary change in housing investment is equal to the ordinary-change in private dwelling investment *minus* the ordinary change in government dwelling investment.

4.5.5 Weighted average cost of capital (WACC)

The capital creator agents (i.e., industries and housing) issue new liabilities for funding investment if the rate of return they have to pay on the new liabilities is less than or equal to expected return on physical investment as determined in the real-side of the model. In this regard, the WACC on new liabilities as calculated in the financial-side of the model must equal the ROR on new units of physical capital in the real-side of the model, as follows:

$$\mathrm{EROR}_{(\mathrm{i})} = \mathrm{WACC}_{(\mathrm{Inds})}, \quad \mathrm{i} \in \mathrm{NOD} \tag{4.20}$$

$$\mathrm{EROR}_{(\mathrm{i})} = \mathrm{WACC}_{(\mathrm{Housing})}, \quad \mathrm{i} \in \mathrm{OD} \tag{4.21}$$

where,

- $\mathrm{EROR}_{(\mathrm{i})}$ is expected rate of return on capital of industry (i) in real-side model;

- $\text{WACC}_{(\text{Inds})}$ is weighted average cost of capital of industry as a financial agent; and
- $\text{WACC}_{(\text{Housing})}$ is weighted average cost of capital of housing sector as a financial agent.

Equation (4.20) describes that the rates of return of non-owner dwelling industries (NOD) in the real-side model uniformly follow the WACC of industry financial agent in the financial-side model. Similarly, Equation (4.21) explains that the rate of return of owner dwelling (OD) industry in real-side model moves one-in-one with WACC of housing agent determined in financial-side model.

The ordinary change form of Equation (4.20) and (4.21) are respectively rewritten in Equation

(4.22) and (4.23), as follows:

$$100 \cdot \text{d\_WACC}_{(\text{Inds})} = \text{AVE\_ROI}_{(\text{NOD})} \cdot \text{ave\_ror\_}s_{(\text{NOD})} \quad (4.22)$$

$$100 \cdot \text{d\_WACC}_{(\text{Housing})} = \text{AVE\_ROI}_{(\text{OD})} \cdot \text{ave\_ror\_}s_{(\text{OD})} \quad (4.23)$$

where,

- $\text{d\_WACC}_{(\text{Inds})}$ is the ordinary change in the weighted average cost of capital of liabilities raised by Industries financial agent;
- $\text{d\_WACC}_{(\text{Inds})}$ is the ordinary change in the weighted average cost of capital of liabilities raised by Housing financial agent;
- $\text{AVE\_ROI}_{(\text{i})}$ is level of the power of the average rate of return on liabilities raised by industry (i); and
- $\text{ave\_ror\_s}_{(\text{i})}$ is the percentage change in the average rate of return on liabilities raised by industry (i).

4.6 Commercial Banks

This section explains further details of the modelling of commercial banks with respect to financial regulations. As pure financial agents, the general behaviour of commercial banks is broadly similar to that of the other pure financial agents, e.g., NBFIs. These behaviours have been previously outlined in Section 4.4.1; 4.4.2; and 4.4.3. To incorporate financial regulations, the modelling of commercial banks needs to be extended to accommodate changes in common measures in banking reforms. The first extension is related to bank capital. The second is about bank foreign borrowing and lending. The third is about commercial banks' reserves with the central bank.

4.6.1 Modelling Bank Capital Adequacy Ratio

The financial-side of AMELIA-F incorporates bank capital regulation in its specification of commercial bank activity. It includes the bank capital adequacy ratio (CAR), a regulatory ratio advocated by the Basel Committee on Banking Supervision (BCBS) to strengthen financial stability. The CAR is calculated from the ratio of tier-1 equity capital to risk weighted assets (RWA). RWA is a measure of the market risk exposure on bank assets, governed by regulatory coefficients attached to specific bank assets. The CAR measure is purposed to determine how much equity capital the commercial banks require to fund their activities, given the composition of their asset holdings. For example, an 8 per cent CAR implies that commercial banks need to have Rp 8 of equity capital for every Rp 100 increase in RWA.

A higher CAR implies better loss absorptive capacity on the part of commercial banks. However, a higher CAR can raise bank financing costs (i.e., weighted average cost of capital, WACC), as equity capital typically carries a higher rate of return compared with other bank funding instruments. To include the CAR policy instrument in the modelling of commercial banks, the equity liability optimisation must be excluded from the overall bank liability optimisation statement as explained in Section 4.4. Meanwhile, the RWA must also be incorporated into the asset side of bank balance sheets.

The restatement of the optimisation problem governing bank asset allocation, taking account of prevailing regulatory CAR rules, is as follows:

Choose $\mathrm{A1}_{(\mathrm{s,f,Banks})}$, by (4.24)

Maximise: $\mathrm{CES}\big(\mathrm{R}_{(\mathrm{s,f,Banks})} \cdot \mathrm{A1}_{(\mathrm{s,f,Banks})}, \forall \mathrm{s,f}\big)$,

Subject to: $\sum_{\mathrm{s\in LA, f\in FI}} \mathrm{A1}_{(\mathrm{s,f,Banks})} = \mathrm{BB}_{(\mathrm{Banks})}$, And $\sum_{d \in AA} A1_{(Banks,Equity,d)} = Max \begin{bmatrix} \sum_{d} A1zero_{(Banks,Equity,d)}, \\ KAR \cdot \sum_{s,f} W_{(s,f,Banks)} \cdot A1_{(s,f,Banks)} \end{bmatrix}$.

$s \in LA, f \in FI$

where,

- KAR is the required capital adequacy ratio; and
- $W_{(s,f,Banks)}$ are regulatory risk weights (see Table 4.3);
- $\sum_{d \in AA} A1zero_{(Banks,Equity,d)}$ is commercial bank equity issuance in the absence of regulatory CAR; and
- $BB_{(Banks)}$ is the value of commercial bank assets.

When commercial banks are compelled by the regulatory CAR, the last constraint in the optimisation problem becomes $\sum_{d \in AA} A1_{(Banks,Equity,d)} = KAR \cdot \sum_{s,f} W_{(s,f,Banks)} \cdot A1_{(s,f,Banks)}$. Now, banks' optimal asset allocations are affected by the regulatory CAR. The optimisation statement governing asset acquisitions is redefined further as follow:

Choose $A1_{(s,f,Banks)}$, by (4.25)

Maximise: $CES\left(NR_{(s,f,Banks)} \cdot A1_{(s,f,Banks)}\right)$,

Subject to: $\sum_{s \in LA, f \in FI} A1_{(s,f,Banks)} = BB_{(Banks)}$,

And $NR_{(s,f,Banks)} = R_{(s,f,Banks)} - \Psi \cdot KAR \cdot W_{(s,f,Banks)}$,

$s \in LA, f \in FI, d \in AA$.

where,

- Ψ is a positive parameter reflecting the difference between the rate of return on commercial bank equity and that which must be paid on other bank liabilities.

Parameter	Description	Weight
$RISKWGT_{(CB,f)}$ $(\forall f \in FI)$	Liabilities issued by the Central Bank	0.0
$RISKWGT_{(Govt,f)}$ $(\forall f \in FI)$	Liability issued by the governments	0.1
$RISKWGT_{(s,Cash)}$ $(\forall s \in LA)$	Cash instrument	0.0

Parameter	Description	Weight
$RISKWGT_{(s,Equity)}$ $(\forall s \in LA)$	Equity	3.0
$RISKWGT_{(ROW,DepLoans)}$	Loans to foreigners	0.5
$RISKWGT_{(Inds,DepLoans)}$	Loans to industry	0.5
$RISKWGT_{(NBFI,DepLoans)}$	Loans to NBFI	0.5
$RISKWGT_{(Housing,DepLoans)}$	Loans to housing sector	0.5
$RISKWGT_{(NBFI,Bonds)}$	Bonds issued by NBFI	0.5
$RISKWGT_{(ROW,Bonds)}$	Bonds issued by foreigners	0.4

Source: adapted from Giesecke et al. (2017).

Table 4.3 Regulatory Risk weights on Commercial Banks

Equation (4.25) describes an environment in which commercial banks are mindful of the impact on their cost of funds when choosing the composition of their asset portfolio. They consider the net rate of return (NR) calculated from held assets' rates of return ($R_{(s,f,Banks)}$) less the implied penalty rate for having more equity finance ($\Psi \cdot KAR \cdot W_{(s,f,Banks)}$). For example, if Ψ = 0.1, KAR = 0.1, and W = 1.0, the commercial banks are mindful of a 0.01 or 100 basis points financing penalty from regulatory CAR. By increasing the value of KAR to 0.12 for example, the penalty rate increases to 0.012 or 120 basis points (rising 20 basis points). If the banks choose to own a financial asset with a lower risk weight (W) of, say, 0.5, the penalty rate would become 0.005 or 50 basis point (falling 50 basis points). For a given value of R, the lower penalty rate would make the value of NR for the latter asset higher than the former assets, encouraging the bank to hold more of the former asset. This process explains how commercial bank choice of asset combinations adjusts when a change in regulatory CAR is imposed.

As aforementioned, commercial bank equity issuance is excluded from the optimisation process in section 4.4. Equity issuance by commercial banks in relation to the regulatory CAR is governed by the following equations:

$$RABANK \times prabank = \sum_{s \in LA} \sum_{f \in FI} \left[RISKWGT_{(s,f)} \cdot A1_{(s,f,Banks)}\right] \cdot \left(priskwgt_{(s,f)} + a1_{(s,f,Banks)}\right), \tag{4.26}$$

$$EQBANK \cdot peqbank = \sum_{d \in AA} A1_{(Banks,Equity,d)} \cdot a1_{(Banks,Equity,d)}, \tag{4.27}$$

$$pratio = peqbank - prabank, \tag{4.28}$$

$$\text{BBNEQ}_{(\text{Banks})} \cdot \text{pbblneq}_{(\text{Banks})} = \qquad (4.29)$$

$$\text{BBL}_{(\text{Banks})} \cdot \text{pbbl}_{(\text{Banks})} - \sum_{d \in AA} \text{A1}_{(\text{Banks,Equity,d})} \cdot \text{a1}_{(\text{Banks,Equity,d})},$$

$$\text{averorne}_{(\text{Banks})} = \qquad (4.30)$$

$$\sum_{d \in AA} \sum_{f \in FINEQ} \left[\text{A1}_{(\text{Banks,f,d})}/\text{BBNEQ}_{(\text{Banks})}\right] \cdot \text{rpow}_{(\text{Banks,f,d})},$$

$$\text{a1d}_{(\text{Banks,f})} = \qquad (4.31)$$

$$\text{pbblneq}_{(\text{Banks})} + \text{TAU} \times \left[\text{rpowd}_{(\text{Banks,f})} - \text{averorne}_{(\text{Banks})}\right],$$

where $(f \in FINEQ)$.

Table 4.4 describes definitions of all variables, coefficients, and sets given in Equation (4.26)-(4.31).

Variable	Description
$\text{BBL}_{(\text{Banks})}$	The level of total end-of-year commercial bank liabilities (including equity).
$\text{BBNEQ}_{(\text{Banks})}$	The level of the equity-exclusive value of end-of-year commercial bank liabilities.
RABANK	The level of the value of end-of-year risk-weighted bank assets.
$\text{RISKWGT}_{(s,f)}$	The level of the risk weights attached to financial instrument (f) issued by liability agent (s).
$\text{A1}_{(s,f,d)}$	The level of end-of-year holdings by agent (d) of asset type (f) issued by agent (s).
TAU	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	The value of bank equity.
prabank	The percentage change in risk-weighted bank assets.
$\text{priskwgt}_{(s,f)}$	The percentage change in the value of the risk weight attached to commercial bank holdings of financial instrument (f) issued by liability agent (s).
$\text{a1}_{(s,f,d)}$	The percentage changes in end-of-year holdings by agent (d) of asset type (f) issued by agent (s).
peqbank	The percentage change in end-of-year bank equity.
$\text{pbblneq}_{(\text{Banks})}$	The percentage change in the equity-exclusive value of commercial bank liabilities.
$\text{pbbl}_{(\text{Banks})}$	The percentage change in end-of-year (equity-inclusive) commercial bank liabilities.
$\text{averorne}_{(\text{Banks})}$	The percentage change in the average rate of return on non-equity financial instruments issued by commercial banks as liability agents.
$\text{rpow}_{(\text{Banks,f,d})}$	The percentage change in the power (one 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.

Variable	Description
$a1d_{(Banks,f)}$	The percentage change in end-of-year non-equity liabilities issued by commercial banks as liability agents.
$Rpowd_{(Banks,f)}$	The percentage-change in the power of the rate of interest paid by commercial banks on non-equity financing instrument (f).

Table 4.4 Variables and Coefficients in the Main Capital Adequacy Equations

Equation (4.26) is the percentage change in the aggregate value of commercial bank risk weighted assets. Equation (4.27) describes the percentage change in the value of commercial bank equity at the end-of-year, as the weighted average of the percentage-changes in bank equity held by asset agent $(d) \in AA$. Equation (4.28) is the capital adequacy ratio in percentage terms, as expressed by outstanding equity liabilities divided by risk weighted assets. Equation (4.29) is the sum of commercial bank non-equity liabilities. Equation (4.30) is the percentage change in the average rate of return paid by the commercial bank on its non-equity financing instruments. Equation (4.31) determines the percentage changes in the optimal composition of the non-equity liabilities of commercial banks.

4.6.2 Modelling Bank Net Open Position (NOP)

The bank NOP is a macroprudential policy instrument that governs bank capital provision for the accumulation of net foreign liabilities. For example, a 25 per cent regulatory NOP means that the commercial banks have to provide Rp 4 of equity funding for every Rp 1 of net foreign liability accumulation. An increase in the NOP could be seen as a policy relaxation, as banks may access more net foreign liabilities with a given level of equity capital.

To model the NOP in the FCGE framework, I introduce a phantom tax along similar lines to the approach used by Dixon et al. (2021) to analyse the impact of financial decoupling between China and the U.S.. using the Global Trade Analysis Project (GTAP) model. These phantom taxes are not actual taxes, in the sense that no revenue is collected by government. They are instead tax equivalents, representing the impact on decision making of regulatory constraints faced by commercial banks. The NOP ratio is defined as a policy variable in AMELIA-F, which I assume to be a binding constraint for commercial banks. The levels form of the main equations representing the NOP theory in AMELIA-F are:

$$\mathrm{RNOP} = \frac{\mathrm{NOP}}{\mathrm{EQ\_BANK1}}, = \begin{Bmatrix} \mathrm{A1}_{(\mathrm{Banks,DepLoans,Row})} \\ -\mathrm{A1}_{(\mathrm{RoW,DepLoans,Banks})} \end{Bmatrix} / \mathrm{EQ\_BANK1} \tag{4.32}$$

$$\begin{aligned} &\mathrm{ROIL\_T}_{(\mathrm{Banks,DepLoans,RoW})} \\ &\qquad = \mathrm{ROIL}_{(\mathrm{Banks,DepLoans,RoW})} \\ &\qquad \cdot \mathrm{PTAX\_L}_{(\mathrm{Banks,DepLoans,RoW})} \end{aligned} \tag{4.33}$$

$$\mathrm{ROIA\_T}_{(\mathrm{RoW,DepLoans,Banks})} = \frac{\mathrm{ROIA}_{(\mathrm{RoW,DepLoans,Banks})}}{\mathrm{PTAX\_A}_{(\mathrm{RoW,DepLoans,Banks})}} \tag{4.34}$$

All levels-form variables that appear in Equation (4.32) to (4.34) are defined in Table 4.5.

No	Variable	Definition
1.	RNOP	NOP ratio.
2.	NOP	Nominal value of commercial bank net foreign liabilities (bank borrowing from foreigners minus bank lending to foreigners).
3.	EQ_BANK1	Commercial bank equity $\left(\sum_{d \in AA} \mathrm{AT1}_{(\mathrm{Banks,Equity,d})}\right)$.
4.	$\mathrm{ROIL\_T}_{(\mathrm{Bank,DepLoans,RoW})}$	Commercial banks' perceived power of the interest rate on bank deposits and loans supplied by foreign asset owners.
5.	$\mathrm{ROIL}_{(\mathrm{Bank,DepLoans,RoW})}$	Actual interest rate on bank deposit and loan liabilities held by foreign asset agents.
6.	$\mathrm{PTAX\_L}_{(\mathrm{Bank,DepLoans,RoW})}$	Power of the phantom tax on rates of return on bank deposits and loans provided to Indonesian banks by foreign asset agents.
7.	$\mathrm{ROIA\_T}_{(\mathrm{RoW,DepLoans,Banks})}$	Commercial banks' perceived power of the interest rate received on loans to foreign liability agents.
8.	$\mathrm{ROIA}_{(\mathrm{RoW,DepLoans,Banks})}$	Actual interest rate received by banks on loans to foreign liability agents.
9.	$\mathrm{PTAX\_A}_{(\mathrm{RoW,DepLoans,Banks})}$	Power of the phantom tax on interest rates on bank loans to foreign liability agents.

Table 4.5 Definitions of Level Term Variables

Equation (4.32) is the regulatory NOP ratio (RNOP) which is calculated as the ratio of the commercial bank's net foreign liabilities (foreign liabilities *minus* foreign assets) and their equity liabilities. The latter is largely determined by the bank capital adequacy ratio; see Section 4.6.1. In Equation (4.32), the numerator is defined to be the bank NOP, where the bank NOP is set equal to the amount of commercial bank deposit liabilities (DepLoans) held as assets by foreign investors, *minus* commercial bank loans (DepLoans) to foreigners. Equation (4.33) and (4.34) define the perceived cost to commercial banks of foreign deposit finance, and the perceived income received by commercial banks from foreign loans. I explain the key terms on the right-hand side of each equation via an example. Consider a rise in the regulatory NOP ratio. From Equation (4.32), this may be accommodated by commercial banks in three ways:

(i) by increasing foreign deposit liabilities ($\uparrow A1_{(\text{Banks,DepLoans,RoW})}$); or,

(ii) by decreasing loans provided to foreigners ($\downarrow A1_{(\text{RoW,DepLoans,Banks})}$); or,

(iii) By decreasing equity capital liabilities, but the level of these are regulated by the (exogenous) bank capital adequacy ratio.

To capture point (i) above, I introduce phantom taxes on the liability-side of the commercial bank decision making, via $\text{PTAX\_L}_{(\text{ROW})}$ in Equation (4.33). When the regulatory NOP rises in Equation (4.32), this is accommodated by lowering the regulatory cost to commercial banks of raising deposit finance. In AMELIA-F, this reduction in regulatory constraints is modelled as a lower phantom tax on foreign deposit financing $\left(\downarrow \text{PTAX\_L}_{(\text{ROW})}\right)$, reducing the regulatory *plus* actual cost of foreign deposit financing perceived by Indonesian commercial banks. This reduction in total cost drives $\text{ROIL\_T}_{(\text{Bank,DepLoans,ROW})}$ down in Equation (4.33). When setting their capital structure, $\text{ROIL\_T}_{(\text{Bank,DepLoans,ROW})}$ enters into commercial bank decision making via Equation (4.33).

Simultaneously, in AMELIA-F a rise in regulatory NOP can be accommodated through a lower incentive for commercial banks to allocate financial capital to the purchase of foreign loan liabilities. Ceteris paribus, $\text{ROIA\_T}_{(\text{RoW,DepLoans,Banks})}$ in Equation (4.34) decreases, via a rise in the phantom tax on the asset-side, i.e., $\uparrow$

$PTAX\_A_{(ROW)}$. When setting their financial asset allocation, $ROIA\_T_{(ROW,DepLoans,Banks)}$ enters into commercial bank decision making via Equation (4.25).

The percentage change form of the equations underlying the AMELIA-F NOP modelling are summarised in Equations (4.35) to (4.41) :

$$
\begin{aligned}
RNOP \cdot EQ\_BANK1 \cdot (pr\_nop + p\_eq\_bank1) \\
= A1_{(Banks,DepLoans,RoW)} \cdot at1_{(Banks,DepLoans,RoW)} \\
- A1_{(RoW,DepLoans,Banks)} \cdot at1_{(RoW,DepLoans,Banks)},
\end{aligned} \tag{4.35}
$$

$$
100 \cdot \Delta pr\_nop = RNOP \cdot pr\_nop, \tag{4.36}
$$

$$
\begin{aligned}
ROIL\_T_{(Banks,DepLoans,RoW)} \cdot rl\_t_{(Bans,DepLoans,RoW)} \\
= ROIL_{(Bans,DepLoans,RoW)} \cdot PTAX\_L_{(Bans,DepLoans,RoW)} \\
\cdot \left(roipowl_{(Bans,DepLoans,RoW)} + tl_{(RoW)}\right)
\end{aligned} \tag{4.37}
$$

$$
\begin{aligned}
ROIA\_T_{(RoW,DepLoans,Banks)} \cdot ra\_t_{(RoW,DepLoans,Banks)} \\
= \frac{ROIA_{(RoW,DepLoans,Banks)}}{PTAX\_A_{(RoW,DepLoans,Banks)}} \\
\cdot \left(roipowa_{(RoW,DepLoans,Banks)} - ta_{(RoW)}\right)
\end{aligned} \tag{4.38}
$$

$$
tl_{(RoW)} = -\alpha \cdot ta_{(RoW)} + ft \tag{4.39}
$$

$$
at1_{(s,f,d)} = liabilities_{(s)} - \tau_{(s)} \cdot \left(rl\_t_{(s,f,d)} - wacc\_t_{(s)}\right), \tag{4.40}
$$

$s \in LALF, f \in FI, d \in AA.$

$$
at1_{(s,f,d)} = assets_{(d)} + \sigma_{(d)} \cdot \left(ra\_t_{(s,f,d)} - averor\_t_{(d)}\right), \tag{4.41}
$$

$s \in LA, f \in FI, d \in AALF.$

All percentage change variables and parameters in Equations (4.35) to (4.41) are defined in Table 4.6 and 4.7.

No	Variable	Definition
1.	pr_nop	Percentage change in the NOP ratio.
2.	p_eq_bank1	Percentage change in bank equity.
3.	$at1_{(s,f,d)}$	Percentage change in end-of-year of asset instrument (f) issued by liability agent (s), held by asset agent (d).
4.	Δpr_nop	Ordinary change in the NOP ratio (percentage point).

No	Variable	Definition
5.	$rl\_t_{(s,f,d)}$	Percentage change in the perceived interest rate faced by liability agent (s) when issuing liability instrument (f) held by asset agent (d).
6.	$roipowl_{(s,f,d)}$	Percentage change in actual interest rate faced by liability agent (s) when issuing liability instrument (f) held by asset agent (d).
7.	$tl_{(d)}$	Percentage change in the power of the phantom tax on interest payments made by banks on deposits by agent (d).
8.	$ra\_t_{(s,f,d)}$	Percentage change in the perceived interest rate received by asset agent (d) for holding financial instrument (f) issued by liability agent (s).
9.	$roipowa_{(s,f,d)}$	Percentage change in actual interest rate of instrument (f) charged to agent (s) by asset agent (d).
10.	$ta_{(s)}$	Percentage change in the power of the phantom tax on bank loans given to agent (s).
11.	ft	A shift variable on the symmetric phantom tax adjustment equation.
12.	$liabilities_{(s)}$	Percentage change in the total liabilities of agent (s).
13.	$assets_{(d)}$	Percentage change in the total financial assets of agent (d).
14.	$wacc\_t_{(s)}$	Percentage change in the weighted average cost of capital faced by liability agent (s), phantom tax inclusive.
15.	$averor\_t_{(d)}$	Percentage change in average financial asset rate of return received by agent (d), phantom tax inclusive.

Table 4.6 Definition of Variables

No.	Parameter	Description
1.	α	Positive parameter on symmetric liability/asset phantom tax adjustment.
2.	$\tau_{(s)}$	Parameter governing the sensitivity of the composition of liability agent (s) financing sources to changes in the relative cost of alternative financing sources.
3.	$\sigma_{(d)}$	Parameter governing the sensitivity of asset agent (d)'s portfolio allocation to changes in relative rates of return across assets.

Table 4.7 Definition of Parameters

In what follows, I briefly describe each of Equations (4.35) to (4.41), and how they relate to the levels forms in Equations (4.32) to (4.34). Equation (4.35) is the percentage change in the NOP ratio given in Equation (4.32). Because this is assumed to be binding herein, this ratio is typically exogenous and shocked in line with shocks to the regulatory NOP ratio. In Equation (4.36), I convert the percentage change form of the NOP ratio into percentage points, which is useful in simulating changes to the regulatory

NOP ratio. Equations (4.37) and (4.38) are the percentage changes (respectively) in the perceived interest rate by commercial banks on their foreign deposit liabilities and foreign loan assets. Each equation is thus a function of the percentage change in the phantom tax on commercial banks deposit liabilities $\left(\text{rl\_t}_{(\text{Bank,DepLoans,ROW})}\right)$, and their loans $\left(\text{ra\_t}_{(\text{ROW,DepLoans,Banks})}\right)$ to foreigners.

Equation (4.39) links the phantom tax rates on the liability- and asset-sides of the commercial banks' optimisation problems, up to a difference in sign. If the parameter $\alpha = 1$ and ft is exogenously determined and unshocked, the commercial banks have no preferential bias toward adjusting their cost structure versus their asset allocation, as they seek to accommodate exogenously-imposed changes in the regulatory NOP ratio. Such symmetrical adjustment means that $\text{ta}_{(\text{ROW})} = \text{tl}_{(\text{ROW})}$. If $0 < \alpha < 1$ however, the commercial banks have a bias toward asset-side adjustments. Alternatively, $\alpha > 1$ means that the commercial banks tend to prefer to alter their capital structure to accommodate changes in the regulatory NOP ratio. Without prior knowledge about the value of α, herein I set α equal 1 in my financial model parametrisation and explore how the impact of regulatory NOP changes is altered under two alternative choices: $\alpha = 0$ (pure asset-side adjustment) and $\alpha \gg 1$ (pure liability-side adjustment).

Equations (4.40) and (4.41) are percentage change forms for the optimal setting of end-of-year capital structures and asset portfolios, respectively. In Equation (4.40), constrained by their financing needs $\left(\text{liabilities}_{(\text{s})}\right)$ liability agent (s) chooses its mix of end-of-year liabilities of instrument type (f) held by asset agent (d) $\left(\text{at1}_{(\text{s,f,d})}\right)$. As total costs for an (f,d) pair rises, i.e., $\uparrow \text{rl\_t}_{(\text{s,f,d})}$, relative to the weighted average costs of capital, i.e., $\text{wacc\_t}_{(\text{s})}$, due either to increases in the actual rate of interest payable or increases in perceived regulatory/phantom costs, liability agents tilt their end-of-year capital structure towards less expensive sources of finance because $\tau_{(\text{s})} > 0$. In contrast to the optimal decision faced by liability agents, the optimal asset decision depends on the budget for asset purchases $\left(\text{assets}_{(\text{d})}\right)$, and is an increasing function of the relative rate of return $\left(\text{ra\_t}_{(\text{s,f,d})} - \text{averor\_t}_{(\text{d})}\right)$.

4.6.3 Commercial Banks' Reserves in the Central Bank

The financial side of AMELIA-F facilitates interactions between commercial banks and the central bank. As a policy instrument, the central bank compels commercial banks to set reserve ratios in order to affect liquidity conditions in financial markets. At the same time, commercial banks also hold additional reserves with the central bank for exchange settlement purposes with other banks. In AMELIA-F, the reserve ratio requirement together with the settlement account comprises cash (Cash) and deposit (DepLoans) instruments. To incorporate reserve requirements in banks asset optimisation process, this requires deactivation of optimal bank asset allocations with regard to Cash and DepLoans in the standard bank behaviour.

In percentage-change terms, the commercial bank reserve ratio can be expressed as follows:

$$\mathrm{p\_resratio} = \mathrm{p\_bankresr} - \mathrm{at1}_{(\mathrm{Banks,DepLoans,HH})}, \tag{4.42}$$

where,

- $\mathrm{p\_resratio}$ is the percentage change in the reserve ratio;
- $\mathrm{p\_bankresr}$ is the percentage change in the value of commercial bank reserves in the central bank; and
- $\mathrm{at1}_{(\mathrm{Banks,DepLoans,HH})}$ is the percentage change in household deposits in the commercial banks.

The variable $\mathrm{p\_bankresr}$ is determined in the following equation:

$$\begin{aligned}\mathrm{BANKRESR}\cdot\mathrm{p\_bankresr} &= \mathrm{A1}_{(\mathrm{CB,Cash,Banks})}\cdot\mathrm{at1}_{(\mathrm{CB,Cash,Banks})}\\ &+ \mathrm{A1}_{(\mathrm{CB,DepLoans,Banks})}\cdot\mathrm{at1}_{(\mathrm{CB,DepLoans,Banks})}.\end{aligned} \tag{4.43}$$

Exclusion from the standard optimisation framework of the commercial banks reserves at the central bank requires a new optimisation setting for the commercial banks. The commercial bank optimal asset allocation problem must be redefined to cover only the rest of the assets held by banks. The process of excluding reserve assets from the optimisation problem is undertaken in four steps: (i) redefining the relevant asset budget,

(ii) recalculating average rates of return for non-reserve assets, (iii) restating the non-reserve asset optimisation problem, (iv) applying profit maximisation principles.

The non-reserve asset portfolio is determined by the following equation:

$$\begin{aligned} &\mathrm{BIGBUDNR}_{(\mathrm{Banks})} \cdot \mathrm{big\_bud\_nr}_{(\mathrm{Banks})} = \\ &\mathrm{BIGBUDGET}_{(\mathrm{Banks})} \cdot \mathrm{big\_bud}_{(\mathrm{Banks})} \\ &\qquad - \mathrm{A1}_{(\mathrm{CB,Cash,Banks})} . \mathrm{at1}_{(\mathrm{CB,Cash,Banks})} \\ &\qquad - \mathrm{A1}_{(\mathrm{CB,DepLoans,Banks})} . \mathrm{at1}_{(\mathrm{CB,DepLoans,Banks})}, \end{aligned} \tag{4.44}$$

where,

- $\mathrm{BIGBUDNR}_{(\mathrm{Banks})}$ is the commercial banks' asset budget for holdings of non-reserve assets; and
- $\mathrm{big\_bud\_nr}_{(\mathrm{Banks})}$ is the percentage change in commercial banks' asset budget for non-reserve assets holdings.

The RHS of equation (4.44) shows the commercial banks' overall asset holdings less cash and deposit liabilities issued by the central bank and held by commercial banks.

The average rate of return on non-reserve assets is recalculated in the following equation:

$$\begin{aligned} &\mathrm{ave\_ror\_nr}_{(\mathrm{Banks})} \\ &= \sum_{s \in \mathrm{LANCB}} \sum_{f \in \mathrm{FI}} \left[\frac{\mathrm{AT1}_{(s,f,\mathrm{Banks})}}{\mathrm{BIGBUDNR}_{(\mathrm{Banks})}} . \mathrm{roipowa}_{(s,f,\mathrm{Banks})} \right] \\ &+ \sum_{f \in \mathrm{NONCASHDEP}} \left[\frac{\mathrm{AT1}_{(\mathrm{CB},f,\mathrm{Banks})}}{\mathrm{BIGBUDNR}_{(\mathrm{Banks})}} . \mathrm{roipowa}_{(\mathrm{CB},f,\mathrm{Banks})} \right]. \end{aligned} \tag{4.45}$$

where,

- $\text{ave\_ror\_nr}_{(\text{Banks})}$ is the weighted average rate of return on non-reserve assets received by the commercial banks.

The set LANCB comprises non-central bank financial agents (=LA-("CB")). The set NONCASHDEP consists of non-cash and non-deposit financial instruments (=FI-("Cash")-("DepLoans")). The RHS of Equation (4.45) comprises the weighted average rates of return of financial instruments issued by non-central bank liability agents $\left(\sum_{s \in \text{LANCB}} \sum_{f \in \text{FI}} \left[\frac{\text{AT1}_{(s,f,d)}}{\text{BIGBUDNR}_{(d)}} . \text{roipowa}_{(s,f,d)}\right]\right)$ *plus* the weighted average rate of return on non-cash and deposit assets issued by the central bank $\left(\sum_{f \in \text{NONCASHDEP}} \left[\frac{\text{AT1}_{(CB,f,d)}}{\text{BIGBUDNR}_{(d)}} . \text{roipowa}_{(CB,f,d)}\right]\right)$.

Given the new asset budget and average rate of return for non-reserve assets, the new optimal asset allocation held by the commercial banks is given by the following equations:

$$\text{at1}_{(s,f,\text{Banks})} = \text{assets\_nr}_{(\text{Banks})} + \sigma_{(\text{Banks})}\left[\text{roipowa}_{(s,f,\text{Banks})} - \text{ave\_ror\_nr}_{(\text{Banks})}\right], \quad (4.46)$$
$$s \in \text{LANCB}, f \in \text{FI}.$$

$$\text{a\_t\_1}_{(CB,f,\text{Banks})} = \text{assets\_nr}_{(\text{Banks})} + \sigma_{(\text{Banks})}\left[\text{roipowa}_{(CB,f,\text{Banks})} - \text{ave\_ror\_nr}_{(\text{Banks})}\right], \quad (4.47)$$
$$f \in \text{NOTCASHDEP}.$$

Equations (4.46) and (4.47). calculate the banks' asset allocations across financial instruments issued by non-central bank and the central bank agents, respectively.

4.7 The Central Bank

Describing the behaviour of the central bank asset allocation decision making begins with determining its asset budget for purchasing domestic assets and the average return on these assets. The central bank budget to purchase domestic assets is formulated in the following equation:

$$\text{BIGBUDNF}_{(CB)} \cdot \text{big\_bud\_nf}_{(CB)} = \text{BIGBUDGET}_{(CB)} \cdot \text{big\_bud}_{(CB)} \quad (4.48)$$

$$-\sum_{f \in FI} AT1_{(ROW,f,CB)} \cdot at1_{(ROW,f,CB)},$$

where,

- $BIGBUDNF_{(d)}$ and $big\_bud\_nf_{(d)}$ are respectively the level and the percentage change in the central bank's holdings of domestic assets.

The RHS of Equation (4.48) describes the overall budget of the central bank *minus* the central bank's holdings of foreign assets. The average rate of return received by the central bank on assets issued by domestic agents are given as follow:

$$ave\_ror\_nf_{(CB)} = \sum_{s \in LALF} \sum_{f \in FI} \left[\frac{A1_{(s,f,CB)}}{BIGBUDNF_{(CB)}} . roipowa_{(s,f,CB)} \right], \tag{4.49}$$

where,

- $ave\_ror\_nf_{(CB)}$ is the percentage change in average power of the rates of return received by the central bank on its holdings of domestic assets.

Having the budget and average rate of return for domestic assets in place, the central bank domestic asset allocation decision process is formulated as follows:

$$at1_{(s,f,CB)} = big\_bud\_nf_{(CB)} + \sigma_{(CB)} \left[roipowa_{(s,f,CB)} - ave\_ror\_nf_{(CB)} \right] \tag{4.50}$$
$$s \in LALF, f \in FI.$$

Following the same concept, the central bank's foreign asset allocation decision making can be defined. The central bank's aggregate holding's of foreign assets is expressed as follows:

$$\mathrm{BIGBUDFOR}_{(CB)} \cdot \mathrm{big\_bud\_for}_{(CB)} = \mathrm{BIGBUDGET}_{(CB)} \cdot \mathrm{big\_bud}_{(CB)} - \sum_{s \in LALF, f \in FI} \mathrm{A1}_{(s,f,CB)} \cdot \mathrm{at1}_{(s,f,CB)}, \tag{4.51}$$

where,

- $\mathrm{BIGBUDFOR}_{(CB)}$ and $\mathrm{big\_bud\_for}_{(CB)}$ are the level and the percentage-change in central bank holdings of foreign assets.

The RHS of Equation (4.51) explains the overall budget reduced by the total acquisitions of domestic assets. Next, the composite rate of return on foreign assets is given by the following equation:

$$\mathrm{ave\_ror\_for}_{(d)} = \sum_{f \in FI} \left[\frac{\mathrm{A1}_{(ROW,f,d)}}{\mathrm{BIGBUDFOR}_{(d)}} . \mathrm{roipowa}_{(ROW,f,d)} \right], \tag{4.52}$$

where,

- $\mathrm{ave\_ror\_for}_{(d)}$ is the power of the weighted average rates of return on foreign instruments held by asset agent $d \in AA$.

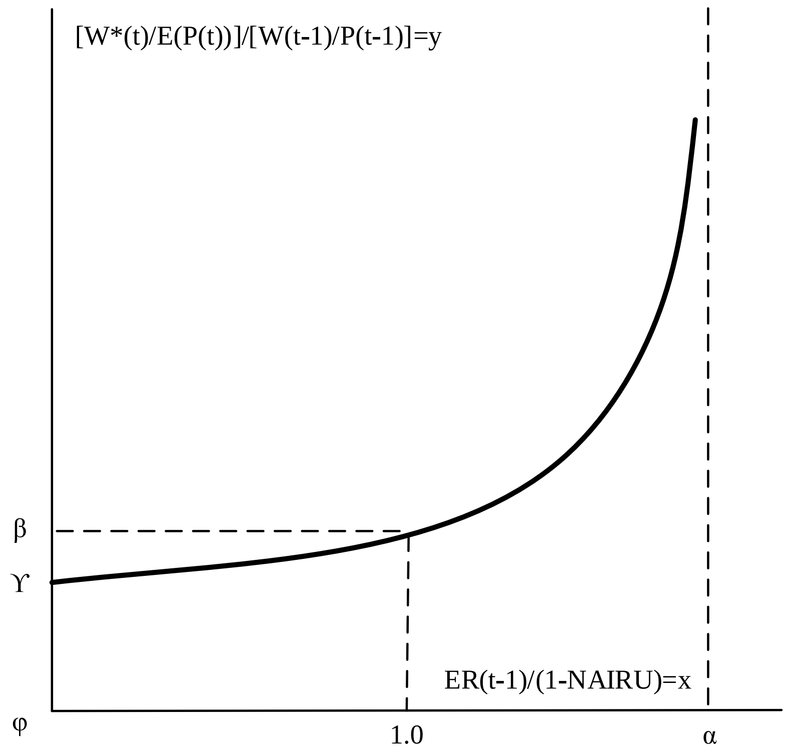
Similarly, the asset optimising problem for the composition of central bank foreign asset holdings is given by:

$$\mathrm{a\_t\_1}_{(ROW,f,CB)} = \mathrm{big\_bud\_for}_{(CB)} + \sigma_{(CB)} \left[\mathrm{roipowa}_{(ROW,f,CB)} - \mathrm{ave\_ror\_for}_{(CB)} \right] \tag{4.53}$$

$f \in FI, d \in LALF.$

4.8 Asymmetric Wage Adjustment

In a typical real-side CGE model, standard treatments of the labour market allow for short-run wage stickiness, with transition to a long-run in which employment is given and wages adjust. In AMELIA-F, I impose a Phillips curve (Phillips, 1958) describing the relationship between the price level and unemployment as illustrated by Figure 4.1.



Source: Giesecke et al. (2015)

Figure 4.1 Asymmetric Wage Adjustment (Phillip's Curve)

In Figure 4.1, the x axis describes the strength of the labour market, represented by the lagged deviation of the employment rate from its natural rate (1-NAIRU). The y axis describes desired wage growth on the part of workers, represented by the deviation of the expected real wage from the previous year's actual real wage. β is desired real wage growth when the lagged unemployment rate is at the NAIRU. γ is the lowest level of wage growth that workers will accept in the worst labour market conditions. At this point, employment rate deviates over its natural level by ϕ.

The functional form of the Phillip's Curve in Figure 3.1 is given by the following equation:

$$y = \frac{A}{(e^{\beta(x-\alpha)})}, \tag{4.54}$$

where,

- $y = \left[W^*_{(t)}/E\left[P_{(t)}\right]\right]/\left[W_{(t-1)}/P_{(t-1)}\right]$ and $x = ER_{(t-1)}/(1 - \text{NAIRU})$;

- $W^*_{(t)}$ is year t expected nominal wage;
- $E[P_{(t)}]$ is year (t) expected consumer price index (CPI);
- $W_{(t-1)}$ is lagged actual nominal wage;
- $P_{(t-1)}$ is lagged actual CPI;
- $ER_{(t-1)}$ is lagged actual employment rate.

The parameterisation of A and β in Equation (4.68) must guarantee that $y(\cdot)$ satisfies points (ϕ, γ) and $(1, \beta)$.

Equation (4.55) then can be transformed into percentage change form, as follows:

$$(\mathrm{p1lab\_oi\_targ} - \mathrm{p3tot\_exp}) - (\mathrm{p1lab\_oi\_l} - \mathrm{p3tot\_l}) = \mathrm{WAGE\_ELAS2} \cdot \mathrm{emprate\_l} + \mathrm{fp1lab\_oi4}, \quad (4.55)$$

where,

- p1lab_oi_targ is the percentage change in the expected nominal wage;
- p3tot_exp is the percentage change in the expected consumer price index;
- p1lab_oi_l is the percentage change in the lagged actual nominal wage;
- p3tot_l is the percentage change in the lagged actual consumer price index;
- emprate_l is the percentage change in the lagged employment rate;
- fp1lab_oi4 is a shift variable; and
- WAGE_ELAS2 is a positive parameter which ensures the $y(\cdot)$ pass through points (ϕ, γ) and $(1, \beta)$.

To activate Equation (4.55), fp1lab_oi4 needs to be exogenised. At the same time, the shifter on the standard sticky-wage equation (del_f_wage_c) in the real-side of the model must be endogenously determined in order to de-activate the standard real-side sticky wage theory. By undertaking these swaps, the asymmetric adjustment of the wage (the Phillip curve) replaces the traditional sticky-wage adjustment principle operating in the real model.

The expected inflation in AMELIA-F follows the adaptive expectation principle. This setting is implemented in the level form, as follows:

$$E\left[P^{(3)}_{(t)}\right] = P^{(3)}_{(t-1)} \cdot E\left[T^{(3)}_{(t)}\right], \quad (4.56)$$

where,

- $E\left[P_{(t)}^{(3)}\right]$ is the expected CPI at year t;
- $E\left[T_{(t)}^{(3)}\right]$ is the expected trend of CPI expressed in power terms (one plus the percentage rate); and
- $P_{(t-1)}^{(3)}$ is the lagged CPI.

The percentage-change of Equation (4.57) is given as follows:

$$\mathrm{p3tot\_exp} = \mathrm{p3tot\_l} + \mathrm{p3tr\_pow\_exp} + \mathrm{fp3tot\_exp2}, \tag{4.57}$$

where,

- p3tot_exp is the percentage change in the expected consumer price index;
- p3tot_l is the percentage change in the lagged consumer price index;
- p3tr_pow_exp is the percentage change in the trend of the consumer price index; and
- fp3tot_exp2 is a shift variable.

Meanwhile, the expected trend equation is defined in the following way:

$$T_{(t)}^{(3)} = \xi \cdot T_{(t-1)}^{(3)\mathrm{Trend}} + (1-\xi) \cdot T_{(t-1)}^{(3)}, \tag{4.58}$$

where,

- $T_{(t-1)}^{(3)\mathrm{Trend}}$ is lagged inflation trend;
- ξ is a share parameter valued at 0.5.

Equation (4.59) explains that the expected trend is determined as a weighted average of trend CPI inflation and lagged inflation. In percentage-change terms, the equation can be restated as follows:

$$\mathrm{p3tr\_pow\_exp} = \mathrm{p3tr\_pow}, \tag{4.59}$$

$$\begin{aligned} \mathrm{TREND\_P3} \cdot \mathrm{p3tr\_pow} \\ &= [\mathrm{TREND\_ADJ2} \cdot \mathrm{TREND\_P3\_L}] \cdot \mathrm{p3tr\_pow} \\ &+ \big[[1-\mathrm{TREND\_ADJ2}] \cdot \mathrm{INF3POW\_L}\big] \cdot \mathrm{p3inf\_pow\_l}, \end{aligned} \tag{4.60}$$

where,

- p3tr_pow is the percentage-change in the power of (CPI) inflation trend;
- p3inf_pow_l is the percentage-change in lagged inflation;

- TREND_P3 is level variable $T_{(t)}^{(3)}$;
- TREND_P3_L is level variable $T_{(t-1)}^{(3)}$;
- TREND_ADJ2 represents parameter ξ; and
- INF3POW_L is level term power of lagged inflation.

Both Equation (4.60) and (4.61) explain the moving average of the lagged trend of inflation.

4.9 Central Bank's Policy Rule

The central bank is required to respond to movements in the aggregate price level and the unemployment rate. Depending on details of its mandate, the central bank tries to direct the actual rate of inflation towards its target and the actual unemployment rate towards its natural level (i.e., the non-accelerating inflation rate of unemployment, NAIRU). The central bank's policy is assumed in AMELIA-F to follow a policy rule in setting its policy rate (cash rate). It follows mechanism defined as a Taylor rule (Taylor, 1993, and Orphanides, 2007). The policy rate is a function of the deviations in the inflation and employment rates from their targets. Following Giesecke et al. (2015), the Taylor rule in AMELIA-F is formulised as follows:

$$\left(\frac{\mathrm{ROIL}_{(\mathrm{CB,DepLoans,Banks})(t)}}{\mathrm{ROIL}_{(\mathrm{CB,DepLoans,Banks})(t-1)}}\right) = \mathrm{FR}\cdot\left(\frac{P_{(t)}^{(3)}}{P_{(t)}^{(3)(T)}}\right)^{\alpha}\cdot\left(\frac{\mathrm{ER}_{(t)}}{\mathrm{ER}_{(t)}^{(T)}}\right)^{1-\alpha}, \tag{4.61}$$

where,

- $\mathrm{ROIL}_{(\mathrm{CB,DepLoans,Banks})(t)}$ and $\mathrm{ROIL}_{(\mathrm{CB,DepLoans,Banks})(t-1)}$ are the current and lagged powers of the rates of return received by and paid by banks on exchange settlement balances with/loans from the central bank (i.e., the policy rate);
- FR is a shift variable;
- $P_{(t)}^{(3)}$ and $P_{(t)}^{(3)(T)}$ are the actual and target levels for the CPI in year (t);
- $\mathrm{ER}_{(t)}$ and $\mathrm{ER}_{(t)}^{(T)}$ are the actual and target levels for the employment rate respectively;

- α is weight parameter valued (0,1).

In AMELIA-F, I assume that the central bank takes an intermediate position between prioritising price and employment rate stability, hence setting $\alpha = 0.5$. This assumption is based on my observation that the central bank often explains that its determination of the policy rate (cash rate) is to achieve both inflation and economic stability.[13]

The percentage-change form of Equation (4.61) is given as follows:

$$\begin{aligned}(\mathrm{cash\_rate\_pow} - \mathrm{cash\_rate\_pow\_lag}) \\ = \mathrm{INFCOEF} \cdot (\mathrm{p3tot} - \mathrm{p3tot\_targ}) + \mathrm{GAPCOEF} \\ \cdot (\mathrm{emp\_rate} - \mathrm{emp\_rate\_targ}) + \mathrm{ftaylor2},\end{aligned} \tag{4.62}$$

where,

- $(\mathrm{cash\_rate\_pow} - \mathrm{cash\_rate\_pow\_lag})$ is the percentage change in the year (t) policy rate relative to the (t-1) policy rate;
- $(\mathrm{p3tot} - \mathrm{p3tot\_targ})$ is the percentage change in the consumer price index relative to the target for the consumer price index;
- $(\mathrm{emp\_rate} - \mathrm{emp\_rate\_targ})$ is the percentage change in the employment rate relative to the target for the employment rate;
- $\mathrm{ftaylor2}$ is a shift variable;
- $\mathrm{INFCOEF}$ is the α parameter in Equation (4.62), hence $\mathrm{GAPCOEF}$ is $1 - \alpha$.

When Equation (4.62) is activated (by exogenising $\mathrm{ftaylor2}$), the model has a balancing mechanism via which the central bank aims to correct price and employment deviations towards the predetermined targets.

4.10 Conclusions

This chapter provides an overview of the financial-side of the AMELIA-F model. The financial-side model comprises the theory describing the interactions between financial agents and their linkages to the real-side model of AMELIA-F. The behaviours of financial agents are derived from constrained optimisation processes or describe institutional settings and restrictions. In general, liability agents choose the combination

[13] For a recent example, please see Bank Indonesia's Monetary Policy Report Q1 2022 (Bank Indonesia, 2022).

of financing instruments that minimises the value of a function of the weighted average cost of servicing its liabilities. Asset agents allocate their portfolios to maximise a function of the weighted average of the returns on the financial assets they own. In general, departures from these general settings reflect institutional and regulatory constraints on financial agent behaviour.

There are five linkages through which the financial-side model connects to the real-side model of AMELIA-F. First, the current account deficit, as calculated in the real-side model, is financed by net domestic asset acquisition by foreigners in the financial-side model. Second, the public sector borrowing requirement, as determined in the real-side model, is financed through net liability issuance by the government in the financial-side model. Third, investment, as calculated in the real-side model, is financed by the net liabilities raised by capital creating agents in the financial-side model. Fourth, aggregate household savings from the real-side model is linked to new asset acquisitions by the household agent in the financial-side model. Fifth, the required rates of return that determine investment activity in the real-side model are linked to the weighted average cost of financial capital (WACC) of the industry and housing sectors as determined in the financial-side of the model.

To answer the central questions of this thesis i.e., what are the economic effects of financial regulations on the banking industry, the modelling of commercial banks is further detailed. This task is undertaken by incorporating three financial policies relating to the commercial banks. First is the bank capital adequacy ratio (CAR). To accommodate change in bank CAR, the standard bank's decision making has to be redefined to allow bank compliance with regulatory capital. Second is the constraint on bank deposits and loans with foreigners, represented by regulated bank net open position (NOP). For this policy instrument, the bank decision making process incorporates a phantom tax (a regulatory cost) in their perceived interest rates. This affects bank decision making on their deposits and loans with foreigners. Third is the modelling of bank reserves, to allow direct interactions between commercial banks and the central bank.

The central bank can affect economic activity in two ways. First, by directly influencing bank lending through its capacity to set mandated bank reserves with the central bank. Second, by undertaking open market operations to hit the policy rate target. Setting of the latter in AMELIA-F is endogenised by introducing a Taylor rule arrangement that weights an inflation target and an employment target (Taylor, 1993, and Orphanides, 2007).

CHAPTER 5
Real-side Database

5.1 Introduction

The AMELIA-F database consists of two major structures: (i) a real-side database; and (ii) a financial-side database. The real-side database underlies the theoretical structure explained earlier in Chapter 3. The financial-side database underlies the theories explained in Chapter 4. This chapter focuses on the steps taken to develop the real-side database of AMELIA-F. The real-side database of AMELIA-F has a similar structure to that used in ORANI-G (Dixon et al. 1982), *plus* dynamic mechanisms, government accounts, and foreign accounts as explained in the MONASH model documentation (Dixon & Rimmer, 2002), the successor of ORANI-G.

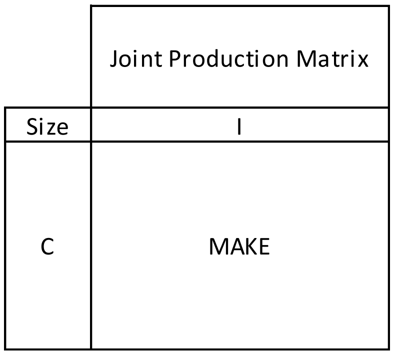
This chapter reports the necessary processes in developing the real-side database of AMELIA-F. The main source of the database is the 2010 Indonesian input-output table (IOT) of the Indonesian Statistical Agency (BPS, 2015); the national labour survey of BPS (2015a); the Indonesian Economic and Financial Statistics of Bank Indonesia (2020); and the Joint Publication Indonesian Public Debt Statistics of Indonesian Central Bank and Ministry of Finance (Kementerian Keuangan & Bank Indonesia, 2012). Where the required statistics are not available via official sources, I refer to Indonesian data in GTAP database 9 (Aguiar et al. 2016). The values of parameters and elasticities are mostly taken from previous Indonesian CGE studies (e.g., Horridge & Yusuf, 2017; Abimanyu, 2000; and Wittwer, 1999).

The chapter begins with the identification of the discrepancies between the database required by the AMELIA-F model and the available data from official sources. Based on this identification, I then undertake several manipulations to transform the official data to the required model format. Once the database is ready, I perform validity tests recommended by Horridge (2013): e.g., nominal and real homogeneity tests, equality of expenditure and income GDP, and the balance of total costs and sales to validate the zero-pure-profits assumption of the model and database.

5.2 Required Structure of the Real-Side Database

The structure of the real-side database is illustrated in Figure 5.1. The column labels represent the real economic agents or users: (1) producers, (2) investors, (3) households, (4) exports, (5) government, and (6) net addition to stocks (inventory). The rows are the sources or types of transaction: basic flows, margins, taxes, primary factors (i.e., labour, capital, land), and other costs (i.e., production taxes). A single column entry indicates the consumption or purchase by a real economic agent of a specific transaction type. The sum up of the column entries shows the total purchases or total costs of a particular real-side economic agent.

		Users (U)					
		1	2	3	4	5	6
		Producers	Investors	Household	Exports	Government	Change in Inventory
	Size	←I→	←I→	←1→	←1→	←1→	←1→
Basic Flows	CxS	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Margins	CxSxM	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	n/a
Taxes	CxS	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	n/a
Labour	OCC	V1LAB					
Capital	←1→	V1CAP					
Land	←1→	V1LND					
Production Taxes	←1→	V1PTX					



Source: Adapted from Horridge, (2003)

Figure 5.1 Structure of the real-side database

In Figure 5.1, basic flows show the value of commodity $(c) \in \mathrm{COM}$ from source $(s) \in \mathrm{SRC}$ consumed by user $(u) \in \mathrm{USERS}$. Margins are trade and transportation related commodities $(m) \in \mathrm{MAR}$ which facilitates delivery of commodity $(c) \in \mathrm{COM}$ from source $(s) \in \mathrm{SRC}$ consumed by user $(u) \in \mathrm{USERS}$. Taxes are indirect taxes for consumption of commodity $(c) \in \mathrm{COM}$ from source $(s) \in \mathrm{SRC}$ by user $(u) \in \mathrm{USERS}$. Labour, Capital, and Land are respectively the value of the wage bill, rental of capital, and rental of land by industry $(i) \in \mathrm{IND}$. Herein, $\mathrm{IND} \subset \mathrm{USERS}$ and $\mathrm{IND} = \mathrm{COM}$. In AMELIA-F, it is possible for an industry to produce more than one commodity in the current production process. This is captured by the MAKE matrix of $(c) \in \mathrm{COM}$ by $(i) \in \mathrm{IND}$ at the bottom of Figure 5.1. The definitions of the sets and elements are given in Table 5.1. Set of IND and COM have the same number of elements. SRC denotes the source of commodity supplies which can be obtained from domestic or imported. The set of margins, MAR, has 6 elements covering trade and transport related commodities. FAC denotes the set of primary factors, whose elements are labour, capital, and land.

Set	Description	Index	Element
IND	Set of industries	i	51 industries
COM	Set of commodities	c	51 commodities
SRC	Set of sources	s	domestic and import
MAR	Set of margin commodities	m	(1) Sales and Maintenance; (2) Retail; (3) Land transportation; (4) Water transportation; (5) Air transportation; and

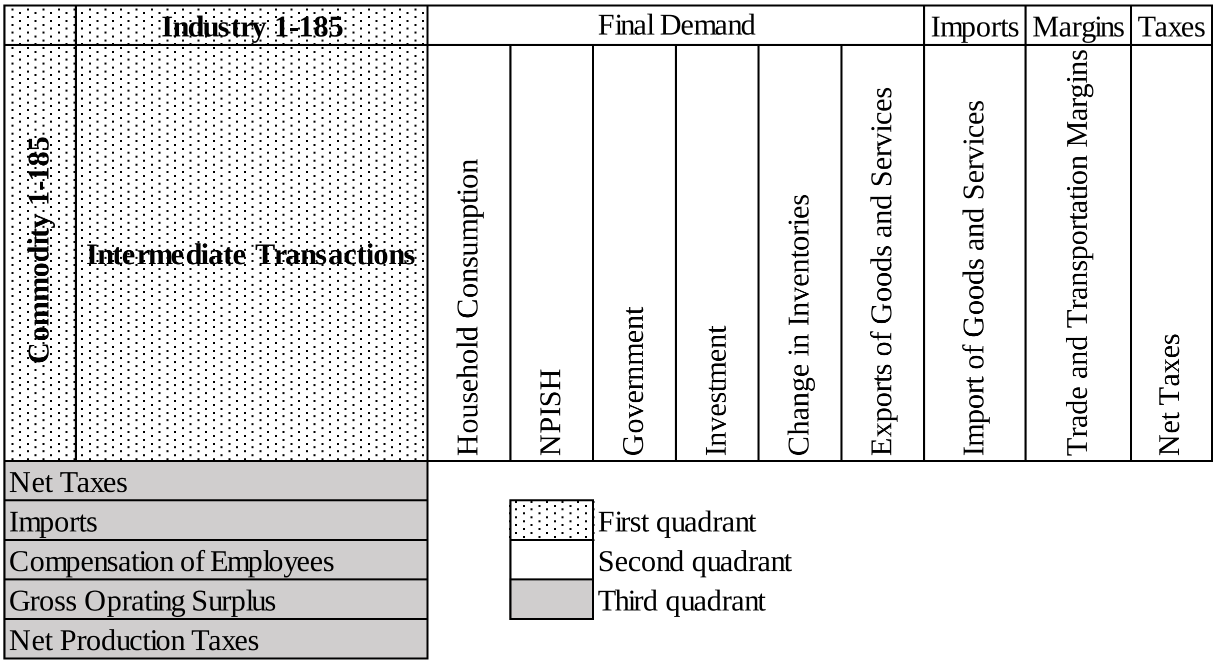
Set	Description	Index	Element
FAC	Set of Primary Factors	f	(6) Others. (1) Labour; (2) Capital; and (3) Land.

Table 5.1 Definition of Set in the Real-side Database

In the real-side database development, I follow notation conventions used in the real-side modelling in Chapter 3. The basic flows are conventionally written as V<*agent's number*>BAS. Hence, the basic value of intermediate input purchases by industry is written as V1BAS. Indirect taxes can be levied on the use of commodities. This is denoted as V<*agent's number*>TAX. For example, the value of indirect taxes on commodities used by industry is written as V1TAX. To deliver the commodities to final users, agents require transportation and trade services. These are valued in "Margin Flows" matrices recorded via the naming convention (V<*agent's number*>MAR). The margin commodities required to facilitate purchases of intermediate inputs by industry are written as V1MAR. The sum of the basic value, indirect taxes, and margins yields the purchasers value, denoted via (V<*agent's number*>PUR). The purchaser's value of commodities used by industry is written as V1PUR, where V1PUR = V1BAS + V1TAX + V1MAR. The labour costs, capital rentals, and land rentals are denoted respectively by V1LAB, V1CAP, V1LND. The production taxes are denoted by V1PTX. The sum up of overall matrices in current production is the total production costs (V1TOT), where V1TOT = V1PUR + V1LAB + V1CAP + V1LND + V1PTX.

5.3 The Structure of Official Data

The structure of the 2010 Indonesian input-output table (IOT) can be illustrated in Figure 5.2. The table is divided into three quadrants. The first quadrant (small dots shaded area) indicates the intermediate use of commodity (c) $\in \mathrm{COM}$ by the industries (i) $\in \mathrm{IND}$ for current production. The second quadrant (white shaded area) shows commodity (c) $\in \mathrm{COM}$ used by final demand agents; imported commodities; margins; and indirect taxes. The third quadrant (grey shaded area) represents indirect taxes; imports; primary factors (compensation of employee and gross-operating surplus); and net production taxes of industries (i) $\in \mathrm{IND}$. The sum of the first and second quadrant reflects the total output of the economy valued at purchaser prices. The sum of first and third quadrant describe the input structure and total industry costs of production. A balancing condition of the database is that total output (row totals) must equal total input (column totals).



Adapted from: BPS (2015)

Figure 5.2 Original Structure of 2010 Indonesian Input-Output Table

Table 5.2 summarises the calculations of 2010 Indonesian GDP as reported by BPS (2015). Indonesian 2010 GDP was Rp6,864 trillion, calculated via production, expenditure, and income approaches in what follows. Under the production approach, total domestic output of Rp13,109 trillion, minus intermediate inputs of Rp6,425 trillion, provides aggregate GDP from the income side. Under the expenditure approach, total demand for goods and services of Rp8,402 trillion, less the value of imports of Rp1,538, provides GDP at market prices from the expenditure side. Under the income approach, GDP at market prices is the sum of total factor income (wage bill or employment), capital owner (gross operating surplus-GOS)), and indirect tax revenue. These numbers will be useful in the later sections to validate the newly created database.

Production		Expenditure		Income	
Domestic output	13109	Final demand	8402	Employment	2170
Intermediate consumption	-6425	Import	-1538	Gross operating surplus	4456
				Indirect taxes	58
				Production taxes	180
GDP	6684	GDP	6864	GDP	6864

Table 5.2 Summary of GDP Calculations (in Rp Trillion)

By comparing Figure 5.1 and Figure 5.2, I find structural differences between the required database and the existing official database. This requires further database processing that aims to transform the official database to the targeted database.

5.4 Construction of the Required Database

This section records the steps undertaken to transform the original IOT into the required form for the model database. To aid with checking, and for the convenience of future development work with the model, the data construction processes are recorded in GEMPACK codes. The conversion processes can be divided into three steps, as follows:

(i) **Splitting** the original database into a few partitioned matrices. The matrices are saved into a few different HAR files (*.har).

(ii) **Preparing** essential matrices which have similar dimensions to the matrices in the required database.

(iii) **Converting** the essential matrices into the final required database.

5.4.1 Splitting the original database

Table 5.3 reports six matrices to accommodate the partition of the original IO table. All definitions of matrices, sets, and elements are given in Table 5.4. $\mathrm{BASDOM}_{(c,u)}$ accounts for the basic value of domestically-produced commodities $(c) \in \mathrm{COM}$ consumed by user $(u) \in \mathrm{USERS}$. The users of these commodities comprise industries and final demanders. The expenditures of these agents on domestic commodities accounts for Rp13,109 trillion. This number is equal to the domestic output entry in Table 5.2. $\mathrm{BASIMP}_{(c,u)}$ records the basic value of imported commodity $(c) \in \mathrm{COM}$ used by user $(u) \in \mathrm{USERS}$. The total value of $\mathrm{BASIMP}_{(c,u)}$ is Rp1,538 trillion or 10 per cent of the total basic value of commodities purchased by all users.

No	Coefficient	Dimension	Value
1	$BASDOM_{(c,u)}$	COM*USERS	Rp13,109 trillion
2	$BASIMP_{(c,u)}$	COM*USERS	Rp1,538 trillion
3	$MARGINS\_M_{(c)}$	COM	Rp1,448 trillion
4	$TAXS_{(c)}$	COM	Rp180 trillion
5	$VA\_0_{(v,i)}$	ROWVA*USERS	Rp6,683 trillion
6	$PRODTAX_{(i)}$	IND	Rp180 trillion

Table 5.3 Basic Splits from the Original IO Table

No	Set	Index	Description	Formula/Element of Set
1	COM	c	Commodity	COM = IND
2	IND	i	Industry	
3	DEMAND	d	Final Demander	House, NPISH (Non-profit institutions serving households),[14] Govern, Invest, Stocks, ExpGoods, ExpServ
4	USERS	u	All Users	IND + DEMAND
5	MARCOM	m	Margin Commodities	CarTrading, OthTrade, RailTransprt, LandTransprt, SeaTransport, RiverTrnsprt, AirTransport,TransportSvc
6	NMARCOM	nm	Non-Margin Commodities	COM-MARCOM
7	DMAR	dm	Margin Demander	DMAR = USERS - Stocks
8	VA	v	Value Added	COE, GOS, ProdTax
9	OCT	o	Other Costs Tickets	OCT
10	SRC	s	Source	Dom, Imp

Table 5.4 Definitions of Matrices, Sets, and Elements used in Database Transformation Process

Users directly or indirectly consume margin commodities. Direct margin consumption is when an industry uses a margin commodity for other than a margin purpose (e.g. use of insurance commodity for worker compensation insurance purposes). Indirect margin commodity use is when an industry uses margin commodities to facilitate the use of non-margin commodities (e.g. use of insurance to insure transit of material inputs). $MARGINS\_M_{(c)}$ is the value of margin to facilitate the consumption of commodity $(c) \in COM$ valued at Rp1,448 trillion. The net taxes on commodities, valued at Rp180

[14] NPISH agent is non-profit organisations including sport clubs, charities, religious organisations, etc. This agent is assumed to behave similarly to traditional household sector.

trillion, purchased by aggregated user agents, are stored in $TAXS_{(c)}$. $VA\_0_{(v,i)}$ is the primary factor compensation of factor (v) ∈ FAC in industry (i) ∈ IND, valued at Rp6,683 trillion. $PRODTAX_{(i)}$ records net production tax by industry and valued at Rp180 trillion.

The workflows of the database split process in this section are summarised in Figure 5.3. Line 1 to 5 creates the basic matrices as in Table 5.3. However, $BASDOM_{(c,u)}$ still includes margin values, which does not fit the arrangement of the required database. The process to take the margin values from $BASDOM_{(c,u)}$ will be explained later. For $MARGINS\_M_{(c)}$, $TAXS_{(c)}$, $VA\_0_{(v,i)}$, and $BASIMP_{(c,u)}$, the splitting process is relatively straight forward. It does not require additional treatment to create the targeted database (line 9, 10, 11, and 12).

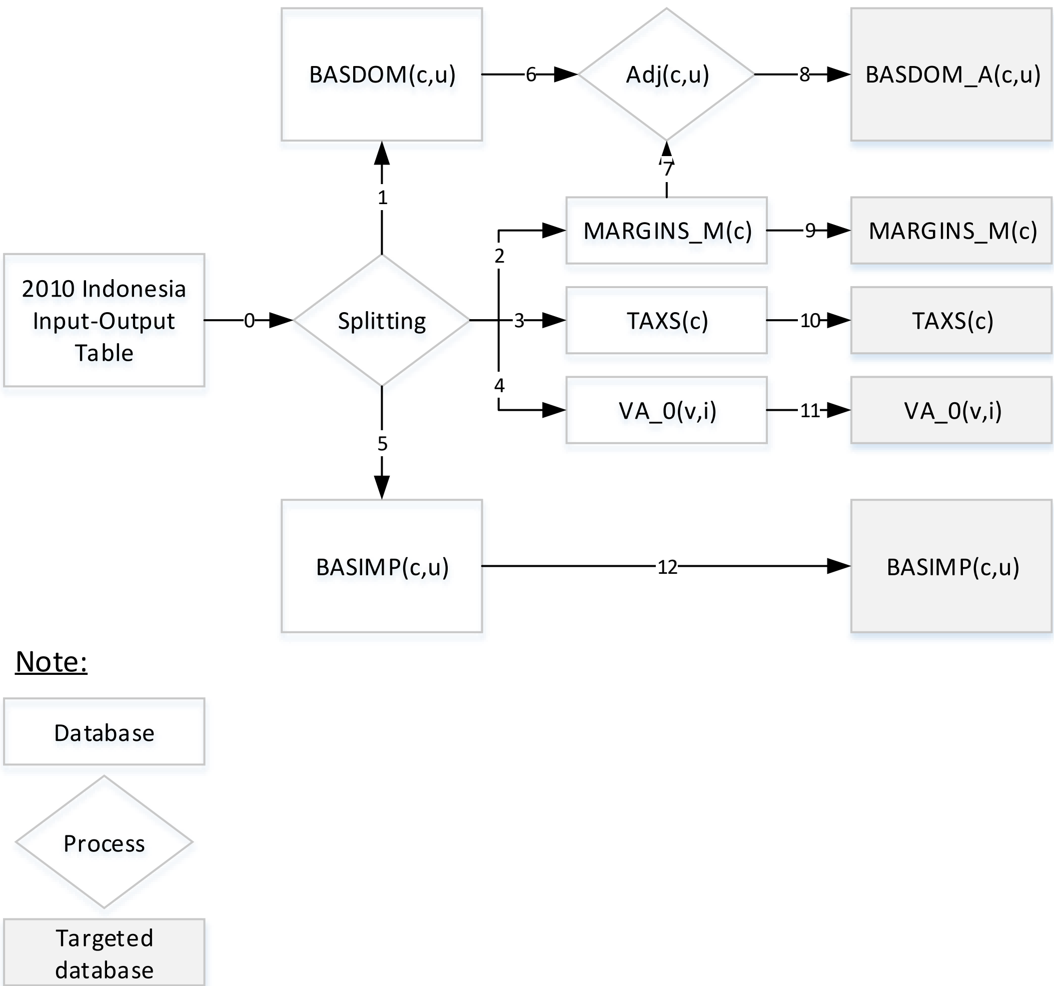


Figure 5.3 Splitting Process

To take margin commodities out of $\mathrm{BASDOM}_{(c,u)}$, I firstly create a share matrix of commodity $(c) \in \mathrm{COM}$ by user $(u) \in \mathrm{USERS}$, formulated by:

$$\mathrm{DOM\_SHR0}_{(c,u)} = \frac{\mathrm{BASDOM}_{(c,u)}}{\sum_{u \in \mathrm{USERS}} \left[\mathrm{BASDOM}_{(c,u)} + \mathrm{BASIMP}_{(c,u)}\right]}, \tag{5.1}$$

where $\mathrm{DOM\_SHR0}_{(c,u)}$ is the shares matrix. Secondly, I use this share matrix, toegether with the vector $\mathrm{MARGINS\_M}_{(c)}$, to estimate the margin consumption by user, expressed as follows:

$$\mathrm{Adj}_{(c,u)} = \mathrm{DOM\_SHR0}_{(c,u)} \cdot \left|\mathrm{MARGINS\_M}_{(c)}\right|, \tag{5.2}$$

where $\mathrm{Adj}_{(c,u)}$ is the estimated margin value in consuming domestic commodity $(c) \in \mathrm{COM}$ by user $(u) \in \mathrm{USERS}$. Finally, I deduct the margin values from the consumption of basic commodity via the following expression:

$$\mathrm{BASDOM\_A}_{(c,u)} = \mathrm{BASDOM}_{(c,u)} - \mathrm{Adj}_{(c,u)}. \tag{5.3}$$

where $\mathrm{BASDOM\_A}_{(c,u)}$ is the new domestic basic consumption of commodity $(c) \in \mathrm{COM}$ by user $(u) \in \mathrm{USERS}$ without margin values. The $\mathrm{BASDOM\_A}_{(c,u)}$ is the targeted matrix from the splitting process of $\mathrm{BASDOM}_{(c,u)}$ (line 8 of Figure 5.3).

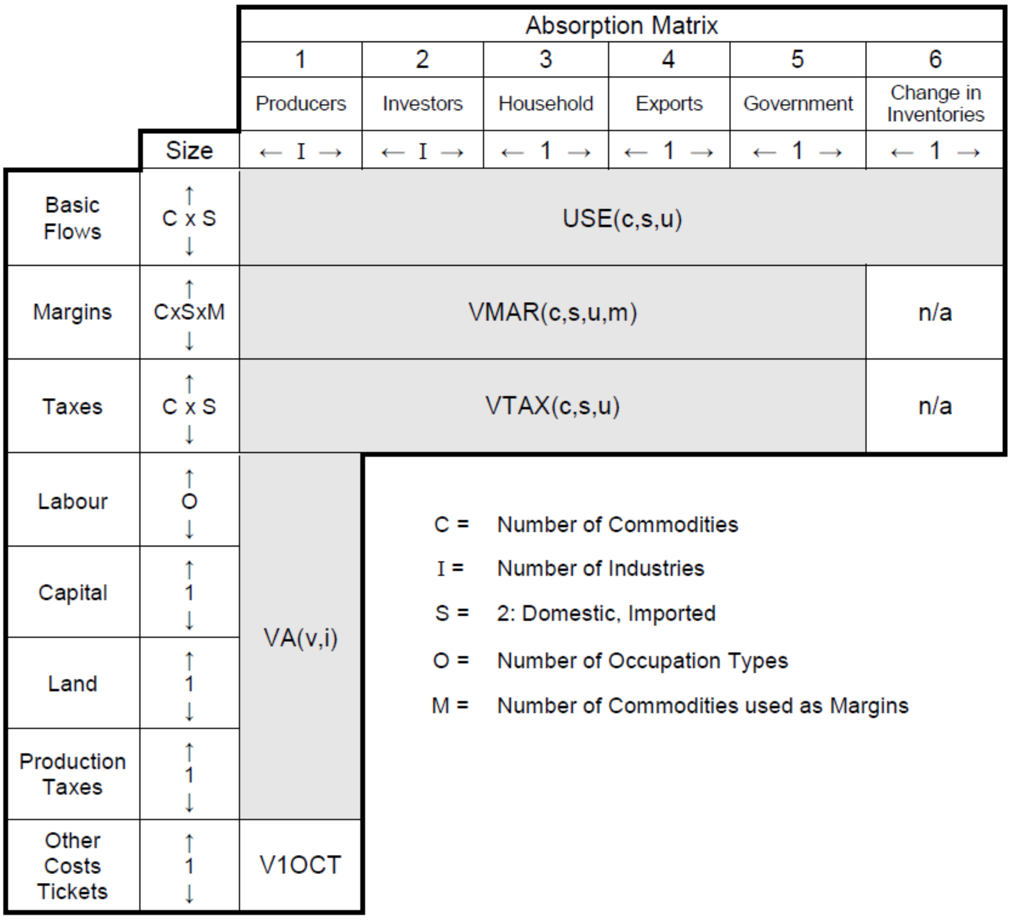


Figure 5.4 Illustration of Prepared Matrices for Final Database

5.4.2 Preparing Essential Matrices

In this step, I prepare the matrices whose dimensionality is similar to that of the required database. The arrangement of the matrices is illustrated in Figure 5.4. The prepared partitioned matrices must have the same dimensions as the required database. The targeted matrices at this point are (i) $USE_{(c,s,u)}$; (ii) $VMAR_{(c,s,u,m)}$; (iii) $VTAX_{(c,s,u)}$; and (iv) $VA_{(v,i)}$.

5.4.2.1 Creation of $\mathbf{USE_{(c,s,u)}}$ matrix

In the creation of $USE_{(c,s,u)}$, I use the matrices which have been prepared in the previous step. Figure 5.5 shows the simple way to merge $BASDOM\_A_{(c,u)}$ and $BASIMP_{(c,u)}$ into $USE_{(c,s,u)}$. The combination of $BASDOM\_A_{(c,u)}$ and $BASIMP_{(c,u)}$ is accommodated by adding source s dimension where $(s) \in SRC$(domestic, imported).

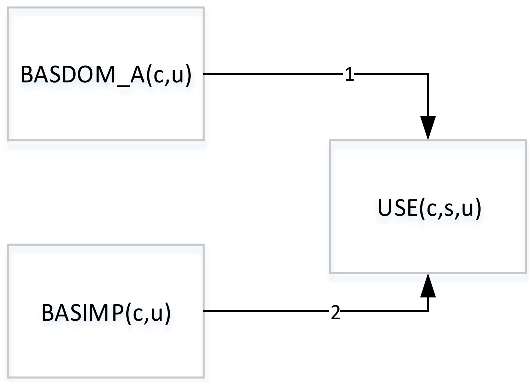


Figure 5.5 Creation of USE Matrix

Mathematically, the creation of $\mathrm{USE}_{(c,s,u)}$ can be formulated as follows:

$$\mathrm{USE}_{(c,dom,u)} = \mathrm{BASDOM}_{(c,u)}, \tag{5.4}$$

$$\mathrm{USE}_{(c,imp,u)} = \mathrm{BASIMP}_{(c,u)}. \tag{5.5}$$

5.4.2.2 Creation of the margin matrix

$\mathrm{VMAR}_{(c,s,u,m)}$ is located below the $\mathrm{USE}_{(c,s,u)}$ matrix in Figure 5.4. The matrix has more dimensions compared to the use matrix, i.e., $(c) \in \mathrm{COM}, (s) \in \mathrm{SRC}, (u) \in \mathrm{DMAR},$ and $(m) \in \mathrm{MAR}$. For the margin matrix, I exclude the stock/inventory from the set of USERS, on the assumption that margins are not required for additions to inventories. Table 5.5 describes all definitions and settings used to create the margin matrix.

No.	Set	Description	Elements of Set
1	COM	Commodity	$\mathrm{COM} = \mathrm{IND}, \mathrm{IND} \in \mathrm{USERS}.$
2	IND	Industry	
3	DEMAND	Final Users	House, NPISH, Govern, Invest, Stocks, ExpGoods, ExpServ, $\mathrm{DEMAND} \in \mathrm{USERS}.$
4	USERS	All Users	$\mathrm{IND} + \mathrm{DEMAND}.$
5	MARCOM	Margin Commodities	CarTrading, OthTrade, RailTransprt, LandTransprt, SeaTransport, RiverTrnsprt, AirTransport,TransportSvc, $\mathrm{MARCOM} \in \mathrm{COM}.$
6	MAR0	Types of Margin Aggregation	Wholesale, Retail, Transport.
7	NMARCOM	Non-Margin Commodities	$\mathrm{COM} - \mathrm{MARCOM}$

No.	Set	Description	Elements of Set
8	DMAR	Margin USERS	$\mathrm{USERS} - \mathrm{USERS}(\text{"Stocks"})$
9	ROWVA	Value Added	$\mathrm{COE}, \mathrm{GOS}.$
10	OCC	Occupation Types	$\mathrm{Agric}, \mathrm{OtherManual}, \mathrm{Clerical}, \mathrm{Managerial}.$
11	OCT	Other Costs Tickets	$\mathrm{OCT}.$

Table 5.5 Definition and Arrangement Sets

There are seven steps to transform $\mathrm{MARGINS\_M}_{(c)}$ into $\mathrm{VMAR}_{(c,s,u,m)}$ as presented in Figure 5.6. First, I create a source composite matrix of margin transactions of commodity $(c) \in \mathrm{COM}$ by user $(u) \in \mathrm{USERS}$, using the shares matrix composed from $\mathrm{USE}_{(c,s,u)}$. Second, I remove inventories from the set of user agents. Third, I create the source specific margin transaction matrix. Four, I assign margin transaction by type of margin.

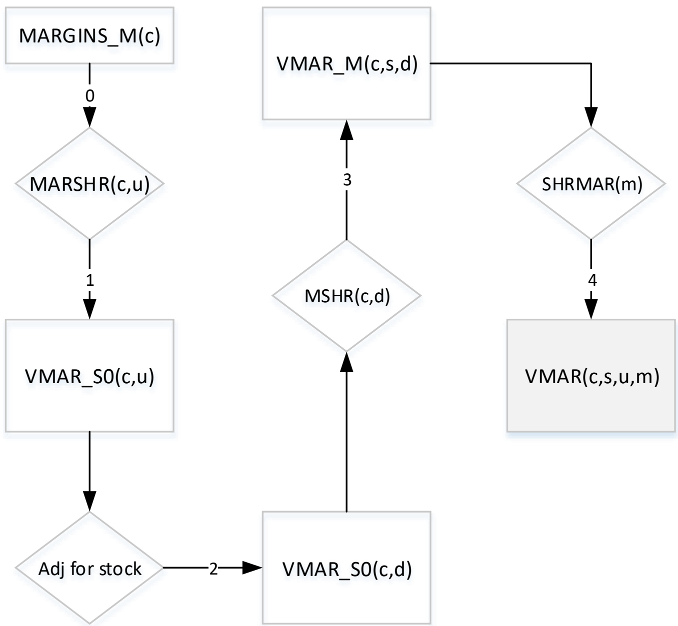


Figure 5.6 Creation of Margin Matrix

In what follows, I mathematically explain the steps in the creation of the margin matrix based on the workflow in Figure 5.6. First, I create a share matrix composed in the following equation:

$$\mathrm{MARSHR}_{(c,u)} = \frac{\sum_{s \in SRC} \mathrm{USE}_{(c,s,u)}}{\sum_{c \in COM} \sum_{s \in SRC} \mathrm{USE}_{(c,s,u)}}, \tag{5.6}$$

where $\mathrm{MARSHR}_{(c,u)}$ is the share of total expenditure by user (u) represented by spending on commodity (c). The share matrix is then used to create the source composite margin matrix in the following equation:

$$\mathrm{VMAR\_S}_{(c,u)} = \mathrm{MARSHR}_{(c,u)} \cdot \sum_{c \in COM} \{\mathrm{DOM\_SHR0}_{(c,u)} \cdot \mathrm{MARGINS\_M}_{(c)}\}, \tag{5.7}$$

where $\mathrm{VMAR\_S}_{(c,u)}$ is the value of use of margin commodity $(c) \in \mathrm{COM}$ by user $(u) \in$ USERS.

In the second step, inventories are removed from the margin users. The value of margin consumption for stock allocation is then redistributed proportionately to the new margin users. To eliminate margins from the stock allocation, I set the value of margins for stocks equals to zero, as follow:

$$\mathrm{VMAR\_}S0_{(c,\mathrm{Stocks})} = 0.0. \tag{5.8}$$

where $\mathrm{Stocks} \in \mathrm{USERS}$ but $\mathrm{Stocks} \notin \mathrm{DMAR}$. I then redistribute the residual of margins allocated to stocks in the old set of users proportionally to the new margin users as follows:

$$\mathrm{VMAR\_S}_{(c,d)} = \mathrm{VMAR\_S0}_{(c,d)} + \mathrm{DMARSHR}_{(c,d)} \cdot \mathrm{TOTMARSTOCKS}\,, \tag{5.9}$$

where

- $d \in \mathrm{DMAR}$;
- $\mathrm{TOTMARSTOCKS} = \sum_{c \in COM} \mathrm{VMAR}_{S(c,\mathrm{Stocks})}$;
- $\mathrm{DMARSHR}_{(c,d)} = \frac{\sum_{s \in SRC} \mathrm{USE}_{(c,s,d)}}{\sum_{c \in COM} \sum_{s \in SRC} \sum_{d \in DMAR} \mathrm{USE}_{(c,s,d)}}$.

The separation of margins on domestic and import commodities is performed by creating the $\mathrm{VMARM}_{(c,s,u)}$ matrix, as follow:

$$\mathrm{VMARM}_{(c,\mathrm{Imp},u)} = \mathrm{MSHR}_{(c,u)} \cdot \mathrm{VMAR\_S}_{(c,u)}, \tag{5.10}$$

where,

$$\mathrm{MSHR}_{(c,u)} = \frac{\mathrm{USE}_{(c,imp,u)}}{\sum_{s \in \mathrm{SRC}} \mathrm{USE}_{(c,s,u)}}, \tag{5.11}$$

and,

$$\mathrm{VMARM}_{(c,dom,u)} = [1.0 - \mathrm{MSHR}(c,u)] \cdot \mathrm{VMAR\_S}_{(c,d)}. \tag{5.12}$$

The final process in preparing the margin matrix is adding the margin dimension (m), as follows:

$$\mathrm{VMAR}_{(c,s,u,m)} = \mathrm{MARCOMSHR}_{(m)} \cdot \mathrm{VMARM}_{(c,s,u)}, \tag{5.13}$$

where,

$$\mathrm{MARCOMSHR}(m) = \frac{|\mathrm{MARGINS\_M}_{(m)}|}{\sum_{m \in \mathrm{MAR}} |\mathrm{MARGINS\_M}_{(m)}|}. \tag{5.14}$$

The $\mathrm{VMAR}_{(c,s,u,m)}$ in the (5.13) represents the required margin matrix illustrated by Figure 5.4.

5.4.2.3 Creation of the tax matrix

The workflow in creating the tax matrix ($\mathrm{VTAX}_{(c,s,u)}$) is illustrated in Figure 5.8. First, the official net tax vector by user is represented by the $\mathrm{UTAXCOST}_{(u)}$ matrix. The matrix is then converted into a source composite tax matrix using the share matrix deterimined in the previous step. Second, net taxes are eliminated from the inventory allocation on the assumption that sales taxes are not paid on additions to stocks. Third, the source specific net taxes matrix is created.

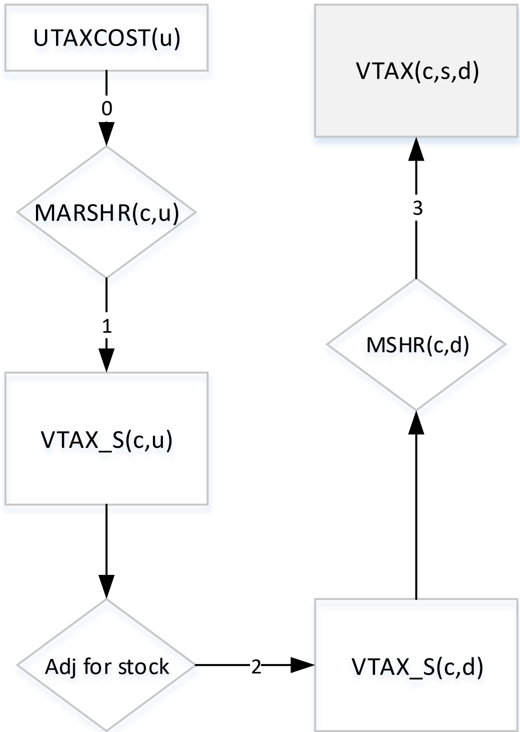


Figure 5.8 Creation of Tax Matrix

Recall that $\mathrm{MARSHR}_{(c,u)}$ is the share of total expenditure by user (u) represented by spending on commodity (c). Hence, adopting a similar step to that taken in creation of the margin matrix, the source composite net taxes matrix by commodity is created by the following equation:

$$\mathrm{VTAX\_S}_{(c,u)} = \mathrm{MARSHR}_{(c,u)} \cdot \mathrm{UTAXCOST}_{(u)}. \qquad (5.15)$$

Because there are identical elements of the set of user agents between margins and taxes, the previous commodity flows in the $\mathrm{MARSHR}_{(c,u)}$ matrix can be used to define the aggregate payments of net taxes across commodities and users in the $\mathrm{VTAX\_S}_{(c,u)}$ matrix. The next equation mirrors the configuration used in the creation of the margin matrix in the previous section, as follows:

$$\mathrm{VTAX\_S}_{(c,\mathrm{Stock})} = 0.0, \qquad (5.16)$$

where Stocks $\in$ USERS but Stocks $\notin$ DMAR, and

$$\text{VTAX\_S}_{(c,d)} = \text{VTAX\_S}_{(c,d)} + \text{TOTTAXSTOCKS} \cdot \text{DMARSHR}_{(c,d)}, \quad (5.17)$$

where,

- $\text{d} \in \text{DMAR}$;
- $\text{TOTTAXSTOCKS} = \sum_{c \in COM} \text{VTAX}_{\text{S(c,"Stocks")}}$;
- $\text{DMARSHR}_{(c,d)} = \frac{\sum_{s \in SRC} \text{USE}_{(c,s,d)}}{\sum_{c \in COM} \sum_{s \in SRC} \sum_{d \in DMAR} \text{USE}_{(c,s,d)}}$.

The deployment of net taxes on imported and domestic commodities are arranged by the following expressions:

$$\text{VTAX}_{(c,imp,u)} = \text{MSHR}_{(c,u)} \cdot \text{VTAX\_S}_{(c,u)}, \quad (5.18)$$

$$\text{VTAX}_{(c,dom,u)} = \left[1.0 - \text{MSHR}_{(c,u)}\right] \cdot \text{VTAX\_S}_{(c,u)}. \quad (5.19)$$

5.4.2.4 Creation of the value-added matrix

Construction of the value added (VA) matrix is more straightforward than previous steps. It is undertaken by combining the set of ROWVA matrix into $\text{VA}_{(v,i)}$. Mathematically, it is expressed by:

$$\text{VA}_{(v,i)} = \text{VA\_0}_{(v,i)}, \quad (5.20)$$

where, $\text{v} \in \text{ROWVA(COE, GOS)}$.[15]

5.4.2.5 Creation of the production tax matrix

The last part of the database preparation process is creating the production tax matrix. Production taxes are part of the cost of current production. The production tax matrix is provided as part of the original IO table. The task in this step is to match the production vector in the original IO table to the desired model matrix via the following equation.

$$\text{VTAXPROD}_{(i)} = \text{PRODTAX}_{(i)}. \quad (5.21)$$

[15] COE and GOS stand for compensation of employment and gross operating surplus respectively.

where

- $i \in \mathrm{IND}$,
- $\mathrm{VTAXPROD}_{(i)}$ is the value of production tax paid by industry i.

5.4.2.6 Equilibrium balancing condition

As the model requires equilibrium condition between supply and demand, the database should satisfy the requirement that the domestic supply of commody $(c) \in \mathrm{COM}$ ($\mathrm{SALES}_{(c)}$) is equal to the costs of industry $(i) \in \mathrm{IND}$ ($\mathrm{COST}_{(i)}$). That is:

$$\mathrm{SALES}_{(i)} = \mathrm{COST}_{(i)}, \tag{5.22}$$

where, COM = IND.

The value of domestic sales is specified in the following equation:

$$\mathrm{SALES}_{(c)} = \sum_{u \in \mathrm{USERS}} \mathrm{USE}_{(c,dom,u)} + \mathrm{MARGINS\_M}_{(c)}. \tag{5.23}$$

The cost by industry (i) is specified in the following equation:

$$\begin{aligned}\mathrm{COST}_{(i)} = &\sum_{c \in \mathrm{COM}} \sum_{s \in \mathrm{SRC}} \mathrm{USE}_{(c,s,i)} + \mathrm{VTAX}_{(c,s,i)} \\ &+ \sum_{m \in \mathrm{MAR}} \mathrm{VMAR}(c,s,i,m) + \sum_{v \in \mathrm{ROWVA}} \mathrm{VA}(v,i) \\ &+ \mathrm{VTAXPROD}_{(i)}.\end{aligned} \tag{5.24}$$

Therfore,

$$\mathrm{SDIFF}_{(c)} = \mathrm{SALES}_{(c)} - \mathrm{COST}_{(c)} \cong 0, \tag{5.25}$$

where $\mathrm{SDIFF}_{(c)}$ is the residual between domestic sales and costs. Vector $\mathrm{SDIFF}_{(c)}$ is a gauge to evaluate deviations between $\mathrm{SALES}_{(c)}$ and $\mathrm{COST}_{(c)}$. The expected values of $\mathrm{SDIFF0}(c)$ are zero. Checking the generated database, I find that the values of $\mathrm{SDIFF}_{(c)}$ are very small and considerably close to zero (Figure 5.8).

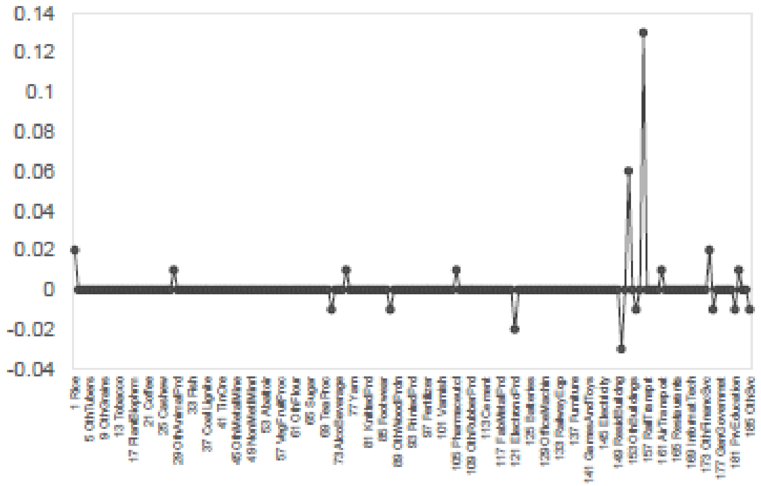


Figure 5.8 Values of Sales-Costs $\left(\mathbf{SDIFF_{(c)}}\right)$

5.4.3 Final conversion of processed data into the required model database

This section describes the final conversion of the matrices generated in the previous section into their final forms. The notational convention of the matrices presented herein follow the arrangements explained in section 5.2. The definition of sets and elements are defined in Table 5.1. The matrices to be converted are $\mathrm{USE_{(c,s,u)}}$, $\mathrm{VMAR_{(c,s,u,m)}}$, $\mathrm{VTAX_{(c,s,u)}}$, $\mathrm{VA_{(v,i)}}$, and $\mathrm{VTAXPROD_{(i)}}$. The target matrices for this conversion process are those comprising the database illustrated in Figure 5.1. The matrix $\mathrm{USE_{(c,s,u)}}$ is coverted to $\mathrm{V1BAS_{(c,s,i)}}$, $\mathrm{V2BAS_{(c,s,i)}}$, $\mathrm{V3BAS_{(c,s)}}$, $\mathrm{V4BAS_{(c,s)}}$, $\mathrm{V5BAS_{(c,s)}}$, and $\mathrm{V6BAS_{(c,s)}}$. The matrix $\mathrm{VMAR_{(c,s,u,m)}}$ is converted to $\mathrm{V1MAR_{(c,s,i,m)}}$, $\mathrm{V2MAR_{(c,s,i,m)}}$, $\mathrm{V3MAR_{(c,s,m)}}$, $\mathrm{V4MAR_{(c,s,m)}}$, $\mathrm{V5MAR_{(c,s,m)}}$, and $\mathrm{V6MAR_{(c,s,m)}}$. The matrix $\mathrm{VTAX_{(c,s,u)}}$ is converted to $\mathrm{V1TAX_{(c,s,i)}}$, $\mathrm{V2TAX_{(c,s,i)}}$, $\mathrm{V3TAX_{(c,s)}}$, $\mathrm{V4TAX_{(c,s)}}$, $\mathrm{V5TAX_{(c,s)}}$, and $\mathrm{V6TAX_{(c,s)}}$. The matrix $\mathrm{VA_{(v,i)}}$ is converted to $\mathrm{V1LAB_{(i)}}$, $\mathrm{V1CAP_{(i)}}$, and $\mathrm{V1LND_{(i)}}$. $\mathrm{VTAXPROD_{(i)}}$ is converted to $\mathrm{V1PTX_{(i)}}$.

5.4.3.1 Creation of basic value matrices

Figure 5.9 shows the process for converting $\mathrm{USE_{(c,s,u)}}$ to the target matrices. There are six lines indicating the conversion across the six types of real-side economic agents. In the first line, the translation to the industry dimension of V1BAS is performed by the following equation:

$$\mathrm{V1BAS}_{(c,s,u)} = \mathrm{USE}_{(c,s,u)}, u \in \mathrm{IND} \tag{5.26}$$

The second step represents the disagregation of the basic value of investment by the industry agent, via the following equation:

$$\mathrm{V2BAS}_{(c,s,i)} = \mathrm{USE}_{(c,s,\mathrm{Invest})} \cdot \mathrm{INVSHR}_{(i)} \tag{5.27}$$

where,

$$\mathrm{INVSHR}_{(i)} = \frac{\mathrm{V1CAP(i)}}{\sum_{i \in \mathrm{IND}} \mathrm{V1CAP(i)}}, \qquad i \in \mathrm{IND}, c \in \mathrm{COM}, s \in \mathrm{SRC}. \tag{5.28}$$

$\mathrm{INVSHR}_{(i)}$ is the share of the value of industry (i)'s returns to capital in economy-wide capital returns. In the absence of official information about the level of investment by industry, this approach is considerably intutitive, as it ties the initial allocation of investment across industries to official data on the distribution of capital rentals across industries.

In the third step, the conversion to the single representative household agent is undertaken by the following equation:

$$\mathrm{V3BAS}_{(c,s)} = \mathrm{USE}_{(c,s,\mathrm{House})} + \mathrm{USE}_{(c,s,\mathrm{NPISH})}. \tag{5.29}$$

Equation (5.29) calculates the single representative household demand as the sum up of spending by households and by non-profit institutions serving households (NPISH) from the original official database.

The fourth step creates a single representative export demand category as follows:

$$\mathrm{V4BAS}_{(c,s)} = \mathrm{USE}_{(c,s,\mathrm{ExpGoods})} + \mathrm{USE}_{(c,s,\mathrm{ExpServ})}. \tag{5.29}$$

As previously noted, export demand is the sum of export of goods (ExpGoods) and services (ExpServ), which are otherwise identified separately in the official input output data.

The fifth and sixth steps explain the conversion of government expenditure and inventories, respectively. The conversion of government expenditure into the desired model format is described by the following equation:

$$\mathrm{V5BAS}_{(c,s)} = \mathrm{USE}_{(c,s,\mathrm{Govern})}. \tag{5.31}$$

The conversion of inventory demand to the desired format is undertaken by the following equation:

$$\mathrm{V5BAS}_{(c,s)} = \mathrm{USE}_{(c,s,\mathrm{Stocks})}. \tag{5.32}$$

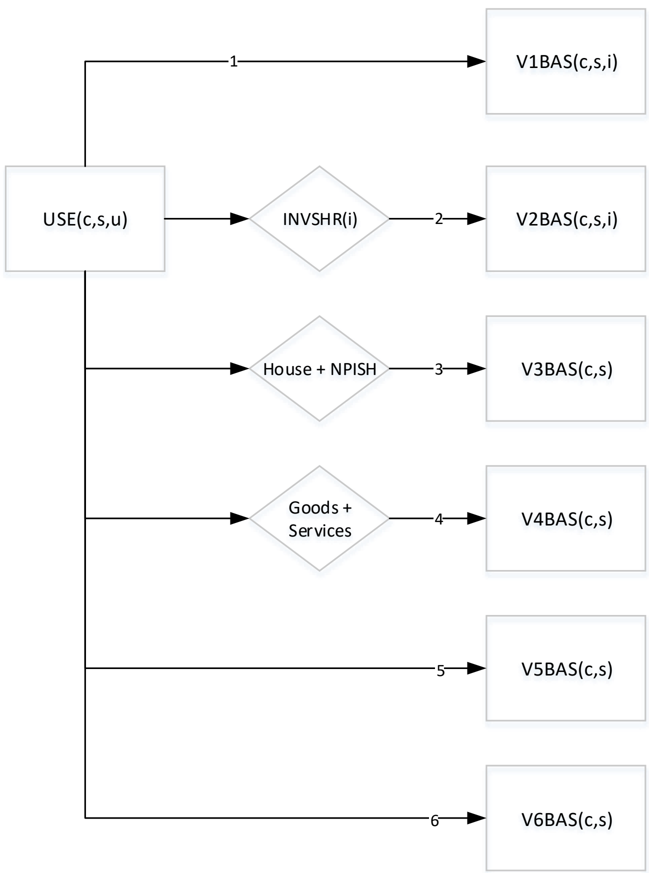


Figure 5.9 Conversion Basic Matrices

5.4.3.2 Creation of margin matrices

The creation of margin values is very similar to the previous section except there are no margins on inventories. There is a sum of House and NPISH for consumption expenditure, and a sum of ExpGoods and ExpServ for export demand. Margins on investment are split across industries using INVSHR. There are no further manipulations required to convert $\mathrm{VMAR}(c, s, u, m)$, since the subscript u represents all coresponding margin demanders in the final database. Translation of the margin values to the industry, investment, households, exports, and government agent matrices are described as follows:

$$\mathrm{V1MAR}_{(c,s,i,m)} = \mathrm{VMAR}_{(c,s,i,m)}, \tag{5.33}$$

$$\mathrm{V2MAR}_{(c,s,i,m)} = \mathrm{VMAR}_{(c,s,Invest,m)} \cdot \mathrm{INVSHR}_{(i)}, \tag{5.34}$$

$$\mathrm{V3MAR}_{(c,s,m)} = \mathrm{VMAR}_{(c,s,House,m)} + \mathrm{VMAR}_{(c,s,NPISH,m)}, \tag{5.35}$$

$$\mathrm{V4MAR}_{(c,m)} = \mathrm{VMAR}_{(c,dom,ExpGoods,m)} + \mathrm{VMAR}_{(c,dom,ExpServ,m)}, \tag{5.36}$$

$$\mathrm{V5MAR}_{(c,s,m)} = \mathrm{VMAR}_{(c,s,Govern,m)}. \tag{5.37}$$

5.4.3.3 Creation of indirect tax matrices

The creation of the net indirect tax matrices is undertaken following similar principles to those followed in constructing the margin matrices. The translation of the indirect tax data into the agent-specific tax matrices required by the model is performed via following equations:

$$\mathrm{V1TAX}_{(c,s,i)} = \mathrm{VTAX}_{(c,s,i)}, \tag{5.38}$$

$$\mathrm{V2TAX}_{(c,s,i,m)} = \mathrm{TAX}_{(c,s,Invest)} \cdot \mathrm{INVSHR}_{(i)}, \tag{5.39}$$

$$\mathrm{V3TAX}_{(c,s,m)} = \mathrm{VTAX}_{(c,s,House)} + \mathrm{VTAX}_{(c,s,NPISH)} \tag{5.40}$$

$$\mathrm{V4TAX}_{(c)} = \mathrm{VTAX}_{(c,dom,ExpGoods)} + \mathrm{VTAX}_{c,dom,ExpServ)}; \tag{5.41}$$

$$\mathrm{V5TAX}_{(c,s)} = \mathrm{VTAX}_{(c,s,Govern)}. \tag{5.42}$$

5.4.3.4 Creation of primary factor payment matrices

The workflow creating the primary factor matrices is illustrated by Figure 5.10. There are four lines in Figure 5.10 explaining the steps that convert $\mathrm{VA}_{(v,i)}$ into the required primary factor matrices. In the first line, the evaluation of the matrix containing labour compensation by industry is straight forward. Unlike ORANI-G, the AMELIA-F database does not require labour to be distinguished by occupation. Hence, it does not require further decomposition of labour compensation by the type of occupation. Line 2 describes the evaluation of the matrix of capital rental payments by industry. This is relatively straight forward, because the original IO table provides the value of gross operating surplus by industry. However, as the AMELIA-F database requires the value of land rental payments by industry, some part of the initially-allocated capital rental must be reallocated to the land rental matrix. This is done using the share matrix created from GTAP version 9 database (Aguiar et al., 2016).

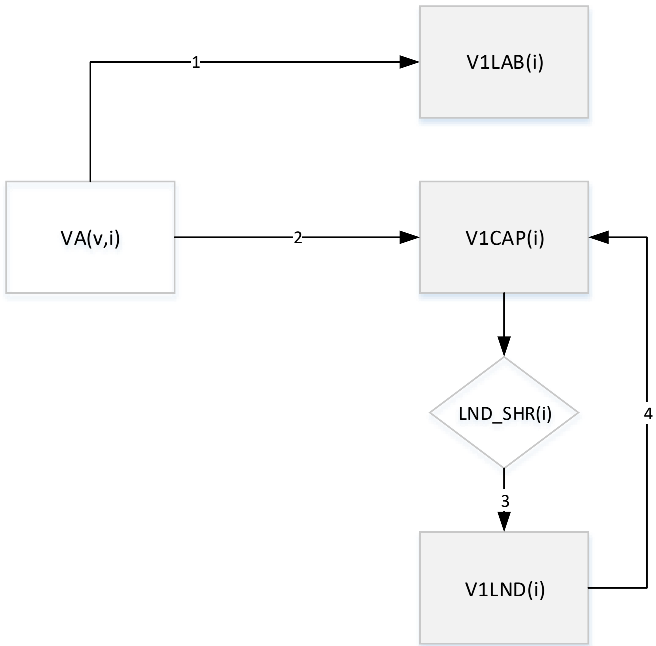


Figure 5.10 Creation of Value Added Matrices

The creation of the value of labour compensation matrix is undertaken via the following equation:

$$\mathrm{V1LAB}_{(\mathrm{i})} = \mathrm{VA}_{(\mathrm{COE,i})}, \tag{5.43}$$

where $\mathrm{VA}_{(\mathrm{COE,i})}$ is the compensation of employment (COE) by industry $(\mathrm{i}) \in \mathrm{IND}$. The first round in the creation of the capital rental matrix is performed as follows:

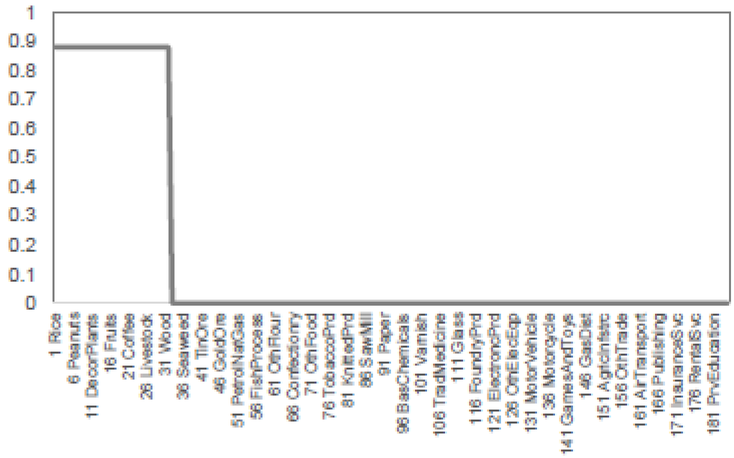
$$\mathrm{V1CAP}_{(\mathrm{i})} = \mathrm{VA}_{(\mathrm{GOS,i})}, \tag{5.44}$$

where $\mathrm{VA}_{(\mathrm{GOS,i})}$ is the gross operating surplus (GOS) by industry $(\mathrm{i}) \in \mathrm{IND}$.

The value of land rental payments must then be taken from the initial allocation to capital rentals using the share matrix constructed from the GTAP version 9 database, as follows:

$$V1LND_{(i)} = LND\_SHR_{(i)} \times V1CAP_{(i)}. \quad (5.45)$$

According to the GTAP version 9 database, among agricultural sectors the share of land rentals in the total value of payments to land and capital is 88 per cent (Figure 5.11). There are 32 industries in AMELIA-F that depend on land in their production activities. The estimated values of land rental for these industries are given in Table 5.8.



Source: GTAP version 9 database

Figure 5.11 Share of Land Use by Industry

Industry	Value	Industry	Value
1 Rice	128,506	17 PlantBiophrm	1,448
2 Corn	25,799	18 Rubber	32,698
3 SweetPotato	3,924	19 Coconut	14,262
4 Cassava	13,576	20 PalmOil	59,943
5 OthTubers	574	21 Coffee	9,154
6 Peanuts	3,666	22 Tea	463
7 Soy	2,526	23 Cocoa	23,302
8 OthNuts	1,363	24 Clove	5,209
9 OthGrains	144	25 Cashew	860
10 Vegetables	35,122	26 Livestock	25,543
11 DecorPlants	3,994	27 FreshMilk	934
12 Cane	3,741	28 PoultryEggs	36,031
13 Tobacco	1,811	29 OthAnimalPrd	867
14 PlantFiber	47	30 AgricSvc	12,444
15 OthPlantaton	5,100	31 Wood	30,728
16 Fruits	44,209	32 OthForestPrd	7,520

Table 5.8 The value of land rental in AMELIA-F database (in Rp Billion)

Having calculated $\mathrm{V1LND}_{(i)}$, the next task is to remove the value of $\mathrm{V1LND}_{(i)}$ from $\mathrm{V1CAP}_{(i)}$, as follows:

$$\mathrm{V1CAP}_{(i)} = \mathrm{V1CAP}_{(i)} - \mathrm{V1LND}_{(i)}. \tag{5.46}$$

According to the GEMPACK command rules, the $\mathrm{V1CAP}_{(i)}$ on the left hand side (LHS) of Equation (5.46) represents the new value of capital rentals after removing the value of land rentals from the V1CAP on the RHS of equation (5.46) which was evaluated by equation (5.44).

5.4.3.5 Creation of the production tax matrix

This step is straight forward. It uses the vector $\mathrm{VTAXPROD}_{(i)}$ defined in the previous section to create the vector of production tax payments by industry $(i) \in \mathrm{IND}$.

$$\mathrm{V1PTX}_{(i)} = \mathrm{VTAXPROD}_{(i)} \tag{5.47}$$

5.5 Multi-product (MAKE) Matrix

The AMELIA-F model has the capacity to model multi-production, i.e. a situation where an industry produces more than one commodity and/or a commodity is produced by more than one industry. Data on multi-production is recorded in the MAKE matrix. However, there are no published join-production statistics from official Indonesian statistics. Hence, I evaluate the MAKE matrix on a unique product basis. Because the MAKE matrix is aimed at capturing the capacity of an industry to produce multiple types of commodities and vice-versa, the MAKE matrix has two dimensions, i.e. $c \in \mathrm{COM}$ and $i \in \mathrm{IND}$. However as noted, due to data limitations, I assume each industry produces only its own unique commodity. For example, the rice industry produces the rice commodity. As such, the MAKE matrix in AMELIA-F is diagonal, with off-diagonal values of 0. According to Horridge (2013), diagonal MAKE matrices are common in applications of ORANI-G outside Australia.

The MAKE matrix must satisfy the following balance conditions:

$$\sum_{c \in \mathrm{COM}} \mathrm{MAKE}_{(c,i)} = \mathrm{V1TOT}_{(i)}, \tag{5.48}$$

$$\sum_{i \in IND} MAKE_{(c,i)} = SALES0_{(c)},$$

The value of total sales of commodity (c) is constructed from:

$$SALES0_{(c)} = \sum_{i \in IND} (V1BAS_{(c,dom,i)} + V2BAS_{(c,dom,i)}) + V3BAS_{(c,dom)} + V4BAS_{(c)} + V5BAS_{(c,dom)} + V6BAS_{(c,dom)} + V0MAR_{CSI(c)}. \quad (5.49)$$

The total costs of industry i are given by,

$$V1TOT_{(i)} = V1OCT_{(i)} + V1LAB_{(i)} + V1CAP_{(i)} + V1LND_{(i)} + V1PTX_{(i)} + \sum_{c \in COM} \sum_{s \in SRC} (VIBAS_{(c,s,i)} + V1TAX_{(c,s,i)} + \sum_{m \in MAR} V1MAR_{(c,s,i,m)}). \quad (5.50)$$

5.6 Elasticities and Parameters of the Real-side Database

This section explains the elasticities and parameters used in the real-side model of AMELIA-F, as listed in Table 5.7. The values of the elasticities and parameters are mostly adopted from estimates in previous Indonesian CGE modelling studies, INDORANI and INDOTERM. Where the required elasticities and parameters are not given in the previous studies, the values are adapted from the MONASH model, as the template of the real-side CGE modelling within AMELIA-F.

No	Elasticities and Parameters	Description	Set Dimension
1	SIGMA1PRIM	Elasticity of substitution between primary factors	IND
2	SIGMA0	CET transformation elasticity on industry output	IND
3	SIGMA1	Armington elasticity for intermediate inputs	COM
4	SIGMA2	Armington elasticity for investment	COM
5	SIGMA3	Armington elasticity for household consumption	COM
6	FRISCH	Frisch parameter	1
7	EPS	Household expenditure elasticity	COM
8	EXP_ELAST	Export elasticities	COM

Table 5.7 Elasticities and Parameters in the Real-side Database

5.6.1 Elasticity of substitution over primary factor demands

The values assigned to SIGMA1PRIM govern the sensitivity of demand for specific primary factors to relative factor prices faced by each industry. The relative price refers to the change in the specific price of a primary factor relative to the average price of primary factors. The higher the elasticity value the more sensitive is factor demand with respect to a change in relative price in a particular industry.

Industry	INDORANI[16]	INDOTERM[17]	MONASH[18]
Agriculture	0.24	0.24	0.5
Forestry-Mining	0.20	0.20	0.5
Food products	1.12	1.12	0.5
Manufactures	1.26-1.40	1.26-1.40	0.5
Services	1.26-1.68	1.26-1.68	0.5

Table 5.8 Reference values of elasticity substitution for primary factors (SIGMA1PRIM)

Table 5.8 reports the reference values for primary factor substitution elasticities used in AMELIA-F, which follow the values assigned in INDORANI and INDOTERM. The table implies that in INDORANI and INDOTERM manufacturing and services have higher elasticities than those in primary sectors (agriculture and forestry-mining). While the theoretical structure of MONASH supports differentiated elasticities across industries, as parameterised, the model does not differentiate the elasticity values across industries.

5.6.2 Armington Elasticities

The Armington elasticities (e.g., SIGMA1, SIGMA2, SIGMA3) govern the sensitivity of demand for source-specific commodities to changes in their relative price. INDORANI and INDOTERM do not have similar values of Armington elasticities for most industries,

[16] The version of INDORANI referred here is the INDOCEEM in which the Indonesian CGE modelling version to estimate energy-related issue. INDORANI closely follows the theories implemented in ORANI-G (Dixon et al., 1982). For further details please refers to INDOCEEM achieve at https://www.copsmodels.com/archivep.htm.
[17] This version of INDOTERM refers to the update of INDOTERM database archive in 2018 by Horridge & Yusuf (2017).
[18] The MONASH version used in this section refers to the Mini-MONASH provided by Dixon & Rimmer (2005).

except Services. I adopt elasticity values from INDOTERM, as the values are estimated more recently than those of INDORANI.

Industry	INDORANI	INDOTERM	MONASH
Agriculture	2.20-2.80	1.3-5.05	2.0
Forestry-Mining	2.80	2.50	2.0
Food products	2.20	2.00-4.40	2.0
Manufactures	3.10-3.14	1.15-4.40	2.0
Services	1.90	1.90	2.0

Table 5.9 Reference values of Armington elasticities (SIGMA1, 2, 3)

From Table 5.9, both INDORANI and INDOTERM assign greater values in manufactures compare to the rest of the commodities. This means that the determination of source-specific commodity inputs in manufactures are more sensitive to change in relative prices. This notion is plausible considering that the manufactures are tradable and more import-intensive relative to other commodities.

5.6.3 Constant elasticity of transformation (CET)

Industry	INDORANI	INDOTERM	MONASH
Agriculture	0.50	0.50	2.0
Forestry-Mining	0.50	0.50	2.0
Food products	0.50	0.50	2.0
Manufactures	0.50	0.50	2.0
Services	0.50	0.50	2.0

Table 5.10 Reference values of Constant Elasticity of Transformations (SIGMA0)

The CET elasticities govern the sensitivity of the commodity composition of industry output to price-induced transformation around industry production frontiers. Table 5.12 reports the elasticity values assigned to the multi-production CET functions in INDORANI, INDOTERM, and MONASH. INDORANI and INDOTERM assign homogenous 0.5 elasticity values for all industries, while MONASH assigns 2.0. The choice of 0.5 for INDORANI and INDOTERM is conservative in relation to the MONASH values. INDORANI and INDOTERM, like AMELIA-F, have diagonal joint-production matrices (MAKE matrices).

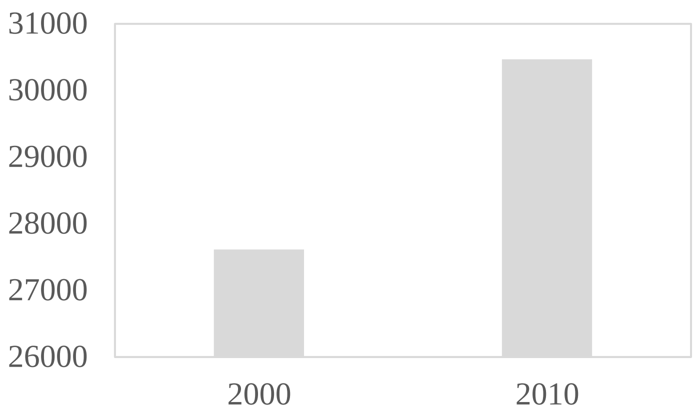
5.6.4 Export elasticities

Export elasticities determine the sensitivity of demand for each export commodity to its foreign currency price. Table 5.10 shows the differences in the values of export elasticities in INDORANI, INDOTERM, and MONASH. MONASH adopts default values of 4, but with flexibility to set alternative values on a commodity-specific basis as required. As parameterised, INDORANI and INDOTERM assign a variety of elasticity values across commodities. I adopt the export elasticities assigned in the INDOTERM model, as it has a similar database and sectoral aggregation to AMELIA-F.

Commodity	INDORANI	INDOTERM	MONASH
Agriculture	4.40-5.60	2.60-12.90	4.0
Forestry-Mining	5.60	1.80-34.40	4.0
Food products	3.60-5.60	2.30-8.80	4.0
Manufactures	3.60-7.21	4.20-8.80	4.0
Services	3.80-5.60	3.8-5.360	4.0

Table 5.11 Reference values of export elasticities (EXP_ELAS)

According to Table 5.11, there are significant differences in the range of elasticity values between INDORANI and INDOTERM. This implies a change in the intensity of some export demand responses between the time of INDORANI's and INDOTERM's construction. For example, there was a significant increase in export of natural gas between 2000 and 2010 (Figure 5.13). At the same time, the value of the export demand elasticity was increased markedly: INDORANI assumes 5.60 for the natural gas export elasticity, while INDOTERM assumes 34.40. This might reflect a movement from lower volume dedicated contracts to a much greater participation in a world gas market over the period. For AMELIA-F, I choose the INDOTERM values.



Source: Badan Pusat Statistics.[19]

Figure 5.13 Natural gas exports (in thousand tonnes)

5.6.5 Household expenditure elasticity and Frisch parameter

Since AMELIA-F has a similar database and aggregation to the INDOTERM model, in this study I adopt the values of the expenditure elasticities and Frisch parameter defined in the INDOTERM model. A summary of the expenditure elasticities and Frisch parameter are provided in Table 5.12. The table does not show a significant difference between INDORANI and INDOTERM.

Commodity	INDORANI	INDOTERM
Agriculture	0.30-0.66	0.36-1.29
Forestry-Mining	0.53-1.52	1.06-1.30
Food products	0.30-1.52	0.32-0.82
Manufactures	0.79-1.52	0.65-1.60
Services	0.96-1.67	0.86-2.13
Frisch parameter	-1.82	-1.82

Table 5.12 Reference values for expenditure elasticities and Frisch parameter (EPS)

The values appear in the Table 5.14 must satisfy the Engel aggregation principle, as follow:

$$\sum_{c \in COM} \alpha_{(c)} \cdot EPS_{(c)} = 1, \tag{5.48}$$

[19] https://www.bps.go.id/indicator/8/1753/12/nilai-ekspor-migas-nonmigas.html.

where,

- $\alpha_{(c)} = \text{V3TOT}_{(c)} / \sum_{c \in COM} \text{V3TOT}_{(c)}$,
- $\text{EPS}_{(c)}$ is the expenditure elasticity by commodity c.

Because the values for $\alpha_{(c)}$ are given by the input-output database, initial values for EPS from Table 5.12 are scaled to ensure the Engel aggregation property holds. This provides final values for EPS that are heavily influenced by the values in Table 5.12, but which are consistent with Equation 5.48. For this study, I adopt -1.82 for the Frisch parameter, as this number is used in the INDORANI and INDOTERM models. This value for the Frisch parameter implies that 55 per cent of household consumption expenditure is allocated to supernumerary consumption (=100/1.82*%) and 45 per cent covers subsistence consumption.

5.7 Database for Dynamic Mechanisms

The real-side model of AMELIA-F has dynamic mechanisms to allow for multi-year CGE simulations. While the equations that underlie the dynamic mechanism have been explained in Chapter 4, this section describes the elements of the database required by those equations. Table 5.13 describes three elements of the required dynamic database, including capital stock, government accounts, and balance of payments.

Tablo Name	Description	Dimension
1. Capital Stocks		
VCAP	Value of the stock of capital in the base year	IND
DEP	Industry-specific capital depreciation rates	IND
TREND_K	Trend growth rate of capital	IND
DIFF	Difference between maximum growth rate of capital and trend growth rate of capital	1
SMURF	Parameter governing the sensitivity of capital growth to variation in expected returns in the vicinity of trend growth and normal rate of return.	1
RINT	Real interest rate	1
LEV_CPI	Level of the CPI	1
LEV_CPI_L	Level of the CPI Lagged	1
2. Government Accounts		
G_VINVEST	Government investment	IND
BENEFITS	Welfare payments paid to households	1
NETINT_G	Net interest payments by government	1
PSDATT	Public sector debt	1
NFCURTGOV	Net foreign transfers to the government	1

Tablo Name	Description	Dimension
NONTAXREV	Non-tax revenue	1
TAX_K	Tax revenue on capital income	1
TAX_L	Tax revenue on labour income	1
3. Balance of Payments		
FDATT	Net foreign liabilities	1
ROIFOREIGN	Interest rate on foreign debt	1
NCURTRANS	Net primary income received	1
PHI	Level of the nominal exchange rate	1

Table 5.13: List of required data for dynamic mechanisms

5.7.1 Capital stock

There are limited official sources that can be referenced for capital stock data in Indonesia. Eng (2009) estimated Indonesia's capital stock to be around Rp8,000 trillion in 2005, and growing at 5% annually. Assuming a constant annual growth over five years, the value of the capital stock in 2010 would thus be Rp8,000*$(1+0.05)^5$=Rp10,210 trillion. The U.S. Federal Reserve Bank's statistics (FRED) estimated that in 2010, the capital stock of Indonesia at constant national 2011 prices was Rp10,508 trillion.[20] The INDOTERM model accounts the capital stock of Indonesia in 2010 at Rp14,171 trillion (Horridge & Yusuf, 2017).

The various values of the capital stocks suggested by these studies motivates a further check to ascertain appropriateness to the case of Indonesia. If the value of capital rentals is divided by the value of the three capital stock estimates, the implied gross rates of return on capital are reported in Table 5.14.

	Estimated Capital Stock in 2010 (in Rp trillion)	Implied rates of return (V1CAP_I/VCAP_I)
Eng (2009)	10,210	0.35
FRED	10,508	0.34
Horridge & Yusuf (2017)	14,171	0.29

Table 5.14: Implied Rates of Return of Capital (in Rp trillion).

[20] https://fred.stlouisfed.org.

The implied rates of return on capital as reported in Table 5.14 are high relative to the rate of return statistics available for Indonesia. For example, according to IMF Financial Soundness Indicators, the aggregate return on equity in Indonesia in 2010 was 26 per cent, but on a downward trend to 17 per cent over the next decade (Figure 5.14). In this regard, the implied rates of return on capital in Horridge & Yusuf (2017) are closer to the number suggested by the IMF, but still high.

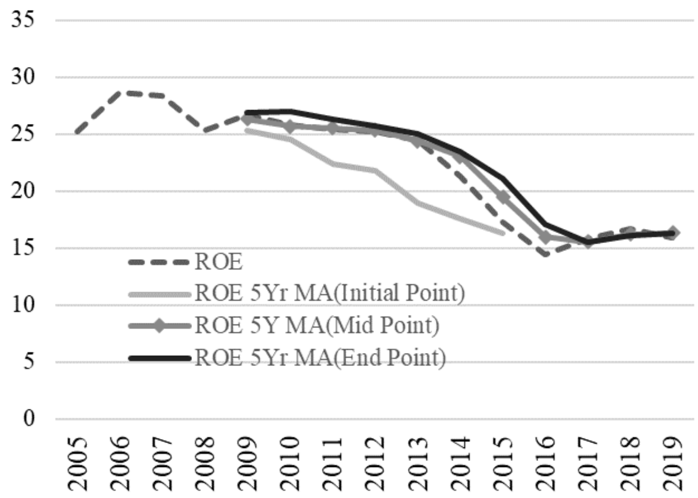
Assuming rates of return of 17% i.e., as suggested by the IMF soundness indicator, the total value of VCAP_I can be calculated. By dividing capital rental rates by the rate of return of 17%, the calculated VCAP_I is Rp21,200 trillion. Values for the capital stock by industry are then obtained by multiplying the aggregate capital stock with the capital rental shares by industry, as follows:

$$\mathrm{VCAP}_{(\mathrm{i})} = \mathrm{VCAP\_I} \cdot \mathrm{INVSHR}_{(\mathrm{i})}. \tag{5.52}$$

where,

- $\mathrm{VCAP}_{(\mathrm{i})}$ is the capital stock of industry i;
- $\mathrm{INVSHR}_{(\mathrm{i})}$ is the share of capital rentals in industry i in economy-wide capital rentals.

The other required data to implement the capital stock dynamics are: depreciation rates, trend capital growth rates, maximum capital growth rates, and the sensitivity of capital growth to rates of return. Depreciation rates ($\mathrm{DEP}_{(\mathrm{i})}$) are set at 2 per cent for all industries. This defines the minimum limit of capital growth. The maximum limit is defined by the sum of trend capital growth ($\mathrm{TREND\_K}_{(\mathrm{i})}$) and a uniform positive deviation (DIFF), which are set to 5% and 10% respectively. The parameter (SMURF) governing the sensitivity of capital growth to variation in expected return in the vicinity of the trend capital growth rate is set at 0.5.



Source: IMF Financial Soundness Indicators

Figure 5.14 Return on equity (in per cent)

The data for inflation are taken from the Economic and Financial Statistics of Indonesia (EFS) of Bank Indonesia (2020). The current (LEV_CPI) and lagged (LEV_CPI_L) are set at 3.72 per cent and 2.78 per cent respectively.

5.7.2 Government accounts

Information from Table 5.15 are used to fill the required government account data described in Table 5.13, except for the stock of public debt (PSDATT). The government investment data (G_VINVEST) uses the value of "Capital" expenditure of Rp80 trillion. This amount is distributed across government related investment, namely: electricity, gas and water; other construction; and public administration. Welfare payments paid to households (BENEFITS) uses the value of "Transfer" payments of Rp606 trillion. Net interest payments by government (NETINT_G) uses the value of "Interest Payments" of Rp88 trillion. Non-tax revenue (NONTAXREV) uses the value of "Non-Tax" revenue of Rp269 trillion. Net foreign transfers to government (NFCURTGOV) is set at 0. I evaluate the initial values for capital income (TAX_K) and tax revenue on labour income (TAX_L) by setting the initial capital and labour tax rates at 10 per cent. Data for the stock of public debt are taken from the Report of Public Debt (PSDATT) Statistics by Kementerian Keuangan & Bank Indonesia (2012) of Rp1,681 trillion.

Description		
Personnel	148,078	
Material	97,597	
Capital	80,287	
Transfer (made up of:)	606,116	
Regional Transfer		344,728
Subsidies		192,707
Grant		70
Social Assistance		68,611
Interest Payment	88,383	
Others	21,673	
Adjustment	-17	
Total Outlays	1,042,117	
Income tax	357,046	
made up of:		
Oil and Gas		58,873
Non-Oil and Gas		298,173
International Taxes	28,915	
Value Added Tax	230,605	
Land & Building Tax	28,581	
Duties on Land & Bld. Trf.	8,026	
Excises Duties	66,166	
Other Taxes	3,969	
Non-Tax	268,942	
Total Revenue	992,249	
Public-Sector Deficit	49,869	

Source: CEIC.

Table 5.15: Summary of 2010 Government Budget (in Rp Billion)

5.7.3 Balance of Payments

The balance of payments (BOP) data are taken from Bank Indonesia (2020) publication. The net foreign liability (NCURTRANS) for the current year (2010) is U.S.$ 20,698 million or Rp 188 trillion. The interest rate on foreign debt is assumed to be 2.7 per cent. The net foreign liability (FDATT) for the current year is U.S.$ 30,343 million or Rp 288 trillion. The level term exchange rate (PHI) for the current year is Rp 9,085 per U.S.$.

5.8 Tests of the Real-side Model and Database Validity

As a final step, it is necessary to perform validity tests of the database, such as those recommended by Horridge (2013). The tests include: (i) nominal and real homogeneity tests, (ii) equality of expenditure and income GDP, (iii) the balanced update, (iv) consistency of results with different solution methods, and (v) explainable results.

5.8.1 Nominal and Real Homogeneity Tests

The theory of AMELIA-F requires that all real variables respond to changes in relative prices, but a change in the absolute price level will have no effect on real variables or relative prices. All prices are calculated relative to a single price, called the numarairé. The real-side model of AMELIA-F assumes that the nominal exchange rate (phi) is the numarairé. When phi is shocked by 1 per cent, all prices and nominal variables in the model also change by 1 per cent. The simulation results indicate that AMELIA-F has passed the nominal homogeneity test. By shocking phi by 1 per cent, all prices and nominal variables also changed by 1 per cent.

The production theory of AMELIA-F exhibits constant return to scale (CRS). Hence, a 1 per cent increase in the availability of primary factor resources, together with a 1% increase in exogenous commodity demand categories, should cause a 1 per cent increase in all quantity variables while leaving prices unchanged. The shock variables for the purpose of this are capital stock ($x1cap_{(i)}$), employment (emp_hours), aggregate investment (x2tot_i), aggregate household consumption (x3tot), aggregate government consumption (x5tot), aggregate export volumes (x4tot), population (pop), the number of household (q), the change in foreign debt (d_fd_t), and the change in public debt (d_psd_t). The shock to these variables causes a 1 per cent increase in all quantity variables while leaving prices unchanged, therefore the AMELIA-F model is consistent with the expected CRS property.

5.8.2 Equal expenditure and income GDP

Table 5.16 reports results from the first year of the baseline simulation for GDP from both the expenditure and income sides. The table demonstrates the required equality of expenditure and income GDP. The total value of GDP generated herein is similar to that recorded in official statistics (see Table 5.2).

	Expenditure GDP			Income GDP
Household consumption		3,865.77	Land	535.51
Investment		1,481.60	Labour	2,170.08
Government exp.		1,269.98	Capital	3,920.59
Stocks		96.93	Indirect taxes	237.96
Exports		1,671.03		
Imports	-	1,521.17		
Total		6,864.13	Total	6,864.13

Table 5.16: First Year Baseline Simulation of Expenditure and Income GDP (in Rp Trillion)

5.8.3 Balance of the Updated Database

Every year of simulation with AMELIA-F generates an updated database for that year. A required property of the model, helpful for checking the model implementation, is that the model should retain the balance of the updated databases throughout each year of the simulation. For this purpose, I create a check file to which are written the results of the balance check equation (Equation (5.25)) in each year of the simulation. In undertaking the multiple year baseline forecast, the results of this check indicate that the difference between sales and costs ($SDIFF_{(c)}$) in the database remains close to zero. This means that the model is able to keep the balance of the database in any updated database. If the initial database is unbalanced, this equilibrium condition of the database would not hold, especially in longer run simulations. Nor would it hold if there was an error in the computer coding governing update statements, or if an error in the coding failed to implement the assumed market clearing and zero pure profit conditions embedded in the model theory.

5.8.4 Consistent Results Using Different Solution Methods

For this test, I compared results for the baseline forecast using two different solution methods. First, I used the Euler 16-steps solution method. Second, I use Gragg 2-4-6 step extrapolation solution method. From a careful observation, I concluded that the differences of the results of both solution methods were small (see Table 5.17).

No	Variables	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Result of Euler 16 steps											
1	GNE	4.9235	4.9302	4.9363	4.9391	4.9458	4.9518	4.9571	4.9619	4.9663	4.9704
2	HH Cons	4.8980	4.9069	4.9153	4.9187	4.9279	4.9362	4.9437	4.9504	4.9566	4.9622
3	Exports	4.7210	4.7982	4.8478	4.8854	4.9107	4.9327	4.9516	4.9675	4.9807	4.9915

No	Variables	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Result of Euler 16 steps											
4	Imports	4.3843	4.4867	4.5610	4.6090	4.6627	4.7110	4.7534	4.7909	4.8239	4.8532
5	Stocks	4.6440	4.6756	4.7015	4.7236	4.7447	4.7638	4.7812	4.7970	4.8114	4.8245
Result of Gragg 2-4-6 steps											
1	GNE	4.9236	4.9303	4.9365	4.9393	4.9459	4.9518	4.9571	4.9620	4.9664	4.9704
2	HH Cons	4.8981	4.9070	4.9154	4.9189	4.9281	4.9363	4.9437	4.9505	4.9566	4.9622
3	Exports	4.7222	4.7993	4.8486	4.8863	4.9115	4.9338	4.9527	4.9684	4.9815	4.9924
4	Imports	4.3859	4.4881	4.5624	4.6104	4.6640	4.7120	4.7544	4.7920	4.8249	4.8539
5	Stocks	4.6445	4.6760	4.7019	4.7239	4.7450	4.7641	4.7814	4.7972	4.8116	4.8247
Euler 16 steps *minus* Gragg 2-4-6 steps											
1	GNE	-.0001	-.0001	-.0002	-.0001	-.0001	.0000	.0000	-.0001	-.0001	.0000
2	HH Cons	-.0001	-.0001	-.0002	-.0002	-.0002	-.0001	-.0001	-.0001	-.0001	.0000
3	Exports	-.0012	-.0011	-.0008	-.0009	-.0008	-.0011	-.0011	-.0009	-.0008	-.0009
4	Imports	-.0016	-.0014	-.0015	-.0014	-.0013	-.0010	-.0010	-.0011	-.0010	-.0008
5	Stocks	-.0005	-.0004	-.0003	-.0003	-.0003	-.0003	-.0002	-.0002	-.0002	-.0002

Table 5.17 Selected Baseline Results

5.8.5 Explainable results

This test is to confirm that the results are consistent with those expected given the theory that underlies the model and database. Although the database has satisfied the four tests outlined in Sections 5.8.1 to 5.8.4, there are still potential errors that could slip through these checks (e.g., placing the wrong sign on an elasticity or parameter). These types of error can be identified when the results are interpreted using the model's theories. For this exercise, I ran a positive shock to the shifter on required rates of return. This should cause a negative impact on investment and the capital stock, and therefore also the overall economy. When this shock was implemented, the simulation results were as expected.

5.9 Remap and Update of the Real-side Database

This section explains the final step in creation of the real-side database. To simplify both the computation and the links with the financial database, I reduced the number of sectors through aggregation. In addition, to match the financial database, which is for 2018, the real-side database needs to be updated to 2018.

5.9.1 Remap the Aggregation of Commodities and Industries

For the re-aggregation, I used the AggHAR program in GEMPACK to reduce the number of sectors from the original 185 to 51. The original aggregation follows those provided in the 2010 Indonesian IO table, while the new aggregation adopts the patterns of the Asian Development Bank (ADB, 2020).

5.9.2 Dwelling Investment

One contribution of this study is the creation of an ownership of dwellings (OD) sector in the CGE database. The creation of an OD sector is an important part of the real-side database construction process, as later it needs to be linked by to activities of the housing agent in the financial database and theory, as one of the capital creator agents. In the original database, the OD sector is recorded in residential buildings, which is only valued at 3 per cent of total investment. This looked suspiciously low, and thus may not reflect the reality. For example, housing investment is estimated at 15% of the total investment in BKPM, (2019). Based on this information, I performed an adjustment of the investment share composition without changing the overall value of investment. The adjustment is undertaken both in purchaser value of investment commodities ($V2PUR_{(c,s,i)}$) and the rental value of capital ($V1CAP_{(i)}$), hence maintaining desired relationships between investment, capital stocks, and capital rental rates.

5.9.3 Updating the real-side database

I use the ADJUSTER program provided by Horridge (2009) to update the real-side database in order to hit the components of nominal expenditure GDP in 2018. The ADJUSTER program is designed to create an updated database that follows the ORANI-G database structure. In this activity, I set the expenditure components of GDP equal to the values described in Table 5.19.

		Expenditure GDP
Household consumption		426,719
Investment		129,817
Government exp.		157,223
Exports		152,357
Imports	-	153,938
Total		712,820

Source: Bank Indonesia (2021)

Table 5.18 2018 Nominal Expenditure GDP (in Rp Trillion)

After updating the database, I repeated the tests explained in Sections 5.8.1 to 5.8.5 to confirm the validity of the real-side database.

5.10 Conclusions

This chapter describes the steps taken to create the real-side database of AMELIA-F. The real-side database has a similar structure to the MONASH CGE model (Dixon & Rimmer, 2002). To create this database, adjustments and additions must be made to official input-output data. The adjustment processes consist of three steps: (i) preparing essential matrices, (ii) balancing sales and costs, and (iii) converting to the final database. The essential matrices comprise the basic values of commodity purchases made by user agents, margins, indirect taxes, and value added. Every step of the database creation process requires the continued balance of sales and costs. Keeping this assumption for every adjustment step is helpful for error checking and for avoiding the accumulation of balance issues to the final step of the conversion to the final database.

The real-side database includes elasticities and parameters that govern the strength of certain economic relationships in the real-side model of AMELIA-F. Where possible, the values assigned to the elasticities and parameters have been taken from previous CGE studies of Indonesia e.g., Horridge & Yusuf (2017), Abimanyu (2000), and Wittwer (1999). This chapter discusses the parameterisation of: the elasticity substitution between primary factors, the Armington elasticities, the CET elasticities, export demand elasticities, and the expenditure elasticities and Frisch parameter of the Klein & Rubin (1947) consumption system.

The model's dynamic mechanisms allow it to perform multi-period CGE simulations. The mechanisms comprise capital accumulation and accumulations of public and foreign debt. Due to data limitations, the capital stocks are created by applying implied industry-specific rates of return on capital, calibrated by using previous studies and available statistics. Meanwhile, initial data of public and foreign debt are sourced from official publications.

To ensure the validity of data construction, the real-side database is tested using methods recommended by Horridge (2013). The tests are mostly related to the neoclassical CGE modelling properties i.e., nominal and real homogeneity and the balance of sales and costs. The test results show that the model exhibits the expected nominal and real homogeneity properties. The balance between sales and costs in the baseline simulation is maintained over the forecast time period. In addition, the initial simulation outcome shows that the baseline hits the value of nominal GDP as it appears in official statistics.

The final process is preparing the real-side database for its integration with the financial database. This required the creation and adjustment of the ownership of dwellings sector in the real-side database. The official input-output data shows this sector accounting for only a small (3 per cent) share of the total value of nominal investment. This is unlikely to reflect the reality, as other official statistics record a more reasonable 15 per cent share. Hence, the size of the ownership of dwellings sector was adjusted while keeping in place the database assumptions defined in the previous steps.

CHAPTER 6
Financial Database

6.1 Introduction

This chapter records the process of creating the financial-side database of AMELIA-F. The objective of this task is to transform the original financial data from official sources to the required financial database of AMELIA-F. At the same time, the transformation itself must not significantly alter the structure of the database for representing current configurations of the Indonesian financial system. The task includes a remapping process, calibration, and determination of coefficient values. The task of creating the financial database includes several tests to ensure database validity and consistency with the real-side AMELIA-F database and official statistics.

The rest of the sections are set out as follows. Section 6.2 describes the detailed structure of the required database for AMELIA-F. This covers the required general structure of the financial database, parameters, and elasticities. Section 6.3 documents details of the original data. Section 6.4 explains discrepancies between the original and required database and the approach to narrow these discrepancies. Section 6.5 elucidates the steps in parameterising rates of return matrices. Section 6.6 discusses bank risk weights. Section 6.7 discusses calibration of the Phillips' curve sensitivity parameters. Section 6.8 discusses determination of coefficients in the Taylor rule. Section 6.9 describes the general arrangement of elasticity of substitution. Section 6.10 and 6.11 discusses database validation tests. Section 6.12 concludes the chapter.

6.2 Required Financial Databases

Table 6.1 presents the list of elements of the required financial database for AMELIA-F. It consists of financial data, parameters, and elasticities. The financial data represents the initial solution of AMELIA-F in levels terms. $AT_{(s,f,d)}$ and $FLOW_{(s,f,d)}$ respectively represent the values of stocks and flows of financial instruments (f) transacted by liability agent (s) and asset agent (d). The powers (1 *plus* the rates) of the rates of return on these instruments are arranged in $ROIA_{(s,f,d)}$ for asset instruments and $ROIL_{(s,f,d)}$ for liability instruments. The power of the rate of return means that one *plus* the actual rate of return (e.g. a 1.12 power rate of return means a 12 per cent rate of return).

Tablo codes	Description	Dimension
Financial data		
$AT_{(s,f,d)}$	The value of financial instrument (f) issued by liability agent (s) held by agent (d) in the beginning of the year.	$s \in LA$, $f \in FI$, $d \in AA$.
$FLOW_{(s,f,d)}$	The change in the value of financial instrument (f) issued by liability agent (s) held by agent (d) accumulated within the year.	
$ROIA_{(s,f,d)}$	The power of the rate of return on asset (f) issued by liability agent (s) held by agent (d).	
$ROIL_{(s,f,d)}$	The power rate of the rate of return on liability (f) issued by liability agent (s) held by agent (d).	
Parameters		
$RISKWGT_{(s,f)}$	The regulatory risk-weights on commercial banks' holding of asset (f) issued by liability agent (s).	$s \in LA$, $f \in FI$.
NAIRU	Non-accelerating inflation rate of unemployment.	1
WAGE_ELAS	Elasticity of expected real wage growth to employment gap.	1
INFCOEF	Taylor rule: Inflation rate coefficient.	1
GAPCOEF	Taylor rule: Output gap/employment rate coefficient.	1
Elasticities		
ELAS_AS	Elasticity of domestic asset agents' portfolio weights to changes in relative rates of return.	AALF
ELAS_FOR	Elasticity of foreign asset agent's portfolio weights to changes in relative rates of return.	ROW
TAU	Transformation elasticity: capital structure problem for liability agents.	LA

Table 6.1 Required Financial Database

Table 6.2 provides definitions of financial instruments and agents used in all parts of AMELIA-F. When a financial agent acts in its capacity to raise liabilities, it is referred to as a liability agent (LA). When a financial agent acts in its capacity to purchase financial assets, it is referred to as an asset agent (AA). Financial agents have symmetric capacity for being LA and AA, thereby LA = AA. For example, when commercial banks make loans, they are acting in their capacity as asset agents. When commercial banks accept deposits, they are acting in their capacity as liability agents. Both LA and AA have eight elements: industries (Inds), central bank (CB), commercial banks (Banks), Non-bank financial institutions (NBFIs), government (Govt), households (HH), foreigners (RoW), and the housing sector (Housing). The set of financial instruments (FI) have five elements: bonds (Bonds), cash (Cash), deposits and loans (DepLoans), equity (Equity), and gold and IMF special drawing rights (GldSDRs).

Set	Description	Index	Elements
LA	Liability agents	(s)	Industries (Inds) Central Bank (CB) Commercial Banks (Banks) Non-bank financial institutions (NBFIs) Government (Govt) Households (HH) Foreigners (ROW) Housing (Housing)
AA	Asset agents	(d)	Industries (Inds) Central Bank (CB) Commercial Banks (Banks) Non-bank financial institutions (NBFIs) Government (Govt) Households (HH) Foreigners (ROW) Housing (Housing)
FI	Financial Instrument	(f)	Bonds (Bonds) Cash (Cash) Deposits or Loans (DepLoans) Equity (Equity) Gold and IMF-Special Drawing Rights (GoldSDRs)

Table 6.2 Definition of Sets in the Financial Database

Liability Agent ($s \in LA$) \ Asset Agent ($d \in AA$)	Inds	CB	Banks	NBFI	Govt	HH	ROW	Housing
Inds								
CB								
Banks		$f \in FI$						
NBFI								
Govt								
HH								
ROW								
Housing								

Figure 6.1 Illustration of AT(s,f,d) in financial database

For illustration, Figure 6.1 rearranges AT in a two-dimensional array. The shaded cell reflects the value of beginning-of-year of financial instrument $(f) \in FI$ issued by commercial banks as liability agents and held by the central bank as asset agent. The financial instrument can be specified for example as "DepLoans" instrument. This could represent loans of exchange settlement balances by the commercial banks from the central bank. The financial stocks cannot be negative at any time. However, FLOW could be negative, representing a reduction in holdings/issuance of the instruments within the year. In similar principle, Figure 6.1 can also be used to illustrate the power of rates of return (ROIL and ROIA).

The parameters and elasticities listed in the second and third section of Table 6.1 are responsible for governing certain financial regulations and theories installed in AMELIA-F. $RISKWGT_{(s,f)}$ are the regulatory parameters that represent the authorities' perceptions of market risks faced by the commercial banks on the assets they hold. The value of $RISKWGT_{(s,f)}$ is instrument and counterparty specific. For example, the risk weight for bank lending given to a foreigner is typically higher than for domestic borrowers. WAGE_ELAS is a parameter of the Phillips Curve (Phillips, 1958).[21] INFCOEF and GAPCOEF are the weights attached to central bank decision trade-offs on inflation and output stability aims.[22] ELAS_AS, TAU, and ELAS_FOR,[23] are the substitution elasticities describing how the structure of the liability and asset sides of financial agent balance sheets respond to changes in relative rates of return.

6.3 The Original Financial Database

The main financial database of AMELIA-F is sourced from the 2018 Financial Account and Balance Sheet of Indonesia (2018 FABSI). FABSI is an integrated approach that aims to capture the transactions in the real economy and financial markets in one framework. The FABSI database is constructed and administered by Bank Indonesia. It aims to improve the understanding of financial authorities about the linkages between the financial and real sides of the economy. The database is constructed according to the

[21] The description of the Phillips curve specification is provided in the Section 4.8 of Chapter 4.
[22] The description of Taylor's rule is discussed in the Section 4.9 of Chapter 4.
[23] Elasticity substitution in financial-side of AMELIA-F is explained in Section 4.4 of Chapter 4.

methodology outlined in System of National Account (SNA) 2008, and accounting standards given in Monetary and Financial Statistics Manual (MFSM) 2000 and 2008, Government Financial Statistics (GFS) 2014, and the IMF Balance of Payment Manual 6 (BPM6) (Karyawan et al., 2015).

Broadly, FABSI has a similar descriptive purpose to that of the required financial database in AMELIA-F. It complies the stocks and flows of financial instruments between liability agents and asset agents. For illustration, the format of FABSI can be presented in Figure 6.2. This figure is rather similar to the financial database displayed in Figure 6.1, however with transposed rows and columns. The shaded cell in Figure 6.2 represents the values of financial instruments issued by the ODCs (Other Depository Corporations) held by HH (Households). In this case, ODCs is the liability agent and HH is the asset agent. If index (f) is specified as loans, the cell implies the value of household deposits placed in ODCs. Since this figure represents the directions of values of financial instruments between agents, this table is also known as the whom-to-whom matrix (WTW).

		Liability Agent (s ∈ LA_O)							
		NFCs	CB	ODCs	OFCs	CG	LG	HH	ROW
Asset Agent (d ∈ AA_O)	NFCs								
	CB								
	ODCs								
	OFCs								
	CG								
	LG								
	HH			f ∈ FI_O					
	ROW								

Source: adapted from WTW Matrix of 2018 FABSI

Figure 6.2 Reporting Format of Whom-to-whom (WTW) Matrix of FABSI

Set	Description	Short name
Financial institutions		
(LA_O = AA_O)	Non-Financial Corporations	NFC
	Central bank	CB
	Other depository corporations	ODC
	Central government	CG
	Local government	LG

Set	Description	Short name
	Households	HH
	Rest of the World	ROW
Financial instruments (FI_O)	Monetary Gold and SDRs	GoldSDRs
	Currency and deposits	CurrDep
	Debt and securities	Debts
	Loans	Loans
	Equity	Equity
	Insurance and pension	InsPen
	Financial derivatives	Derivative
	Other accounts receivable/payable	Other

Source: adapted from Karyawan et al., (2015)

Table 6.3 Definitions of Financial Institutions and Instruments

6.3.1 Financial Agent in The Original Database

In what follows, I summarise the definitions of financial agent and instruments presented in FABSI (Table 6.3). The explanations here refer to those explained in Karyawan et al. (2015).

6.3.1.1 Non-financial corporations (NFC)

NFC represents the real-side industries as a capital creating agent in the financial system. It serves similarly to the Inds agent in the required financial database for AMELIA-F (see Table 6.2). It raises liabilities to finance the investment activities for creating physical capital. The NFC can be purely private, state owned, foreign owned, or a mixture of all types of ownership.

6.3.1.2 Central bank

The central bank is given authority to perform monetary policy. It can influence liquidity and interest rates in financial markets via commercial banks' settlement balances and undertaking open market operations.

6.3.1.3 Deposit taking corporations (ODC)

ODCs take the role of financial intermediaries. This means they take deposits from other financial agents and provides loans to other financial agents. This role has become a traditional institutional behaviour of commercial banks.

6.3.1.4 Other financial corporations (OFC)

OFCs are financial institutions other than the central bank and commercial banks. In this classification, the OFC comprises money market funds (MMF), non-MMF investment funds, other financial intermediaries, financial auxiliaries, captive financial institutions and money lenders, insurance corporations, and pension funds.

6.3.1.5 General government

The general government agent has a significant role in the economy, especially in relation to income redistribution. This means the general government agent can levy taxes and make transfers and subsidies. In FABSI, the general government is disaggregated into the central government (CG) and local government (LG). However, for the required financial database, I only recognise a single representative government agent, hence the CG and LG should be aggregated.

6.3.1.6 Households (HH)

The Household financial agent generates savings from the surplus of disposable income after consumptions in the real-side economy. The savings can be allocated to financial agents and instruments (e.g., commercial banks deposits) or non-financial assets (e.g., housing equity).

6.3.1.7 Rest of the world (ROW)

ROW is the non-resident financial agent that make transactions with domestic financial agents. There is only single representative ROW agent that aggregates all classifications of foreign financial institutions.

6.3.2 Financial Agents in The Original Database

The FABSI database categorises the financial instruments into eight classifications as follows:

6.3.2.1 Monetary gold and SDRs (GoldSDRs)

Monetary gold is the gold asset owned by the central bank or government and stored as part of reserve assets. Special drawing rights (SDRs) are international financial claims issued by the IMF. The IMF-SDRs are also classified as international reserve assets of the central banks and government.

6.3.2.2 Currency and deposits

Currency comprises notes and coins issued by the central bank as liabilities. Deposits are the claims of the holders to the issuers. The deposit ownerships are transferable and can be converted into currencies or be used for the payments of cheque, bill of exchange, and other payment instruments. Deposits includes interbank positions that represent claims of a commercial banks to the other commercial banks or the central bank.

6.3.2.3 Debt securities

Debt securities are liability instruments including bill of exchange, bonds, negotiable certificates of deposit, debentures, commercial paper, and asset backed securities.

6.3.2.4 Loans

In contrast to deposits, loans are not negotiable. Loans are proven by legal documents between debtors and creditors. In this classification, loans consist of overdrafts, and instalment loans. The receivable and payable could not be included in loans classification.

6.3.2.5 Equity and investment funds

In general, equity can be interpreted as a proof of ownership in a financial institution. Equity is the value of the residual after the value of liabilities are covered by the value of assets. Equity could appear in a variety of instruments e.g., shares, stocks, depository receipts, and fund participation. The equity can further be categorised as listed shares, unlisted shares, and other equity. The listed shares are tradable financial instruments in the stock market. The unlisted shares are non-tradable but transferable. Other equity is unlisted and not-transferable.

Investment funds are collective funds to be invested by a financial institution. For example, investment funds can be money market funds (MMF) to purchase money market instruments e.g., treasury bills, commercial papers, and certificates of deposit. The maturity of the investment funds is normally one year at maximum. For non-MMFs, the investment funds can be allocated to the purchase of longer maturity financial instruments, e.g., real estate investment trust (REITs) instruments.

6.3.2.6 Insurance, pension, and guarantee schemes

These instruments represent the liabilities of other financial corporations (OFCs) to industries (NFCs) and households (HH). The OFCs aggregation includes insurance companies, pension funds, and other institutions that provide insurance and pension instruments. On the other side, the beneficiaries of these instruments are NFCs and HHs.

6.3.2.7 Derivatives and stock options

Derivative financial instruments are financial instruments that are tied to other financial instruments, e.g., indices of financial instruments or commodities. The option derivative agreement is a right to purchase (call option) or to sell (put option) a financial instrument at a specific price and time. Forward derivatives are agreements to settle a transaction at a specific time. The stock option is an agreement to purchase company stock at pre-agreed price and time.

6.3.2.8 Other accounts receivable and payable

This classification includes trade credit, advance payments, and other payments. Trade credits are financing made other than loans for trade purposes. Advance payments are payments made for an unfinished transaction. The other payments include the rest of the payments such as advanced tax payments and late income payments.

6.4 Remapping Financial Agents and Instruments for AMELIA-F

After learning the structure of FABSI, it becomes clear that FABSI is not ready for a direct use in AMELIA-F. There are important differences between the sets of agents and instruments between FABSI and the required AMELIA-F database. To narrow down the differences, I perform a remapping process as summarised in Table 6.4.

Column (1) of Table 6.4 describes the original disaggregated financial agents from where the FABSI's raw data were collected. Column (2) and (3) are the aggregated version of FABSI which becomes the stylised representation of current structure FABSI database. The appearance of this aggregation setting is similar to that in the whom-to-whom (WTW) matrix (Figure 6.2). Column (2) provides more information on the data collections in other financial corporations (OFCs). For example, derivative instruments are collected from money market fund participants. Column (4) and (5) describes arrangement of financial agents and instruments in the required database of AMELIA-F. The arrangement is represented in illustrative figure outlined in Figure 6.1.

6.4.1 Remapping Financial Agents

The non-financial corporations (NFCs) of FABSI (column (2) of Table 6.4) are disaggregated into Inds and Housing agents in the AMELIA-F database (column (4)). This conclusion is taken by considering that the NFCs in FABSI is defined using SNA 2008 and Karyawan et al. (2015). Under this definition, the NFCs should represent the set of industries in the real economy that includes non-housing industries (Inds) and the dwelling industry (the housing sector). The weights to split the non-housing industry and housing sector herein uses the nominal investment data from the real-side database of AMELIA-F which has been developed earlier.

The remapping process for the pure financial institutions (CB, Banks, and NBFIs) are relatively simple. The CB, ODCs, and OFCs in column (2) can be remapped straight to CB, Banks, and NBFIs in column (4). The central government (CG) and local government (LG) in column (2) are merged to form a single representative government agent (Govt) in column (4). The Household (HH) and foreign (ROW) agents in column (2) are respectively remapped on a one-to-one basis to HH and ROW agents in column (4).

6.4.2 Remapping Financial Instruments

Figure 6.3 illustrates the remapping process for the financial instruments. The left column lists the financial instruments in the FABSI database and the right column lists the financial instruments in the AMELIA-F database. GoldSDRs instrument in FABSI is mapped on a one-to-one basis to the GoldSDRs instrument in AMELIA-F (line 1).

The value of CurrDep in FABSI is split into two categories: Cash and Deploans. The CurrDep issued by the CB agent is remapped to Cash (line 2), while that raised by other institutions (e.g., Banks) is remapped to Deploans in AMELIA-F database (line 3). Loans issued by all liability agents and held by all asset agents in FABSI become an addition to DepLoans in AMELIA-F (line 4).

Debt in FABSI is directly remapped to Bonds in AMELIA-F (line 5). Equity in FABSI is remapped to Equity in AMELIA-F (line 6). The value of the Equity instrument in AMELIA-F includes the FABSI instrument categories Insurance and Pension (InsPen) (line 7) and other instruments (Other) (line 8). In the FABSI database, the share of Inspen and Other is as small as 7 per cent of total financial instruments. Finally, considering the nature of the transaction, the Derivatives are remapped to DepLoans. However, the value of derivatives is negligible, with the share being just 0.02 per cent of total financial instruments.

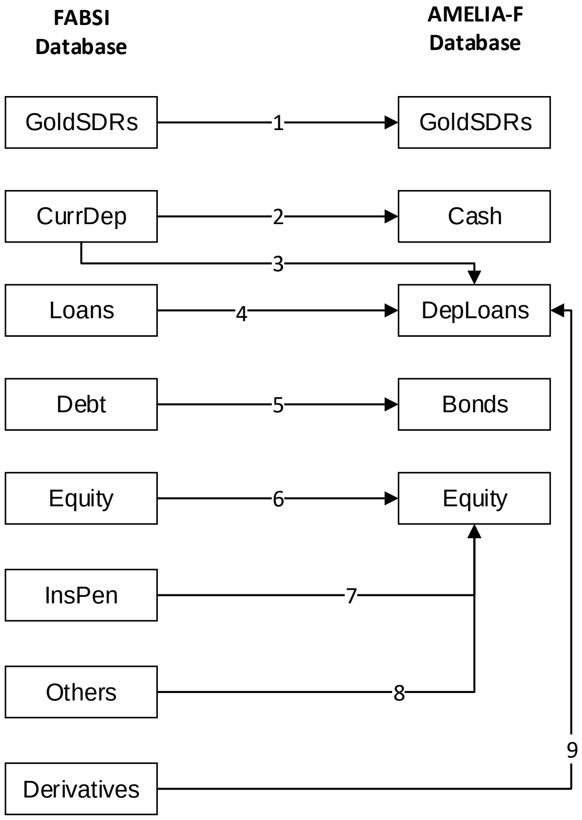


Figure 6.3 Remapping Financial Instruments

No	Financial Institutions in Raw Data	FABSI		AMELIA-F	
		Agent	Instrument	Agent	Instrument
	(1)	(2)	(3)	(4)	(5)
1	NFCs	NFCs	FI_O	Inds	FI
				Housing	FI
2	CB	CB	FI_O	CB	FI
3	ODCs	ODCs	FI_O	Banks	FI
4	MMFs	OFCs	FI_O + Derivatives	NBFI	FI
5	Non-MMFs		FI_O + Other Instruments		
6	Fin-Auxiliaries				
7	Captive Financial Institutions and money lender				
8	Insurance corporations		FI_O + Insurance and pension funds		
9	Pension funds				
10	Central Government	CG	FI_O	Govt	FI
11	Local Government	LG	FI_O		FI
12	Households	HH	FI_O	HH	FI
13	ROW	ROW	FI_O	ROW	FI

Source: adapted from Karyawan et al., (2015)

Table 6.4 Remapping of Financial Institution and Instruments

6.5 Parametrisation of Financial Rates of Return

Where possible, data sources for the rates of return are taken from official resources e.g., Bank Indonesia, OJK, Ministry of Finance of Republic of Indonesia, and Indonesian Stock Exchange (IDX). When not publicly available, the data are taken from private data providers, such as Bloomberg and CEIC. Because ROIA and ROIL are equalised, all formulae written for ROIA are mirrored for ROIL.

6.5.1 Basic rates of return

Table 6.5 describes reference values for market rates of return in 2018. Cash and monetary gold and SDR (GoldSDR) are given a zero rate of return since holders of these instruments receive no interest or dividend income from holding them. The basic rate for debt instruments (B_DL) is calculated from a simple average of 2-month saving and loan interest rates, and the 10-year (benchmark) government bonds yield. Commercial bank rate of return is set larger than the corporate rate of return. The larger equity rate of return can be attributed to smaller profitability in banking industry compared to those in the non-banking industry (Pennacchi & Santos, 2018). This is possibly because the expansion of productive assets in the banking industry is limited by capital provision regulation to reduce credit risk. With limited data availability, the equity return for NBFI is as low as 3.73 per cent, which is taken from venture capital statistics.[24]

Financial Instrument	Formula	Remarks
Cash	$\mathrm{ROIA}_{(\mathrm{LA,Cash,AA})} = 1.0;$	No interest or dividend return.
Monetary gold and SDRS	$\mathrm{ROIA}_{(\mathrm{LA,GoldSDR,AA})} = 1.0;$	No interest or dividend return.
Debt instruments	$\mathrm{ROIA}_{(\mathrm{LA,B\_DL,AA})} = 1.0 + 0.0832;$	B_DL includes Bonds and DepLoans. Source: Bank Indonesia (2021a), Bank Indonesia (2021b), CEIC (2021).[25]
Commercial banks equity	$\mathrm{ROIA}_{(\mathrm{LA,Equity,AA})} = 1.0 + 0.1673;$	Source: SSKI, Bank Indonesia (2020b).

[24] Venture capital the element of NBFIs.
[25] The rate of return for this entry is measured from the simple average of 1-year commercial bank loans, savings, and benchmark government bond yields (10-year maturity). The loan and saving statistics are from Bank Indonesia (2021a) and Bank Indonesia (2021b), while the benchmark government bond yield is from the CEIC (2021).

Financial Instrument	Formula	Remarks
Corporation (non-financial) equity	$\text{ROIA}_{(\text{Inds,Equity,AA})} = 1.0 + 0.1033;$	Source: SSKI, Bank Indonesia (2020b).
Central bank equity	$\text{ROIA}_{(\text{CBLA,Equity,AA})} = 1.0 + 0.040;$	Source: Giesecke et al. (2015)
NBFI equity	$\text{ROIA}_{(\text{NBFILA,Equity,AA})} = 1.0 + 0.0373;$	Source: Venture capital, SSKI, Bank Indonesia (2020b).

Source: Summarised from multiple sources

Table 6.5 Basic Setting of Rates of Return

6.5.2 Bond Yields

Table 6.6 shows the adjustment of bond instruments issued by various liability agents. Table 6.11 provides the list of coefficients and corresponding reference rates used for adjusting the basic rates of return. Government yield is normally higher than the central bank certificate (SBI or SDBI).[26] Investors usually ask additional premiums for an implied sovereign risk (GOVSPREAD). Corporate yield is set even higher due to more complicated risks associated with the private bond issuance. Commercial banks yield is as low as the deposit rate, as commercial banks are more protected from default risk via lender of last resort (LOLR) and deposit insurance. Consumer and foreign yields respectively use NONBANKYIELD and FINYIELD, although these financing schemes are not common in Indonesian financial markets.

Financial Instrument	Formula
Government bonds Corporate bonds	$\text{ROIA}_{(\text{GOVLA,Bonds,AA})} = 1.0 + \text{REPO} + \text{GOVSPREAD};$ $\text{ROIA}_{(\text{KAGENTS,Bonds,AA})} = 1.0 + \text{NONFINYIELD};$
NBFI bonds	$\text{ROIA}_{(\text{NBFILA,Bonds,AA})} = 1.0 + \text{NONFINYIELD};$
Commercial bank bonds	$\text{ROIA}_{(\text{BNKLA,Bonds,AA})} = 1.0 + \text{FINYIELD};$
Consumer bonds	$\text{ROIA}_{(\text{HSELA,Bonds,AA})} = 1.0 + \text{NONBANKYIELD};$
Foreign bonds	$\text{ROIA}_{(\text{ROW,Bonds,AA})} = 1.0 + \text{FINYIELD};$

Table 6.6 Adjustment of Bond (Yield) Rates

6.5.3 General DepLoans Rates

Deposits and loans (DepLoans) are the important instruments for commercial banks and the central bank. Commercial banks use DepLoans to raise loan finance from customers. Central banks use DepLoans to affect commercial bank behaviour through reserve

[26] SBI and SDBI stand for Sertifikat Bank Indonesia and Sertifikat Deposito Bank Indonesia respectively.

requirements. Table 6.7 describes the initial calibration process for DepLoans rates of return for commercial banks and the central bank. For the commercial banks, deposit rate is calculated from the risk-free rate plus the spread for the commercial deposit rate. When accepting DepLoans, the central bank offers the repo rate which is the risk-free rate. When offering DepLoans instruments to commercial banks (by purchasing commercial banks' securities), the central bank charges the lending facility rate which is higher than the repo rate.

Financial Instrument	Formula
Commercial banks deposits	$\mathrm{ROIA}_{(\mathrm{BNKLA,DLSET,AA})} = 1.0 + \mathrm{BNKDEPRTESPD} + \mathrm{REPO};$
Central bank's risk free rate	$\mathrm{ROIA}_{(\mathrm{CBLA,DLSET,AA})} = 1.0 + \mathrm{REPO};$
Central bank's lending facility rate	$\mathrm{ROIA}_{(\mathrm{LA,DLSET,CBLA})} = 1.0 + \mathrm{LENDING\_RATE};$

Table 6.7 Adjustment of DepLoans rates

6.5.4 Bank DepLoans Rates

Table 6.8 describes initial settings for loan rates of the commercial banks. The commercial bank mortgage rate refers to a 15-year rate offered at 10.68 per cent. The reference rate for non-housing bank financing is slightly lower than the mortgage reference, as it is commonly provided in a shorter maturity period. The rate offered on lending between commercial banks and NBFIs uses interbank money market rates e.g., Jakarta Interbank Offered Rate (JIBOR).

Financial Instrument	Formula
Long term mortgage rate Commercial banks non-mortgage rate	$\mathrm{ROIA}_{(\mathrm{LA,DLSET,BNKLA})} = 1.0 + \mathrm{KPR15};$ $\mathrm{ROIA}_{(\mathrm{NONHSELA,DLSET,BNKLA})} = 1.0 + \mathrm{BANK\_INV\_R};$
Commercial bank loan for NBFI	$\mathrm{ROIA}_{(\mathrm{NBFILA,DLSET,BNKLA})} = 1.0 + \mathrm{INTERB\_RT};$

Table 6.8 Adjustment of Loan Rates provided by Commercial Banks

6.5.5 NBFI DepLoan Rates

Table 6.9 compiles the adjustment process for NBFI rates of return with respect to DepLoans. As aforementioned, the offered rates for financial transactions intra-NBFI or between NBFI and commercial banks use the interbank money market rates. The NBFI acquisition of government bonds uses the normal yield defined in Table 6.6.

Financial Instrument	Formula
NBFI loans rate	$\mathrm{ROIA}_{(\mathrm{BANKLA,DLSET,NBFI})} = 1.0 + \mathrm{INTERB\_RT};$
Non-bank Money Market rate	$\mathrm{ROIA}_{(\mathrm{NBFI,DLSET,NBFI})} = 1.0 + \mathrm{INTERB\_RT};$
NBFI acquisition on government debt	$\mathrm{ROIA}_{(\mathrm{NBFI,DLSET,NBFI})} = 1.0 + \mathrm{REPO} + \mathrm{GOVSPREAD};$

Table 6.9 Adjustment of Loan Rates provided by NBFI

6.5.6 Non-Bank Equity Rates

Table 6.10 describes non-commercial bank equity rates for the key financial agents in AMELIA-F. The corporate equity rate not only covers the corporate ROE, but also includes the country risk. In this study, the country risk is represented by 5-year credit default swap (CDS) of 1.38 per cent, which is significantly higher than those in advanced countries. Due to data limitations, central bank equity is set at the repo rate.

Financial Instrument	Formula
Corporate equity rate	$\mathrm{ROIA}_{(\mathrm{NONHSELA,EQU,AA})} = 1.0 + \mathrm{IND\_ROE} + \mathrm{IND\_RISKP};$
Set initial central bank equity rate to Repo rate	$\mathrm{ROIA}_{(\mathrm{NONHSELA,EQU,AA})} = 1.0 + \mathrm{REPO};$

Table 6.10 Adjustment of Equity Rates

Coefficient	Reference rate (%)	Description	Source
REPO	5.25	7D Reverse repo rate	Bank Indonesia (2020b)
GOVSPREAD	1.89	10YR GB - REPO	CEIC (2021)
NONFINYIELD	9.28	10YR Corp yield	CEIC (2021a)
FINYIELD	6.51	1YR Deposit rate	Bank Indonesia (2020b)
NONBANKYIELD	24.18	Rural bank rate (BPR)	OJK (2021)
KPR15	10.68	Average bank mortgage rate	Bank Indonesia (2020b)
BNKDEPRTESPD	0.76	Bank deposit rate – REPO	Bank Indonesia (2020b)
LENDING_RATE	5.75	Central bank lending facility rate	Bank Indonesia (2021a)
BANK_INV_R	10.56	Commercial bank investment loan rate	Bank Indonesia (2021c)
BANK_CONS	11.73	Commercial bank consumer loan rate	Bank Indonesia (2021c)
INTERB_RT	4.80	JIBOR-overnight rate	Bank Indonesia (2020b)

Coefficient	Reference rate (%)	Description	Source
IND_ROE	10.33	Corporate ROE	Bank Indonesia (2020b)
IND_RISKP	1.37	CDS converted from bps	Bank Indonesia (2020b)
GLO_ROE	2.81	LIBOR 3M	Bank Indonesia (2020b)

Source: summarised from multiple sources

Table 6.11 Reference Rates for Adjustments

6.6 Risk Weighted Asset of Commercial Banks

Risk weights are regulatory parameters that tie the equity capital financing of the banking sector to the composition of commercial bank assets. As a reminder, the regulatory bank capital adequacy ratio can be formulated as:

$$\mathrm{KAR} = \frac{\mathrm{Equity}}{\sum \mathrm{ASSET}(\mathrm{s},\mathrm{f},\mathrm{Banks}) \cdot \mathrm{RW}(\mathrm{s},\mathrm{f})}, \tag{6.1}$$

where,

- KAR is regulatory capital adequacy ratio,
- Equity is commercial banks equity capital,
- $\mathrm{ASSET}(\mathrm{s},\mathrm{f})$ is commercial bank holdings of instrument (f) issued by agent (s),
- RW(s,f) is the risk weight attached to instrument (f) issued by agent (s).

From Equation (6.1), given an exogenously determined value for KAR and given values for $\mathrm{ASSET}(\mathrm{s},\mathrm{f})$, higher values for RW(s,f) require the banks to finance a larger share of their asset purchases via equity. In this study, I refer to the risk weights used in Giesecke et al. (2016). The values for risk weights are presented in Table 6.12. The table shows that bank holdings of equity assets carry the highest risk weights. The purpose for this arrangement is that the commercial banks should not accumulate too large a portion of equity assets financed via debt instruments, as equity assets are considerably risky for the banking business. If banks wish to hold equity assets, they need to issue more equity capital on the liability side of their balance sheets for loss absorption.

	Bonds	Cash	DepLoans	Equity	GoldSDRs
Inds	0.5	0	0.5	3	0.5
CB	0	0	0	3	0

	Bonds	Cash	DepLoans	Equity	GoldSDRs
Banks	0.5	0	0.5	3	0.5
NBFI	0.5	0	0.5	3	0.5
Government	0	0	0	3	0
Households	0.5	0	0.5	3	0.5
ROW	0.5	0	2.0*	3	0.5
Housing	0.5	0	0.5	3	0.5

Source: Giesecke et al. (2016);
*author's judgment.

Table 6.12 Risk Weights

6.7 Calibration of Asymmetric Wage Adjustment (the wage Phillips Curve)

This section focuses on the setting of the parameters of the wage Phillips Curve (WPC), which sets out the relationship between wages growth and the unemployment rate. The values for the parameters of the WPC used in AMELIA-F are described in the Table 6.13. The values of NAIRU, UR, ER, W*, EP, and P are taken from statistical records. WAGE_ELAS, which is the parameter governing the sensitivity of the WPC, is calculated from calibration. The values in the second part are generated in a pragmatic approach using the *goal seeker* function in a Microsoft-excel spreadsheet to ensure the overall statistical assumptions are satisfied by that parameter.

Parameters	Reference Value	Description
NAIRU	0.0600	Non-accelerating inflation rate of unemployment
UR	0.0645	Unemployment rate
ER	0.9355	Employment rate
W*	1.0375	Expected wage (% change)
EP	1.0313	Expected CPI inflation (% change)
P	1.0300	Lagged inflation (% change)
WAGE_ELAS	0.1615	Expected real wage growth to employment gap

Table 6.13 Parameters Setting to Activate the Phillips Curve

Figure 6.4 visualises the shape of the WPC in AMELIA-F. The figure shows that the curve passes through the cartesian point of (1,1) at point N. At point N, on the horizontal axis (X=1), and the unemployment rate is at its natural level (NAIRU). On the vertical axis (Y=1) means that the expected growth in real wages in year t is the same as the actual rate of real wage growth in year t-1. When the unemployment rises above the natural rate, X moves below 1. Via the WPC, this moderates the rate of real wage growth. When the unemployment falls below the natural rate, X moves above 1. Via the WPC, this raises the rate of real wage growth, damping employment growth.

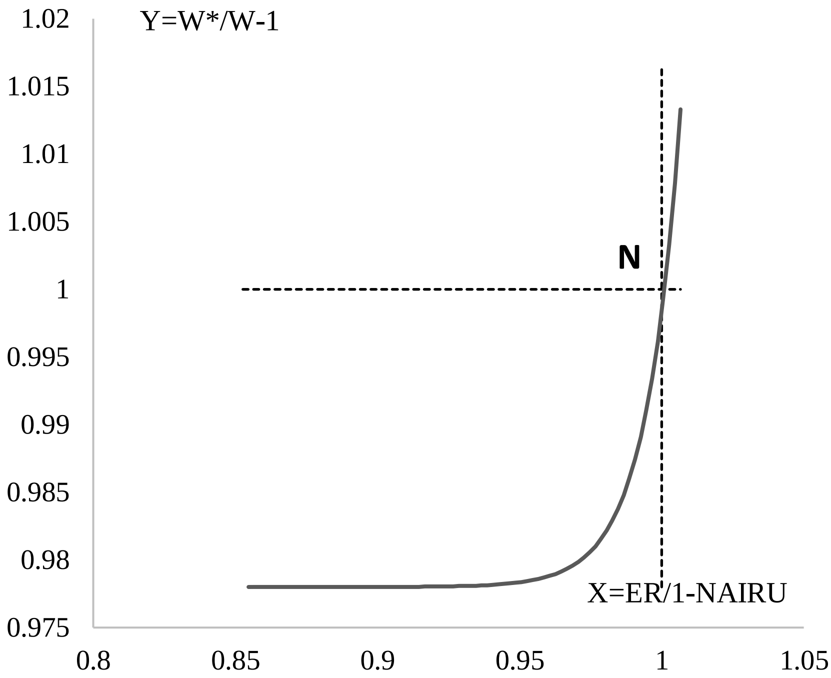


Figure 6.4 Shape of the wage Phillips Curve in AMELIA-F

6.8 Parameterisation of the Taylor rule

The Taylor rule in AMELIA-F is specified as follows:

$$\begin{aligned}(\mathrm{cash\_rate\_pow} - \mathrm{cash\_rate\_pow\_lag}) &= \mathrm{INFCOEF} \cdot (\mathrm{p3tot} - \mathrm{p3tot\_targ}) + \mathrm{GAPCOEF} \\ &\cdot (\mathrm{emp\_rate} - \mathrm{emp\_rate\_targ}) + \mathrm{ftaylor2},\end{aligned} \tag{6.2}$$

where,

- $(\mathrm{cash\_rate\_pow} - \mathrm{cash\_rate\_pow\_lag})$ is the difference between the percentage-change of the power of cash rate and the lagged percentage-change in the power of the cash rate;
- $(\mathrm{p3tot} - \mathrm{p3tot\_targ})$ is the difference between the percentage change in the consumer price index and the percentage change in the target level of the consumer price index;

- $(\text{emp\_rate} - \text{emp\_rate\_targ})$ is the difference between the percentage change in the employment rate and the percentage change in the target employment rate;
- ftaylor2 is a shift variable, which, when exogenous, activates Equation (6.2);
- INFCOEF is Taylor rule coefficient on inflation gap; and
- GAPCOEF is Taylor rule coefficient in employment gap.

When Equation (6.2) is activated (by exogenising ftaylor2), the model has a balancing mechanism through the central bank to correct price and employment deviations toward the predetermined targets. In the medium- to long-run, wage adjustment, via the mediation of the wage Phillips curve, is the primary mechanism for equilibrating demand and supply for labour. Hence, while Equation (6.2) provides an avenue for short-run labour market conditions to influence monetary policy settings in the short-run, in the medium- to long-run Equation (6.2) acts on interest rate setting primarily via deviations in inflation from target.

In AMELIA-F, I assume that the central bank takes an intermediate position between prioritising price and employment rate stability in the short-run. Hence, I set $\text{INFCOEF} = \text{GAPCOE} = 0.5$. This assumption is based on the many instances where the central bank explains that it determines the policy rate (cash rate) to achieve inflation and economic stability at the same time.[27]

6.9 Elasticities

The model theory governing asset acquisition and liability issuance are articulated in CES and CET functional forms. In this regard, there must be elasticities which govern the sensitivity to relative rates of return across instruments of both supply of and demand for specific financial instruments. In AMELIA-F, the elasticities closely follow those in VU-NatF by Giesecke et al. (2017) and USAGE2F by Nassios et al. (2019). Table 6.14 shows the values of the elasticities of substitution.

Elasticity	Value	Description
ELAS_AS	5.0	Elasticity of demand for assets by domestic investors
ELAS_FOR	4.0	Elasticity of demand for local assets by foreigners
TAU	5.0	Transformation elasticity: capital structure problem for liability agents

[27] For example, see Bank Indonesia's Monetary Policy Report Q1 2022 (Bank Indonesia, 2022).

Table 6.14 Elasticities of Substitution of Asset Acquisition and Liability Issuance

6.10 Financial Database Validations

There are several essential checks to confirm the validity of the created financial database at each step of the database process. Table 6.15 compiles seven key validation tests with their critical values. The first test is that the sum of AT and FLOW must not result in negative elements, as this sum reflects end-of-year financial stocks. Second, pure financial institutions, i.e., CB, Banks, and NBFIs, must have equal FLOW values on both the asset and liability sides.

No.	Validation Tests	Critical Value	Description	AMELIA-F
1.	$\sum_{s,f,d} AT_{(s,f,d)} + FLOW_{(s,f,d)}$	≥ 0	Financial stock end-of-year must not be negative	≥ 0
2.	$\sum_{f,d} FLOW_{(s,f,d)} - \sum_{f,s} FLOW_{(s,f,d)},$ $s, d \; \forall \; CB, Banks, NBFI$	0	Total liabilities and assets for pure financial agents (CB, Banks, NBFI) must be equal	0
3.	NH_VINVESTDF	0	Difference between the value of non-housing investment in real-side and financial database.	0
4.	H_VINVESTDF	0	Difference between value of housing investment in real-side and financial database.	0
5.	HOUS_SAVEDF	0	Difference between value of household savings in real-side and financial database.	0
6.	GOV_DEFDF	0	Difference between value of fiscal deficit in real-side and financial database.	0
7.	CADDF	0	Difference between value of current account deficit in real-side and financial database.	0

Table 6.15 Validity Checks of Financial Database

Third, the value of nominal investment in the real-side and financial database must be equal. NH_VINVESTDF is the difference between the values for nominal investment in the real-side and financial database. $\mathrm{NH\_VINVESTDF}$ is calculated from the following equation:

$$\begin{aligned}\mathrm{NH\_VINVESTDF} &= \mathrm{V2TOT}_{(\mathrm{Ownerdwelling})} \\ &- \left(\sum_{\mathrm{f}\in\mathrm{FI},\mathrm{d}\in\mathrm{LA}} \mathrm{FLOW}_{(\mathrm{Inds,f,d})} - \sum_{\mathrm{f}\in\mathrm{FI},\mathrm{s}\in\mathrm{AA}} \mathrm{FLOW}_{(\mathrm{s,f,Inds})}\right),\end{aligned} \tag{6.3}$$

where,

- $\mathrm{NH\_VINVESTDF}$ is difference between nominal investment in the standard CGE model database and the financial CGE database;
- $\mathrm{V2TOT}_{(\mathrm{NonOwnerdwelling})}$ is nominal investment in the real-side CGE database for non-owner dwelling industries;
- $\sum_{\mathrm{f}\in\mathrm{FI},\mathrm{d}\in\mathrm{AA}} \mathrm{FLOW}_{(\mathrm{Inds,f,d})}$ is the value of non-dwellings investment in the financial database;

The first part of the RHS accounts for the sum of nominal investment of non-dwelling industries in the standard CGE model database. The second part of the RHS computes the net issuance of liabilities by the industry agent in the financial database. A zero critical value for NH_VINVESTDF implies that nominal investments in both databases equal. The test of AMELIA-F shows that the gap between databases is zero.

Fourth, in a similar way, the nominal investment of the housing sector ($\mathrm{H\_VINVESTDF}$) in the real-side and financial databases should be equal. $\mathrm{H\_VINVESTDF}$ is calculated in the following equation:

$$\begin{aligned}\mathrm{H\_VINVESTDF} &= \mathrm{V2TOT}_{(\mathrm{Notownerdwelling})} - \sum_{\mathrm{f}\in\mathrm{FI},\mathrm{d}\in\mathrm{AA}} \mathrm{FLOW}_{(\mathrm{House,f,d})},\end{aligned} \tag{6.4}$$

where,

- $\mathrm{H\_VINVESTDF}$ is the difference between the values of real-side and financial housing investment;
- $\mathrm{H\_VINVEST}_{(\mathrm{j})}$ is the value of housing investment in the real-side CGE database;
- $\mathrm{H\_VINVEST\_F}$ is the value of housing investment in the financial database.

The first part in the RHS is taken from the investment data in the real-side CGE database with respect to the dwellings sector ($\mathrm{V2TOT}_{(\mathrm{Ownerdwelling})}$). The second part in the RHS accounts for new issuance of liabilities by the housing agent across all financial instruments and asset agents ($\sum_{\mathrm{f \in FI, d \in AA}} \mathrm{FLOW}_{(\mathrm{House,f,d})}$). The calculated value for H_VINVESTDF is zero, meaning that the housing investment values in both databases are equal.

Fifth, HOUS_SAVEDF is a gauge to watch the difference between real-side and financial household savings. The formula to compute HOUS_SAVEDF is given as follow:

$$\mathrm{HOUSE\_SAVEDF} = \mathrm{HOUSE\_SAVE} - \mathrm{HOUSE\_SAVE\_F}, \tag{6.5}$$

where,

- HOUSE_SAVEDF is the difference between nominal household savings in the standard CGE database and the financial CGE database;
- HOUSE_SAVE is aggregate household savings in the standard CGE database;
- HOUSE_SAVE_F is household savings in the financial database.

HOUSE_SAVE is calculated from aggregate disposable income less the purchasers' value of aggregate consumption. HOUSE_SAVE_F is computed from net asset acquisitions financial instruments by households in the financial database. As expected, the value of HOUSE_SAVEDF in AMELIA-F database is zero, meaning that the household savings in the real-side and financial databases are equal.

Sixth, the standard and financial database should have equal values for the fiscal deficit. The difference between the fiscal deficit values in the real-side and financial databases is calculated via GOV_DEFDF, and expected to be zero. GOV_DEFDF is computed in the following equation:

$$\begin{aligned} \mathrm{GOV\_DEFDF} = \mathrm{GOV\_DEF} &- \sum_{\mathrm{f \in FI, d \in AA}} \mathrm{FLOW}_{(\mathrm{Govt,f,d})} \\ &- \sum_{\mathrm{f \in FI, s \in LA}} \mathrm{FLOW}_{(\mathrm{s,f,Govt})} \end{aligned} \tag{6.6}$$

where,

- $\mathrm{GOV\_DEFDF}$ is the difference between the fiscal deficit values in the standard CGE and financial CGE databases;
- $\mathrm{GOV\_DEF}$ is the fiscal deficit value in the standard CGE database;
- $\sum_{f \in FI, d \in AA} \mathrm{FLOW}_{(Govt,f,d)}$ is flows of government liabilities;
- $\sum_{f \in FI, s \in LA} \mathrm{FLOW}_{(s,f,Govt)}$ is flows of government assets.

The first part of the RHS is calculated from the net value of expenditure and revenue in the real-side database. The second and third parts are the net liability issuance of government agent in financial database. The net liability issuance of government agent is assumed to finance the fiscal deficit.

Seventh, equal values for the current account deficit (CAD) have a similar property as in the sixth step. The CAD is determined in the standard database and financed by net asset acquisition by foreigners. The net asset acquisition by foreigners is determined in the financial database. The difference between the two CAD measures (CADDF) is expected to be zero. The formula to calculate CADDF is given as follows:

$$\begin{aligned} \mathrm{CADDF} = \mathrm{CADEF} &- \sum_{f \in FI, s \in LA} \mathrm{FLOW}_{(s,f,ROW)} \\ &- \sum_{f \in FI, d \in AA} \mathrm{FLOW}_{(ROW,f,d)}, \end{aligned} \tag{6.7}$$

where,

- CADDF is the difference between the CAD values as calculated in the standard and financial databases,
- CADEF is calculated CAD in the standard CGE database,
- $\sum_{f \in FI, s \in LA} \mathrm{FLOW}_{(s,f,ROW)}$ is foreigners' asset purchase,
- $\sum_{f \in FI, d \in AA} \mathrm{FLOW}_{(ROW,f,d)}$ is foreigners' liabilities.

CADEF is the CAD in real-side database which is calculated from the sum of trade deficit plus net foreign income. The second and third components of Equation (6.7) is the net foreigner purchase on domestic assets. The calculated CADDF is zero, indicating that a matching of the current account deficit value in the standard database and the flow of net asset acquisitions by foreigners in the financial database.

6.11 Checks for Macroeconomic Indicators

This check is to ensure the consistency of key macroeconomic variables in the real- and financial-sides of the database with the official statistics. The key variables are: (i) saving rate; (ii) investment to GDP; (iii) public deficit to GDP; (iv) public debt to GDP; (v) current account deficit to GDP. Initially, the values for these macroeconomic checks showed inconsistency between the financial database and with the official statistics and real-side database as reported in Table 6.16.

Selected Macroeconomic Ratios	Official Statistics (2018)	Real-side Database of AMELIA-F	Financial-side Database of AMELIA-F
Saving rate	0.3163	0.3434	0.0257
Investment to GDP	0.3304	0.3310	0.0553
Public deficit to GDP	0.0182	0.0182	0.0065
Public debt to GDP	0.3042	NA	0.2909
CAD to GDP	0.0298	0.0298	0.0169

Table 6.16 Macroeconomic Results of the Database

In Table 6.16, the macroeconomic results of the real-side database are relatively consistent with the official statistics. The public debt to GDP ratio has no record in the real-side database because the stock of public debt is not stored in it. However, the financial-side database initially has large differences with both the real-side database and official statistics, except for the public debt to GDP ratio. Noting these discrepancies, I perform recalibration of the financial database and pay more attention to the feasibility of the flow/stock ratios in financial database. Flow/stock ratios of financial agents in initial database represent the first-year growth of balance sheet of financial agents. Most of the time, I want the balance sheets of every financial agent to be growing at feasible rates (for instance, following the growth of baseline nominal GDP), while also demonstrating consistent macroeconomic results with official statistics and the real-side database.

The recalibrations are preliminary done by adjusting the stock values of financial database. Table 6.17 shows the key macroeconomic accounts after the recalibration of financial database. The database issues identified in Table 6.16 arise from inconsistencies between official financial stock/flow data and official national accounts data, and thus signal an urgent need for official data improvement in the near future. The FABSI[28] data has great potential to be used in many applications for financial policy modelling in the future. However, the inconsistencies between FABSI data and official macroeconomic data could undermine the potential benefits of data itself.

Selected Macroeconomic Ratios	Official Statistics (2018)	Real-side Database of AMELIA-F	Financial-side Database of AMELIA-F
Saving rate	0.3163	0.3434	0.3434
Investment to GDP	0.3304	0.3310	0.3072
Public deficit to GDP	0.0182	0.0182	0.0182
Public debt to GDP	0.3042	NA	0.3727
CAD to GDP	0.0298	0.0298	0.0298

Table 6.17 Macroeconomic Results of the Database after Recalibrated

6.12 Conclusions

This chapter records the creation process for the financial-side database of AMELIA-F. The task is devoted to transforming the original database which was sourced from Financial Account and Balance Sheet Indonesia (FABSI) into the required form for AMELIA-F. The required financial database of AMELIA-F is classified into three categories. First is financial data comprising stocks, flows, and rate of return matrices. Second is parameterisation of financial theories. Third are relevant elasticity values.

The first task identified several potential discrepancies in key economic aggregates implicit in financial agent and instrument data and the standard CGE database. To narrow down these discrepancies, I performed agent and instrument remapping processes to better map the FABSI data with the required database. The original elements of the agents are remapped from seven to eight aggregations (industries, central bank, commercial banks, NBFIs, government, households, rest of the world, and the housing sector). The elements of the financial instruments are reduced from eight to five aggregations (bonds, cash, deposits and loans, equity, gold and IMF-SDRs).

[28] FABSI stands for Financial Account and Balance Sheet Indonesia.

The parameterisation of the rate of return matrices was undertaken in a two-step approach. The first step defined the basic rates of return of specific instruments for all asset and liability agents. The second step adjusted rates of return of specific pairs of agent and instrument e.g., for government and private bond yields, deposit or loan rates, and equity rate. The data for this parameterisation was mainly taken from official sources e.g., Bank Indonesia, OJK, Ministry of Finance of Republic of Indonesia, and Indonesian Stock Exchange (IDX). When data were not publicly available, the data were taken from the private data providers, such as Bloomberg and CEIC.

In AMELIA-F, the modelling of commercial banks is fairly detailed, as this thesis focuses on policy reform in the banking system. To capture the role of bank capital reform, there is a need for parametrisation of bank regulatory risk weights. The risk weights are essential to determine bank capital provision given banks' asset compositions. To parameterise the regulatory risk weights, this study follows those used in Giesecke et al. (2016). In the risk weights matrix, the riskier assets are weighted higher. For example, bank lending to foreigners is perceived by regulators to be riskier than loans to domestic agents, and thus attract higher risk weights.

There are several parameters needed to calibrate macroeconomic adjustment mechanisms in AMELIA-F. First, the database needs parameters specifying the wage Phillips curve (WPC). These are obtained by calibrating the slope and position of the WPC to satisfy a few target labour market variables, in particular, the NAIRU, unemployment rate, employment rate, expected wage, expected inflation, and lagged inflation. Second, parameters are required for a Taylor rule for central bank decision making over setting of the policy rate. In this case, the central bank is assumed to have symmetrical interest in price and output stability. For the elasticity of substitution across assets and liabilities on the part of financial agents, this study follows the values used in Giesecke et al. (2017) and Nassios et al. (2019).

During construction, the database is tested for two types of validity: (i) non-negativity of stock values, and equality of relevant measures across the financial and non-financial sides of the database; and, (ii) conformity with relevant official statistics.

Regarding the first, the database must pass seven distinct validity tests. First, end-of-year financial stock values must not be negative. Second, the values for the liability and asset sides of the financial balance sheets for pure financial agents (CB, Banks, NBFIs) must be equal. Third, there should be no significant difference between the value of non-housing investment in the traditional CGE database and the financial-side of the CGE database. Fourth, there should be no significant difference between the value of housing investment in the traditional CGE database and the financial-side CGE database. Fifth, there should be no significant difference between the value of household savings in the traditional CGE database and the financial-side CGE database. Sixth, there should be no significant difference between values for the fiscal deficit in the traditional CGE database and the financial-side CGE database. Seventh, there should be no significant difference between the values of the current account deficit as measured in that part of the database relevant to the traditional side of the CGE model and that part of the database relevant to the financial side of the CGE model. The results of the created financial database satisfy all of these tests.

Regarding the second, the financial database is tested for consistency with macroeconomic indicators from: (a) that part of the model's database supporting the traditional elements of the CGE model; and (b) official statistics. There are five macroeconomic ratios that I check in this way: (i) saving rate; (ii) investment to GDP; (iii) public deficit to GDP; (iv) public debt to GDP; (v) current account deficit to GDP. Initially, these checks indicated inconsistencies between official data sources. While noting the data issues in the original form, the flow/stock recalibration process successfully fixed these problems, with a heavy weighting in this recalibration towards trusting official national accounts data rather than official financial stock / flow (FABSI) data. The inconsistencies I found between the two data sources suggests there is an urgent need for official data improvement in the near future. FABSI data has a great potential to be used in many applications for financial policy modelling. However, the inconsistencies between these data and national accounts macroeconomic data could undermine the utility of the FABSI data in future research. This could be addressed in future by the compilers of the FABSI data working with the compilers of national accounts data to ensure that the two data sources are consistent.

CHAPTER 7
Baseline Simulation

7.1 Introduction

AMELIA-F can be used to investigate the economy both without and with policy influence. The focus of the simulations in this thesis are the policy simulations, rather than development of a highly-detailed baseline forecast. Nevertheless, when performing a policy simulation, I run it against a simple baseline forecast, and report the effects of the policy as deviations from that baseline. This chapter discusses arrangements for constructing a simple "baseline" "business as usual" (BAU) simulation with AMELIA-F. In explaining these arrangements, I first describe the standard model closure of AMELIA-F. The model closure is described using a high-level description of AMELIA-F's system of equations aimed at helping with macroeconomic interpretations of the model. It is represented in a simple array without changing the original meaning of the model. Second, I explain how the standard model closure needs to be modified to allow for the imposition of a baseline forecast for key macroeconomic variables. The forecast variables in my baseline simulation are relatively straightforward. The baseline forecasts are guided by year-on-year growth of real GDP, real investment, and the terms of trade. In the real-side baseline results, I report the dynamics of the key macro-aggregates and price variables. In the financial-side baseline results, I describe the movements in the balance sheets of financial institutions.

7.2 Standard Macroeconomic Closure of AMELIA-F

7.2.1 Real-side model closure of AMELIA-F

AMELIA-F is a large-scale FCGE model with a complex equation system. To help with macroeconomic interpretation of the model, I use a miniature model called a "Back-Of-The-Envelope" (BOTE) model, following Dixon and Rimmer (2002). The BOTE is a high-level aggregation of the macroeconomic relationships aimed at simplifying the CGE models equation system. The BOTE equation system also facilitates the presentation of the model's macroeconomic closure. In this section, I describe the representation of the closure of the real-side model of AMELIA-F, hereafter the real closure.

Table 7.1 shows the short-run closure of the real-side of the model (left column) and effective long-run closure of the real-side of the model (right column). It is a 14 equation system, with 25 macroeconomic variables. Hence, to solve the equation system, 11 macroeconomic variables need to be determined exogenously. This setting leaves 14 equations and 14 endogenous macroeconomic variables for both short-run and long-run closures. Definitions of all macroeconomic variables are given in Table 7.2. In Table 7.1, the **black-bolded** letter variables denote exogenous variables, while the un-bolded letter variables are endogenous. The choice of endogenous/exogenous division follows the neoclassical framework described in Dixon and Rimmer (2002).

Short-run real closure	Effective long-run real Closure	
$\mathrm{Y} = \mathrm{C} + \mathrm{I} + \mathbf{G} + (\mathrm{X} - \mathrm{M})$	$\mathrm{Y} = \mathrm{C} + \mathrm{I} + \mathbf{G} + (\mathrm{X} - \mathrm{M})$	(7.1)
$\mathrm{Y} = \frac{1}{\mathbf{A}} \mathrm{f}(\mathrm{L}, \mathbf{K})$	$\mathrm{Y} = \frac{1}{\mathbf{A}} \mathrm{f}(\mathbf{L}, \mathrm{K})$	(7.2)
$\mathrm{I} = \mathrm{g}\left(\frac{\mathrm{ROR}}{\mathbf{\Lambda}}\right)$	$\mathrm{I} = \mathrm{g}\left(\frac{\mathbf{ROR}}{\Lambda}\right)$	(7.3)
$\mathrm{M} = \mathrm{h}(\mathrm{Y}, \mathrm{TOT})$	$\mathrm{M} = \mathrm{h}(\mathrm{Y}, \mathrm{TOT})$	(7.4)
$\mathrm{TOT} = \frac{\mathrm{PX}}{\mathbf{PM}}$	$\mathrm{TOT} = \frac{\mathrm{PX}}{\mathbf{PM}}$	(7.5)
$\mathrm{PX} = \mathrm{i}\left(\frac{1}{\mathrm{X}}\right) \mathbf{V}$	$\mathrm{PX} = \mathrm{i}\left(\frac{1}{\mathrm{X}}\right) \mathbf{V}$	(7.6)
$\Psi = \frac{\mathrm{I}}{\mathbf{K}}$	$\boldsymbol{\Psi} = \frac{\mathrm{I}}{\mathrm{K}}$	(7.7)
$\mathrm{f_L}(\mathbf{K}/\mathrm{L}) = \frac{1}{\mathrm{TOT}} \cdot \mathbf{W} \cdot \mathbf{A}$	$\mathrm{f_L}(\mathrm{K}/\mathbf{L}) = \frac{1}{\mathrm{TOT}} \cdot \mathrm{W} \cdot \mathbf{A}$	(7.8)
$\mathrm{f_K}(\mathrm{L}/\mathbf{K}) = \mathrm{TOT} \cdot \mathrm{ROR} \cdot \mathbf{A}$	$\mathrm{f_K}(\mathbf{L}/\mathrm{K}) = \mathrm{TOT} \cdot \mathbf{ROR} \cdot \mathbf{A}$	(7.9)
$\mathrm{T} = \mathrm{j}(\mathrm{Y})$	$\mathrm{T} = \mathrm{j}(\mathrm{Y})$	(7.10)
$\mathrm{G_{def}} = \mathbf{G} - \mathrm{T} + \mathbf{T_g} - \mathbf{R_g}$	$\mathrm{G_{def}} = \mathbf{G} - \mathrm{T} + \mathbf{T_g} - \mathbf{R_g}$	(7.11)
$\mathrm{CAD} = -(\mathrm{X} - \mathrm{M}) + \mathbf{NFP}$	$-(\mathrm{X} - \mathrm{M}) + \mathbf{NFP}$	(7.12)
$\mathrm{C} = \mathbf{APC} \cdot \mathrm{Y} \cdot \mathrm{k}(\mathrm{TOT})$	$\mathrm{C} = \mathbf{APC} \cdot \mathrm{Y} \cdot \mathrm{k}(\mathrm{TOT})$	(7.13)
$\mathrm{S} = \mathrm{Y} - \mathrm{C}$	$\mathrm{S} = \mathrm{Y} - \mathrm{C}$	(7.14)

Note: adapted from Nassios and Giesecke (2018)

Table 7.1 Representation of Real-side BOTE Model of AMELIA-F

As aforementioned, Table 7.1 describes a miniature representation of the AMELIA-F equation system. Equation (7.1) is the macroeconomic expenditure-side identity, where GDP (Y) is the sum up of gross national expenditures (GNE) (i.e., household consumption (C), investment expenditure (I), government expenditure (G)) and the trade balance (X-M). Equation (7.2) is the aggregate production function where GDP (Y) is a positive function of labour (L) and capital (K). Equation (7.3) describes that investment (I) is a positive function of the ratio of the rate of return (ROR) and the required rate of return (Λ). In Equation (7.4), import volumes are a positive function of GDP (Y) and the terms of trade (TOT) (a proxy for the real exchange rate). Equation (7.5) formulates the terms of trade (TOT) as the ratio of export prices (PX) to import prices (PM). Equation (7.6) describes export volumes (X) as a positive function of inverse of export price (PX) and a shifter on export demand schedules (V). Equation (7.7) is the investment/capital ratio (Ψ).

No.	Variables	Definition
1	A	Primary-factor augmenting technical change
2	C	Real private consumption
3	G	Real government consumption
4	I	Real investment
5	K	Capital stock
6	L	Labour input
7	M	Import volume
8	PM	Import price
9	PX	Export price
10	ROR	Rate of return of capital
11	TOT	Terms of trade
12	V	Export shifter
13	W	Real wage
14	X	Export volume
15	Y	Real GDP
16	Ψ	Investment to capital ratio
17	T	Tax receipts
18	G_{def}	Government deficit
19	T_g	Government transfer
20	R_g	Other receipt
21	CAD	Current account deficit
22	NFP	Net foreign payment
23	APC	Average propensity to consume
24	S	Aggregate household saving
25	Λ	Required rate of return of capital

Table 7.2 Definitions of Macro-variables of Real-side Closure

Equation (7.8) is the labour demand function, derived from the profit maximisation process, whereby labour demand is a negative function of the real wage (W) and a positive function of the terms of trade (TOT). Equation (7.9) is the optimal capital demand function, whereby capital (K) is a decreasing function of the rate of return (ROR) and an increasing function of the terms of trade (TOT). Equation (7.10) describes tax receipts (T) as an increasing function of GDP. Equation (7.11) defines the government deficit (G_{def}) as equal to government expenditure (G) and transfers (T_g) *minus* tax (T) and other receipts (R_g). The current account deficit (CAD) is formulated as the trade balance deficit (M – X) plus net foreign payments (NFP) in Equation (7.12). In Equation (7.13), consumption is a fixed proportion (APC) of income (Y), and a positive function of TOT. Finally, saving (S) is the gap between Y and C in Equation (7.14).

The real closure presented in Table 7.1 is composed of 14 equations and 25 variables, of which 11 are exogenous (G, A, K, Λ, PM, V, W, T_g, R_g, NFP, and APC for the short-run, and G, A, L, ROR, PM, V, Ψ, T_g, R_g, NFP, and APC for the long-run). The model under a short-run real closure can be solved in the following way. Suppose a financial shock causes the required rate of return (Λ) to rise. How does this transmit through the real economy? The starting point is to begin not with Equation (7.3), in which Λ appears, but Equation (7.8) which determines L in the short-run. Our first guess is that any shock to the economy should have limited impact on TOT, because import prices are fixed and export demand schedules are quite elastic. If TOT cannot move by much, then Equation (7.8) tells us that L must be largely determined by the exogenous status of W, A and K. If there is limited scope for L to move in the short-run, then via Equation (7.9), I can also infer, as a first-round matter, that there is limited scope for movement in ROR. I will return to whether TOT, L and ROR move in response to Λ via second-round effects. But for the moment, if ROR moves little, then via Equation (7.3), I expect the increase in Λ to cause I to fall.

Turning to Equations (7.1) and (7.2), I expect that as a first-round matter, there is limited scope for Y to change. This is clear from Equation (7.2): if there is limited scope for L to change via Equation (7.8), then there is limited scope for Y to change via Equation (7.2). With limited scope for C to change via Equation (7.13), given a fixed government expenditure (G), the decline of I causes GNE to fall by more than Y. This implies the trade balance (X - M) must move towards surplus.

Via Equation (7.6), an increase in X causes a fall in PX. Via Equation (7.5), the decrease in PX causes a fall in TOT. In Equation (7.8), a fall of TOT causes demand for labour (L) to decrease. With the decrease of L, Y falls via Equation (7.2). As TOT and L fall, the ROR in Equation (7.9) decreases. The fall in ROR adds to the reduction of I in Equation (7.3) via the rise in Λ. The fall in TOT and Y translates into a decline in M via Equation (7.4). With a movement to trade surplus, the CAD moves towards surplus in Equation (7.12). The decline in Y causes tax receipts (T) to fall via Equation (7.10). As T declines, G_{def} increases in Equation (7.11). A decrease in Y and TOT causes a decline in C in Equation (7.13). This adds to the fall in GNE in Equation (7.1). As Y falls by more than C, aggregate savings (S) in Equation (7.14) decreases.

A similar approach can also be applied to show economic causation under the long-run real closure in Table 7.1. The key closure changes in the long-run are that L, K and ROR are exogenous, while W, Ψ and Λ and endogenous. While ROR is not really exogenous in the long-run in AMELIA-F, the process of adjustment of capital accumulation to changes in rates of return in AMELIA-F have the effect of driving rates of return towards normal rates of return over time. In BOTE, this can be represented by ROR being exogenous and Λ being endogenous in the long-run.

7.2.2 Financial-side closure

Table 7.3 shows the closure arrangements in the balance sheets of financial agents. The shaded-cells indicate values that are determined via a link to the real-side of the model. The new asset acquisitions of commercial banks are endogenous and determined via a fixed mark-up on the cost of their financial capital and a balance sheet constraint, linking the size of their overall liability portfolio to the size of their asset portfolio, i.e., commercial banks are pure financial agents. Central bank purchases of government bonds are endogenous via the Taylor policy rule. The central bank's new liabilities move in line with its new asset purchases. Net foreigners' purchases of domestic assets finance the current account deficit (CAD).[29] The government's net liability issuance finances the public sector borrowing requirement (PBSR).[30] New asset acquisitions by households

[29] CAD here is similar to that in Equation (7.12).
[30] The PBSR here equals to Gdef in Equation (7.11).

come from current aggregate savings defined in the real-side of the model.[31] The household financial agents do not raise liabilities directly. For example, mortgage finance is issued by the housing agent in row number 7. Financial asset acquisitions by non-housing industries are endogenous. The net liability financing of the non-housing industry agent covers the funding of capital formation determined in the real-side model.[32] There are no new financial assets purchased by the housing sector, i.e., they fund physical asset purchases only. Liability issuance by the housing agent is thus equal to new investment in dwellings.[33]

No	Financial agent	New financial liabilities	New financial assets
1.	Commercial banks	Equal to new assets	New asset is determined by fixed mark-up rule on cost of financial capital
2.	Central Bank	Equal to new assets	Endogenous via the Taylor policy rule.
3.	Foreigners	Domestic purchase of foreign assets	CAD *plus* Domestic purchase of foreign assets
4.	Government	PBSR	Exogenous.
5.	Households	No liabilities raised by households. Mortgages are taken out by housing agent (8)	New assets equal to aggregate household savings (S)
6.	Industries	Capital formation in non-housing industries *plus* new asset	Indexed to GNP
7.	Housing	Capital formation in owner-dwelling industry	No financial asset purchases

Note: adapted from Giesecke et al. (2017)

Table 7.3 Balance Sheet Closure of Financial Agents

[31] The aggregate savings here equals to S in Equation (7.14).
[32] The capital formation here is similar to I in Equation (7.3).
[33] Owner-dwelling industry is subset of I in in Equation (7.3).

7.3 Modifications to the Standard Closure for Baseline Simulation

For running the baseline simulation, I modify the standard model closure given in Table 7.1. There are three naturally-endogenous variables for which I would like to dictate values to the model to simulate the economy under the business as usual (BAU) baseline: GDP (Y), real investment (I), and the terms of trade (TOT). I do this by making closure swaps in order to exogenise these variables. Real GDP (Y in Table 7.1) is turned exogenous by endogenising A. I is exogenised by endogenising the required rate of return (Λ). The TOT is exogenised by endogenising V. In creating the baseline simulation, the settings do not consider the impacts of COVID-19 on the economy.[34]

7.4 Baseline Forecasts

7.4.1 Forecast data

The AMELIA-F baseline forecast uses the institutional forecasts available in the pre-COVID-19 period. For GDP, I take the Indonesian long-run economic growth forecast of the IMF (2019) provided in the April 2019 World Economic Outlook report. In that publication, the GDP of Indonesia is projected to grow around 5.2 to 5.3 per cent per annum over 2020-2024. Conservatively, I decided to assume a constant 5 per cent GDP growth into the baseline shock from 2019-2028. Also, I tied year-on-year growth in investment to GDP, and thus it too expands by 5 per cent per annum, yielding stable capital movements.

In the financial-side of the model, I impose the annual inflation target by the Central bank, taken from Bank Indonesia's official inflation target for 2019-2022. The inflation targets of 2019 and 2020 were decided under a coordinating framework between Bank Indonesia and Ministry of Finance 2017.[35] The inflation targets for 2019 and 2020 were determined to be 3.5 +/- 1 per cent and 3.0 +/- 1 per cent respectively. The inflation

[34] I commenced work on this thesis in August 2018, and worked on baseline construction throughout 2019. I considered building COVID-19 effects into my baseline, but decided against it for three reasons. First, building COVID-19 shocks into the baseline would be a significant research undertaking in its own right, beyond the scope of the current thesis. Second, during the pandemic, there were considerable uncertainties from month to month about its measured impacts on the Indonesian economy, and official statistics are released with lags too long to hold up work on the thesis. Three, the focus of the thesis is policy impacts, not baseline forecast detail.

[35] According to Ministry of Finance's Regulation No.124/2017 (PMK No. 124/PMK.010/2017, 18th Sep 2017).

targets for 2021 and 2022 were both determined to be 3.0 +/- 1 per cent.[36] Given these settings, I assume an inflation target of 3 per cent per year for the full baseline scenario.

7.4.2 Baseline Simulation of The Real-Side Model

Figure 7.1 reports the key macroeconomic variables in the baseline simulation. Aggregate expenditures (household and government consumption, export and import volumes) grow by around 5 per cent per annum, following the baseline GDP and investment targets. Private and public consumption spending are linked in aggregate to growth in national income via a fixed propensity to consume out of national income. The ratio of real private to real public consumption is exogenous, which is why the two lines move together in Figure 7.1. I assume that real investment in the baseline grows at the same pace as real GDP, which is why real investment and real GDP growth are the same in Figure 7.1.

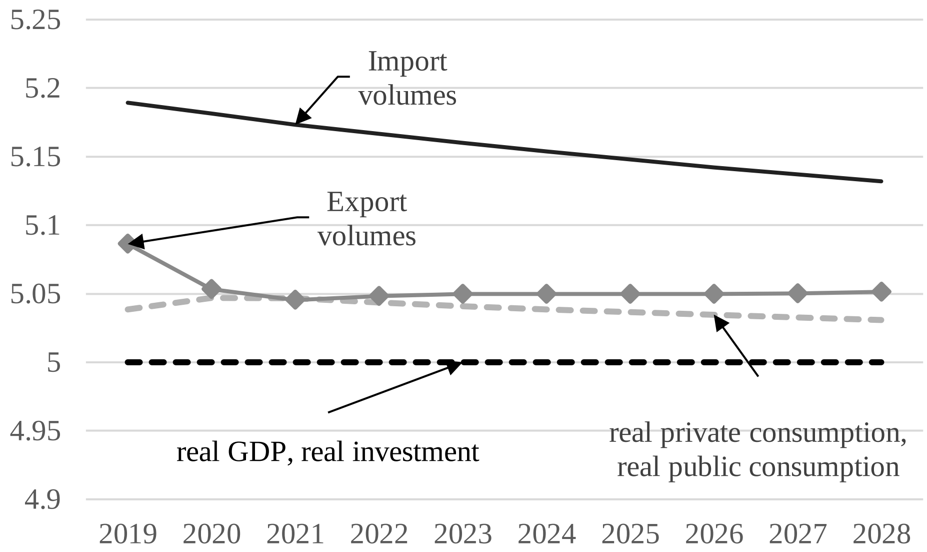


Figure 7.1 Macroaggregates of Real-Side Model of AMELIA-F (% year-on-year)

Figure 7.2 shows the price dynamics in the baseline simulation of AMELIA-F. As explained in Chapter 4, the financial-side of AMELIA-F has a balancing mechanism via which the central bank aims to correct price deviations toward the predetermined targets. Recall the Central banks' price setting target discussed in Section 7.4.1; this explains the 3 per cent year-on-year inflation target (dashed black line) in Figure 7.2. Also in Figure

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[36] According to Ministry of Finance's Regulation No.101/2021 (PMK No.101/PMK.010/2021, 28th Jul 2021).

7.2, I plot year-on-year CPI inflation (solid black line) and GDP deflator (dashed grey line) movements, which converge to the inflation target of 3 per cent by the fifth year of the baseline simulation. The movements in the nominal exchange rate closely mirror those of domestic prices. The nominal exchange rate in AMELIA-F is defined as foreign currency unit per Rupiah. Hence, the paths of the nominal exchange rate and the CPI in Figure 7.2 indicate that there is little movement in the real exchange rate. This is consistent with the exogeneity of the terms of trade in the baseline simulation.

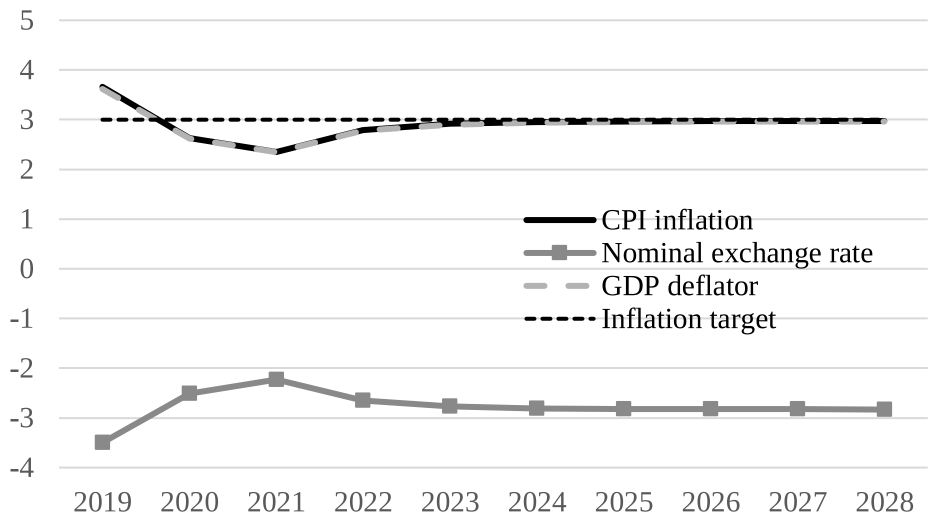

Figure 7.2 Prices in Real-Side Model of AMELIA-F (% year-on-year)

7.4.3 Baseline Simulation of Financial-Side Model

The expansion of the asset- and liability-side of financial agent balance sheets are shown in Figure 7.3 and Figure 7.4, respectively. Figure 7.3 illustrates the baseline growth of balance sheets for each financial agent. The asset holdings of pure financial agents (the central bank, commercial banks, and NBFIs) and the household agent exhibit year-on-year growth that is similar to the rate of growth in nominal GDP (nominal GDP grows around 8 per cent per year over the baseline period). The foreigners' (RoW) assets grow at a faster pace than that of other financial agents. This reflects requirements for the current account deficit (CAD) to be financed. Government assets grow at a slower pace than that of other financial agents, because financial asset acquisitions by Government are exogenous and held at their base period levels by assumption; see Table 7.3.

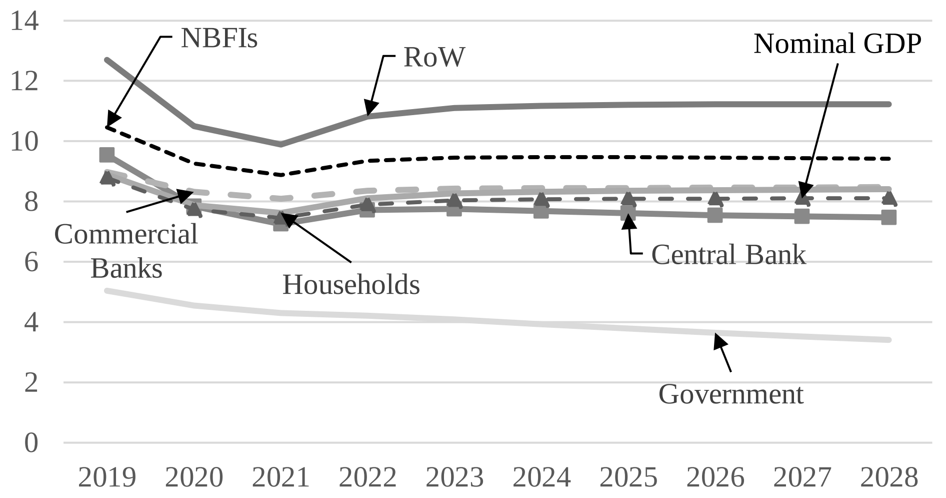

Figure 7.3 Financial Asset Holdings by Financial Agent (% year-on-year)

Figure 7.4 shows that the growth in the liability-sides of financial agents' balance sheets trend towards the annual growth rate in nominal GDP. Government liabilities grow at a higher rate in the first year relative to other agents, reflecting a high level of fiscal deficit financing in the simulation's first year. The growth of government liabilities decreases gradually in the long-run converging to growth of nominal GDP as well. Housing liabilities grow at a faster pace than growth of nominal GDP, indicating a high housing investment financing need. This reflects high demand for housing arising from growth in real income of Indonesian households in the baseline.

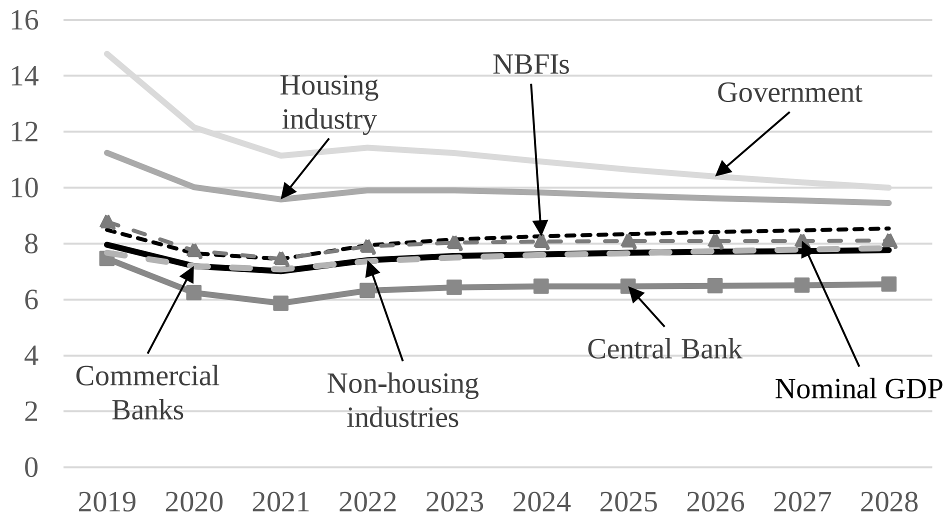

Figure 7.4 Financial Liabilities of Financial Agent (% year-on-year)

7.5 Conclusions

This chapter describes arrangements to create a baseline simulation with AMELIA-F. In this research, I provided a simple forecast for the Indonesian economy under BAU conditions over 2019-2028 excluding the influence of COVID-19. In explaining the baseline simulation, I first presented the standard macroeconomic closure for AMELIA-F. I exogenously impose independent forecast values for growth of real GDP, investment, and the terms of trade to guide the model in forming a baseline simulation. Using independent institutional forecast data, I set growth rates for real GDP and investment at 5 per cent annually. The results show the long-run convergence of macroeconomic variables to the growth of GDP and investment (5 per cent). There is little variability exhibited by the expenditure-side components of GDP. The growth of assets and liabilities of financial agents are in general close to the movement of baseline simulation of nominal GDP (of around 8 per cent).

With only key macro variables determined exogenously, the baseline simulation in this study is relatively simple when compared to the type of detail that could be incorporated in a future study. I made this choice for two reasons. First, the COVID-19 pandemic began about one year into my thesis. A detailed baseline would have required me to try to track the constantly changing effects of the pandemic on Indonesia, which was not the focus of my thesis. Second, my thesis is primarily concerned with simulating the effects of financial regulation. Hence, I focussed my simulations on the policy simulations, which are discussed in Chapters 8 and 9. In future work, the model can be used to develop more detailed baseline forecasts. This would involve taking on the sort of detailed forecasts for changes in sector-specific technologies and tastes discussed in Dixon and Rimmer (2002). But it might also take on board exogenous detail about changes in the baseline structure of the financial sector.

CHAPTER 8
Assessing the Economy-wide Impacts of Strengthened Bank Capital Requirements in Indonesia using a Financial Computable General Equilibrium Model: A policy simulations[37]

8.1 Introduction

Following the 2008 Global Financial Crisis (GFC), authorities across the globe stressed the importance of financial sector reform. In 2010, the Basel Committee on Banking Supervision (BCBS) introduced the Basel III regulatory standard as a reform package to strengthen stability in the global financial sector. The regulatory standard highlights the role of the equity capital of commercial banks to absorb losses during crises. While enhancing financial stability, higher bank capital requirements raise the weighted average cost of capital (WACC) of commercial banks, potentially slowing credit growth and weakening the real economy e.g., [Miles et al. (2012); Lin and Yang (2016); Slovik and Cournède (2011); Akram (2014); Liu and Molise (2019); Bank for International Settlements (2010); Taskinsoy (2018); IIF (2011); Surhaningsih et al. (2015); and Giesecke et al. (2017)].

With more countries adopting bank capital reforms, there are nonetheless few studies investigating the economy-wide impacts of strengthening mandated bank capital requirements in emerging economies.[38] For instance, Surhaningsih et al. (2015) explain that for maintaining the existing return on equity (ROE) when CAR is increased, Indonesian commercial banks must increase lending interest rates. Fang et al. (2018) analyse the impact of bank capital reforms on lending growth in Peru. They find that a 1 percentage point increase in bank capital adequacy requirements (CAR) leads to a 4-6 percentage points fall of lending growth in the first quarter and the fall diminishes after two quarters. Taskinsoy (2018) finds that an increase in bank capital requirements has a negative impact on the long run GDP growth in ASEAN5.

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[37] I published material from this chapter in Rasyid et al. (2022).

[38] The Bank for International Settlement (BIS) reports that in 2014, 23 of 27 BCBS countries (85%) have issued final or draft rules on the leverage ratio (CAR) (Bank for International Settlements, 2014). Another BIS report in 2017 mentions that 16 of 100 surveyed jurisdictions (16%) outside BCBS countries have also implemented Basel III bank capital requirements (Hohl et al. 2018).

<table>
<tr><th>2013</th><th>2014</th><th>2015</th><th>2016</th><th>2017</th><th>2018</th><th>2019</th></tr>
<tr><td rowspan="3">Capital regulation enacted</td><td rowspan="3">CET1=4.5% +AT1= 6% +Tier2=8%</td><td>Capital Conservation Buffer enacted</td><td>0.625ppt</td><td>1.25ppt</td><td>1.875ppt</td><td>2.5ppt (for capital >Rp5 trillion)</td></tr>
<tr><td>Capital Counter-cyclical Buffer enacted</td><td>Maximum 0.625ppt</td><td>Maximum 1.25ppt</td><td>Maximum 1.875ppt</td><td>Maximum 2.5ppt</td></tr>
<tr><td>Capital Surcharge D-SIB enacted</td><td colspan="4">1-3.5ppt</td></tr>
</table>

Source: Adapted from Indonesian Banking Booklet 2019.

Note: ppt = percentage points, AT1=Alternative Tier-1 capital equivalent, Tier2= Tier2 capital equivalent, D-SIB = domestically systemic important bank.

Table 8.1 Implementation of Basel III Principles on Capital Requirements in Indonesia

Beginning in 2013, Indonesia has steadily implemented bank capital reforms as recommended by the Basel III principles (Table 8.1). In 2014, banks were required to set the Common Equity Tier-1 (CET1) at the minimum of 4.5 per cent of risk weighted assets (RWA).[39,40] The CET1 is supplemented by the Alternative Tier-1 capital equivalent (AT1), therefore increasing the regulatory capital ratio to 6 per cent of RWA. Adding Tier 2 capital to the CET1 and AT1 increases the minimum capital ratio to 8 per cent of RWA in 2014 (Column 2 of Table 8.1). Indonesia's Financial Services Authority, the Otoritas Jasa Keuangan (OJK) implemented risk-based capital regulation to differentiate bank capital requirements based on individual risk profiles. Banks with the lowest risk level (risk level 1) must hold a minimum CAR of 8 per cent; banks with a medium risk level (risk level 2) must hold a minimum CAR of 9 per cent; banks with risk level 3 must hold a minimum CAR of 10-11%; while banks with the highest risk level (risk level 4 and 5) must hold a minimum CAR of between 11 per cent and 14 per cent.

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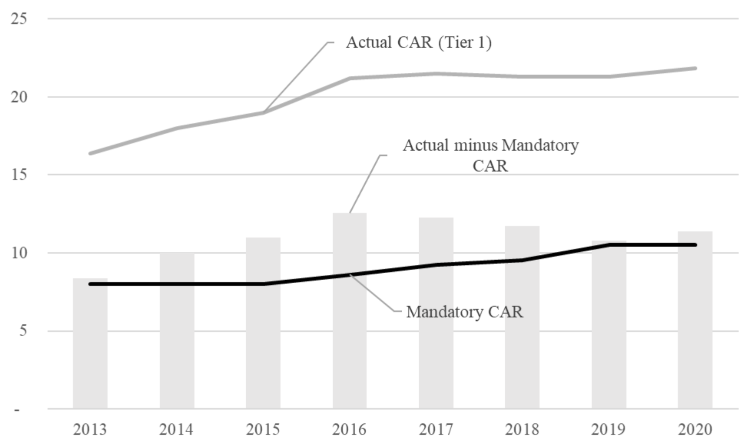
[39] Common Equity Tier 1 is the equity component of bank capital that can be used directly to absorb losses (Bank for International Settlements, 2010b).

[40] The risk weighted asset (RWA) explains to what extent that bank assets are exposed to market risks. RWA is calculated by summing up the different types of assets after multiplied by their respective regulatory risk weights.

In 2015, banks were obliged to provide supplementary capital buffers (Table 8.1 column 3). Supplementary capital buffers are categorised into: (i) capital conservation buffer; (ii) countercyclical buffer, and (iii) capital surcharge for the largest banks.[41] The supplementary capital buffers were gradually increased between 2016 and 2019 (Columns 4 to 7 of Table 8.1). In 2019, banks with capital exceeding Rp 5 trillion had to increase CAR further by 2.5 percentage points under capital conservation buffer requirements. The capital countercyclical buffer (CCB) is used as a macroprudential policy instrument to manage changes in credit risks. The CCB can be tightened during a credit boom cycle to reduce excessive lending expansion and relaxed in a slower credit cycle to support a slowing economy. In 2019, the CCB rose to a maximum of 2.5 percentage points. In the same year, the banks within the D-SIB category were required to hold additional CAR of 1 to 3.5 percentage points.



Source: CEIC

Note: The mandatory CAR is calculated based on the information in Indonesian Banking Booklet 2019

Figure 8.1 Indonesia's Mandatory and Actual Bank CAR, Tier-1 (%)

An interesting characteristic of the Indonesian banking sector is that the actual CAR of the banking sector exceeds the mandated CAR (Figure 8.1). Moreover, actual bank CAR rises in lock step with scheduled increases in mandatory CAR. This

[41] Domestic systemic important bank (D-SIB). The OJK and Bank Indonesia define D-SIBs based on the size of balance sheets, business complexity, and interconnectedness in the financial markets.

phenomenon is manifested across all types of banks (Table 8.2). In general, banks tend to hold a relatively stable wedge between mandatory and actual CAR over time (Figure 8.1). The financial authority in Indonesia routinely advises banks to maintain enough buffer, and the banks show a strong inclination to comply.[42] Bank compliance to the mandated CAR is also highlighted in Murtiyanti et al. (2015). For this reason, I expect that when the authority raises the level of the mandated CAR, the actual CAR will rise by approximately the same amount.

	2013	2014	2015	2016	2017	2018	2019	2020*
Private Banks	16.4	18.0	19.0	21.2	21.5	21.3	21.9	22.2
State Owned Banks	15.9	17.1	19.3	21.0	21.1	20.9	21.2	18.8
Regional Banks	17.6	17.8	20.6	21.7	21.7	22.0	21.2	22.1
Foreign Banks	34.5	44.8	46.5	48.9	53.1	47.9	50.4	54.6

Source: CEIC
*as of November 2020

Table 8.2 Indonesia's Banks' CAR by Type of Ownership (%)

Country's	Indonesia 2019Q1	Malaysia 2019Q1	Thailand 2018A1	Australia 2019Q1	Japan 2018Q3	U.K. 2018Q3	U.S. 2019Q1
Capital ratios							
Capital to RWA	23.3	18.0	17.8	14.7	17.0	20.9	14.8
Tier 1 Capital to RWA	21.6	14.3	15.0	12.7	14.8	17.7	13.8
Profitability							
Return on Assets	2.5	1.3	1.3	0.8	0.3	0.5	0.4
Return on Equity	16.4	11.9	9.4	12.9	7.3	7.4	3.4

Source: IMF Financial Soundness Indicators

Table 8.3 Bank Capital and Profitability Indicators in Selected Countries (%)

In 2020, the authority reported that the aggregate CAR of Indonesian banks reached 22 per cent of risk-weighted assets, which is larger than the mandated level by authority. The high level of CAR is not unusual for many countries. Table 8.3 reports

[42] For instance, when Bank Bukopin experienced a fall in its CAR to 12 per cent in May 2020, it was considered an alarming level as it was near the threshold. The OJK encouraged Bank Bukopin's major investor to add more capital. As a result, the CAR increased to 16 per cent on August 2020 well above the mandated CAR (Kontan.co.id, 2020a; Kontan.co.id, 2020b).

bank capital and profitability indicators for several ASEAN and major advanced countries. This shows banks in these countries normally hold CAR above requirement. Banking crises, unreliable interbank markets, and search for quality possibly motivate the banks to have larger capital buffers than mandated (Andrle et al. 2019). Interbank in Indonesia is characterised as a fragmented market. Large banks that have ample domestic currency supply are more likely to transact with foreign banks with large foreign currency supplies (International Monetary Fund, 2018). The better-capitalised banks could gain more counterparty trust, thus strengthening their position to access the interbank markets.

In general, the high bank CAR in Indonesia is obtained through offering new shares to the existing equity holders (via rights issue) and through retained earnings (Bank Indonesia, 2018). Banks in emerging countries mostly raise their CAR via retained earnings (Andrle et al. 2019; Cohen & Scatigna, 2016). This option is likely to be undertaken by the banks with higher profitability. High profitability allows banks to increase equity capital without reducing dividend payments to the existing shareholders. By doing this, banks raise the attractiveness of the equity and increase the portion of equity in bank balance sheets.

Study	Impact on bank WACC	Impact on real GDP growth	Scope
Miles et al., (2012)	18 basis points increase	0.15% reduction in the long run real GDP growth	U.K.
Slovik & Cournède (2011)	50 basis points increase	0.05-0.15% reduction in the real GDP growth in 5 year	OECD countries
BIS (2010)	13 basis points increase	0.09% reduction in real GDP growth	6,600 banks in emerging and advanced countries in 1993-2007
Taskinsoy (2018)	N.A.	0.33% reduction in average long run real GDP	ASEAN5
IIF (2011)	N.A.	3.2% reduction in average real GDP in 5 years	U.S., E.A., Japan, U.K., and Switzerland
Surhaningsih, et. al., (2015)	6 basis points increase	N.A.	Indonesia
Giesecke et al., (2017)	4 basis points increase	0.005% reduction in the long run real GDP relative to baseline	Australia
Nassios et al., (2020)	decrease in WACC	Increase in real GDP growth relative to baseline	U.S.

Table 8.4 Summary of Previous Studies

Several studies find that a rise in bank CAR causes the weighted average cost of bank capital (WACC) to rise, in turn raising the WACC of other financial agents, and negatively impacting on the real economy e.g., [Miles et al. (2012); Slovik and Cournède

(2011); Liu and Molise (2019); Kapuściński and Stanisławska (2018); Bank for International Settlements (2010); Taskinsoy (2018); IIF (2011); and Giesecke et al. (2017)]. This contrasts with the Modigliani-Miller theorem (MM theorem) which assumes that more equity capital will have no impact on bank capital costs (Modigliani and Miller, 1958). According to the MM theorem, adding equity capital lowers rates of return for both equity and debt instruments because it lowers risk on both instruments. This causes bank capital costs to remain unaffected. However, Baker & Wurgler (2013) argue that this effect is not supported empirically, and indeed, contradicted by the "low risk anomaly", whereby better-capitalised (and thus lower risk) banks have higher rates of return on equity.

Table 8.4 compiles previous studies investigating the impacts of an increase in bank capital on several economies. Most of the studies show that the increase causes a relatively modest impact on real GDP growth e.g., [Miles et al. (2012); Slovik and Cournède (2011); Bank for International Settlements (2010); Taskinsoy (2018); Surhaningsih et. al. (2015); and Giesecke et al. (2017)]. Bank for International Settlements (2010), IIF (2011), and Miles et al., (2012) use a two-step approach to calculate the impact of an increase in bank capital on the economy. First, they use balance sheet data to calculate the effects of an increase in bank CAR on bank WACC. Second, the WACC effects thus calculated are input as shocks to their macroeconomic models. Taskinsoy (2018) uses Probit and Ordinary Least Square (OLS) regressions to calculate the impact of an increase in bank capital on ASEAN5 economies. Surhaningsih et. al., (2015) perform accounting-based analysis to calculate the impacts on interest rate spreads of a 100 basis point increase in the CAR of Indonesian banks. They find that if Indonesian banks maintain the current ROE, a 100 bps increase in CAR forces banks to raise the lending rate by 6 basis points. The increase in the lending rate varies across groups of banks. The high ROE / low capitalised banks require a larger increase in lending rates, and vice versa. However, this approach does not account for general equilibrium effects in the economy, such as the details of macroeconomic adjustments, monetary policy responses, and reactions of other financial institutions.

Giesecke et al., (2017) and Nassios et al., (2020) employ a computable general equilibrium (CGE) framework with a detailed financial-side model for the Australian and U.S. economies respectively. Their financial CGE (FCGE) models connect the traditional

CGE framework with financial markets via networks of financial instruments and financial agents. Giesecke et al., (2017) find that a rise in bank CAR in Australia causes small negative economy-wide impacts. Using a similar framework, Nassios et al., (2020) find a contrasting small positive impact on the U.S. economy. In the U.S., the increase in bank WACC induces substitution towards non-bank financial providers that, relative to banks, have smaller asset holdings with the central bank and higher propensities to lend to investors, therefore stimulating real investment.

8.2 The AMELIA-F Financial Computable General Equilibrium (FCGE) Model

8.2.1 Overview of the model

For this study, I develop a CGE model for Indonesia with a detailed financial model, hereafter AMELIA-F (A Model of Economic Linkage-Financial). The general structure of AMELIA-F comprises two parts: the real-side model and the financial model. The real-side part of the model explains the real economy under the neoclassical theoretical framework which closely follows the MONASH model by Dixon and Rimmer (2002). The financial-side model includes the theories on financial agents' interactions and the linkages to the real side economy. The theories in the financial-side model closely follow the model theories explained in Giesecke et al. (2017) and Nassios et al. (2020). The remainder of this section describes details of the model's theory and database. The real-side model is explained in 8.2.2. The theory underlying the model's financial elements is described in 8.2.3. Settings for the CAR simulation are detailed in 8.2.5 The database for both the model's real-side and financial theory is explained in 8.2.6.

8.2.2 Real-side CGE Model

Economic agents in the real side model are optimisers of their objective functions subject to specific constraints. The behaviours of the key economic agents are modelled as follows: industries produce levels of commodity-specific output that maximise revenue subject to constant elasticity of transformation (CET) functions. This optimisation creates commodity supply functions that connect output by industry, differentiated by commodity, with industry activity levels and relative prices across commodities. At any given level of activity, industries choose inputs to production and investment in a cost-minimising fashion subject to nested fixed-proportions and constant elasticity of substitution (CES) production functions. This creates input demand functions that connect input demands to industry activity levels and input prices. Demands for source-specific inputs depend on relative prices of domestic and imported supplies. Industry demands for labour and capital respond to movements in industry activity levels, wage rates and capital rental prices.

Commodity-specific household demand functions are derived from budget-constrained utility-maximisation assumptions. Commodity-specific demands for exports are negative functions of foreign currency prices. Margin commodities (e.g., retail trade) facilitate the distribution of non-margin commodities from suppliers to users. Demands for margins follow the movement of the use of commodities by the user agents. For example, demands for margins to facilitate inputs to production are a fixed proportion of the associated intermediate input demands. Economic agents are assumed to operate in competitive markets. Production prices for each industry are determined from the total unit cost of production, hence I formally impose a zero pure profit condition in our real-side model. Markets clear so that the prices of commodities and factors are determined by the equalisation of supply and demand.

8.2.3 Financial financial-side model

In the financial-side model, there are eight financial agents and five financial instruments (Table 8.5 and 8.6). Each financial agent is simultaneously concerned with managing both the asset and liability sides of their balance sheets. Hereafter, when a financial agent is concerned with asset acquisition and disposal, I refer to them as “asset agents” (AA). When an agent is concerned with liability issuance and repayment, I refer to them as “liability agents” (LA). In their actions as both asset agents and liability agents, financial agents are assumed to behave as constrained optimisers.

No	Agent short name	Description
1	Inds	Non-financial industry, excluding housing
2	CB	Indonesia central bank
3	Banks	Commercial banks
4	NBFI	Non-bank financial institutions, including insurers and pension funds
5	Govt	Government
6	HH	The representative household
7	ROW	Rest of the world
8	Housing	Single representative housing sector

Table 8.5 Financial Agents in AMELIA-F

There are three matrices used to parameterise the financial-side model. First, $A_{(s,f,d)}$ is the beginning-of-year financial stock of the financial instrument (f) ϵ FI issued by liability agent (s) ϵ LA and held by asset agent (d) ϵ AA. Second, $F_{(s,f,d)}$ describe the within-year flows of financial instrument (f) ϵ FI issued by (s) ϵ LA and held by asset agent (d) ϵ AA. Third, $R_{(s,f,d)}$ is the matrix of the power of the rate of return (one plus percentage rate of return) on financial instrument (f) ϵ FI issued by liability agent (s) ϵ LA and held by asset agent (d) ϵ AA.

No	Instrument short name	Description
1	GldSDR	Gold or Special Drawing Rights
2	Cash	Cash
3	DepLoans	Currency and deposits
4	Debt	Interest-bearing securities, e.g., bonds, of varying terms of maturity
5	Equity	Claims that lie further along the risk-return spectrum than debt and loans

Table 8.6 Financial Instruments in AMELIA-F

When the elements of the conventional real-side CGE model are integrated with the financial model theory, they can influence each other. The results of the real side of the model are constrained by the results of the financial side of the model. Similarly, the results in the financial side are affected by the outcomes of the real side of the model. There are four main channels that connect the real-side and financial sides of the model. First, the public sector borrowing requirement (PSBR) or government deficit defined in the real side determines net liability issuance by the financial-side government agent. Second, gross fixed capital formation within the model's real side determines the net liability issuance of the financial-side industry or housing agents (the two capital creator agents). Third, household saving determines the net asset acquisitions by the household financial agent. Fourth, the current account deficit determines external borrowing requirement, which must equal net domestic asset acquisitions by foreigners.

8.2.4 Modelling Asset Allocation and Capital Structure Decisions

Liability agents in the financial-side model set their capital structure by minimising a constant elasticity of transformation (CET) function of the weighted cost of financial capital. Subject to the need to raise a given level of new financial capital ($NEWLIAB_{(s)}$), liability agent (s) ϵ LA decides the issuance of liability instrument (f) ϵ FI held by asset agent (d) ϵ AA that minimises the financial payment at the end of the year. Algebraically, this is written as follow:

Minimise : $\mathrm{CET}\left(A1_{(s,f,d)} \cdot R_{(s,f,d)}, \forall f, d\right)$ $(s \epsilon LALF)$[43]

Subject to : $\mathrm{NEWLIAB}_{(s)} = \sum_f \sum_d \left(A1_{(s,f,d)} - A0_{(s,f,d)} \cdot V_{(s,f,d)}\right)$.

where $R_{(s,f,d)}$ is the power of rates of return, $A1_{(s,f,d)}$ and $A0_{(s,f,d)}$ are the financial instrument $(f) \in FI$ issued by liability agent $(s) \in LA$ and held by asset agent $(d) \in AA$ at the end of the year and the beginning of the year respectively. $V_{(s,f,d)}$ are revaluation terms.

With the similar settings, I define the optimal behaviour of the asset agents. The asset agent $(d) \in AA$ sets their (asset) instrument $(f) \in FI$ issued by $(s) \in LA$ to maximise their portfolio-weighted average rate of return at the end of the year. The optimisation problem is written as follow:

Maximise : $\mathrm{CES}\left(A1_{(s,f,d)} \cdot R_{(s,f,d)}, \forall s, f\right)$ $(d \epsilon LALF)$

Subject to : $\mathrm{NEWASSET}_{(d)} = \sum_s \sum_f \left(A1_{(s,f,d)} - A0_{(s,f,d)} \cdot V_{(s,f,d)}\right)$.

In percentage change, the liability and asset agents optimisation are declared in the following forms

$$a1_{(s,f,d)} = \mathrm{liabilities}_{(s)} - \tau_{(s)}\left(r_{(s,f,d)} - \mathrm{wacc}_{(s)}\right), \quad (s \epsilon LALF), \tag{8.1}$$

$$a1_{(s,f,d)} = \mathrm{assets}_{(d)} + \sigma_{(d)}\left(r_{(s,f,d)} - \mathrm{averor}_{(d)}\right), \quad (s \epsilon LALF). \tag{8.2}$$

where $a1_{(s,f,d)}$ and $r_{(s,f,d)}$ are the percentage changes of coefficient $A1_{(s,f,d)}$ and $R_{(s,f,d)}$ respectively. The $\mathrm{liabilities}_{(s)}$ and $\mathrm{assets}_{(d)}$ are the percentage changes of coefficient $\mathrm{NEWLIAB}_{(s)}$ and $\mathrm{NEWASSET}_{(d)}$ respectively. The $\mathrm{wacc}_{(s)}$ is the percentage change in weighted average cost of capital of liability agent $(s) \in LA$. The $\mathrm{averor}_{(d)}$ is the percentage change in average rates of return of asset agent $(d) \in AA$. The $\tau_{(s)}$ and $\sigma_{(d)}$ are the parameters that regulate the sensitivity of the liability and asset agents respectively. Equation (8.1) and (8.2) describe demand and supply of financial instruments by liability and asset agents respectively.

[43] where LALF is the set of domestic asset and liability agents ($LALF = LA - ROW$).

8.2.5 Modelling the Capital Adequacy Ratio

8.2.5.1 Asset demand by commercial banks

To run the CAR simulation in our model, I incorporate the risk weighted calculation into banks asset acquisitions decisions. The commercial banks asset acquisition at the end of year is defined by the following expressions

$$U\left(R_{(s,f,Banks)} \cdot A1_{(s,f,Banks)}, \forall s, f\right), \tag{8.3}$$

subject to

$$\sum_{s,f} A1_{(s,f,Banks)} = BB_{(Banks)}, \tag{8.4}$$

and

$$\sum_{d} A1_{(Banks,Equity,d)} = MAX\left[\sum_{d} A1zero_{(Banks,Equity,d)}, KAR \cdot \sum_{s,f} W_{(s,f,Banks)} \times A1_{(s,f,Banks)}\right]. \tag{8.5}$$

where the U is the CES function, KAR is the coefficient of required capital adequacy (comprising the mandated capital requirement and the fixed buffer above the mandated rate), $W_{(s,f,Banks)}$ are the regulatory risk weights,[44] $\sum_{d} A1zero_{(Banks,Equity,d)}$ is the commercial banks equity issuance with the absence of capital adequacy requirement, $BB_{(Banks)}$ is the value of commercial banks asset.

When banks are constrained by KAR, Equation (8.5) becomes

$$\sum_{d} A1_{(Banks,Equity,d)} = KAR \cdot \sum_{s,f} W_{(s,f,Banks)} \cdot A1_{(s,f,Banks)}. \tag{8.6}$$

I allow bank decision making regarding the composition of bank asset holdings to be influenced by capital adequacy requirements, the relatively higher return required on equity liabilities, and risk weights, via Equation (8.7) - (8.9):

$$CES\left(NR_{(s,f,Banks)} \cdot A1_{(s,f,Banks)}, \forall s, f\right), \tag{8.7}$$

subject to:

$$\sum_{s,f} A1_{(s,f,Banks)} = BB_{(Banks)}, \tag{8.8}$$

---

[44] I use the regulatory risk weights similar to those in Giesecke et al. (2017) and Nassios et al. (2020).

and

$$\mathrm{NR}_{(s,f,Banks)} = \mathrm{R}_{(s,f,Banks)} - \Psi \cdot \mathrm{KAR} \cdot \mathrm{W}_{(s,f,Banks)}, \qquad (8.9)$$

where Ψ is a positive parameter reflecting the difference between the rate of return on bank equity and other bank liabilities. Equations (8.8) and (8.9) express the idea that banks will be mindful of a rate of return concept when adjusting bank assets that accounts for both the return on the asset ($\mathrm{R}_{(s,f,Banks)}$) and any penalty required by having to raise additional funding via relatively expensive equity ($\Psi \times \mathrm{KAR} \times \mathrm{W}_{(s,f,Banks)}$). For example, if Ψ = 0.1, KAR = 0.1, and W = 1.0, Equation (8.8) implies that commercial banks receive a 0.01 or 100 basis points penalty rate from regulatory CAR. By increasing the value of KAR to 0.12, the penalty rate increases to 0.012 or 120 basis points (rising 20 basis points). If the banks choose to own a financial asset with a lower risk weight (W) of 0.5, the penalty rate would become 0.005 or 50 basis point (falling 50 basis points). The process described here illustrates how Equation (8.7) - (8.8) cause changes in the portfolio choice of commercial banks in our model.

8.2.5.2 Commercial Bank Liabilities and Equity

I exclude the bank's equity capital from the optimisation settings in Equation (8.1) and (8.2) as I want the equity capital to follow the regulatory capital requirement together with any fixed additional buffer (jointly described by KAR). Herein, I set Equations (8.10) to (8.15) to explain the key behavioural relations that relevant to the CAR simulation.

$$\mathrm{RABANK} \cdot \mathrm{prabank} = \sum_{s \in LA} \sum_{f \in FI} \left[\mathrm{RISKWGT}_{(s,f)} \cdot \mathrm{A1}_{(s,f,Banks)}\right] \cdot \left(\mathrm{priskwgt}_{(s,f)} + \mathrm{a1}_{(s,f,Banks)}\right), \qquad (8.10)$$

$$\mathrm{EQBANK} \cdot \mathrm{peqbank} = \sum_{d \in AA} \mathrm{A1}_{(Banks,Equity,d)} \cdot \mathrm{a1}_{(Banks,Equity,d)}, \qquad (8.11)$$

$$\mathrm{pratio} = \mathrm{peqbank} - \mathrm{prabank}, \qquad (8.12)$$

$$\mathrm{BBNEQ}_{(Banks)} \cdot \mathrm{pbblneq}_{(Banks)} = \mathrm{BBL}_{(Banks)} \cdot \mathrm{pbbl}_{(Banks)} - \sum_{d \in AA} \mathrm{A1}_{(Banks,Equity,d)} \cdot \mathrm{a1}_{(Banks,Equity,d)}, \qquad (8.13)$$

$$\mathrm{averorne}_{(Banks)} = \sum_{d \in AA} \sum_{f \in FINEQ} \left[\mathrm{A1}_{(Banks,f,d)} / \mathrm{BBNEQ}_{(Banks)}\right] \cdot \mathrm{rpow}_{(Banks,f,d)}, \qquad (8.14)$$

$$\mathrm{a1d}_{(Banks,f)} = \mathrm{pbblneq}_{(Banks)} + \mathrm{TAU} \cdot \left[\mathrm{rpowd}_{(Banks,f)} - \mathrm{averorne}_{(Banks)}\right], \qquad (8.15)$$

where $(f \in FINEQ)$.

The definition of variables, coefficients, and sets are presented in Table 8.7.

Variable	Description
$BBL_{(Banks)}$	The level of total end-of-year commercial bank liabilities (including equity).
$BBNEQ_{(Banks)}$	The level of the equity-exclusive value of end-of-year commercial bank liabilities.
$RABANK$	The level of the value of end-of-year risk-weighted bank assets.
$RISKWGT_{(s,f)}$	The level of the risk weights attached to financial instrument (f) issued by liability agent (s).
$A1_{(s,f,d)}$	The level of end-of-year holdings by agent (d) of asset type (f) issued by agent (s).
TAU	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.
$EQBANK$	The value of bank equity.
$prabank$	The percentage change in risk-weighted bank assets.
$priskwgt_{(s,f)}$	The percentage change in the value of the risk weight attached to commercial bank holdings of financial instrument (f) issued by liability agent (s).
$a1_{(s,f,d)}$	The percentage changes in end-of-year holdings by agent (d) of asset type (f) issued by agent (s).
$peqbank$	The percentage change in end-of-year bank equity.
$pbblneq_{(Banks)}$	The percentage change in the equity-exclusive value of commercial bank liabilities.
$pbbl_{(Banks)}$	The percentage change in end-of-year (equity-inclusive) commercial bank liabilities.
$averorne_{(Banks)}$	The percentage change in the average rate of return on non-equity financial instruments issued by commercial banks as liability agents.
$rpow_{(Banks,f,d)}$	The percentage change in the power (one 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.
$a1d_{(Banks,f)}$	The percentage change in end-of-year non-equity liabilities issued by commercial banks as liability agents.
$rpowd_{(Banks,f)}$	The percentage change in the power of the rate of interest paid by commercial banks on non-equity financing instrument (f).

Table 8.7 Variables and Coefficients in the Main Capital Adequacy Equations

Equation (8.10) represents accounting relationship to form banks risk weighted asset in percentage change form. Equation (8.11) represents the percentage change in the value of commercial bank equity at the end of the year, as the weighted average of percentage changes of banks equity held by asset agent $(d) \in AA$. Equation (8.12) is the percentage change in the capital adequacy ratio, expressed as the ratio of outstanding equity liabilities divided by risk weighted assets. Equation (8.13) calculates the value of commercial banks non-equity liabilities, as the total liabilities issuance *minus* equity issuance. Equation (8.14) is the formation of the average rates of return of the commercial bank assets. The Equation (8.15) accounts for the optimisation behaviour of the commercial banks toward non-equity liabilities.

As aforementioned, aggregate CAR in Indonesia is higher than the required level. In our model, I assume the excess bank capital (aggregate CAR *minus* required CAR) is exogenously determined. By this assumption, the change in required CAR causes the change in aggregate CAR. I note that theorising the excess bank capital in our model could become an improvement for future research.

8.2.6 Database

The database in AMELIA-F consists of two parts, namely: the real-side database and the financial database. I use the 2010 Indonesia Input-Output table to develop the required database by the real-side model (Badan Pusat Statistik, 2015). I update the 2010 input-output database to 2018 using published national accounts data available in the Indonesian Financial Statistics (Bank Indonesia, 2020). The real side database distinguishes 51 unique commodities and industries. This is an aggregation of the real-side database the original 185 sectoral disaggregation the 2010 Indonesia Input-Output table. The financial database is developed using the 2018 financial account and balance sheet data for Indonesia (FABSI) provided by Bank Indonesia. I create single representative housing sector and assign the banks financing amount from mortgage available in published Indonesian Financial Statistics (Bank Indonesia, 2020). Using debt to equity ratio of property and real estate sector at the Indonesian stock market statistics (Indonesia Stock Exchange, 2020), I estimate the equity finance of the housing agent held by the households.

8.2.7 Closure and Implementation Method

The closure assumptions I use in our model are similar to those in Giesecke et al. (2017) and Nassios et al. (2020), with the following key elements:

(i) In line with neo-classical framework, the nominal wage is sticky while the employment is flexible in the short run. The nominal wage adjusts over the medium to long run to ensure the employment rate returns to the baseline forecast level in the long run.

(ii) The government consumption and the ratio of public deficit/GDP in are assumed to be fixed. As consequence, the government revenue side needs to be flexible i.e., I endogenously determine tax on households' income.

(iii) I set other GDP expenditures (household consumptions, investments, exports, import, and stocks) endogenously determined.

(iv) Capital stocks are prevented to move in the short run and adjust to respond the movement of expected real of return of industries over medium to long run.

(v) The central bank responds to the deviation in the employment rate and the inflation rate from their medium-term targets according to the Taylor rule [Taylor (1993); Orphanides (2007)]. When the economy weakens, the central bank responds by reducing the policy rate to create an expansionary monetary policy.

8.3 Results

8.3.1 Consequences of A 100 Basis Point Increase in Bank Capital Adequacy Requirement

I investigate the effects of a mandated 100 basis point increase in bank capital adequacy requirements. This can be implemented either via a rise in the regulatory floor CAR in the presence of fixed discretionary buffers, or via persuasion by regulatory authorities that banks raise their discretionary buffer while leaving the regulatory floor CAR unchanged, or via a combination of both.

The 100 basis point increase in the CAR causes the commercial banks to adjust their capital structure (the composition of the liability side of their balance sheet). To increase the CAR, commercial banks raise equity issuance and reduce their reliance on deposits and bonds finance (Figure 8.2). The commercial banks raise the issuance of equity by approximately 3.3 per cent relative to baseline, and reduce deposit and bond finance by nearly 3 per cent relative to baseline.

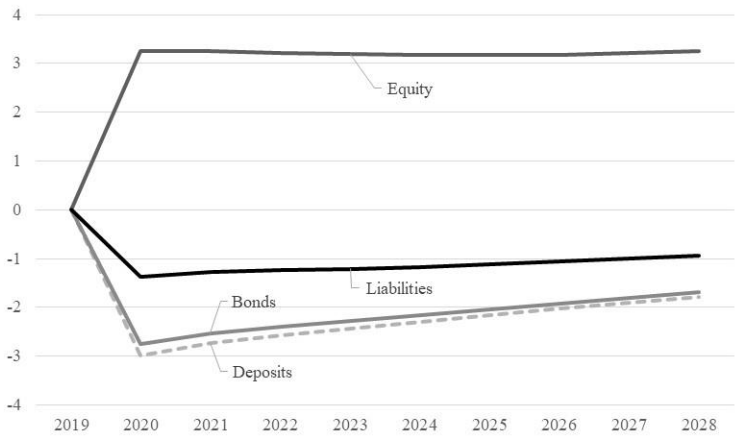


Figure 8.2 Financing Instruments of the Commercial Banks
(% Deviation from Baseline)

To convince asset agents to hold additional equity, banks raise the rate of return on equity, while offering a lower rate of return on deposits and bonds finance (Figure 8.3). Deposits play an important role in banks finance (69 per cent of the total liabilities) and 70 per cent of this are held by households. Figure 8.4 reports a decrease in bank deposits by the large holders (foreigners, households, and NBFI). The fall in deposits finance is not offset by the overall increase in equity capital, thus total bank liabilities decrease (Figure 8.2). This reflects the overall contraction in bank activity, caused by the rise in the relate weighted average cost of bank capital (Figure 8.5) generated by the move towards more expensive equity in bank financing.

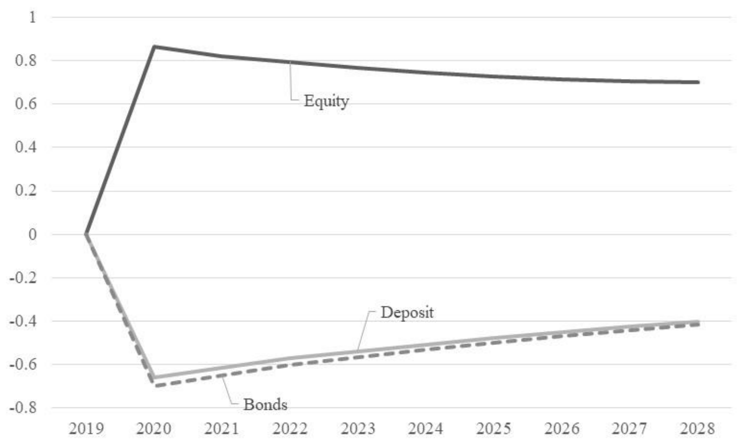


Figure 8.3 Power of Rates of Return on Commercial Bank Liabilities
(% Deviation from Baseline)

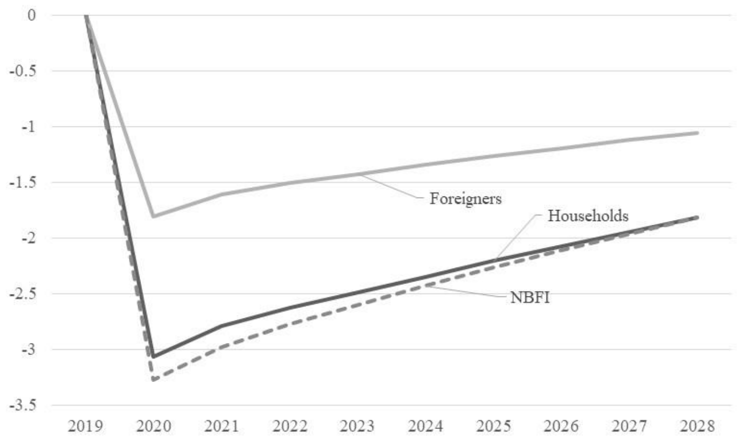


Figure 8.4 Household, NBFI, and Foreign Deposits with Commercial Banks (% Deviation from Baseline)

The increase in the use of equity finance drives a rise in the weighted average cost of bank capital (WACC). Equity typically requires higher rate of return than other financing instruments. Given the higher required rate of return on equity, together with the increase in the rate of return on equity required to induce asset agents to hold more equity, causes overall bank WACC to rise. Figure 8.5 reports that the increase in bank WACC impacts upon the WACCs of other institutions. I see that the NBFI and Housing agents have higher increases in WACC, as they are more reliant on bank funding than other agents. Increase in the WACCs of other agents describes how the bank lending channel impacts the economy at the first round of the policy simulation.

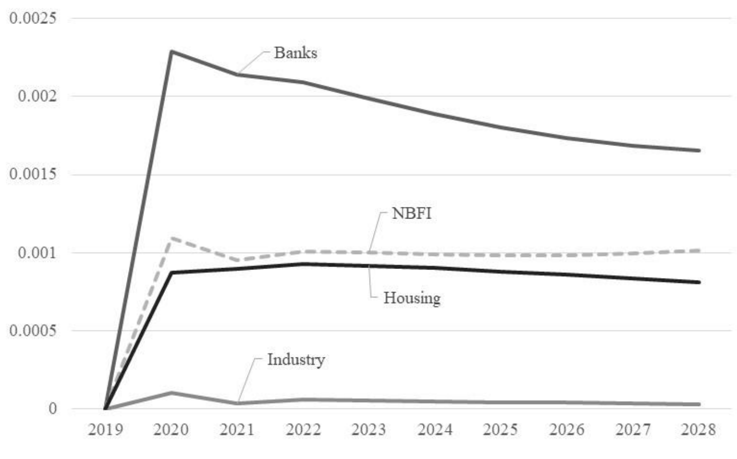


Figure 8.5 Weighted Average Cost of Capital of Banks, NBFI, Housing, and Industry

(Basis Point Change from Baseline)

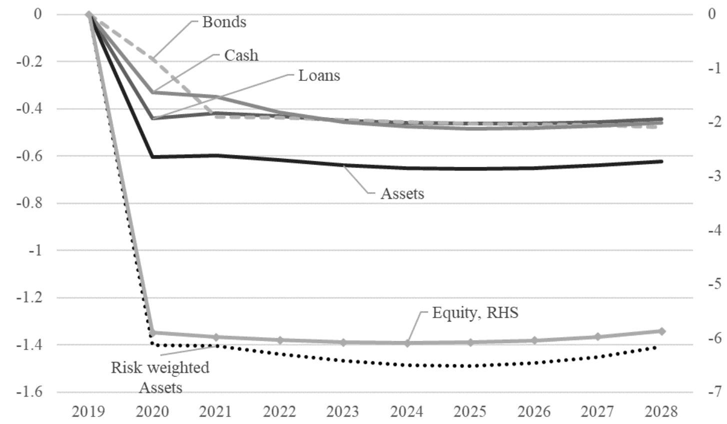


Figure 8.6 Asset Acquisition by the Commercial Banks (% Deviation from Baseline)

On the asset side, the commercial banks reduce the value of their risk weighted assets in response to the rise in CAR (Figure 8.6). The banks move away from riskier assets and weakly retain the less risky assets. Banks tend to reduce their equity holding more relative to other assets, as equity carries a high-risk weight. Reductions in holdings of safer assets (e.g., bonds and cash) are smaller relative to the riskier assets This reflects the operation of Equation (8.9), which imposes a lower penalty (via lower risk weights) on holdings of safer assets.

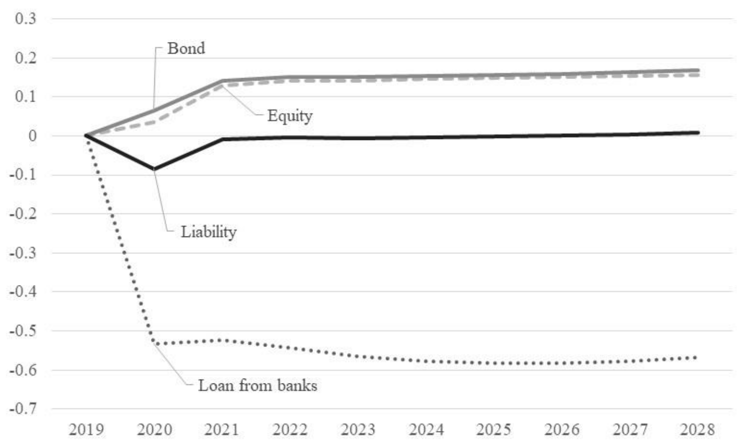


Figure 8.7 Industry Financing Instruments (% Deviation from Baseline)

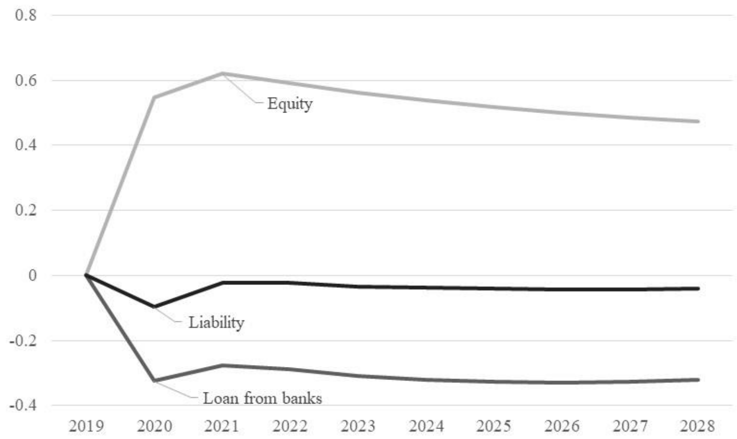


Figure 8.8 Housing Financing Instruments
(% Deviation from Baseline)

The contraction in commercial bank assets reflects the reduction of loans to the industry (non-housing) and housing agents (Figure 8.7 and 8.8). As bank loans get more expensive, the industry agent moves away from banks loans and substitutes the banks loans with industry-issued bonds and equity (Figure 8.7). Meanwhile, with more limited financing alternatives, the fall in banks loans causes a larger impact on the housing sector. Unlike industry, the total liabilities of the housing sector do not return to the baseline after the event year, although equity finance raises as a response to reduced banks loans. This is because the housing agent is more reliant on bank funding relative to the non-housing agent.

In the AMELIA-F database, foreigners finance 42 per cent of non-housing investments. I would have expected that a reduction in domestic bank loans to industry induces a large foreign investment penetration to the country. However, this does not occur in our simulation. There are two things that constrain foreign investment coming to the economy. As I shall see, the foreign financing requirement falls as real investment decreases due to a rise in industry and housing WACC, i.e., the current account deficit moves towards surplus (Figure 8.16). This is an economy-wide reduction in foreign capital demands that constrains the capacity to absorb foreign investment. Second, as banks increase the rate of return on equity in order to achieve the regulatory CAR, their rate of return becomes more attractive than the rates of return of the industry agent. Figure 8.9 reports that foreigners are more attracted to invest more in bank equity than in the industry.

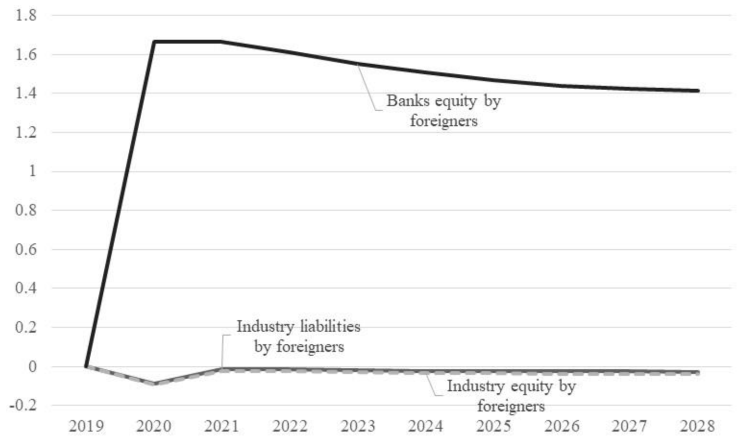


Figure 8.9 Level of foreign asset holdings
(% Deviation from Baseline)

With the commercial banks moving away from riskier financial assets, the WACC of the housing and industry agents increase, driving real investment activity below baseline. Figure 8.10 reports the gross fixed capital formation of the industry and housing sectors, which together constitute economy-wide real investment expenditure. The housing investment fall is deeper because they are more bank reliant than the non-housing investment. In the AMELIA-F database, 80 per cent of housing financing comes from banks loans, while the rest of financing is in the form of equity held by households. Non-housing investment moves back towards baseline in the long-run, reflecting greater access to non-bank financing options for this sector. In contrast, with more limited financing alternatives, constrained bank financing impacts housing investment more severely.

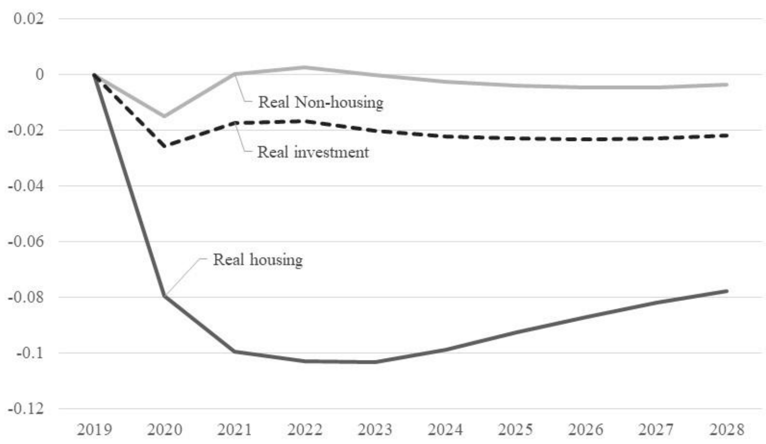


Figure 8.10 Real Industry Investment, Housing Investment, Aggregate Investment
(% Deviation from Baseline)

The central bank to some extent counters the negative impact of the increase in capital adequacy policy. Figure 8.11 reports the reaction of the central bank toward management of the macro consequences of a 100 basis point increase in CAR. The central bank decreases its policy rates (both deposit and financing rates) in response to the weakened economy. The central bank is assumed to act according to Taylor rule whereby policy rates are a function of the deviation of the unemployment rate from the natural rate of unemployment, and the actual inflation rate from the inflation rate target. Figure 8.12 reports the negative deviation of the employment rate and the consumer price from the baseline in the policy year. The Taylor rule translates this into a negative deviation in the policy rate of 6.7 basis points in the event year. In the long run, policy rates move gradually to the order of 4 basis point below baseline.

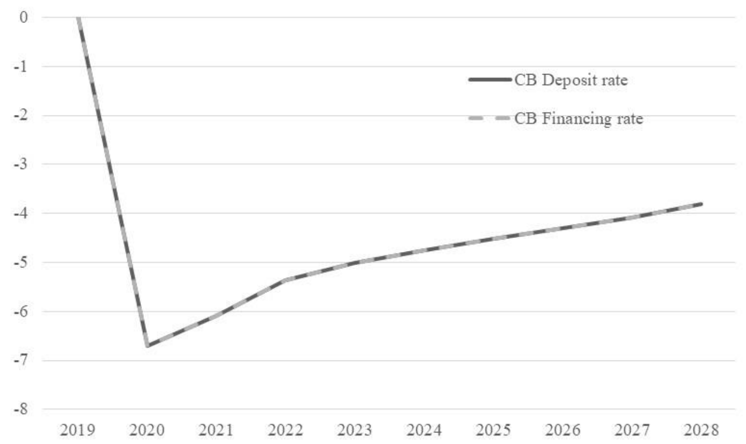


Figure 8.11 Central Bank Policy Rates
(Basis Point Change from Baseline)

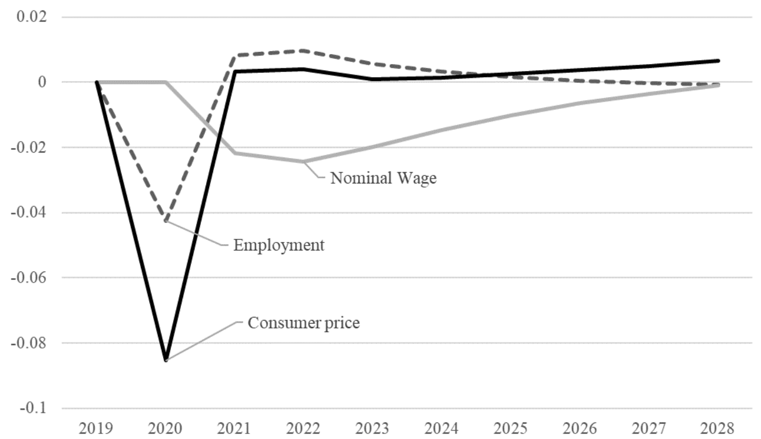


Figure 8.12 Employment Rate and Nominal Wage
(Percentage Deviation from Baseline)

Figure 8.13 reports the deviation from baseline of real GDP, employment, and the capital stock. As the capital stock is fixed in the event year, the movement in real GDP only depends on the short run employment response. As aforementioned, employment falls in the event year due to a weaker economy. In the event year, the nominal wage is fixed (Figure 8.12) while the GDP deflator falls relative to the baseline (Figure 8.14). A negative deviation in the GDP deflator in an environment of nominal wage rigidity causes the real producer wage to rise in the short run. With physical capital stocks unchanged and the real producer wage rising, the employment rate must fall. With a 29 per cent employment contribution to the value of the GDP, given fixed capital stock, a -0.04 per cent deviation of the employment translates to -0.01 per cent real GDP deviation in the event year (=-0.04*0.29). Despite the eventual return of employment to baseline, real GDP is permanently below baseline. This reflects the permanent decline in the capital stock.

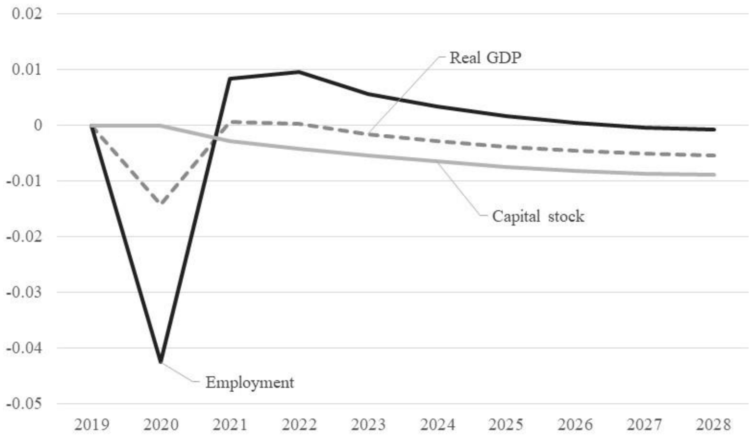


Figure 8.13 Real GDP, Employment, and Capital Stock
(% Deviation from Baseline)

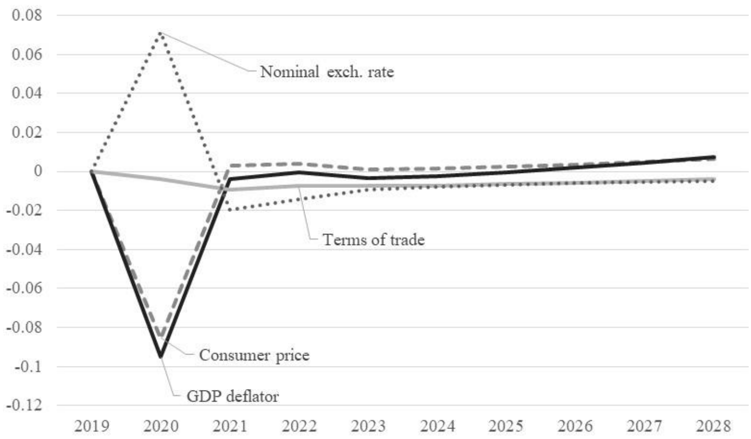


Figure 8.14 GDP Deflator, Consumer Price, Nominal Exchange Rate and Terms of Trade (% Deviation from Baseline)

Figure 8.15 reports the percentage deviation away from baseline for the expenditure components of GDP. In line with income GDP, the expenditure GDP falls in the order of 0.01 per cent from the baseline in the policy year and adjusts to baseline thereafter. As GDP falls, household consumption decreases. A fall in real investment and household consumption induces falls in import demands for capital and consumption goods respectively. Public consumption is unaffected as I set this exogenously determined as aforementioned in closure Section 8.2.7. The smaller negative deviation of the real GDP than the real GNE signals a movement towards surplus in the trade balance. This is supported by a fall in domestic prices relative to foreign prices, which is manifested in the lower terms of trade and rise in export volumes relative to baseline. The current account deficit moves towards surplus, muting the economy-wide external financing requirement.

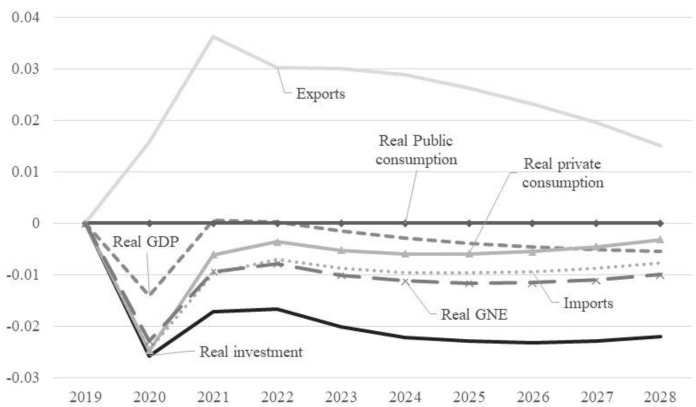


Figure 8.15 Expenditure-side Components of Real GDP at Market Prices (% Deviation from Baseline)

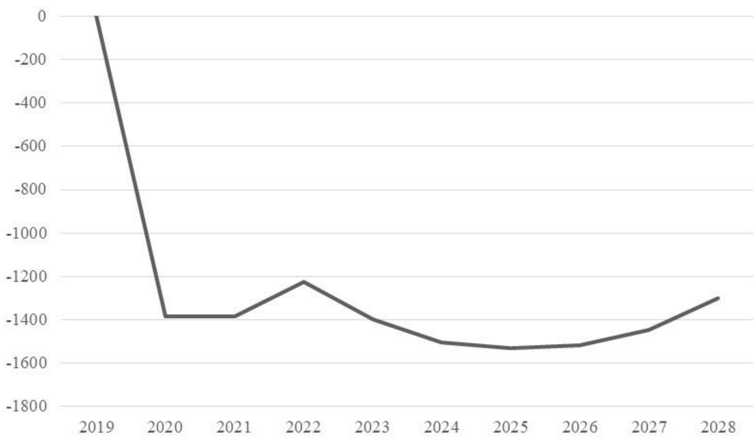


Figure 8.16 Current Account Deficit (Rp billion)

8.3.2 Implications of Higher Bank Capital For Macro Stability

As I have shown in Section 8.3.1, the macroeconomic cost of raising bank capital adequacy requirements in Indonesia are small: for example, I find that long-run real GDP falls by 0.005 per cent relative to baseline, which translates to a dollar cost of Rp78 billion in present value terms. Our analysis thus far has been largely silent on the benefits of raising Indonesian bank capital requirements. As discussed in the introduction, bank capital regulation is used by financial authorities to pursue diverse financial and macro stability objectives. Quantifying the benefits of these objectives is possible with future research using AMELIA-F, but beyond the scope of the present article. Nevertheless, our results can be used to provide a qualitative assessment of the implications of bank CARs for Indonesian macro and financial stability, by studying a number of macro stability indicators evaluated by the model. A similar methodology was used by Nassios et al., (2019), who discuss the macro stability implications of an increase in mandatory pension contributions in Australia.

I study four outputs from our simulations in Section 8.3.2. These are:

(i) The impact of bank CARs on the equity financing share of Indonesian commercial banks (Figure 8.2), which I discuss in Section 8.3.2.1;

(ii) The response of private indebtedness (Figure 8.7 and 8.8) to bank CARs, which I discuss in Section 8.3.2.2;

(iii) The impact of CARs on bank risk-taking behaviour in asset acquisitions (Figure 8.6), which I discuss in Section 8.3.2.3;

(iv) The sensitivity of external financing requirements (Figure 8.15 and 8.16) to changes in bank CARs, which I discuss in section 8.3.2.4.

8.3.2.1 Reduction of macro volatility

The Bank for International Settlements (2010) explains that higher bank equity financing ratios reduce macroeconomic volatility, by acting as a loss absorber in economic downturns, while reducing lending in economic booms. Higher bank equity ratios are thus counter-cyclical. A 100-basis point rise in bank CAR does not necessarily imply bank equity financing shares rise, however: for example, banks may fully accommodate the rise in the CAR by adjusting their risk-weighted asset weights, thus maintaining a fixed equity financing share. To explore whether bank equity financing shares do rise when bank CARs are increased herein, I plot the deviation (in percentage points) of the financing ratios by financial instrument for Indonesian banks from the baseline in Figure 8.17. As I see in Figure 8.17, the equity financing ratio (black dots) rises by 0.013 percentage points in the shock-year, and remains elevated relative to the baseline in the long-run, when the Indonesian bank CAR is increased by 100 basis points. In contrast, there is a reduced reliance on deposits and loan finance (shaded bars) throughout the simulation period.

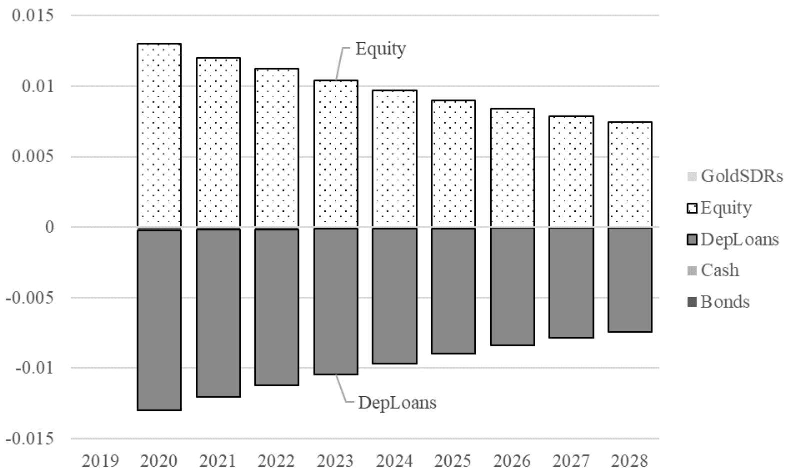


Figure 8.17 Shares of Financing Instruments in Commercial Banks (Percentage Point Deviation from Baseline)

8.3.2.2 Reduction of indebtedness

As outlined by OECD (2012) and summarised by Nassios et al., (2019), high debt levels amplify macro vulnerabilities during periods of economic stress, raising the risk that adverse shocks will migrate through the financial system. Sutherland et al., (2012) also discuss how debt affects macro stability, arguing that it magnifies the exposure of financial agents to income and asset price shocks. With insufficient capital buffers, contagion risk and the possibility of sudden-stop episodes (defined as systemically significant drops in external capital flows) grow. To assess the impact of increased bank CAR on indebtedness, I begin by noting that the ratio of private indebtedness to income falls relative to baseline (solid black line, Figure 8.18). In addition, the debt-to-equity ratio of both the housing sector (solid grey line, Figure 8.18) and the industries responsible for non-residential capital creation (dashed line, Figure 8.18) fall relative to baseline. Reductions relative to baseline in each of these three ratios points to improved long-run macro stability.

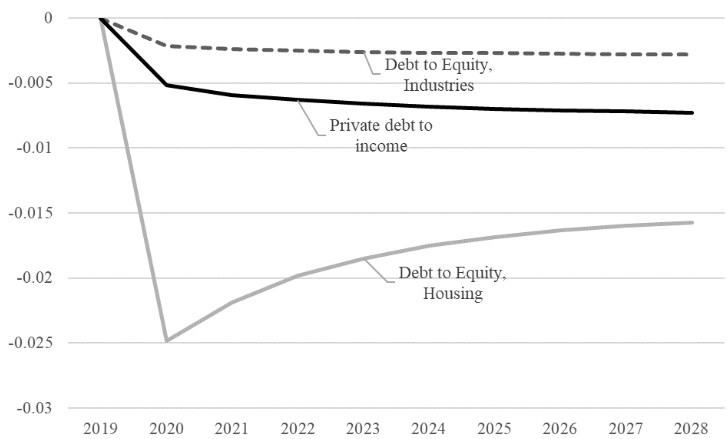


Figure 8.18 Indebtedness Indicators (Deviation from Baseline in percent)

8.3.2.3 Reduction of systemic risk

As discussed by Thakor (2014) in a literature review of the implications of higher bank capital requirements on stability, higher bank capital promotes financial stability by creating a disincentive for risk-taking behaviour by banks. Our findings in Section 8.3.1 reinforce this statement. As discussed in Section 8.2.3 and highlighted in Equation (8.9), the net rate of return on bank financial assets in AMELIA-F is a decreasing function of the risk weight of the financial asset. The risk weights vary by issuer and instrument type. As constrained optimisers, when the bank CAR is increased, the variable *KAR* in Equation (8.9) and thus the penalty from holding higher risk-weight assets also rises. In response, banks substitute towards less risky financial assets when setting their portfolio. This is shown in Figure 8.6, where I see banks reducing their holdings of high risk-weight equities, with smaller reductions in their allocation to other less risky financial instruments, e.g., bonds and loans.

8.3.2.4 Reduction of aggregate external financing requirements

Finally, I consider the implications of bank CAR for Indonesia's foreign financing requirements. In developing economies, a high reliance on external financing is generally considered to increase vulnerability to financial shocks, like bank crises. This is because financial crises have been triggered by foreign capital reversals, which impact domestic firm liquidity and can cause short-run exchange rate volatility (Prasad et al., 2009). The capital reversals themselves are also often triggered by external factors, thus inducing rather than reacting to domestic economic instability (Calvo et al., 2008). A recent example of an Indonesian capital reversal is the "Taper Tantrum" of 2013, where U.S.$4.1 billion capital outflows in May and June 2013 caused sharp nominal depreciation of the exchange rate; a fall in stock prices; a rise in government bond yields; and a reduction in GDP growth [Nugroho et al., (2014); Warjiyo (2015); Basri (2017)].

Herein, the impact of bank CAR increases on foreign financing in Indonesia is mixed. On the one hand, as discussed in Section 8.3.1 I observe small reductions in the level of economy-wide gross foreign debt (see Figure 8.16). Because AMELIA-F carries financial liability agent and financial instrument detail, I can study the movement in foreign ownership shares across financial agents and instruments when I raise the bank CAR; see Figure 8.19, where I plot the long-run deviation from baseline in percent of:

$$\mathrm{FOR\_SHARE}_{(\mathrm{s,f})} = \frac{\mathrm{A1}_{(\mathrm{s,f,ROW})}}{\sum_{\mathrm{d} \in \mathrm{AA}} \mathrm{A1}_{(\mathrm{s,f,d})}}, \tag{8.16}$$

where the sum in the dominator spans the set of financial asset agents AA; the foreign investor ROW is defined in Table 8.5; the index *f* spans the set of financial instruments FI, i.e., $f \in$ FI; and the index $s \in$ LA.

At this level of granularity, I see that some (*s*,*f*) pairs experience small increases in foreign ownership shares, heightening exposure to capital reversals, while others fall. Herein, I study the (*s*,*f*) pairs experiencing the largest rise and largest fall only: bank debt and bank equity, respectively.

In Figure 8.19, I see that the foreign ownership share for bank bonds rises 0.9 percent by 2028 compared to baseline. Why? When the bank CAR rises, banks partially accommodate the rise by substituting cheaper bond and deposit liabilities for more expensive equity (see Figure 8.2). This has two effects: (i) banks reduce the rates of return they offer on their bonds and deposits, while the rate of return on equity must rise to induce capital owners to alter their portfolios towards bank equity; and, (ii) the denominator in Equation (8.16) falls for bank debt and deposits, but rises for equity. The former of these two consequences drives the second, by triggering a substitution effect across financial asset agents' portfolios. This sees financial asset agents tilt their portfolios away from bank deposit and debt, and towards bank equity; see the CES framework governing asset agent decision making in Section 8.2.4. This places downward pressure on the ROW allocations to bank debt and deposits, and thus the numerator in Equation (8.16). However, this effect is second-order compared to the leading-order impact of a rise in the CAR on bank debt and deposit liability stocks. The fall in the denominator in Equation (8.16) thus dominates, and foreign ownership shares for bank debt and deposits rise; see Figure 8.19.

For bank equity, the effects are reversed. From Figure 8.19, I see foreign ownership shares fall by 1.8 percent relative to their baseline forecast level in 2028. This is driven by stronger expansions in bank equity raisings, relative to foreign purchases of bank equity. This also can be seen as a stronger appetite for domestic liability instruments by local investors, relative to foreigners. Other movements in foreign ownership shares can be explained in similar ways.

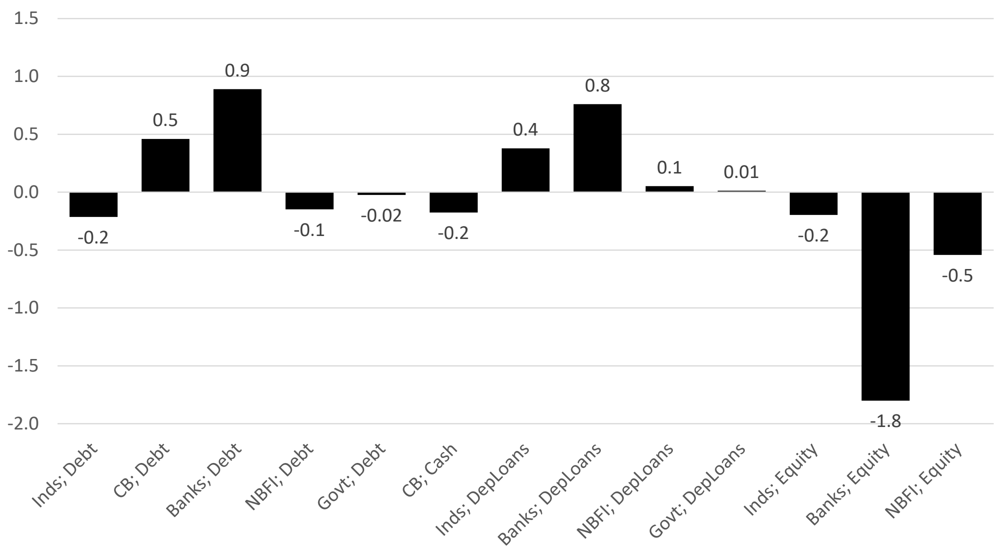


Figure 8.19 Foreign ownership shares by financial liability issuer and financial instrument type in eight years post-shock (Deviation from Baseline in percent in 2028)

8.4 Conclusions

After the 2008 global financial crisis (GFC) authorities across the globe stressed the importance of strengthening commercial bank capital adequacy in accord with Basel III. With many countries raising bank capital adequacy requirements, there are only a few studies evaluating the impacts of the policy for emerging countries from a broader macroeconomic perspective. This study investigates the economy-wide impacts of a 100 basis point increase in bank CAR in Indonesia using a Financial CGE model I call AMELIA-F. The model comprises a real-side CGE model integrated with a detailed finance model.

The real-side of the model explains the real economy under a neoclassical theoretical framework, following the MONASH model by Dixon and Rimmer (2002). The financial-side model includes the theories on financial agents interactions and the linkages to the real side economy following Giesecke et al., (2017) and Nassios et al., (2020). The real-side of the model is connected to the financial-side model via four channels, namely: industry and housing investment are financed by net liability raisings by the corresponding financial liability agents, the current account deficit is financed by net asset purchases by the foreigners, household savings tie down net asset purchases by the household agent, and the government deficit is financed by the net liabilities issued by the government financial agent.

Our model simulation finds a 100 basis points increase in bank CAR causes small negative consequences for the economy. The commercial banks experience a balance sheet reduction as they move away from riskier assets and finance more of their activity by relatively expensive equity rather than debt. This impacts negatively on the industry and housing agents' capacity to invest in physical capital formation. Hence real investment falls by 0.02 per cent relative to baseline in the event year and returns gradually to the baseline in the long run. Real GDP decreases by 0.01 per cent from the baseline in the event year and returns to the baseline thereafter. The central bank reduces its policy rates to counter the negative impacts on the employment rate and consumer prices. Falling real investment decreases the external financing requirement, as indicated by a fall in the current account deficit.

I concluded by discussing the implications of an increase in bank CAR for a number of indicators of Indonesian macro stability. I identified three channels via which bank CAR aids macro stability: (i) bank debt-to-equity ratios fall, and so too those of the housing and non-housing sectors; (ii) bank risk-taking behaviour is attenuated, as partial accommodation of higher CARs sees them tilt away from high risk-weight assets; and, (iii) the economy-wide private debt to income ratio (a leading indicator of enhanced macro stability) falls.

CHAPTER 9
Quantifying The Impact of Capital Controls on Indonesian Commercial Banks Using General Equilibrium Framework

9.1 Introduction

In the previous chapter, I introduced the concept of bank capital regulation via the bank capital adequacy ratio (bank CAR). As I showed via simulation with AMELIA-F, increases in the bank CAR compel Indonesian banks to fund a greater share of their financial asset purchases, e.g., housing loans, via equity issuance. I also outlined how changes in financial regulation can interact with traditional tools of price stability, i.e., monetary policy, by modelling endogenous cash rate responses by the central bank in AMELIA-F.

Other forms of regulation beyond the bank CAR are increasingly important policy tools, allowing regulators to balance traditional responsibilities such as price stability, with an increasing focus on financial stability management. In this section, I introduce and study one such regulatory tool: the bank net open position (NOP). The bank NOP is defined as the ratio of the difference between commercial bank foreign liabilities and foreign assets, and commercial bank equity liabilities. In this chapter, I describe how bank NOP ratios can be exogenously imposed with AMELIA-F. I then present the results of two simulations, where I ease bank NOP regulation on Indonesian banks by raising the bank NOP ratio by 100 basis points relative to the baseline. In each simulation, I activate a single channel via which Indonesian banks can accommodate the change in bank NOP. In simulation one, Indonesian banks accommodate the rise in bank NOP by increasing foreign borrowings, i.e., by issuing more foreign debt. In simulation two, Indonesian banks accommodate the rise in bank NOP on the asset-side, by reducing foreign loans. In the discussion, I explain and contrast the financial market and real economy impacts of each accommodation channel, and finally present a third scenario (joint accommodation) where I allow for proportional liability- and asset-side accommodation.

Accommodation via each channel results in gains for the real economy, measured as expansions in Indonesian long-run real GDP. Net capital inflows cause exchange rate appreciation, which induces the central bank to lower its policy rate, as described by Ikhsan et al. (2012) and Juhro and Goeltom (2015) in the Indonesian context. The lower policy rate contributes to a decrease in bank's WACC, which reinforces the direct responses noted above as the lower bank WACC is passed on to domestic capital creators.

The remaining sections of this chapter are arranged as follows. Section 9.2 describes the early banking deregulations and the use of NOP as macroprudential policy. Sections 9.3, 9.4, 9.5 discuss foreign capital penetration in the context of the Indonesian banking sector in chronological order: (i) 1989-1998, the period following introduction of the bank NOP up to the peak of the AFC; (ii) 1999-2007, the period between the AFC and the GFC; and (iii) 2008 onwards, from the GFC to present day, respectively. Section 9.6 discusses technical details on how the bank NOP is modelled in AMELIA-F. Section 9.7 describes the simulations I present and the discussion of the results. Section 9.8 concludes the chapter.

9.2 Financial Deregulation and the Introduction of the NOP as a Macroprudential Tool

In 1989, Indonesian authorities abolished foreign borrowing limitations for domestic banks. These limitations meant Indonesian banks were heavily constrained in their capacity to access foreign capital markets. Raising of new foreign debt required approval by a regulatory committee (Nasution, 1994). Removing these limitations meant for the first time, Indonesia's banking system could self-manage their foreign capital exposures. In anticipation of a surge in foreign capital inflows to the banking system however, the authorities introduced the bank net open position (NOP) as a macroprudential tool. In essence, the NOP mandates a bank capital provision for net foreign liabilities on a bank-by-bank basis, as represented in the following equation:

$$\text{NOP Ratio} = \frac{\text{Bank Foreign Liabilities} - \text{Bank Foreign Assets}}{\text{Bank Equity}} \tag{9.1}$$

The numerator in the above equation describes the value of net bank foreign liabilities, while the denominator is total bank equity. When it was first introduced in 1989, authorities enforced a maximum bank NOP of 25 per cent. Alternatively, for every Rp 1 increase in net foreign liabilities banks must make a minimum of Rp 4 in equity capital funding.

Sector-wide average NOPs for Indonesia are not publicly available for periods prior to 2005. Instead, from 1989 to 2005, I focus my discussion on Figure 9.1, where I plot (i) the ratio of foreign liabilities raised by the Indonesian banking sector to aggregate banking sector liabilities (solid line, the foreign liability share henceforth), and (ii) the regulatory bank net open position (dashed line). The data underpinning Figure 9.1 plot range spans the period 1985 – 2007. As highlighted by Figure 9.1, the foreign liability share exhibited little change between 1985 and 1989. Following the removal of foreign borrowing limitations and introduction of the NOP in 1989 however, the foreign liability share increased markedly, from 12 per cent in 1989 to 22 per cent in 1994. Agung (1998) argues that this development was attributable to the large interest rate differential between foreign and domestic financial markets. A significantly lower foreign interest rate relative to the domestic interest rate provided an incentive for domestic banks to borrow from offshore markets, while discouraging them from lending to foreigners. In what follows, I describe how foreign capital dependency and volatility have played a role during two profound periods of financial instability in Indonesia: the Asian Financial Crisis (AFC), and the Global Financial Crisis (GFC).

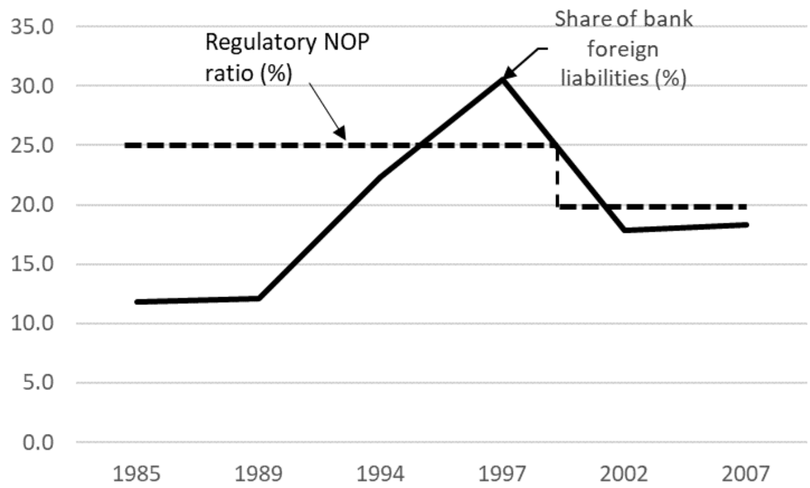


Figure 9.1 Foreign liability share for Indonesian banks (solid line) versus regulatory bank net open position (dashed line): 1985 to 2007

9.3 Foreign Capital Dependency and the AFC

Following the introduction of the bank NOP and abolishment of financial borrowing limits on commercial banks in 1989, bank foreign liabilities continued to increase up to the eve of the AFC, in 1997. As shown in Figure 9.1, the foreign liability share rose from 22 per cent in 1994, to 30 per cent in 1997. In line with Agung (1998), Hamada (2003) explains that during 1992 and 1997 financial deregulations coupled with tight monetary policy coincided with significant expansion of bank foreign liabilities and bank balance sheets.

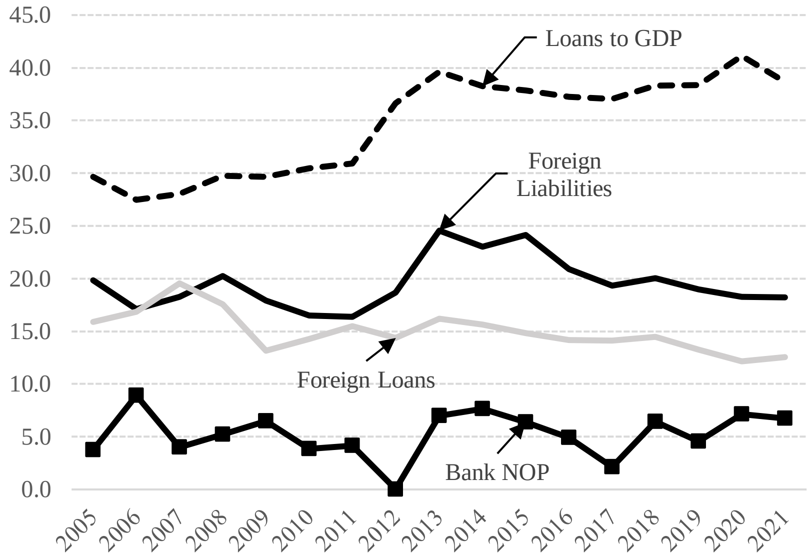
Critically, high foreign liability shares began to exert pressure on the Indonesian banking system in 1997, as the Rupiah depreciated against the US$ by 40 per cent peak-to-trough, which occurred in October 1997. This caused 34 commercial banks to fall into insolvency, leading to a bank run and foreign capital reversals (Enoch et al. 2003). These reversals are clearly evident in Figure 9.1, where from 1997 to 2002 the foreign liability share contracts sharply, from 30 percent to 18 percent. Hamada (2003) estimated that US$24 billion of capital was divested from the Indonesian economy in the period between 1997 and 1999.[45] The banking system became increasingly dysfunctional, materialising in significant real economy effects. By 1998, annual real investment and real GDP growth in Indonesia had contracted 33 per cent and 13 per cent peak-to-trough, respectively.

9.4 Emerging from the AFC

The significant capital reversals from Indonesia's banking system that materialised during the AFC persisted through the mid-2000s. This reversal was reinforced by the country's transition to a free-floating exchange rate post-AFC [(Agung, 1998); Calvo (1998); Grenville and Gruen (1999); Moenjak (2014: 177)]. The Indonesian banking sector was not immune from this downturn in foreign capital provision. To combat bank excessive accumulations of foreign capital, the regulatory NOP was reduced to 20 per cent from 25 per cent in 2000. From Figure 9.1, this change in regulatory NOP corresponds to a stabilisation of the foreign liability share.

[45] Prior to the AFC, US$25 billion of foreign capital went into Indonesian economy between 1994-1997.

From 2005 onwards, publicly-available sector-wide summary statistics are available for the realised banking sector NOP. This data is included in Figure 9.2, which shows the long-run dynamics of actual bank NOP (solid black line with black squares) together with the bank foreign liability share (solid black line), bank foreign loans (solid grey line), and the share of bank loans to Indonesian GDP (dashed black line). Throughout the period spanned by Figure 9.2 (2005 – 2021), the regulatory NOP remained fixed at 20 percent of equity capital; I thus suppress a plot of the regulatory NOP in Figure 9.2.



Source: Indonesia Financial System Statistics, Bank Indonesia

Figure 9.2 Actual Bank NOP (% of equity capital), Foreign Liabilities (% of total bank liabilities), Foreign Loans[46] (% of total bank loans), and Loan to GDP (%)

From Figure 9.2, while the bank NOP has exhibited some variation over the past 20 years, it has remained below the regulatory NOP of 20 per cent. The period between 2005 to 2007 was characterised by considerable volatility however. Jayasuriya and Leu (2012) and Fane (2005) explain that in the beginning of the 2000s, the use of NOP as a macroprudential tool to control foreign capital flows to the Indonesian banks was less effective. The banks could keep the NOP low by performing a swap transaction i.e., providing foreigners Rupiah lending for new foreign borrowing. This drove volatility in the bank NOP.

[46] Bank lending for foreigners.

To improve the effectiveness of NOP regulations, authorities passed a series of regulatory reforms. Bank Rupiah lending for foreigners was prohibited, to limit the banks from performing the aforementioned swap transaction as a means of maintaining a low NOP. The NOP calculation was also broadened, to include on- and off-balance sheet foreign liabilities and assets (Jayasuriya and Leu, 2012). By 2008 (the year of the GFC), the bank NOP was operationally more effective at explaining movements in reported Indonesian bank foreign liability and asset positions. For example, the foreign liability share (solid black line in Figure 9.2) rose to 20 per cent in 2008, from 18 per cent in 2007. Meanwhile, the share of foreign loans to total bank loans (solid grey line in Figure 9.2) fell to 17.6 per cent, from 19.5 per cent in 2007. Following the rise of realised bank NOP, bank loans to GDP increased to 30 per cent (from 28 per cent in previous year).

9.5 Indonesian banking: From the GFC to Present Day

From the GFC to 2011, Figure 9.2 highlights a sharp downward trend in the bank NOP; more specifically, the NOP decreased from 6.5 per cent in 2009 to 0.03 per cent in 2012. During this period, the foreign liability share also fell, while bank foreign lending rose, reducing net capital inflows to Indonesian banks. After 2012, the movements of bank NOP are broadly consistent with the dynamics of foreign capital flows into the Indonesian banks, driving a moderate upward trend in the bank NOP. Mara et al. (2021) explain how during this period, the bank NOP and capital inflows in Indonesia were largely driven by developments in global financial markets. The authors describe four significant global shocks that affected the Indonesian financial system over this time, i.e., the Greek debt crisis, the European sovereign debt crisis, the "taper tantrum", and increases in the Fed Fund Rate (FFR). Portfolio inflows were dominated by government bonds, private loans, other public obligations, and private money and deposits. Interestingly, the movements of capital flows were strongly correlated to bank balance sheets. The study also finds that capital inflows caused credit expansions and reduced domestic banks' interest rate in Indonesia.

9.6 Model Overview

To study the economy-wide impacts of relaxation in the regulatory NOP ratio, this research utilises the financial computable general equilibrium model called AMELIA-F (A Model of Economic Linkage for Indonesia-Finance). AMELIA-F has two main modules: the real-side model, and a financial-side model. The real side model explains the dynamics of the real economy, with the theory closely following MONASH by Dixon and Rimmer (2002). The financial side model comprises theories of financial agent optimisation behaviour, with a series of channels connecting it to the real model. Those channels are: (i) linkage of the current account deficit to net asset acquisition by the foreign financial agent (net capital inflows); (ii) linkage of the fiscal deficit in the real model to net liability raisings by the government agent in the financial side; (iii) linkage of household savings in the real model to financial asset purchases by the household financial agent; (iv) linkage of aggregate investment in the real model to net liability issuance by the capital creator in the financial side i.e., the industry and housing agents. The theories in the financial side are similar to the those explained by Giesecke et al. (2015). One significant departure from the theory in Giesecke et al. (2015), developed in what follows, is the introduction of the regulatory NOP as a constraint faced by commercial banks.

The real side elements of AMELIA-F rely on the 2010 Indonesia Input-Output Table (IOT) database released by BPS (2015). The financial side database is sourced from 2018 Financial Account and Balance Sheet Indonesia (FABSI).[47] In order to match the base year of both databases, the 2010 IOT is updated to 2018 using the Input-Output database adjuster program by Horridge (2009).

9.6.1 Financial agent optimal decision

The liability agent optimal decision is formally written in Equation (9.2). This expression describes that liability agents minimise a constant elasticity of transformation (CET) function of the weighted average cost of financial capital subject to the requirement to issue a given level of new financial capital ($\mathrm{NEWLIAB}_{(s)}$). Formally, the liability agent $(s) \in \mathrm{LALF}$ decides the issuance of liability instrument $(f) \in \mathrm{FI}$ held by asset agent$(d) \in \mathrm{AA}$ that minimises the CET function of weighted average financial payments at the end of the year. LALF is the set of domestic liability agents. Definitions of main sets used in AMELIA-F is given in Table (9.1).

[47] For the detail structure of FABSI database please refer to Karyawan (2017).

Minimise: $\mathrm{CET}\left(\mathrm{A1}_{(s,f,d)} \cdot \mathrm{R}_{(s,f,d)}, \forall f, d\right)$ (9.2)

Subject to: $\mathrm{NEWLIAB}_{(s)} = \sum_{f}\sum_{d}\left(\mathrm{A1}_{(s,f,d)} - \mathrm{A0}_{(s,f,d)} \cdot \mathrm{V}_{(s,f,d)}\right)$,

$s \in \mathrm{LALF}, f \in \mathrm{FI}, d \in \mathrm{AA}$.

where $\mathrm{R}_{(s,f,d)}$ is the power of rates of return, $\mathrm{A1}_{(s,f,d)}$ and $\mathrm{A0}_{(s,f,d)}$ are the financial instrument $(f) \in$ FI issued by liability agent $(s) \in$ LA and held by asset agent $(d) \in$ AA at the end of the year and the beginning of the year respectively. $\mathrm{V}_{(s,f,d)}$ are revaluation terms.

No.	Set	Element	Description
1.	LA (liability agent)	Inds CB Banks NBFI Govt HH ROW Housing	Industry Central Bank Commercial banks Non-bank financial institutions Government Households Rest of the world Housing sector
2.	LALF (Domestic liability agent)	= LA – ROW	
3.	AALF (Domestic asset agent)	= AA – ROW	
3.	AA (asset agent)	= LA	
4.	FI (Financial instruments)	Bonds Cash DepLoans Equity GoldSDRs	Bonds Cash Deposit or Loan Equity Gold and IMF Special Drawing Rights
5	BANKLA (bank liability/asset agent)	Bank	Commercial banks

Table 9.1 Definition of Sets and Elements

Decision-making by the asset agent is formulated in Equation (9.3). The asset agent $(d) \in$ LALF chooses financial instrument $(f) \in$ FI issued by liability agent $(s) \in$ LA to maximise a CES function of portfolio-weighted average rates of return at the end of year, subject to available budget to purchase new financial instruments ($\mathrm{NEWASSET}_{(d)}$).

$$\text{Maximise: } \mathrm{CES}\big(\mathrm{A1}_{(s,f,d)} \cdot \mathrm{R}_{(s,f,d)}, \forall s, f\big), \tag{9.3}$$
$$\text{Subject to: } \mathrm{NEWASSET}_{(d)} = \textstyle\sum_s \sum_f \big(\mathrm{A1}_{(s,f,d)} - \mathrm{A0}_{(s,f,d)} \cdot \mathrm{V}_{(s,f,d)}\big),$$
$$s \in \mathrm{LA}, f \in \mathrm{FI}, d \in \mathrm{AALF}.$$

9.6.2 Modelling the Indonesian bank net open position

To model the NOP in the FCGE framework, I introduce a phantom tax along similar lines to the approach used by Dixon et al. (2021) to analyse the impact of financial decoupling between China and the U.S.. using the Global Trade Analysis Project (GTAP) model. These phantom taxes are not actual taxes, in the sense that no revenue is collected by government. They are instead tax equivalents, representing the impact of decision making of regulatory constraints faced by commercial banks. The NOP ratio is defined as a policy variable in AMELIA-F, which I assume to be a binding constraint for commercial banks. The levels form of the main equations representing the NOP theory in AMELIA-F are:

$$\mathrm{RNOP} = \frac{\mathrm{NOP}}{\mathrm{EQ\_BANK1}}, = \begin{Bmatrix} \mathrm{A1}_{(\mathrm{Banks,DepLoans,Row})} \\ -\mathrm{A1}_{(\mathrm{RoW,DepLoans,Banks})} \end{Bmatrix} / \mathrm{EQ\_BANK1} \tag{9.4}$$

$$\mathrm{ROIL\_L}_{(\mathrm{Banks,DepLoans,RoW})} = \mathrm{ROIL}_{(\mathrm{Banks,DepLoans,RoW})} \cdot \mathrm{PTAX\_L}_{(\mathrm{Banks,DepLoans,RoW})} \tag{9.5}$$

$$\mathrm{ROIA\_T}_{(\mathrm{RoW,DepLoans,Banks})} = \frac{\mathrm{ROIA}_{(\mathrm{RoW,DepLoans,Banks})}}{\mathrm{PTAX\_A}_{(\mathrm{RoW,DepLoans,Banks})}} \tag{9.6}$$

All levels-form variables that appear in equations (9.4) to (9.6) are defined in Table 9.2.

No	Variable	Definition
1.	RNOP	NOP ratio.
2.	NOP	Nominal value of commercial bank net foreign liability (foreign deposit minus foreign loans).
3.	EQ_BANK1	Commercial banks equity $\big(\sum_{d \in AA} \mathrm{AT1}_{(\mathrm{Banks,Equity,d})}\big)$.
4.	$\mathrm{ROIL\_T}_{(\mathrm{Bank,DepLoans,RoW})}$	Commercial banks' perceived power of the interest rate on bank deposits and loans supplied by foreign asset owners.
5.	$\mathrm{ROIL}_{(\mathrm{Bank,DepLoans,RoW})}$	Actual interest rate on bank deposit and loan liabilities held by foreign asset agents.

No	Variable	Definition
6.	$\text{PTAX\_L}_{(\text{Bank,DepLoans,RoW})}$	Power of the phantom tax on rates of return on bank deposits and loans provided to Indonesian banks by foreign asset agents.
7.	$\text{ROIA\_T}_{(\text{RoW,DepLoans,Banks})}$	Commercial banks' perceived power of the interest rate received on loans to foreign liability agents.
8.	$\text{ROIA}_{(\text{RoW,DepLoans,Banks})}$	Actual interest rate received by banks on loans to foreign liability agents.
9.	$\text{PTAX\_A}_{(\text{RoW,DepLoans,Banks})}$	Power of the phantom tax on interest rates on bank loans to foreign liability agents.

Table 9.2 Definitions of Level Term Variables

Equation (9.4) is the regulatory NOP ratio (RNOP) which is calculated as the ratio of the commercial bank's net foreign liabilities (foreign liability *minus* foreign asset) and their equity liabilities. The latter is largely determined by the bank capital adequacy ratio; see chapter 8. In AMELIA-F, the numerator is defined to be the bank NOP; see Equation (9.1), where the bank NOP is set equal to the amount of commercial bank deposit liabilities (DepLoans) held as assets by foreign investors, less commercial bank loans (DepLoans) to foreigners. Equation (9.5) and (9.6) define the perceived cost to commercial banks of foreign deposit finance, and the perceived income received by commercial banks from foreign loans. I explain the key terms on the right-hand side of each equation via example. Consider a rise in the (binding) regulatory NOP ratio. From Equation (9.4), this may be accommodated by commercial banks in three ways:

(iv) by increasing foreign deposit liabilities (↑); or,

(v) by decreasing loans provided to the foreigners ($\downarrow \text{A1}_{(\text{ROW,DepLoans,Banks})}$); or,

(vi) By decreasing equity capital liabilities, but the level of these is regulated by the (exogenous) bank capital adequacy ratio.

To capture point (i) above, I introduce phantom taxes on the liability-side of the commercial bank decision making, via $\text{PTAX\_L}_{(\text{ROW})}$ in Equation (9.5). When the regulatory NOP rises in Equation (9.4), the regulatory cost to commercial banks of raising deposit finance from foreign investors falls, i.e., Rp 1 of equity can now be used to support a larger net foreign liability position. In AMELIA-F, this reduction in regulatory constraints drives phantom taxes on foreign deposit financing down ($\downarrow \text{PTAX\_L}_{(\text{ROW})}$), reducing the regulatory *plus* actual cost of foreign deposit financing perceived by Indonesian commercial banks. This reduction in total cost drives $\mathrm{ROIL\_T}_{(\mathrm{Bank,DepLoans,ROW})}$ down in Equation (9.5). When setting their capital structure, $\mathrm{ROIL\_T}_{(\mathrm{Bank,DepLoans,ROW})}$ enters into commercial bank decision making via Equation (9.12).

Simultaneously, in AMELIA-F a rise in regulatory NOP reduces the incentive for commercial banks to allocate financial capital to the purchase of foreign loan liabilities. Ceteris paribus, $\mathrm{ROIA\_T}_{(\mathrm{s,DepLoans,Banks})}$ in Equation (9.6) decreases, via a rise in the phantom tax on the asset-side, i.e., $\uparrow \mathrm{PTAX\_A}_{(\mathrm{ROW})}$. When setting their financial asset allocation, $\mathrm{ROIA\_T}_{(\mathrm{ROW,DepLoans,Banks})}$ enters into commercial bank decision making via Equation (9.13).

The percentage change form of the equations underlying the AMELIA-F NOP modelling are summarised in Equations (9.7) to (9.13) :

$$\begin{aligned}\mathrm{RNOP}\cdot\mathrm{EQ\_BANK1}\cdot(\mathrm{pr\_nop}+\mathrm{p\_eq\_bank1}) \\ = \mathrm{A1}_{(\mathrm{Banks,DepLoans,RoW})}\cdot\mathrm{at1}_{(\mathrm{Banks,DepLoans,RoW})} \\ - \mathrm{A1}_{(\mathrm{RoW,DepLoans,Banks})}\cdot\mathrm{at1}_{(\mathrm{RoW,DepLoans,Banks})},\end{aligned} \tag{9.7}$$

$$100\cdot\Delta\mathrm{pr\_nop} = \mathrm{RNOP}\cdot\mathrm{pr\_nop}, \tag{9.8}$$

$$\begin{aligned}\mathrm{ROIL\_T}_{(\mathrm{Bans,DepLoans,RoW})}\cdot\mathrm{rl\_t}_{(\mathrm{Bans,DepLoans,RoW})} \\ = \mathrm{ROIL}_{(\mathrm{Bans,DepLoans,RoW})}\cdot\mathrm{PTAX\_L}_{(\mathrm{Bans,DepLoans,RoW})} \\ \cdot\left(\mathrm{roipowl}_{(\mathrm{Bans,DepLoans,RoW})}+\mathrm{tl}_{(\mathrm{RoW})}\right)\end{aligned} \tag{9.9}$$

$$\begin{aligned}\mathrm{ROIA\_T}_{(\mathrm{RoW,DepLoans,Banks})}\cdot\mathrm{ra\_t}_{(\mathrm{RoW,DepLoans,Banks})} \\ = \frac{\mathrm{ROIA}_{(\mathrm{RoW,DepLoans,Banks})}}{\mathrm{PTAX\_A}_{(\mathrm{RoW,DepLoans,Banks})}} \\ \cdot\left(\mathrm{roipowa}_{(\mathrm{RoW,DepLoans,Banks})}-\mathrm{ta}_{(\mathrm{RoW})}\right)\end{aligned} \tag{9.10}$$

$$\mathrm{tl}_{(\mathrm{RoW})} = -\alpha\cdot\mathrm{ta}_{(\mathrm{RoW})}+\mathrm{ft} \tag{9.11}$$

$$\mathrm{at1}_{(\mathrm{s,f,d})} = \mathrm{liabilities}_{(\mathrm{s})} - \tau_{(\mathrm{s})}\cdot\left(\mathrm{rl\_t}_{(\mathrm{s,f,d})}-\mathrm{wacc\_t}_{(\mathrm{s})}\right), \tag{9.12}$$

$\mathrm{s}\in\mathrm{LALF}, \mathrm{f}\in\mathrm{FI}, \mathrm{d}\in\mathrm{AA}.$

$$\mathrm{at1}_{(\mathrm{s,f,d})} = \mathrm{assets}_{(\mathrm{d})} + \sigma_{(\mathrm{d})}\cdot\left(\mathrm{ra\_t}_{(\mathrm{s,f,d})}-\mathrm{averor\_t}_{(\mathrm{d})}\right), \tag{9.13}$$

$s \in LA, f \in FI, d \in AALF.$

All percentage change variables and parameters in Equations (9.7) to (9.13) are defined in Table 9.3 and Table 9.4.

No	Variable	Definition
1.	pr_nop	Percentage change in the NOP ratio.
2.	p_eq_bank1	Percentage change in bank equity.
3.	$at1_{(s,f,d)}$	Percentage change in end-of-year of asset instrument (f) issued by liability agent (s), held by asset agent (d).
4.	Δpr_nop	Ordinary change in the NOP ratio (percentage point).
5.	$rl\_t_{(s,f,d)}$	Percentage change in the perceived interest rate faced by liability agent (s) when issuing liability instrument (f) held by asset agent (d).
6.	$roipowl_{(s,f,d)}$	Percentage change in actual interest rate faced by liability agent (s) when issuing liability instrument (f) held by asset agent (d).
7.	$tl_{(d)}$	Percentage change in the power of the phantom tax on interest payments made by banks on deposits by agent (d).
8.	$ra\_t_{(s,f,d)}$	Percentage change in the perceived interest rate received by asset agent (d) for holding financial instrument (f) issued by liability agent (s).
9.	$roipowa_{(s)}$	Percentage change in perceived interest rate of loans charged to agent (s).
10.	$ta_{(s)}$	Percentage change in the power phantom tax in bank loan given to agent (s).
11.	ft	A shifter variable on symmetric phantom tax adjustment;
12.	$liabilities_{(s)}$	Percentage change in amount of required liabilities by agent (s).
13.	$assets_{(d)}$	Percentage change in available budget of agent (d) for asset purchases.
14.	$wacc\_t_{(s)}$	Percentage change in weighted average cost of capital faced by liability agent (s), phantom tax inclusive.
15.	$averor\_t_{(d)}$	Percentage change in average financial asset rate of return received by agent (d), phantom tax inclusive.

Table 9.3 Definition of Variables

No.	Parameter	Description
1.	α	Positive parameter on symmetric liability-asset phantom tax adjustment.
2.	$\tau_{(s)}$	Constant elasticity transformation parameter of liability agent (s).
3.	$\sigma_{(d)}$	Constant elasticity of substitution parameter of asset agent (d).

Table 9.4 Definition of Parameters

In what follows, I briefly describe each of Equations (9.7) to (9.13), and how they relate to the levels forms in equations (9.4) to (9.6). Equation (9.7) is the percentage change in the NOP ratio given in Equation (9.4). Because this is assumed to be binding herein, this ratio is typically exogenous and shocked in line with shocks to the regulatory NOP ratio. In Equation (9.8), I convert the percentage change form of the NOP ratio into percentage points, which is useful in simulating changes to the regulatory NOP ratio. Equations (9.9) and (9.10) are the percentage change (respectively) in the perceived interest rate by commercial banks on their foreign deposit liabilities and foreign loan assets. Each equation is thus a function of the percentage change in the phantom tax on commercial banks deposit liabilities $\left(\mathrm{rl\_t}_{(\mathrm{Bank,DepLoans,ROW})}\right)$, and their loans $\left(\mathrm{ra\_t}_{(\mathrm{ROW,DepLoans,Banks})}\right)$ to foreigners.

Equation (9.11) links the phantom tax rates on the liability- and asset-sides of the commercial banks' optimisation problems, up to a difference in sign. If the parameter $\alpha = 1$ and ft is exogenously determined and unshocked, the commercial banks have no preferential bias toward adjusting their cost structure versus their asset allocation, as they seek to accommodate exogenously-imposed changes in the regulatory NOP ratio. Such symmetrical adjustment means that $\mathrm{ta}_{(\mathrm{ROW})} = \mathrm{tl}_{(\mathrm{ROW})}$. If $0 < \alpha < 1$ however, the commercial banks have a bias toward asset-side adjustments. Alternatively, $\alpha > 1$ means that the commercial banks tend to prefer to alter their capital structure to accommodate changes in the regulatory NOP ratio. Without prior knowledge about the value of α, herein I set α equal 1 in my financial model parametrisation and explore how the impact of regulatory NOP changes is altered under two alternative choices: $\alpha = 0$ (pure asset-side adjustment) and $\alpha \gg 1$ (pure liability-side adjustment).

Equations (9.12) and (9.13) are percentage change forms for the optimal setting of end-of-year capital structures and asset portfolios, respectively. In Equation (9.12), constrained by their financing needs $\left(\mathrm{liabilities}_{(\mathrm{s})}\right)$ liability agent (s) chooses its mix of end-of-year liabilities of instrument type (f) held by asset agent (d) $\left(\mathrm{at1}_{(\mathrm{s,f,d})}\right)$. As total costs for an (f,d) pair rises, i.e., $\uparrow \mathrm{rl\_t}_{(\mathrm{s,f,d})}$, relative to the weighted average costs of capital, i.e., $\mathrm{wacc\_t}_{(\mathrm{s})}$, due either to increases in the actual rate of interest payable or increases in perceived regulatory/phantom costs, liability agents tilt their end-of-year capital structure towards less expensive sources of finance because $\tau_{(\mathrm{s})} > 0$. In contrast to the optimal decision faced by liability agents, the optimal asset decision depends on the budget for asset purchases $\left(\mathrm{assets}_{(\mathrm{d})}\right)$, and is an increasing function of the relative rate of return $\left(\mathrm{ra\_t}_{(\mathrm{s,f,d})} - \mathrm{averor\_t}_{(\mathrm{d})}\right)$.

9.6.3 Simulations and Closures

10 Variable	Baseline Common	Counterfactuals		
		Sim1	Sim2	Sim3
$\Delta\mathrm{pr\_nop}$	X (unshocked)	X (shocked)	X (shocked)	X (shocked)
$\mathrm{tl}_{(\mathrm{ROW})}$	N	N	X	N
$\mathrm{ta}_{(\mathrm{ROW})}$	N	X	N	N
ft	X	N	N	X

Note: N and X stand for endogenous and exogenous variable respectively.

Table 9.5 Closure Arrangements

My shock is a 100 basis point increase in the Indonesian regulatory NOP ratio. I study two distinct modes of accommodation: (i) full accommodation via capital structure/liability-side adjustment by commercial banks; and, (ii) full accommodation via asset portfolio/asset-side adjustment by commercial banks. In accommodation mode (i), hereafter Sim 1, the phantom tax affects the perceived cost (regulatory *plus* actual cost) of deposits by foreigners as observed by commercial banks only. In mode (ii), hereafter Sim 2, the phantom tax affects the perceived returns earned by commercial banks on their loans to foreigners only. Sim 1 and Sim 2 are studied by running AMELIA-F in counterfactual mode two times, under distinct policy closures; see Table 9.5, which summarises these closure differences. I also perform a third simulation (hereafter Sim 3), where $\alpha = 1$ in Equation (9.11) and banks are compelled to adjust both their asset- and liability-side to accommodate regulatory NOP ratio changes. Hence, Sim 3 can be seen as the weighted average of Sim 1 and 2; see Table 9.5.

In the baseline simulation, $\Delta\mathrm{pr\_nop}$ in Equation (9.9) and ft in Equation (9.11) are exogenous and unshocked. Meanwhile, $\mathrm{tl}_{(\mathrm{ROW})}$ and $\mathrm{ta}_{(\mathrm{ROW})}$ are endogenous. In Sim1, $\Delta\mathrm{pr\_nop}$ is exogenous and shocked, by +0.01; the model subsequently determines the value of $\mathrm{tl}_{(\mathrm{ROW})}$, while $\mathrm{ta}_{(\mathrm{ROW})}$ is exogenous and unshocked. In Sim2, $\Delta\mathrm{pr\_nop}$ is once more exogenous and shocked, with the quantum equivalent to Sim 1; however, $\mathrm{ta}_{(\mathrm{ROW})}$ is now endogenous and $\mathrm{tl}_{(\mathrm{ROW})}$ remains exogenous and unshocked. Accommodation of the rise in the regulatory NOP ratio thus falls on foreign loans. In sim 3, $\mathrm{tl}_{(\mathrm{ROW})}$ and

$ta_{(ROW)}$ are determined by Equation (9.11) and exogenous status of the regulatory NOP. AMELIA-F with the NOP equations described here active is solved using the GEMPACK software package; see Horridge et al. (2019).

9.7 Results

9.7.1 Sim 1: Accommodation by adjustment of foreign deposit finance

Figure 9.3 reports how Indonesian commercial banks alter their foreign asset, foreign liability and equity issuance in response to the increase in regulatory NOP ratio. In the shock-year, the banks raise foreign deposits by approximately 2 per cent relative to baseline in accommodating a 100 basis points increase in the regulatory NOP ratio. The rise of foreign deposits causes bank balance sheets to expand slightly, by 0.02 per cent in the shock-year and by 0.03 per cent 8 years after the shock (Figure 9.4). As bank balance sheets expand, there is an increase in bank loans to foreigners and bank equity issuance, which are both insignificantly small. The small increase in equity raisings is necessary to ensure the capital adequacy ratio remains in line with the baseline, as risk-weighted assets expand slightly.

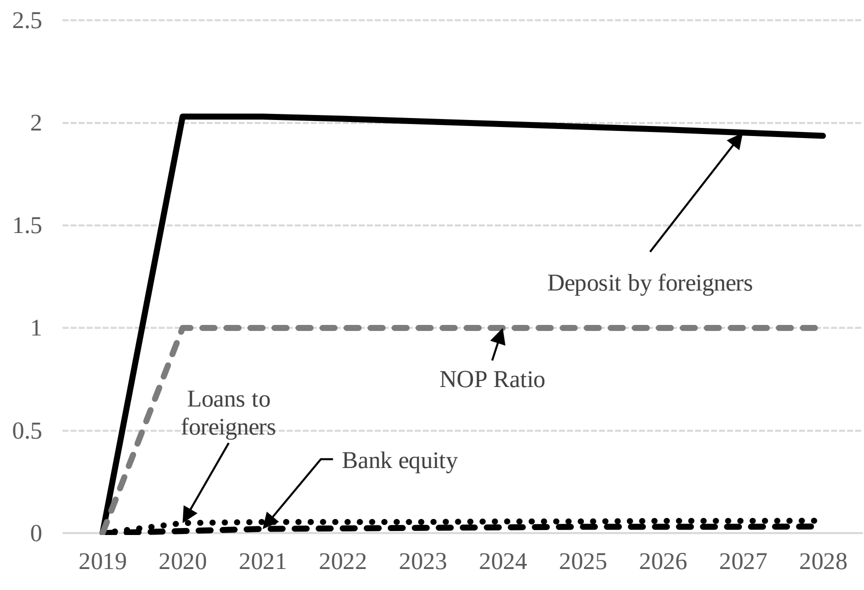


Figure 9.3 Foreign Deposits, Foreign Loan assets, and Equity liabilities of commercial banks (Sim 1) (Percent deviation from baseline)

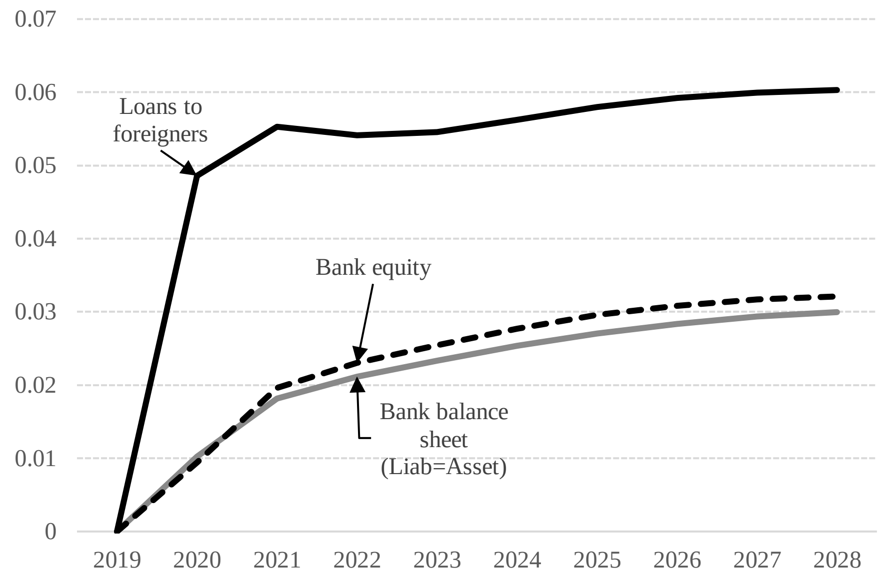


Figure 9.4 Commercial Bank Balance Sheet, Foreign Loan assets, and Equity liabilities (Sim 1) (Percent deviation from baseline)

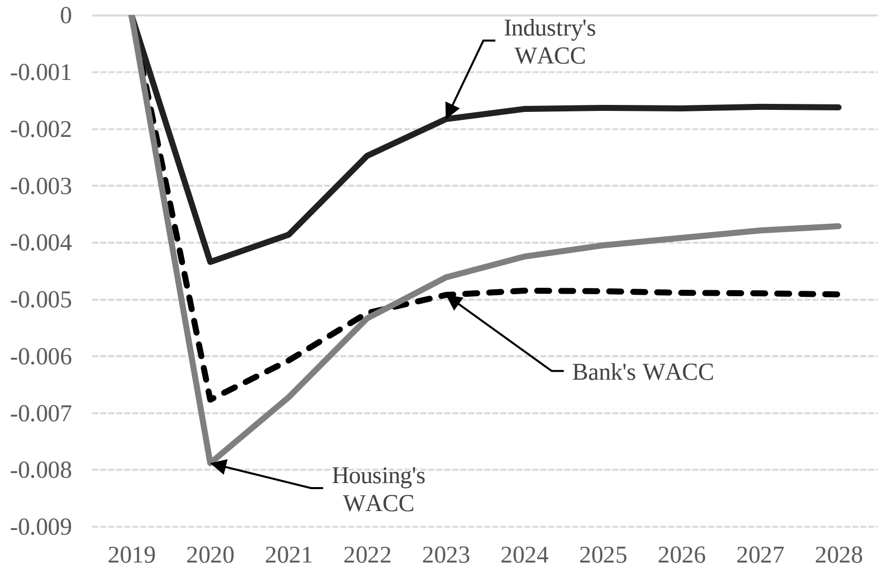


Figure 9.5 Weighted Average Cost of Capital (WACC) of Commercial Banks, Industry, and the Housing Sector (Sim 1) (Percent deviation from baseline)

Interest rates on bank loans from foreigners are lower than domestic interest rates. Hence, from Figure 9.5 I see that the bank's WACC falls, by 0.0067 per cent relative to baseline in the shock-year and 0.005 per cent from baseline 8 years after the shock. Since commercial banks are the largest financial intermediary in Indonesia, the fall in the bank's WACC affects funding costs for the housing and non-residential construction sector. The housing industry's WACC falls by more than the industry WACC. This is because housing investment is more heavily reliant on bank finance than industry. With a lower WACC, bank loans to industry and housing both rise (Figure 9.6). This is consistent with the research of Mara et al. (2021) who find that capital inflow to Indonesian banks causes balance sheets to expand i.e., improve bank landing capacity, due to increases in domestic loan provision.

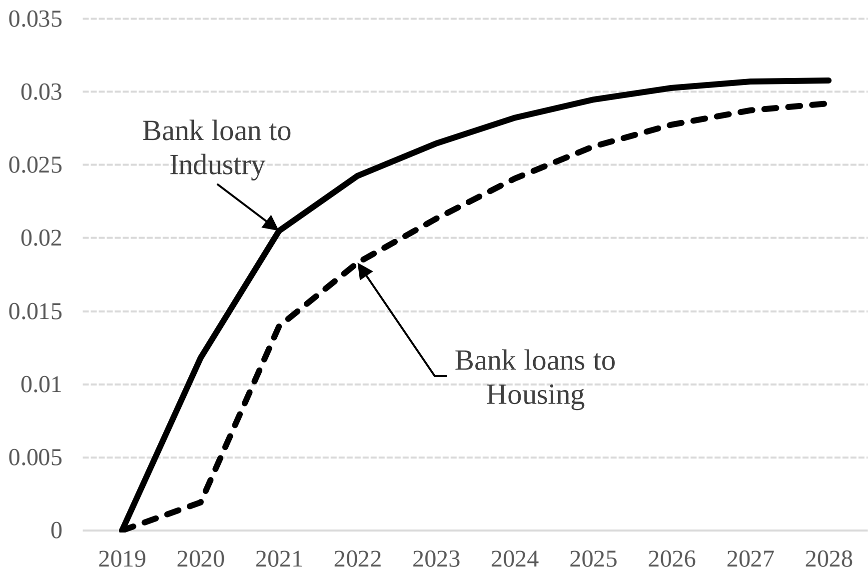


Figure 9.6 Commercial Bank Loans to Industry and Housing Sector (Sim 1) (Percent deviation from baseline)

Figure 9.7 shows that investment in the housing and industry sectors both rise, as expected because bank WACC's and thus housing and industry WACC's have fallen. These bring aggregate investment to rise by 0.017 per cent from baseline in the shock-year, reaching a peak of 0.028 per cent above baseline in year 2 before settling at approximately 0.014 per cent above baseline 8 years after the policy shock.

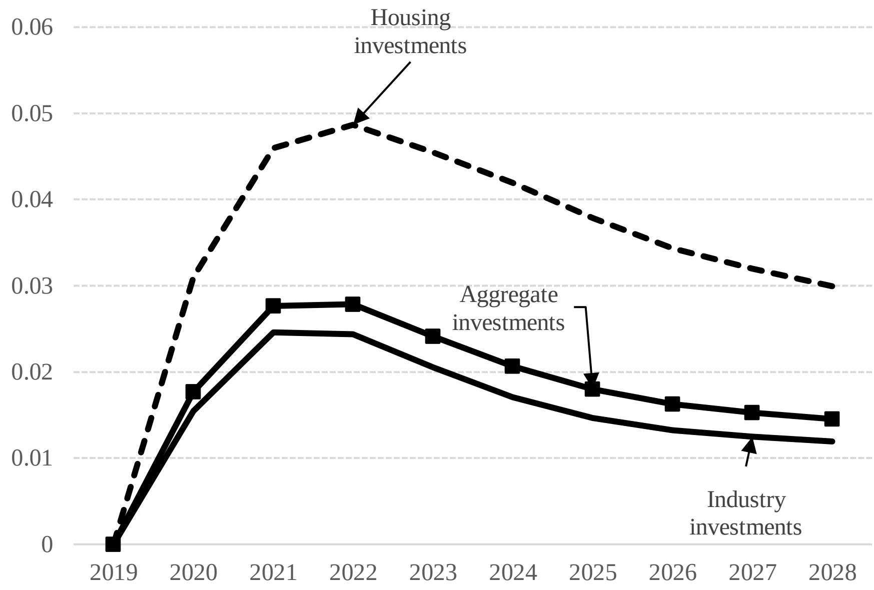


Figure 9.7 Industry and Housing Investment (Sim 1)
(Percent deviation from baseline)

Higher-than-baseline aggregate real investment activity demands greater inputs, which are generally import-intensive in Indonesia. This explains the rise in real import volumes (dashed grey line in Figure 9.8). Increasing the regulatory NOP ratio leads the Indonesian commercial banking sector to expand their foreign financing dependency. This is analogous to an autonomous increase in Indonesian foreign financing. For a given current account deficit, this results in nominal appreciation of the Indonesian currency (Figure 9.9).

In the presence of a sticky short-run nominal wage, nominal appreciation places downward pressure on the domestic price level (Figure 9.11). With the aggregate price of domestic production falling and the nominal wage fixed in the shock-year, a corresponding rise in the real producer wage occurs in the shock-year. With physical capital stocks sticky and a rising real producer wage, a rise in regulatory NOP reduces shock-year employment (Figure 9.10). With employment down and physical capital stocks sticky in the shock-year, real GDP falls slightly (Figure 9.8). With real import volumes elevated and real GDP below the baseline, the real balance of trade tends towards deficit as export volumes fall (solid grey line in Figure 9.8). Decline in export volumes is also explained by increase in terms of trade (solid grey line in Figure 9.9). The current account moves towards deficit in turn, consistent with an increase in foreign capital inflows (Figure 9.9).

With the real balance of trade trending towards deficit, real gross national expenditure expands relative to real GDP. This is in part due to the rise in real investment activity, but is also aided by a rise in real public and private consumption (solid black line in Figure 9.8). In AMELIA-F, real public consumption is tied to real private consumption, which is itself a fixed proportion of national income. Real national income expands because the terms of trade rises (solid grey line in Figure 9.9).

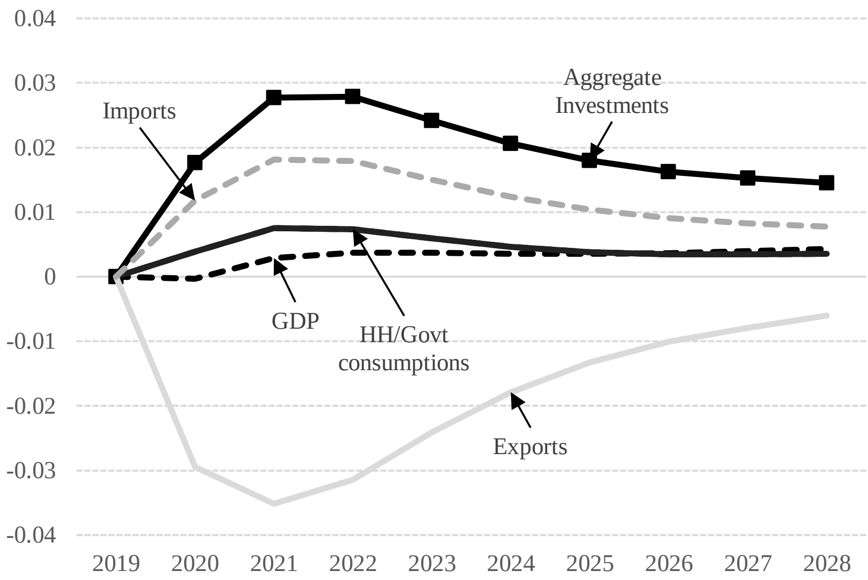


Figure 9.8 Expenditure-side of GDP (Sim 1)
(Percent deviation from baseline)

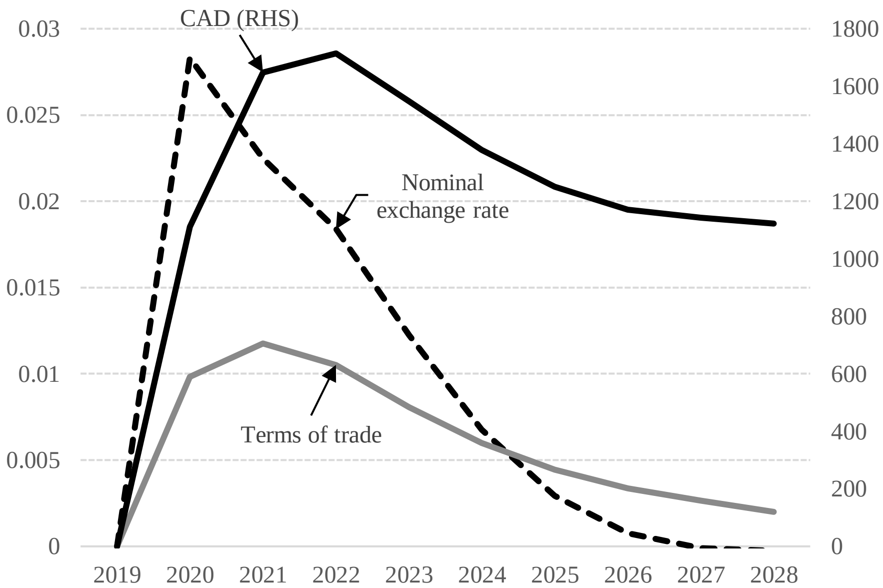


Figure 9.9 Current Account Deficit (RHS),
Terms of Trade, and Nominal Exchange Rate (LHS) (Sim 1)
(Percent deviation from baseline)

Figure 9.10 shows elements of the income side GDP. As capital stocks begin to expand after the shock-year, in response to elevated real investment activity, employment also begins to expand. In the long-run, employment returns to baseline, with real wages elevated relative to baseline.

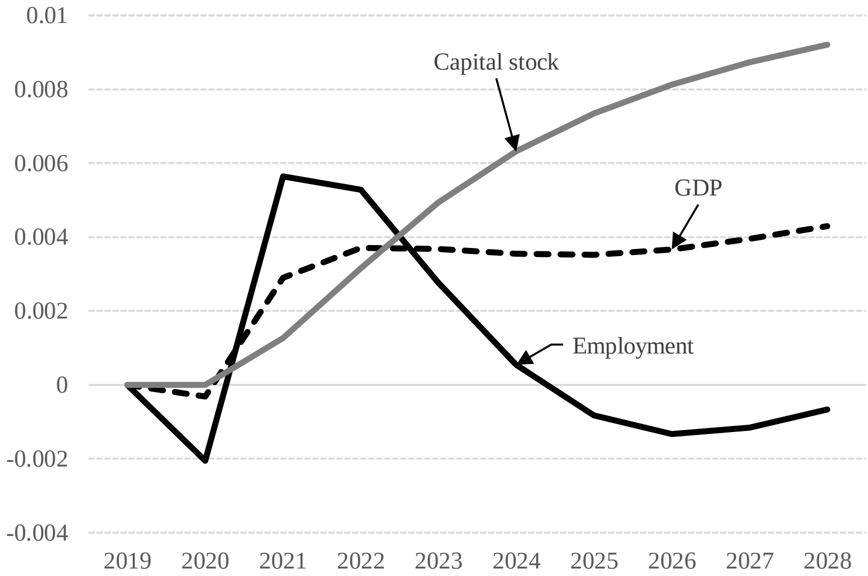


Figure 9.10 Income-side components of GDP (Sim 1)
(Percent deviation from baseline)

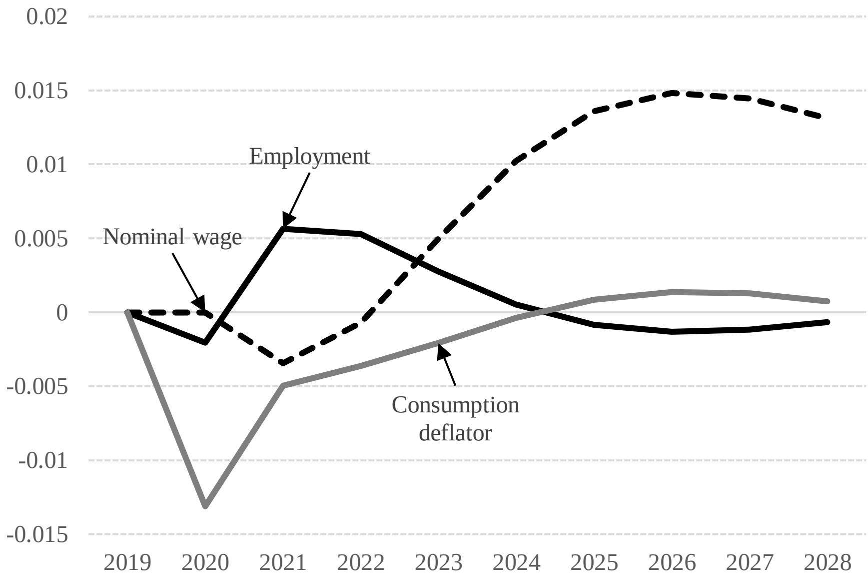


Figure 9.11 Labour Market (Sim 1)
(Percent deviation from baseline)

Appreciation of nominal exchange rate initially damps the domestic consumer price index relative to baseline, as shown in Figure 9.11. In response to this situation, the central bank reduces the cash rate, which reinforces the first-order impact of the rise in regulatory NOP on the bank's WACC (Figure 9.5). The response of the central bank in this case is representing the Mundell-Flemming policy trilemma [Mundell et al. (1963); Fleming (1962)]. The typical response of Indonesian central bank in this trilemma configuration is also recorded in Ikhsan et al. (2012) and Juhro and Goeltom (2015).

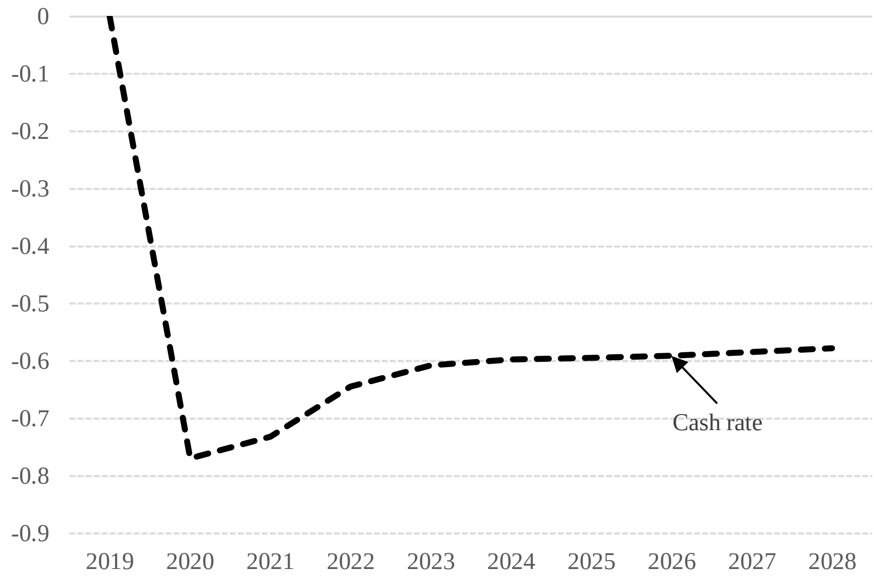


Figure 9.12 Cash Rate (Sim 1)
(Basis point deviation from baseline)

9.7.2 Sim 2: Accommodation by Adjustment of Foreign Loans

In some ways, Sim 2 is similar to Sim 1. In Sim 2, the rise in bank NOP compels a significant financial agent (the commercial bank) in Indonesia to reduce their proclivity for foreign financial assets: in this case, their foreign loan assets fall 4 per cent below baseline in the shock-year (Figure 9.13). For a given current account deficit, this must be matched by a corresponding fall in foreign demand for Indonesian financial assets. This drives nominal appreciation of the Indonesian currency (Figure 9.18), as observed in Sim 1 (Figure 9.9). In the presence of a sticky short-run nominal wage, nominal appreciation places downward pressure on the domestic price level (Figure 9.20). With the aggregate price of domestic production falling and the nominal wage fixed in the shock-year, a corresponding rise in the real producer wage occurs in the shock-year. With physical capital stocks sticky and a rising real producer wage, a rise in regulatory NOP reduces shock-year employment (Figure 9.19). With employment down and physical capital stocks sticky in the shock-year, real GDP falls slightly (Figure 9.17). With real import volumes broadly in line with baseline from Figure 9.17, for reasons I shall explain shortly, and real GDP below the baseline, the real balance of trade tends towards deficit and export volumes fall (solid grey line in Figure 9.17).

The reduction in foreign loans made by commercial banks reduces risk-weighted assets of the commercial banks. This damps equity financing requirements, as the bank capital adequacy ratio is exogenous. This in turn causes bank balance sheets to contract slightly relative to baseline, by 0.05 percent in the shock-year; this contraction persists, with balance sheets 0.03 per cent below baseline 8 years after the policy shock (Figure 9.14). The small contraction of the bank balance sheet reduces foreign deposit financing requirements, by 0.06 per cent relative baseline in the shock-year before returning to the baseline thereafter. With commercial banks contracting, they require less financial capital. Hence, the rates of return they offer on all financial liabilities falls, reducing the bank WACC. The fall in commercial bank WACC is passed on as reduced borrowing costs for the housing. Industry WACC experiences muted falls over the simulation time horizon (Figure 9.15).

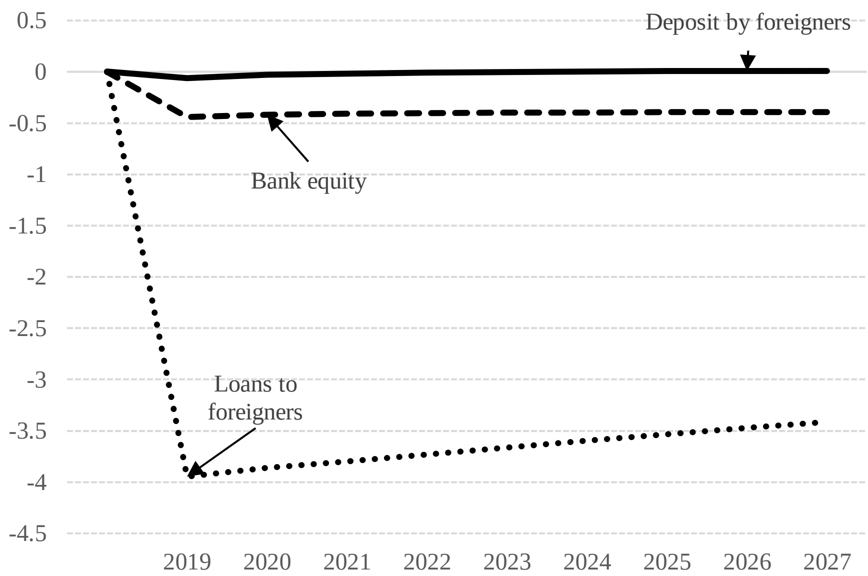


Figure 9.13 Foreign Deposits, Foreign Loan assets, and Equity liabilities by commercial banks (Sim 2)
(Percentage deviation from baseline)

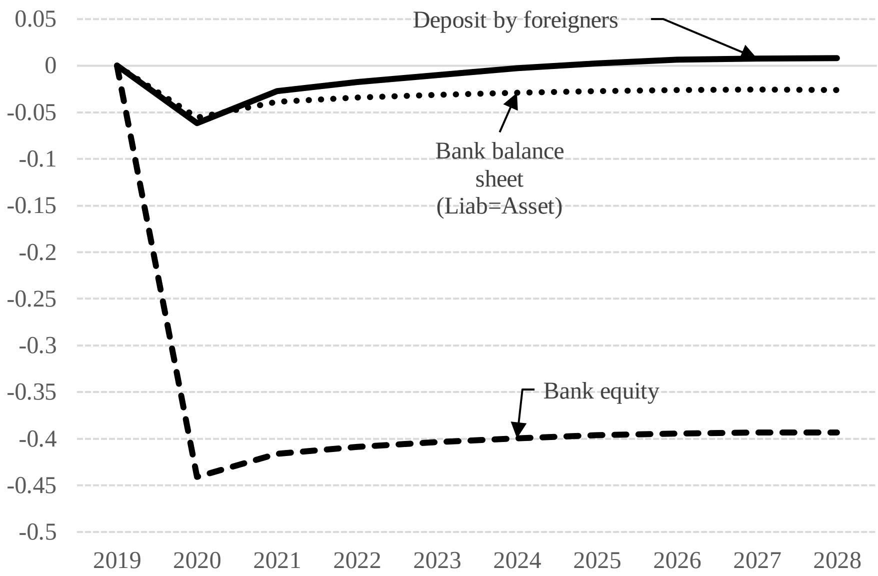


Figure 9.14 Bank Balance Sheet, Foreign Loan, and Equity (Sim 2) (Percentage deviation from baseline)

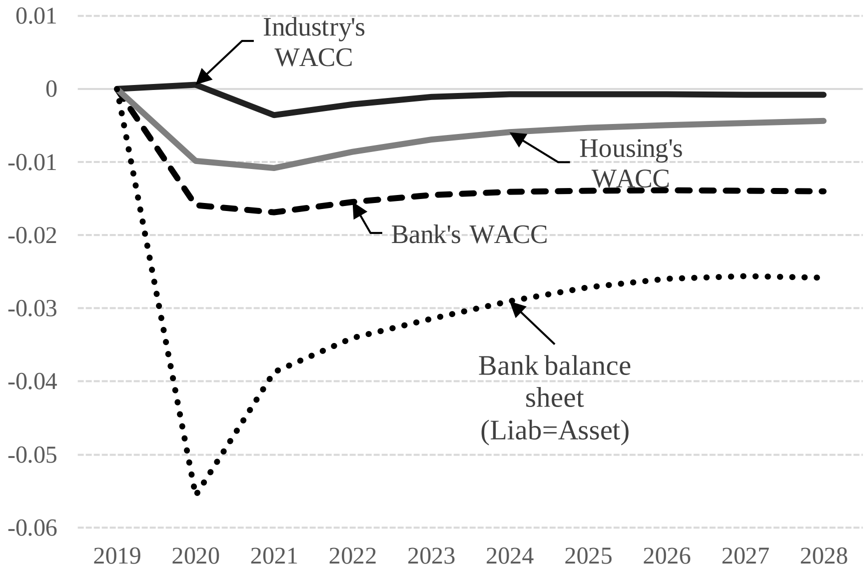


Figure 9.15 Bank, Industry, and Housing WACC, Commercial Bank Balance Sheet (Sim 2) (Percentage deviation from baseline)

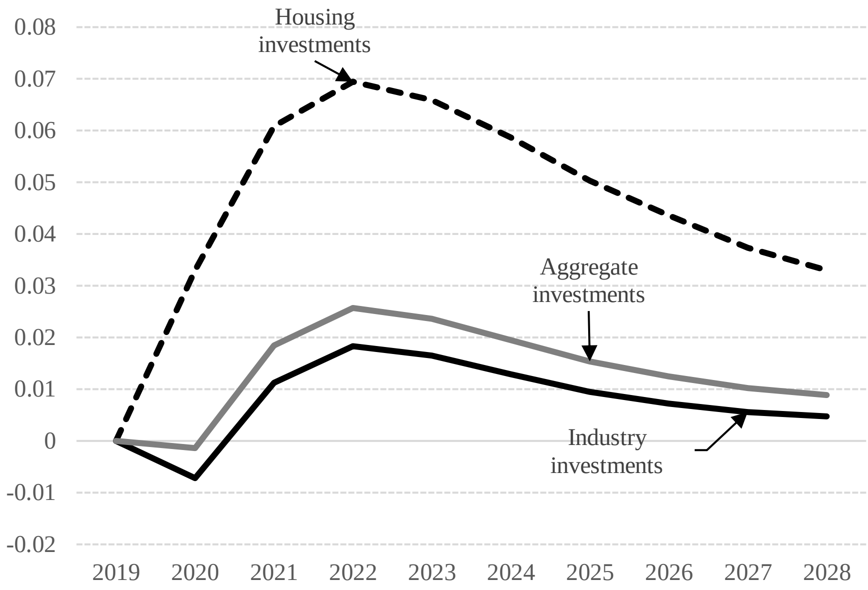


Figure 9.16 Industry and Housing Investment (Sim 2)

(Percentage deviation from baseline)

The movements of industry and housing's WACC are reflected in the real investment of both sectors in Figure 9.16. Housing investment rises in the shock-year by 0.06 per cent relative to the baseline, remaining elevated in the long-run by 0.03 per cent relative to baseline. Industry investment falls slightly in the shock-year, by 0.007 per cent relative to the baseline. Thereafter, it rises as industry WACC falls. In the shock-year, these movements in housing and industry investment leave aggregate investment broadly in line with the baseline, but compositionally different. In the long-run, aggregate investment rises in line with the expansion in both housing and industry investment.

Figure 9.17 reports GDP aggregates from the expenditure side for Sim 2. With aggregate investment unchanged in the shock-year, real import volumes are broadly in line with the baseline. As in Sim 1, contraction in export volumes causes the decline in terms of trade (Figure 9.18). The fall in export volumes given fixed import volumes reflects an increase of GNE in relative to GDP, suggesting the rise of household and government consumptions (solid black line in Figure 9.17).

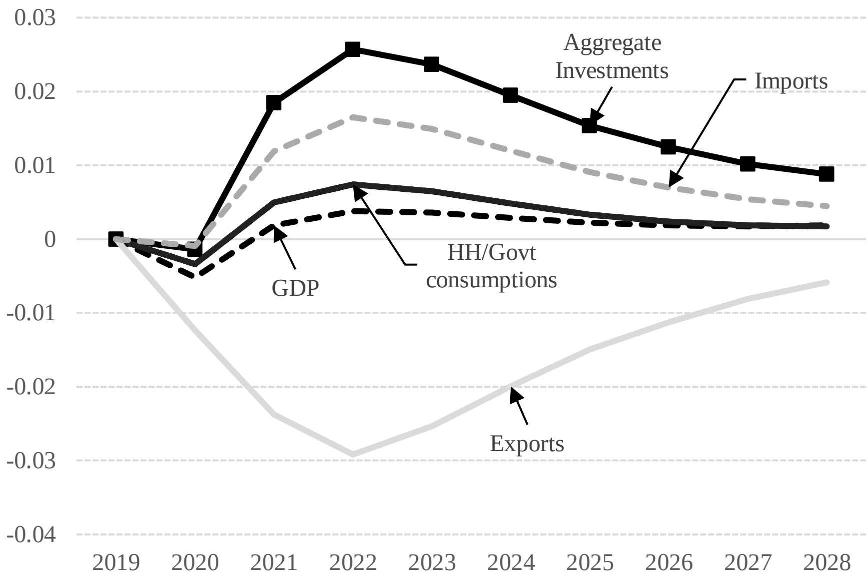


Figure 9.17 Expenditure-side of GDP (Sim 2)
(Percentage deviation from baseline)

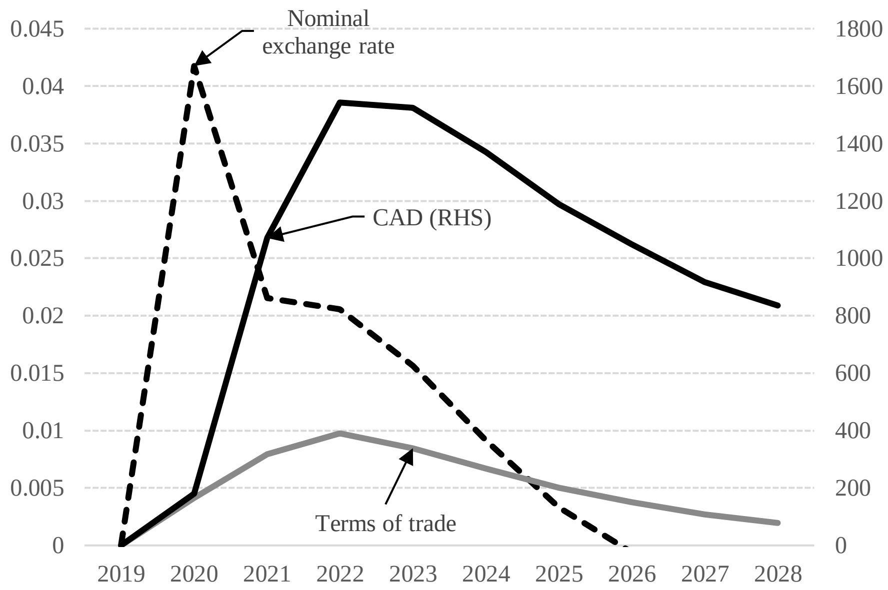


Figure 9.18 Current Account Deficit (RHS),
Terms of Trade, and Nominal Exchange Rate (LHS) (Sim 2)
(Percentage deviation from baseline)

Figure 9.19 plots the elements of GDP from the income-side in Sim 2. I have explained the fall in shock-year employment, which arises due to the sticky shock-year nominal wage and nominal appreciation. In year two, the nominal wage falls in response to the rise in the unemployment rate relative to the NAIRU. Employment begins to rise in turn, also carried along by expansions in GDP. While employment returns to the baseline in the long-run, GDP remains above baseline, supported by the expansion of capital stocks.

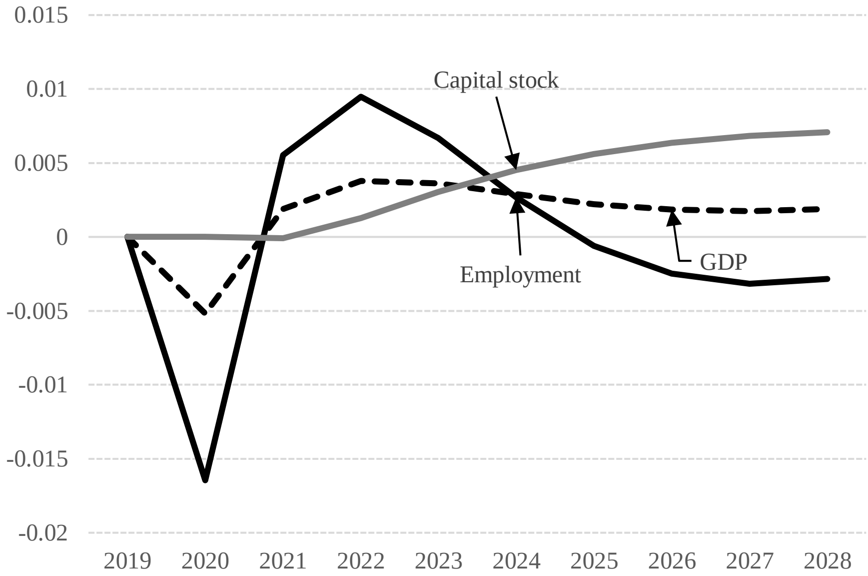


Figure 9.19 Income-side of GDP (Sim 2)

(Percentage deviation from baseline)

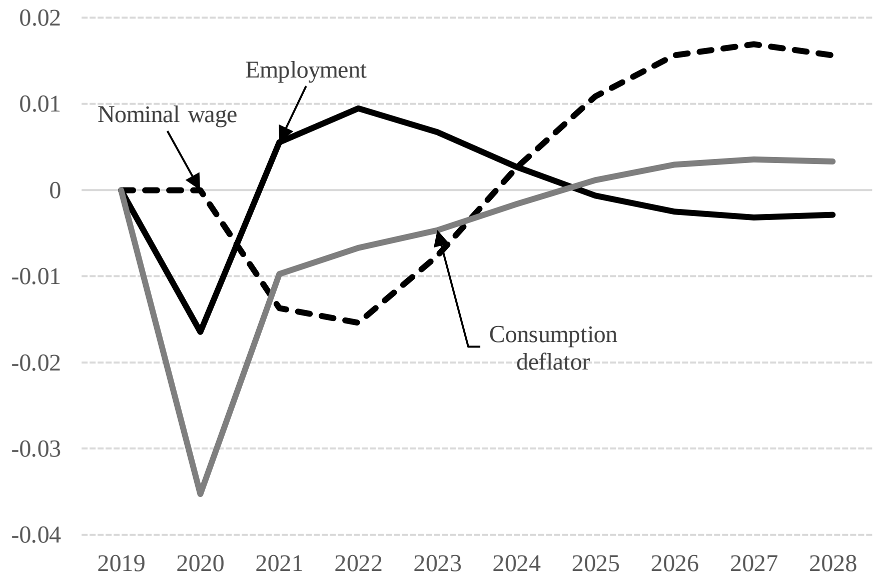


Figure 9.20 Labour Market (Sim 2)

(Percentage deviation from baseline)

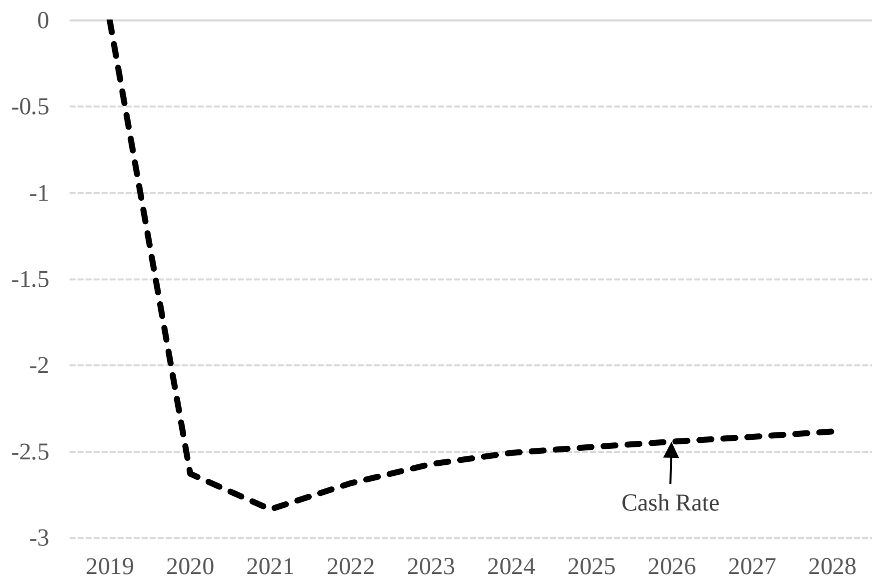


Figure 9.21 Cash Rate (Sim 2)
(Basis point deviation from baseline)

9.7.3 Sim 3: Symmetric Adjustment

Recall that in Sim 3, I model symmetric accommodation by commercial banks of the rise in the regulatory NOP ratio. They therefore adjust both the liability- and asset-side of their balance sheet. Ceteris paribus, I thus expect my results here to largely be explicable in terms of a weighted (straight-line) average of the results from Sim 1 and Sim 2 (see compilation of figures of Sim 1, 2, and 3 in section 9.7.4.

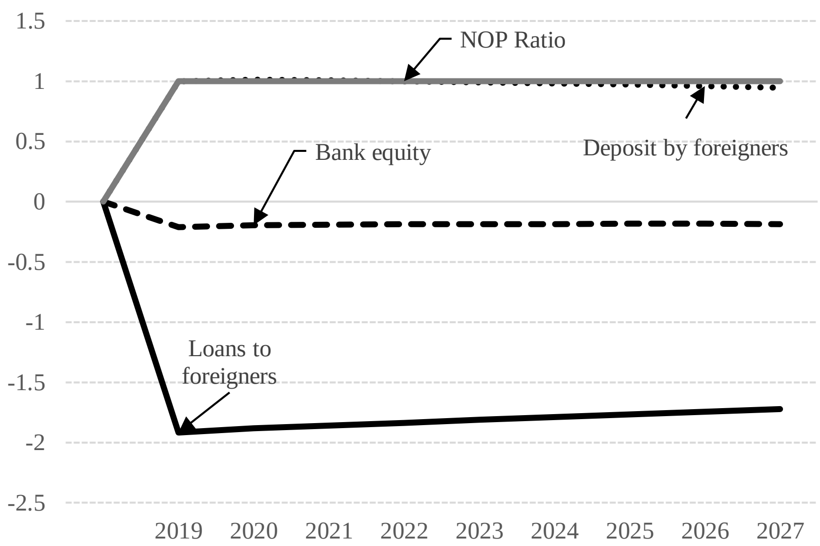


Figure 9.22 Regulatory NOP, Foreign Deposits, Foreign Loans, and Equity (Sim 3)
(Percentage deviation from baseline)

Figure 9.22 illustrates how the commercial banks perform total (symmetrical liability and asset) adjustments to their balance sheet in Sim 3. On the liability side, commercial banks raise foreign deposit finance 1 per cent above baseline in the shock-year. This is about half the rise noted in Sim 1. On the asset-side, commercial banks reduce loans to foreigners by 1.92 per cent relative to baseline in the shock year, and by 1.72 per cent relative to the baseline in the long-run. This is about half the adjustment in Sim 2. Commercial bank equity liabilities also fall slightly; in Sim 2, this was in response to a fall in risk-weighted assets and drove a small contraction in the size of the banks' balance sheet in relative to baseline. This is also evident in Figure 9.23.

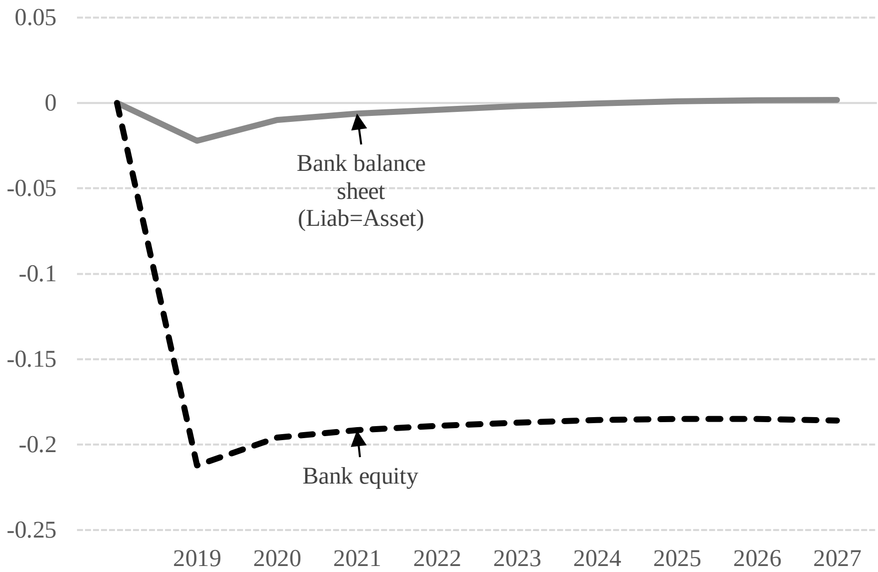


Figure 9.23 Commercial Bank Balance Sheet and Equity (Sim 3) (Percentage deviation from baseline)

In Sim 3, as in both Sim 1 and Sim 2, the bank WACC falls relative to baseline. From Sim 1 and Sim 2, that this is due to a series of factors, such as contraction of the bank and reductions in demand for financial liabilities, use of cheaper financing from foreign deposits, and a reduction in the cash rate by the central bank (Figure 9.24). The decrease in bank WACC is passed on, with industry and housing WACCs falling and stimulating an expansion in real investment activity relative to the baseline (Figure 9.25). In Figure 9.26, the movement in the real expenditure-side aggregates are consistent with a simple average of Sim 1 and 2. The expansion in aggregate investment necessitates expansion of real imports.

The nominal exchange rate appreciates, as in Sim 1 and Sim 2 (Figure 9.27). This causes the consumer deflator to fall (see grey solid line in Figure 9.29) and the terms of trade to rise (grey solid line in Figure 9.27), lifting real national income and increasing real households and government consumption. With the CPI below baseline, and short-run employment below the baseline, the central bank reacts by reducing the cash rate, placing further downward pressure on the bank WACC (Figure 9.30).

The movements in the income-side GDP aggregates are also averages of those in Sim 1 and 2. With fixed capital stocks in the short-run, sticky nominal wages and nominal appreciation of the exchange rate, employment falls due to the rise in the real producer wage (Figure 9.29). Thereafter, capital stocks respond to the rise in investment, and employment begins to rise. In the long-run, employment returns to baseline via wage adjustment, but with capital stocks elevated GDP remains above baseline.

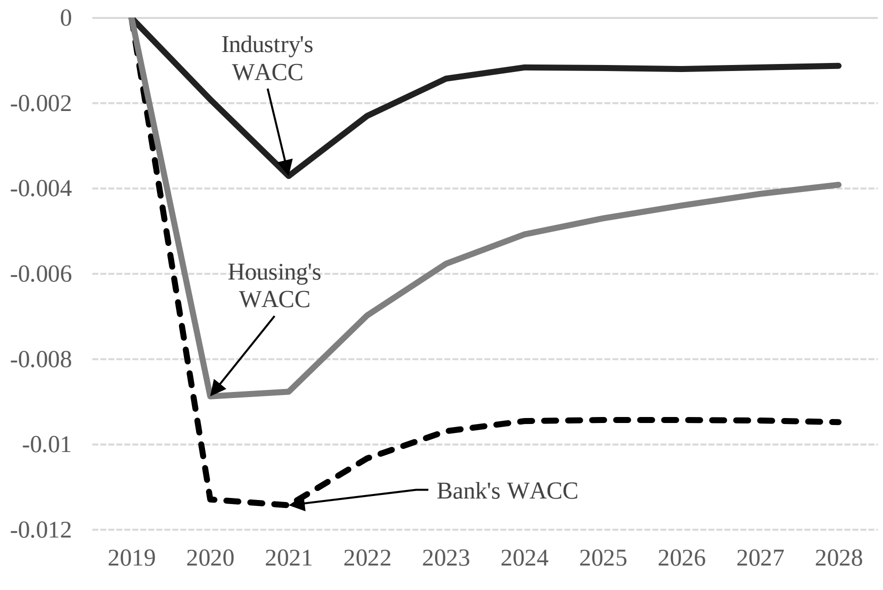


Figure 9.24 Bank, Industry, and Housing WACC (Sim 3) (Percentage deviation from baseline)

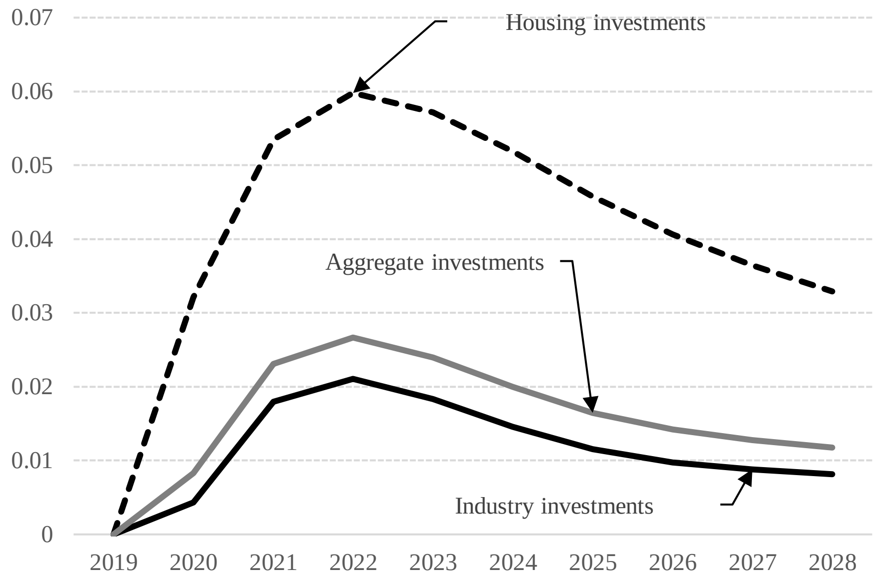


Figure 9.25 Industry, Housing, and Aggregate Investment (Sim 3)
(Percentage deviation from baseline)

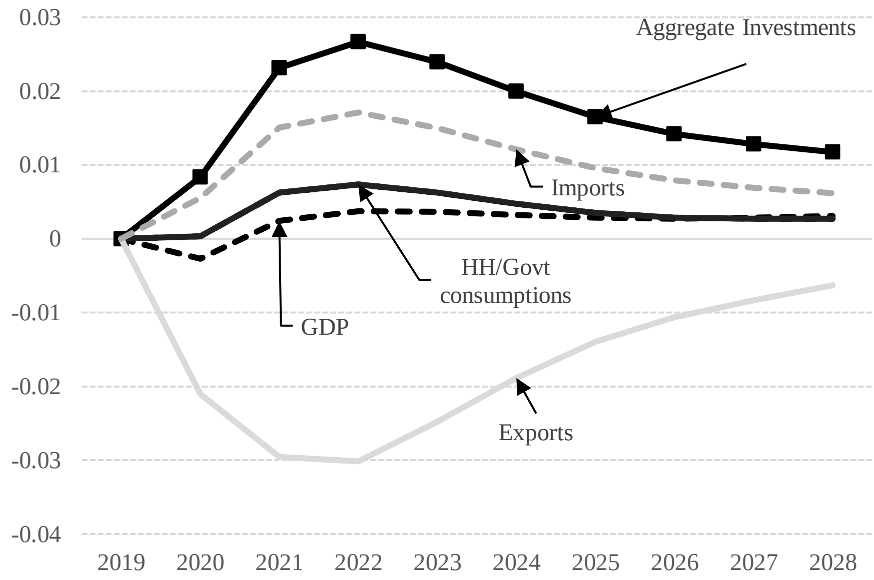


Figure 9.26 Expenditure-side of GDP (Sim 3)
(Percentage deviation from baseline)

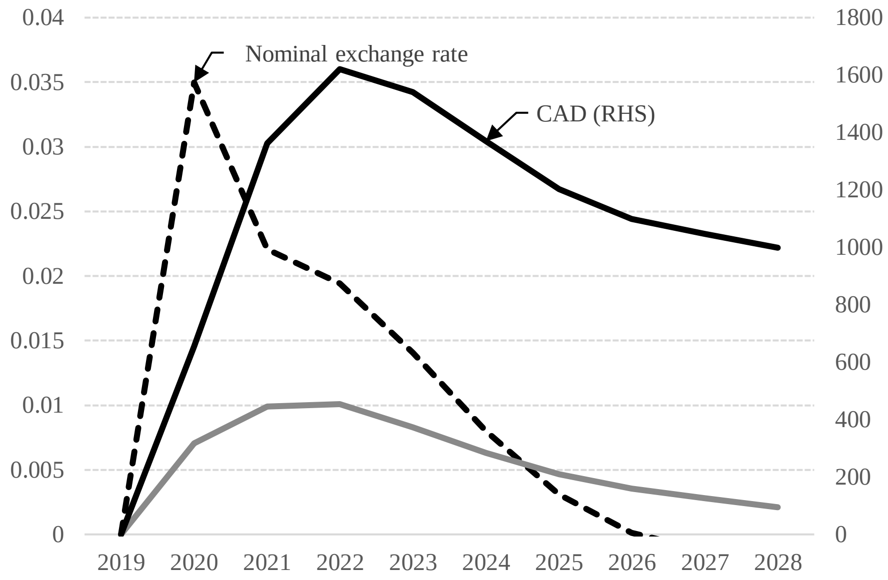


Figure 9.27 Current Account Deficit (RHS), Terms of Trade and Nominal Exchange Rate (LHS) (Sim 3)
(Percentage deviation from baseline)

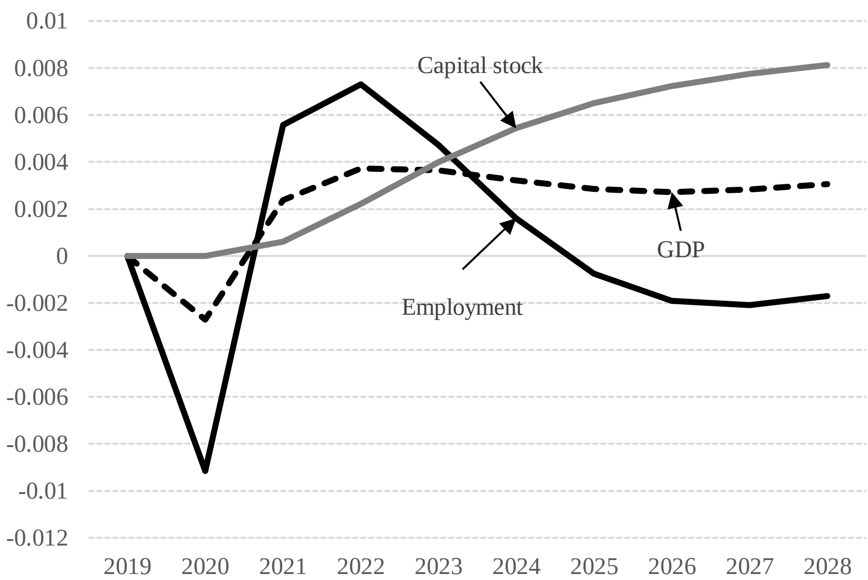


Figure 9.28 Income-side of GDP (Sim 3)

(Percentage deviation from baseline)

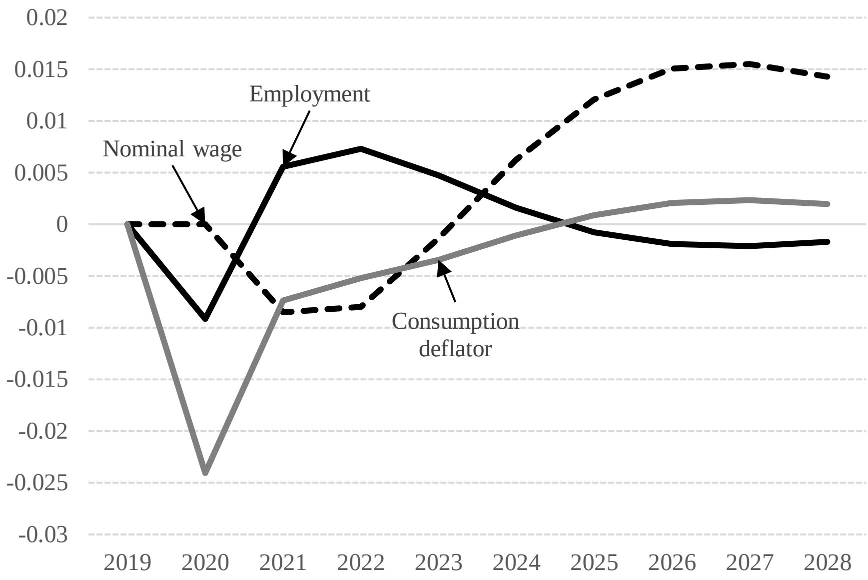


Figure 9.29 Labour Market (Sim 3)
(Percentage deviation from baseline)

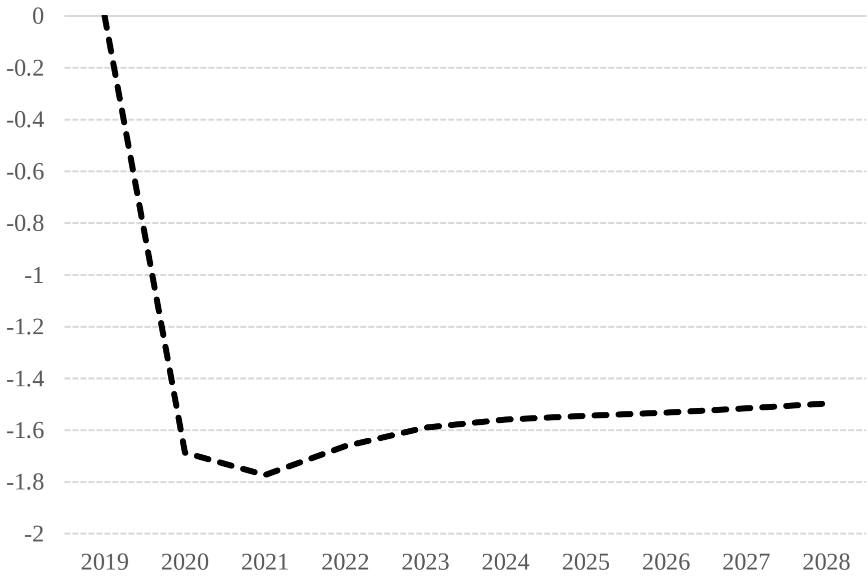


Figure 9.30 Cash Rate (Sim 3)
(Basis point deviation from baseline)

9.7.4 Comparing simulations

For completeness, in each of Figure 9.31 to Figure 9.51 I plot deviations from baseline for a single variable across all three simulations presented and discussed in this chapter (Sim 1, 2, and 3). As established in chapter 9.7.3, the plots shows that the results in Sim 3 lie at the mid-point of those from Sim 1 and 2. In general, the plots suggest that the impacts of a 100 basis points rise in regulatory NOP are relatively small for all simulations.

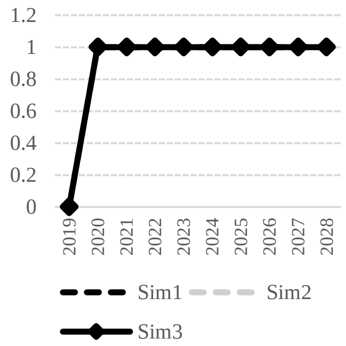


Figure 9.31 Regulatory NOP

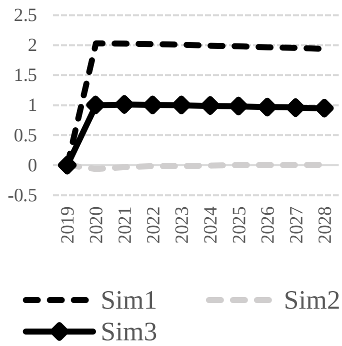


Figure 9.32 Foreign Deposits

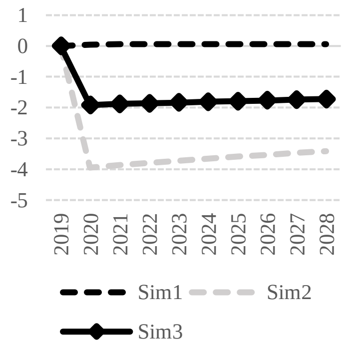


Figure 9.33 Foreign Loans

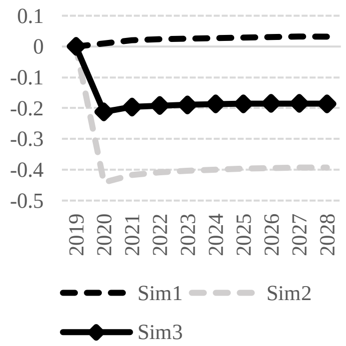


Figure 9.34 Bank Equity

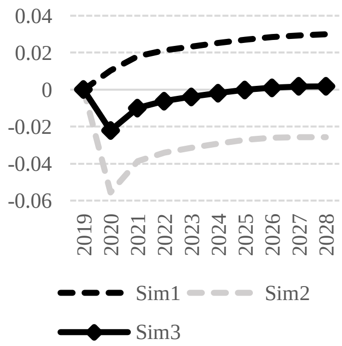


Figure 9.35 Bank Balance Sheets

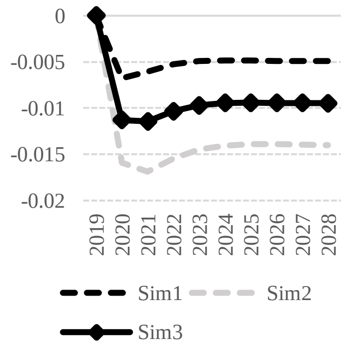


Figure 9.36 Bank's WACC

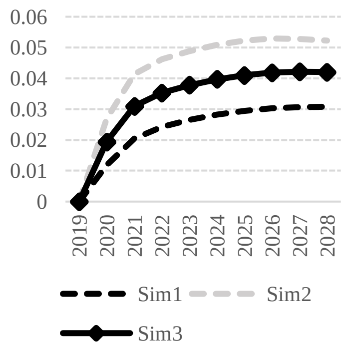


Figure 9.37 Bank Loans to Industry

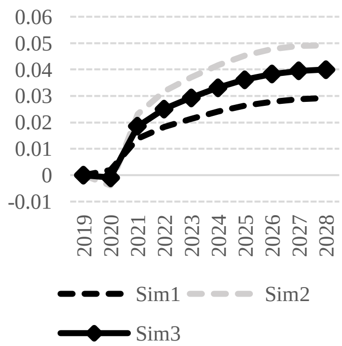


Figure 9.38 Bank Loans to Housing

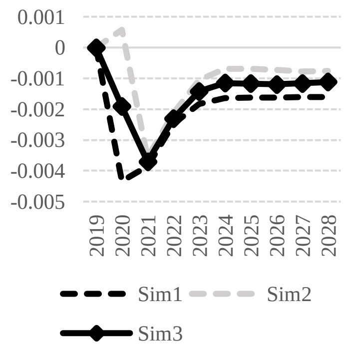


Figure 9.39 Industry's WACC

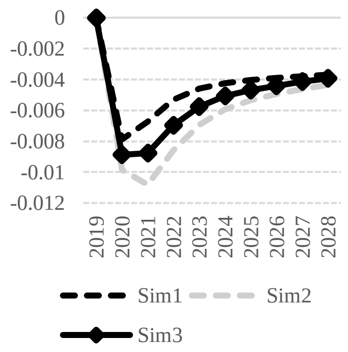


Figure 9.40 Housing's WACC

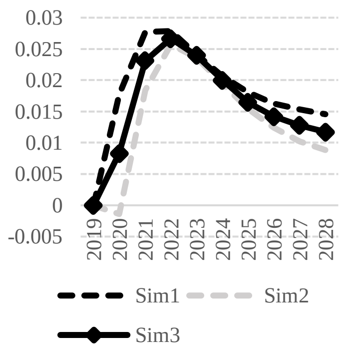


Figure 9.41 Aggregate Investments

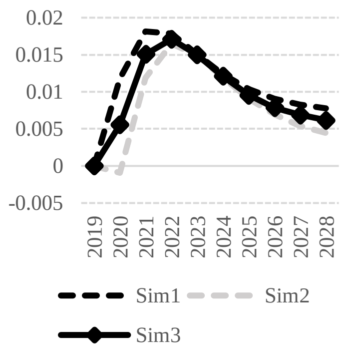


Figure 9.42 Aggregate Imports

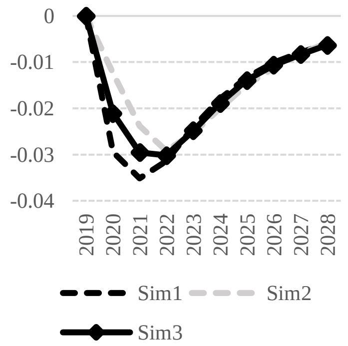


Figure 9.43 Aggregate Exports

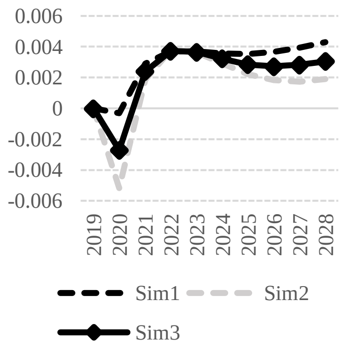


Figure 9.44 GDP

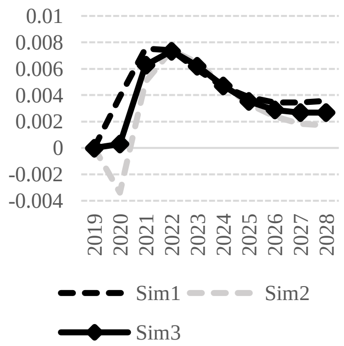


Figure 9.45 Households/Govt Consumptions

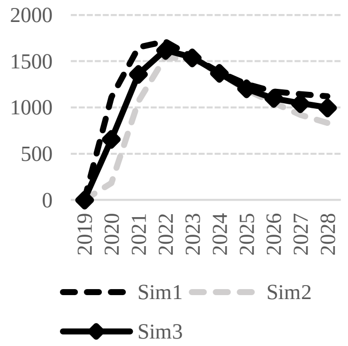


Figure 9.46 Current Account Deficit (Rp Billion)

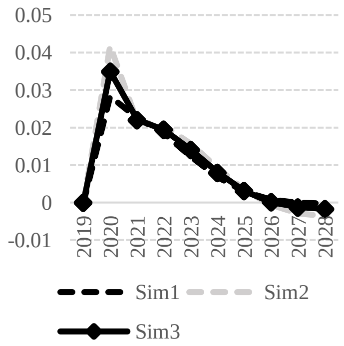


Figure 9.47 Nominal Exchange Rate

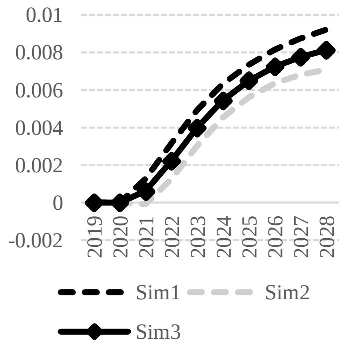


Figure 9.48 Capital Stocks

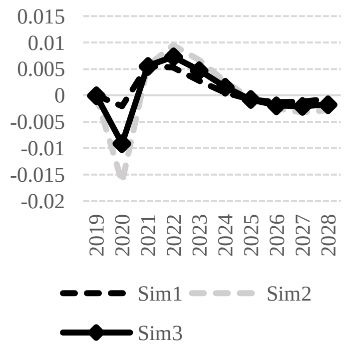


Figure 9.49 Employment

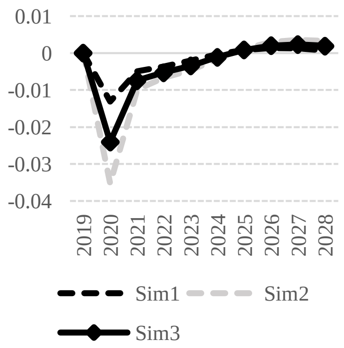


Figure 9.50 Consumption Deflator

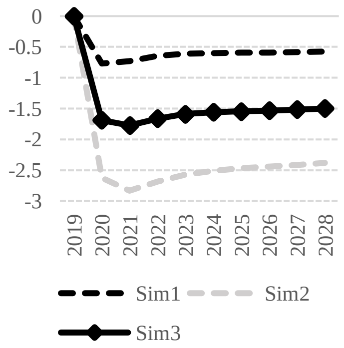


Figure 9.51 Cash Rate (Basis Points)

9.8 Conclusions and the Future Research

This chapter describes the economy-wide impacts of a 100 basis point rise in the NOP of Indonesia's commercial banking sector. The NOP is a macroprudential measure, which compels Indonesian commercial banks to provide a certain amount of capital buffer as they accumulate net foreign liabilities. The NOP ratio is calculated by dividing bank net foreign liabilities (foreign liabilities *minus* foreign assets) by tier-1 bank equity capital. To explain this measure, if the regulatory cap for the NOP was set equal to 25 per cent, banks would be compelled to issue Rp 4 equity capital for each Rp 1 of net foreign liabilities. In 1989, Indonesian authorities introduced a 25 per cent bank NOP to counter the expected increase in net foreign borrowing caused by abolishing bank foreign borrowing regulations. The bank NOP was later reduced to 20 per cent to decrease the risk of a capital reversal from the Indonesian banking system, which nevertheless materialised during the AFC in 1998. While the authorities frequently changed the method for calculating the NOP over subsequent years, the regulatory level remains at 20 per cent to the present day.

The assessment presented in this chapter is motivated by the fact that while the level of regulatory NOP in Indonesia has remained fixed at 20 per cent for over two decades, foreign borrowing is an established and potentially cheaper source of funding for the Indonesian banking industry. To model the NOP in an FCGE framework, a phantom tax is introduced along similar lines to the approach by Dixon et al. (2021), who analyse the impact of financial decoupling between China and the U.S.. using the Global Trade Analysis Project (GTAP) model. These phantom taxes are not actual taxes, in the sense that no revenue is collected by government. They are instead tax equivalents, representing the impact on decision making of regulatory constraints faced by commercial banks. In simulating a 100 basis point increase in regulatory NOP, two distinct modes of accommodation are explored: (i) full accommodation via capital structure/liability-side adjustment by commercial banks (Sim 1); and, (ii) full accommodation via asset portfolio/asset-side adjustment by commercial banks (Sim 2). Results from a third simulation (hereafter Sim 3) are also presented, where the banks simultaneously adjust both their asset- and liability-sides to accommodate regulatory NOP ratio changes. Hence, Sim 3 can be seen as the weighted average of Sim 1 and 2.

In Sim 1, commercial banks accept 2 per cent more foreign deposits to accommodate the 1 percentage point increase in NOP. This causes bank balance sheets to expand by approximately 0.03 per cent 8 years after the policy shock. This requires a relatively small increase in equity to maintain fixed capital adequacy requirements. With interest rates on foreign borrowing lying below domestic interest rates, bank lending capacity is improved, as exemplified by the modelled decrease in bank WACC. As a significant intermediary, the lower bank WACC is passed on to the industry and housing sector WACCs. Bank lending to these sectors expands, consistent with Mara et al. (2021) who found that an increase in capital inflows to the Indonesian banks improves bank lending capacity.

Lower industry and housing WACCs thus translate into a rise in real aggregate investment. However, the rise in aggregate investment necessitates a larger demand for imported commodities for capital formation, and nominal appreciation of the domestic currency. Consistent with the policy trilemma configuration in the Mundell-Flemming model [Mundell et al. (1963); Fleming (1962)], the central bank lowers the cash rate, adding to some degree the impact of falls in the bank WACC.

In Sim 2, the banks adopt asset-side accommodation of the NOP increase. Hence, the banks reduce loans to foreigners by approximately 4 per cent from baseline to accommodate the 100 basis point increase in regulatory NOP. By reducing loans to the foreigners, the bank asset portfolio must tilt towards more domestic loans. However, this asset portfolio tilt causes a small contraction of bank balance sheets relative to Sim 1.

As expected, the results from Sim 3 are effectively equivalent to a mid-point weighted average of Sim 1 and 2, suggesting little in the way of interaction effects between the two modes of accommodation. In Sim 3, commercial banks simultaneously raise foreign deposit finance, and reduce foreign loans as the NOP rises by 100 basis points. Equity issuance falls slightly, as bank balance sheets contract. The balance sheets return to baseline by the fifth year after the policy shock, as commercial banks keep accumulating foreign deposits.

Two extensions to the work presented herein come to mind. First, the regulatory NOP has been taken as a binding constraint on bank decision making. In future work, this could be relaxed by modelling the rate of the regulatory NOP phantom tax as an increasing function of the level of the NOP ratio. With this function in place, the phantom tax rate included to model the regulatory NOP would exhibit increasing growth rates, when the actual NOP approached the regulatory NOP, i.e., there would be an asymptote at the point where the actual NOP was equal to the regulatory NOP of 20 per cent. While this is beyond the scope of this thesis, it presents an exciting generalisation to the theory presented herein.

Second, the bank NOP is identified by the IMF as one element of a broader suite of financial regulations imposed by Indonesian authorities to control the flow of foreign capital in the country's banking system.[48] While evaluating the effects of all these regulations is beyond the scope of this thesis, the phantom tax methodology developed and applied in this chapter has the potential to be expanded, to evaluate the interactions of the regulatory NOP, bank CAR, and other regulatory tools. For example, another significant regulatory constraint to foreign borrowing by Indonesia's banks, in addition to the regulatory NOP, is the short-term foreign borrowing limitation (STFBL) on banks promulgated by Bank Indonesia [Mara et al. (2021); Warjiyo (2017); and Jayasuriya and Leu (2012)]. Under current specifications, commercial banks face a cap on short-term foreign borrowing exposure, equal to 30 per cent of their equity capital. In this sense, the STFBL is similar to the regulatory NOP, however its focus is entirely on (i) the liability side of the commercial bank balance sheet; and, (ii) short-term borrowing. To model this regulation and study possible interaction effects with the bank NOP, a second phantom tax, i.e., in addition to that included to model the regulatory NOP, could be added to AMELIA-F. This would require disaggregation of the existing *Deposits and Loans* financial instrument, by term structure. The STFBL is interesting in this context, because the liabilities regulated fall within the domain of the NOP as well. Hence, I expect some interaction effects to arise when both STFBL and regulatory NOP constraints are modelled.

[48] Please see the IMF Exchange Arrangements and Exchange Restrictions (https://www.elibrary-areaer.imf.org/Pages/Home.aspx).

CHAPTER 10
Conclusions and Future Directions

10.1 Introduction

This chapter concludes overall discussions in the thesis and provides guidance for future research directions. This thesis has demonstrated the feasibility of building a highly detailed and policy relevant model of the Indonesian economy with financial detail (AMELIA-F)[49], a model capable of comprehensively elucidating the economy-wide impacts of financial reforms in Indonesia. It also demonstrated how such a model can assist policy makers by providing impact assessments in a dynamic general equilibrium framework, something that other Indonesian macroeconomic models have a more limited capacity to do. The outcomes of this thesis can also be generalised and potentially applied to other emerging countries with similar economic and financial characteristics to Indonesia. This holds not only for the potential feasibility of building such models for other countries, but also in applying such models to questions like those analysed in this thesis. This chapter also outlines a few directions in which further developments of the model could be made in future research. I also explore possible future institutional arrangements to reap the maximum benefits from using the financial computable general equilibrium (FCGE) framework in a policy analysis and formulation setting. The remaining sections of this chapter are arranged as follows. Section 10.2 describes policy discussions. Section 10.3 presents the academic and practical contributions of the thesis. Section 10.4 outlines caveats and future directions.

10.2 Policy Discussions

This thesis studies two policy scenarios assessed within the AMELIA-F computable general equilibrium framework. The policies are categorised as changes in macroprudential regulations. These are regulations used by authorities to improve

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[49] AMELIA-F is defined as A Model of Economic Linkages of Indonesia-FCGE model.

financial stability or to achieve a specific policy objective, but they also advance other economy-wide aims like improving macroeconomic stability. The first evaluated policy reform is an increase in the bank capital adequacy ratio (bank CAR).[50] The increase in bank CAR is aimed at improving banks' capacity to absorb losses, thus strengthening financial system resilience in the face of adverse shocks. However, some studies have noted that such a policy comes with negative consequences [e.g., Miles et al. (2012); Lin and Yang (2016); Slovik and Cournède (2011); Akram (2014); Liu and Molise (2019); Bank for International Settlements (2010); Taskinsoy (2018); IIF (2011); Surhaningsih et al. (2015); Giesecke et al. (2017)].

This thesis finds that a 100 basis point increase in bank CAR does result in small negative consequences for the Indonesian economy. Indonesian commercial banks experience a balance sheet reduction as they move away from riskier assets and finance more of their activity using relatively expensive equity rather than debt. This impacts negatively on the industry and housing agents' capacity to invest in physical capital formation, because these higher costs are passed on and banks are important financial intermediaries. Hence real investment falls by 0.02 per cent relative to baseline in the event year, and returns gradually to the baseline in the long run. Real GDP decreases by 0.01 per cent from the baseline in the event year and returns to the baseline thereafter. The central bank reduces its policy rates to counter the short-run negative impacts on the employment rate and consumer prices. Falling real investment decreases the external financing requirement, as indicated by a fall in the current account deficit. Alongside these identified economic costs, I identify three channels via which bank CAR increases aid macro stability: (i) the bank debt-to-equity ratio fall, and so too do those of the housing and non-housing sectors; (ii) bank risk-taking behaviour is attenuated, as partial accommodation of higher CARs sees them tilt away from high risk-weight assets; and, (iii) the economy-wide private debt to income ratio (a leading indicator of enhanced macro stability) falls.

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[50] Bank CAR is defined as the required bank's common equity Tier-1 capital for the acquisition of risk weighted assets (RWA). For example, a 10 per cent regulatory CAR compels commercial bank to have Rp 100 of equity for a Rp 10 acquisition of risk weighted assets (RWA). The values of RWA are determined by authorities as a reflection of the official risk perspective on bank asset instruments.

The second policy evaluated herein is a 100 basis point increase in the bank net open position (bank NOP).[51] This policy has been used by Indonesian authorities since 1989 as a macroprudential tool to mitigate foreign exchange risk arising from the accumulation of foreign liabilities by the banking sector. To model the NOP within the FCGE framework, I introduce a phantom tax along similar lines to the approach used by Dixon et al. (2021), who analyse the impact of financial decoupling between China and the U.S. using the Global Trade Analysis Project (GTAP) model. These phantom taxes are not real taxes, in the sense that no revenue is collected by government. They are instead tax equivalents, representing the impact on decision making of regulatory constraints faced by commercial banks.

In simulating a 100 basis point increase in regulatory NOP, two distinct modes of accommodation are explored: (i) full accommodation via capital structure/liability-side adjustment by commercial banks (Sim 1); and, (ii) full accommodation via asset portfolio/asset-side adjustment by commercial banks (Sim 2). Results from a third simulation (Sim 3) are also presented, where the banks are compelled to adjust both their asset- and liability-side to accommodate regulatory NOP ratio changes. Hence, Sim 3 can be seen as the weighted average of Sim 1 and 2.

In Sim 1, commercial banks require 2 per cent more foreign deposits to accommodate the 1 percentage point increase in NOP. This causes bank balance sheets to expand approximately 0.03 per cent 8 years after the policy shock. The banks are required to raise a relatively small amount of equity capital to maintain fixed capital adequacy requirements. With interest rates on foreign borrowing lying below domestic interest rates, bank's lending capacity is improved, as exemplified by the modelled decrease in bank WACC. As a significant intermediary, the lower bank WACC is passed on to the WACCs of the industry and housing sectors. Bank lending to these sectors expands, consistent with Mara et al. (2021) who found that an increase in capital inflows to the Indonesian banks improves bank lending capacity. Lower industry and housing WACCs thus translate into a rise in real aggregate investment. However, the rise in

[51] NOP is calculated from the net bank foreign liabilities (bank liabilities *minus* bank asset position) divided by capital equity. This measure requires commercial banks to use a minimum amount of equity capital to finance net foreign liability acquisition. For example, a 25 per cent bank NOP implies that the banks are required to have Rp 4 of equity capital for an Rp 1increase in net foreign liabilities.

aggregate investment necessitates a larger demand for imported commodities for capital formation, and causes nominal appreciation of the domestic currency. This is in line with Ikhsan et al. (2012) who found that Bank Indonesia (the central bank of Indonesia) is inclined to reduce the policy rate to cope with nominal exchange appreciation resulting from capital inflows.

Enforcing asset-side accommodation in Sim 2, the commercial banks reduce loans to foreigners by approximately 4 per cent from baseline to accommodate the 100 basis point increase in regulatory NOP. By reducing loans to the foreigners, the bank asset portfolio tilts towards domestic loans. However, this asset portfolio tilt causes a small contraction of bank balance sheets relative to Sim 1. As expected, the results from Sim 3 are effectively equivalent to a mid-point weighted average of Sim 1 and 2, suggesting little in the way of interaction effects between the two modes of accommodation. In Sim 3, commercial banks simultaneously raise foreign deposit finance, and reduce foreign loans as the NOP rises by 100 basis points. Equity issuance falls slightly, as bank balance sheets contract. The balance sheets return to baseline by the fifth year after the policy shock, as commercial banks keep accumulating foreign deposits.

10.3 Thesis Contributions

10.3.1 Academic contributions

The academic contributions of this thesis largely come from the development and application of AMELIA-F. AMELIA-F is characterised as a dynamic single country financial computable general equilibrium (FCGE) which includes detailed modelling of the mechanisms of both the real economy and the financial system of Indonesia. AMELIA-F carries considerable detail in relation to previous Indonesian FCGE models e.g., Thorbecke (1991), Simorangkir & Adamanti (2012), Kim et al. (2017), Kim and Samudro (2021). On the financial-side, AMELIA-F includes both CET and CES constrained optimisations which underlie the derivation of financial agent optimal asset and liability decisions in the model. This is a significant academic contribution of this thesis, since in previous Indonesian FCGE models, optimal asset allocations by financial agents are in fixed proportion to their base year financial asset portfolio weights [e.g., in Kim et al. (2017), Kim and Samudro (2021)].

Financial instruments and agents involved in AMELIA-F are relatively detailed compared to previous Indonesian FCGEs. The core database consists of 8 agents and 5 financial instruments. The agents comprise industries, the central bank, commercial banks, NBFIs, government, households, the housing sector, and the rest of the world. The financial instruments include bonds, cash, deposits and loans, equity, and gold and IMF SDRs. This granular pairing of assets and agents (asset by agent) has not been modelled in other Indonesian FCGEs. AMELIA-F's financial database, containing the financial instrument and agent data, is constructed from data reported in the Bank Indonesia Financial Account and Balance Sheet (FABSI), which is regularly updated by Bank Indonesia. This database source is easier to access relative to the Financial Social Accounting Matrix (FSAM) used in previous FCGE models.

AMELIA-F is equipped with standard macroeconomic model properties. As aforementioned, financial agents behave simultaneously as optimising agents in altering the composition of the asset- and liability-sides of their balance sheet. A Phillips curve (Phillips, 1958) governs asymmetric adjustment of nominal wages in response to deviations of the employment rate from the NAIRU. Central bank set the policy rate endogenously via a Taylor rule (Taylor, 1993; Orphanides, 2007). The financial-side of the model creates 5 channels through which the financial and real economy interact with each other. First, the public sector borrowing requirement (PBSR) is financed by net issuance of government liabilities. Second, current account deficits are financed by net domestic asset acquisitions by foreigners. Third, investment in the real economy is financed via net liability issuance by capital creating financial agents (i.e., industries and the housing sector). Fourth, aggregate household savings are connected to the acquisition of financial assets by households, and thus to the funding of gross fixed capital formation, public debts, and foreign assets. Fifth, the weighted average cost of capital of the financial creator agents in the financial-side of the model are aligned with the expected rates of return of all industries in the real-side of economy, thus providing a link between the cost of financial capital and investment.

10.3.2 Practical Contributions

I expect that insights from the applications in this thesis will contribute to policy discussions and policy formulation in Indonesia. Since this thesis reveals the economy-wide impacts of a change in financial regulations, the modelling results and discussion will not only be of interest to directly related entities (e.g., banking supervision authorities (OJK) and the central bank, concerned with financial regulation and financial stability) but also other institutions concerned with the broad impacts of the reforms (like the Ministry of Finance). For the OJK, the impact assessment on bank capital regulation (via simulation of the effects of a 100 basis point increase in bank CAR) could become a reference for evaluating the long-term planning of bank capital reforms. Using the outcomes reported in this thesis, the OJK could consider balancing the negative consequences of increasing bank CAR, specifically the resulting rise in the bank's weighted average cost of capital (WACC) which decelerates economic growth, with benefits like the identified improvement in macroeconomic resilience, specifically via reduction of the country's indebtedness. The model can also be used in the future to evaluate the effects of alternative bank CAR levels under different macroeconomic shock environments. This would involve running multiple baselines distinguished only by differences in mandatory CAR, and then subjecting these baselines to the same counterfactual macroeconomic shock (e.g. a sudden drop in foreign willingness to invest in Indonesia). Such simulations would elucidate the insurance benefits of different CAR levels under a macroeconomic stress environment.

For the central bank, the results of this thesis contribute to the understanding of transmission channels of changing financial regulations on the real economy. Since the central bank's mandate is expanded to maintain both price and financial stability, and also to consider real economic performance, the comprehensive analysis as presented in this thesis is beneficial for the central bankers to observe the range of possible channels available to secure their multiple objectives. In the bank CAR change simulated in Chapter 8, I show the transmission channels through which the increase in CAR affects financial markets and the real economy. I present how much commercial banks must increase equity capital and substitute away from other forms of capital, and its consequences for other financial institutions. The analysis also reports the effects on the real economy via reductions in macro-aggregates. Deceleration of economic growth reduces the country's requirement for foreign borrowings, thus improving financial resilience to external shocks. With the policy rule in place, the central bank decreases policy rates to stimulate economic growth.

In Chapter 9, I explain model-based insights for another financial reform. In this chapter, I simulate a relaxation of capital account regulations via an increase in bank NOP and describe the possible bank responses to accommodate such a policy. To accommodate an increase in NOP, commercial banks could perform the accommodation via liability adjustment only, i.e., by increasing foreign liabilities. This type of decision causes banks to expand their balance sheets and thus increase financial intermediation. Economy-wide investment and economic growth are positively affected by this bank behaviour. Alternatively, the commercial banks could fully accommodate the increase in NOP by reducing their lending to foreigners. In this case, bank balance sheets contract, and the foreign loans are reallocated to domestic agents. This type of bank behaviour causes a similar but weaker stimulation of the real economy, relative to that caused by the bank undertaking NOP adjustment via liability adjustment only. The stimulatory effect is generated by diversion of bank lending from foreign borrowers to domestic borrowers. However, bank balance sheets contract slightly because domestic lending is somewhat less profitable than foreign lending. Ceteris paribus, the CAD financing condition requires that a reduction in domestic capital outflows (in this case, caused by NOP-induced reduced foreign lending) must, for a given CAD, lead to reduced foreign inflows. As discussed in chapter 9, this generates nominal appreciation. As aforementioned, within the Mundell-Flemming policy trilemma configuration, the central bank must then reduce the policy rate to combat the appreciation effect on the domestic price level. This reinforces the reduction in the bank WACC.

The policy simulations reported in chapter 8 and 9 of this thesis could also become a reference for policy coordination across government agencies. Government agencies outside the central bank are typically concerned with a wide range of economic performance indicators that can be affected by financial regulatory and monetary policy action. While small, the negative consequences of an increase in bank CAR on real economic activity as reported in Chapter 8 could call for coordination with other government agencies e.g., Ministry of Finance, Coordinating Ministry for Economic Affairs, or the National Development Planning Agency. Since AMELIA-F includes details of real economic elements, e.g., investment by industry, it is possible to report further which industries are affected the most by the financial reforms. These outcomes can be used by other agencies to propose appropriate responses to minimise the side effects of the financial reforms.

The practical contributions of this thesis can potentially be generalised to other emerging countries. As explained in chapter 8, financial regulations (e.g., changes in bank CAR) are imposed in many emerging countries. Assessment of raising bank CAR as undertaken in this thesis can be applied to emerging countries which have a similar financial structure to Indonesia, especially for bank dominated financial markets. Similarly, the simulation of bank NOP is potentially applicable to other emerging countries. As explained in Hofstetter et al. (2018), bank NOP regulations are currently used by some emerging countries as macro-prudential policy tools to support financial stability. The Bank NOP assessment undertaken in this thesis for the Indonesian economy could provide valuable information for other countries with similar financial structures and economic characteristics (like high reliance on foreign capital).

10.4 Caveats and Future Directions

There are several caveats identified in this research that could potentially be addressed in future research. First, the theoretical structure of AMELIA-F is sufficiently flexible to represent every major financial agent with a specific role in the economy. In the current implementation of AMELIA-F, Non-bank financial institutions (NBFIs) are broadly defined to include the pension funds (superannuation), insurance companies, and other non-bank financial institutions. This is potentially too aggregated, and in future work could potentially be split into its three sub-components, as done in Giesecke et al. (2015). A second caveat related to aggregation is the current generalisation of movements in rates of return of all industries (except housing) in the real economy to be connected to one common rate of return on industry financial capital in financial markets. This treatment might cause common behaviour of industries in the real economy towards movements in rates of return in the financial sector. This treatment misses, for example, the possibility that some industries might be more or less reliant on certain types and sources of financial capital, like bank loan funding, equity funding, and domestic or foreign funding.

Departing from the caveats, what follows are potential future developments to build upon the outcomes of this thesis. First, an improvement can be made by disaggregation of pension funds and insurance financial agents from the present NBFI aggregation in AMELIA-F. This will allow simulation of the effects of policy changes aimed at these sectors (like policies to promote compulsory superannuation). It will also allow for more detailed modelling of financial intermediation channels, as these sectors potentially have quite different funding sources and asset ownership patterns.

Second, further work could be undertaken to differentiate industry rates of return in the financial sector. This would require disaggregation of industry financial agents within the financial part of the model (currently one industry agent), to follow the industrial aggregation in the real-side of the model (currently 51 industry agents). As noted earlier, this would allow the model results to be informed by the possibility that different industries have different financial funding structures. Third, the model could be extended to the regional dimension, thus capturing the effects of financial reforms on the regional economy, like the 37 Indonesian provinces. Fourth, the addition of taxation detail in the model would allow tax policy scenarios with a financial dimension (such as company tax) to be represented in the model.

Further extensions to the model could be implemented in the way that regulatory reforms are modelled. For example, the regulatory NOP has been taken as a binding constraint on bank decision making. In future work, this could be relaxed by modelling the rate of the regulatory NOP phantom taxes as increasing functions of the level of the NOP ratio. With such a function in place, the NOP-related phantom tax rates on bank foreign borrowing and lending would exhibit increasing rates as the actual NOP approached the regulated NOP, i.e., there would be an asymptote at the point where the actual NOP was equal to the regulatory NOP. While this is beyond the scope of the current thesis, it presents an exciting generalisation to the theory presented herein.

The bank NOP modelled herein is one element of a broader suite of financial regulations imposed by Indonesian authorities to control the flow of foreign capital in the country's banking system. While evaluating the effects of all these regulations is beyond the scope of this thesis, the aforementioned phantom tax methodology has the potential to be expanded and applied to other regulations, enabling the evaluation of the interactions of the regulatory NOP, bank CAR, and other regulatory tools. For example, another significant regulatory constraint to foreign borrowing by Indonesia's banks, in addition to the regulatory NOP, is the short-term foreign borrowing limitation (STFBL) on banks promulgated by Bank Indonesia [Mara et al. (2021); Warjiyo (2017); and Jayasuriya & Leu (2012)]. Under current specifications, commercial banks face a cap on short-term foreign borrowing exposure, equal to 30 per cent of their equity capital. In this sense, the STFBL is similar to the regulatory NOP, however its focus is entirely on (i) the liability side of the commercial bank balance sheet; and, (ii) short-term borrowing. To model this regulation and study possible interaction effects with the bank NOP, a second phantom tax, i.e., in addition to that included to model the regulatory NOP, could be added to AMELIA-F. This would require disaggregation of the existing *Deposits and Loans* financial instrument, by term structure. The STFBL is interesting in this context, because the liabilities regulated fall within the domain of the NOP as well. Hence, I expect some interaction effects to arise when both STFBL and regulatory NOP constraints are modelled.

According to Warjiyo (2015), going forward Indonesia will face a more complicated policy challenge in a borderless global financial system. As a small open economy, global financial shocks will more readily transmit to the domestic Indonesian economy. For policy makers, this requires a solid understanding of impact assessment using multiple policy instruments and regulatory tools. To this end, the detailed modelling techniques developed in this thesis could play an important role in future policy formulation. This would be aided by creating a capacity development program in economic modelling techniques. This could involve: joint model-based research by government staff in collaboration with economic modelling institutions; modelling training courses; internal mentoring to ensure the sustainability of capacity development programs; and coordinated inter-agency development and use of models to aid economic communication and build a pool of policy-modellers. By being part of such a program, AMELIA-F could continue to be developed, updated and applied within the Indonesian policy analysis community in coming years.

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Appendices

Stylised structure of macroeconometric models

In what follows, I present core equations that form the basis of the macroeconometric models as described in (Welfe, 2013). I begin with the standard national accounting identity:

$$Y_t = C_t + G_t + I_t + (X_t - M_t), \tag{A.1}$$

The behavioural equations are arranged as follows:

(i) Household consumption:

$$C_t = C(Yd_t, r_t, C_{t-1}) \tag{A.2}$$

(ii) Investment function:

$$I_t = I(Y_t, r_t, K_{t-1}) \tag{A.3}$$

(iii) Exports:

$$X_t = X\left(WT_t, \frac{p_t^w}{p_t}, X_{t-1}\right) \tag{A.4}$$

(iv) Imports:

$$M_t = M\left(Y_t, \frac{p_t}{p_t^m}, M_{t-1}\right) \tag{A.5}$$

(v) Employment:

$$N_t = N(Y_t, N_{t-1}) \tag{A.6}$$

(vi) Producer price:

$$p_t = p\left(w_t, \frac{N_t}{Y_t}, p_t^m\right) \tag{A.7}$$

(vii) Average wage:

$$w_t = w(u_t, p_t) \tag{A.8}$$

(viii) Labour supply:

$$\frac{N_t^s}{L_t} = N\left(u_t, \frac{w_t}{p_t}\right) \tag{A.9}$$

(ix) Money demand:

$$M_t^d = M(Yd_t, p_t, r_t) \tag{A.10}$$

where, Y_t denotes GDP expenditure, C_t is household consumption, G_t is government expenditure, I_t is exports, M_t is imports, Yd_t is disposable income, r_t is the interest rate, K_t is capital stock, WT_t is world trade volumes, p_t^w is the world price, p_t is the producer price, p_t^m is the import price $\left(p_t^m = p(p_t^w)\right)$, N_t is employment, N_t^s is labour supply, L_t is population, w_t is the nominal wage, u_t is the unemployment rate $\left(u_t = \frac{N_t^s - N_t}{N_t}\right)$, and M_t^d is money demand. Subscript (t) denotes a unit of time, e.g., monthly, quarterly, or annually.

The behavioural equations are interpreted as follows. Equation (A.1) is the standard Keynesian final demand identity. The consumption function in Equation (A.2) represents the Keynesian consumption function, where the household consumption is a function of disposable income and lagged consumption. The interest rate explains the trade off with household saving. Equation (A.3) describes investment as a function of economic activity, the interest rate, and the capital stock. In Equation (A.4), exports are determined by world trade volumes, world-domestic relative price, and lagged exports. Imports are modelled as a function of domestic GDP, domestic-import relative price, and import inertia [Equation (A.5)].

Equation (A.6) shows that employment is an inverse of the production function and lagged employment. In Equation (A.7), the producer price is explained by unit costs, nominal wages, and import prices. Equation (A.8) explains that average nominal wage as a function of unemployment and producer prices. Equation (A.9) describes labour supply as a function of population and the attractiveness of the wage (real wage). Equation (A.10) is the Keynesian money demand function, in which money demand is determined by disposable income, the interest rate, and the price level. In this equation system there are feed-back relationships between variables.

Stylised structure of DSGE models

DSGE models expand on the real business cycle (RBC) modelling framework introduced by Kydland and Prescott (1982). With the introduction of policy influence (monetary policy), the models follow New-Keynesian frameworks which combine the theory of rational expectations, price and wage rigidities, and general equilibrium. The structure of the models comprise the following parts: (i) individual utility and profit maximisation; (ii) constraints related to the budget, resources, technology, and demand; (iii) a policy rule which normally follows Taylor rule; (iv) forward-looking expectations.

To provide an overview of the New-Keynesian DSGE models, I outline the stylised key equations as formulated in Kremer et al. (2006).

The optimisation statements of the model are specified as follows:

Choose the value of $C_{i,t}, Y_{i,t}, B_{i,t}, P_{i,t}$ to maximise

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_{i,t}^{1-\gamma}}{1-\gamma} - L_{i,t} \right), \tag{A.11}$$

Subject to multiple constraints:

(i) Individual budget:

$$B_{i,t} + P_t C_{i,t} = P_{i,t} Y_{i,t} - \frac{\phi}{2} \left(\frac{P_{i,t}}{P_t} - \pi_t^* \right)^2 P_t C_t + (1 + R_{t-1}) B_{i,t-1}, \tag{A.12}$$

(ii) Aggregate resources:

$$C_t \equiv \sum_{i=1}^{I} C_{i,t} = \sum_{i=1}^{I} Y_{i,t}, \tag{A.13}$$

(iii) Technology:

$$Y_{i,t} = z_t L_{i,t}, \tag{A.14}$$

(iv) Sectoral demand:

$$Y_{i,t} = \left(\frac{P_{i,t}}{P_t} \right)^{-\theta}, \tag{A.15}$$

where C_t and P_t are aggregate output and price at time (t) respectively; β denotes subjective discount factor; $B_{i,t}$ is wealth accumulation in sector (i) at time (t); $Y_{i,t}$

represents output of sector (i) at time (t); θ and γ are demand elasticity and discount factor respectively; ϕ is an inflation cost parameter; R is the nominal interest rate; L is labour; z_t is labour productivity; and E_0 is the expected value operator.

In what follows are the interpretation of Equations (A.11) to (A.15). Equation (A.11) shows the typical utility function used in DSGE model, known as a habits utility function as specified in Campbell and Cochrane (1995). At a glance, the habit consumption function explains the past behaviours of household consumption. In Equation (A.12), the left-hand-side (LHS) of the equation exhibits the allocations of individual budgets for asset purchases $\left(B_{i,t}\right)$ and nominal consumption $\left(P_t C_{i,t}\right)$. The right-hand-side (RHS) of Equation (A.12) shows the income side, i.e., net individual income *plus* income from financial assets. Equation (A.13) represents the aggregate resource constraint, that is, aggregate real consumption is equal to real output. Equation (A.14) is a production function. Equation (A.15) is demand for a specific commodity.

The first-order solutions of Equations (A.16) to (A.20) are given by the following equations:

$$E_t\hat{C}_{t+1} = \hat{C}_t + \gamma^{-1}\left(\hat{R}_t - \hat{E}_t\hat{\pi}_{t+1}\right), \tag{A.16}$$

$$\hat{\pi}_t = \beta E_t\hat{\pi}_{t+1} + \frac{\theta - 1}{\phi}\left(\gamma\hat{C}_t - \hat{z}_t\right), \tag{A.17}$$

where the cap symbol denotes log difference expression. Equation (A.16) describes that expected consumption is determined by current consumption $\left(\hat{C}_t\right)$ and negatively by the real interest rate $\left(\hat{R}_t - \hat{E}_t\hat{\pi}_{t+1}\right)$. Equation (A.17) represents the Phillips curve, which shows the trade-off between inflation and economic activity. The model's monetary policy rule, a Taylor rule [Taylor (1993); Orphanides (2007)], is as follows:

$$R_t = \delta\left(\frac{\pi_t}{\pi_t^*}\right)^{\lambda_\pi}\left(\frac{C_t}{C_t^*}\right)^{\lambda_y} e^{v_t}, \tag{A.18}$$

where v_t denotes a stochastic shock with expected value of zero and constant variance $\left(v_t \sim \left(0, \sigma_{v_t}\right)\right)$. The stochastic term also applies in the technology variable given by $z_t = \rho z_{t-1} + \varepsilon_t$; $\left(\varepsilon_t \sim \left(0, \sigma_{\varepsilon_t}\right)\right)$. Parameter λ_π and λ_y govern the sensitivity of the monetary policy response towards changes in inflation and output. Equation (A.19) describes that the policy interest rate is determined by the relative change of actual inflation and output from their targets. In percentage change terms it can be expressed by:

$$\hat{R}_t = \lambda_\pi \hat{\pi}_t + \lambda_y \hat{C}_t + v_t, \tag{A.19}$$

Equation (A.20) explains that if inflation and output accelerate, the central bank will respond by raising the policy rate to meet the inflation and output target in the long-run.

For the implementation and solving methods, DSGE use a recursive simultaneous matrix equation, as follows:

$$\mathbf{X_t} = \mathbf{A}\mathbf{X_{t-1}} + \mathbf{B}\mathbf{Z}, \tag{A.20}$$

where **A** and **B** are the matrices representing behavioural and policy parameters. **X** is vector of endogenous variables e.g., $\left[\hat{C}_t, \hat{R}_t, \hat{\pi}_t\right]$ and **Z** is vector of exogenous variables with stochastic process e.g., $[v_t, \varepsilon_t]$.

Derivation of CES Optimal Solutions in Percentage Change

This appendix describes derivations to solve the optimisation problems faced by agents. Suppose an industry wants to choose a combination of inputs that minimise production costs given a CES production function, as follows:

Minimise: $$C = \sum_i P_i X_i, \tag{B.1}$$

Subject to: $$Z = \left(\sum_i \delta_i X_i^{-\rho}\right)^{-\frac{1}{\rho}}, \tag{B.2}$$

$i = 1, 2, 3, \dots., N.$

where,

- C is the total cost,
- P_i is the price of commodity (i);
- X_i is the quantity of commodity (i);
- Z is production capacity (industry activity level) determined by a CES function;
- δ_i is share of commodity (i) in producing Z;
- ρ is a positive parameters.

By combining Equation (B.1) and (B.2), I create the Lagrangian function, described as

$$\mathcal{L} = \sum_i P_i X_i + \lambda \left(\sum_i \delta_i X_i^{-\rho}\right)^{-\frac{1}{\rho}}. \tag{B.3}$$

The first-order conditions arising from equation (A3) are:

$$\Rightarrow \frac{\partial \mathcal{L}}{\partial X_K} = P_K - \frac{1}{\rho}\lambda \left(\sum_i \delta_i X_i^{-\rho}\right)^{-\left(\frac{1+\rho}{\rho}\right)} - \rho \delta_i X_i^{-(1+\rho)} = 0, \tag{B.4}$$

$$\Rightarrow \frac{\partial \mathcal{L}}{\partial \lambda} = \sum_i \delta_i X_i^{-\rho} = 0.$$

Taking the relative price of P_K to P_i produces the following expression:

$$\frac{P_K}{P_i} = \frac{\delta_K X_K^{-(1+\rho)}}{\delta_i X_i^{-(1+\rho)}}.$$

$$= \frac{\delta_K}{\delta_i}\left(\frac{X_i}{X_K}\right)^{(1+\rho)},$$

or,

$$X_i^{-\rho} = \left(\frac{\delta_i P_K}{\delta_K P_i}\right)^{-\left(\frac{\rho}{1+\rho}\right)} X_K^{-\rho}. \tag{B.5}$$

If $X_i^{-\rho}$ in Equation (B.5) is substituted into (B.2), this yields optimal input demand functions as follows:

$$\left[\sum_i \frac{\delta_i^{\left(\frac{\rho}{1+\rho}\right)} P_i^{\left(\frac{\rho}{1+\rho}\right)}}{\delta_K^{\left(\frac{1}{1+\rho}\right)} P_K^{\left(\frac{\rho}{1+\rho}\right)}}\right]^{\frac{1}{\rho}} = Z\,\delta_K^{\left(\frac{1}{1+\rho}\right)} \frac{P_K^{-\left(\frac{1}{1+\rho}\right)}}{\left[\left(\sum_i \delta_i^{\left(\frac{1}{1+\rho}\right)} P_i^{\left(\frac{\rho}{1+\rho}\right)}\right)^{\frac{(1+\rho)}{\rho}}\right]^{-\left(\frac{1}{1+\rho}\right)}}, \tag{B.6}$$

Equation (B.6) implies the quantity demanded of commodity K is a positive function of the production level and a negative function of the relative price of commodity K. Simplifying the demand equation, I obtain the following form:

$$X_K = Z\,\delta_K^{\left(\frac{1}{1+\rho}\right)} \left[\frac{P_K}{P_{ave}}\right]^{-\left(\frac{1}{1+\rho}\right)}, \tag{B.7}$$

where,

$$P_{ave} = \left(\sum_i \delta_i^{\left(\frac{1}{1+\rho}\right)} P_i^{\left(\frac{\rho}{1+\rho}\right)}\right)^{\frac{(1+\rho)}{\rho}}. \tag{B.8}$$

Equation (A8) represents the composite price of input commodities.

Finally, by transforming Equation (B.7) into percentage change form, I obtain the following equation:

$$\tilde{x}_K = z - \sigma(\tilde{p}_K - \tilde{p}_{ave}), \tag{B.9}$$

where,

- $\tilde{x}_K$ is the percentage-change in demand for input commodity K;
- z is the percentage-change in output of industries;
- $\tilde{p}_K$ is the percentage-change in the price of input commodity K;
- $\tilde{p}_{ave}$ is the percentage-change in the composite price of input commodities.

$\sigma = \left(\frac{1}{1+\rho}\right)$ is an elasticity substitution parameter which governs the sensitivity of demand for input commodity K due to change in the price of K relative to the composite price $(\tilde{p}_K - \tilde{p}_{ave})$. The term z describes the scale effect. The term $\sigma(\tilde{p}_K - \tilde{p}_{ave})$ describes the substitution effect.

If I introduce technical change, then equation (B.9) can be re-written as follows:

$$x_K - a_K = z - \sigma(p_K + a_K - \tilde{p}_{ave}), \tag{B.10}$$

where $\tilde{x}_K = x_K - a_K$, $\tilde{p}_K = p_K + a_K$, and

$$\tilde{p}_{ave} = \sum_i S_i(p_i + a_i). \tag{B.11}$$

where S_i is the share of input commodity i in production, and a_i is the percentage change in technical change describing changes in input requirements of industry (i).

The end