The Evolving Role and Limits of Monetary Policy: New Perspectives for Emerging Market Economies
2014 BSP International Research Conference

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Governor Amando M. Tetangco, Jr.

Finding Stability in a Time of Crisis: Lessons of East Asia for Eastern Europe
Paul D. McNelis

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Nur Ain Shahrier and Chuah Lay Lian

An Open Economy DSGE Model for the Philippines
Ruperto Majuca and Lawrence Dacuycuy

Flattening Yield Curve amidst Rapid Inflows: The Malaysian Experience
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Time-Varying Neutral Interest Rates in Emerging Markets
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Global Impact of US Monetary Policy at the Zero Lower Bound
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The Responsiveness of Monetary Policy to Financial Stress: A Dynamic Panel Threshold Analysis
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Estimating Macro-financial Linkages in Asia
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Monetary Policy during Financial Crises: Is the Transmission Mechanism Impaired?
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A Credit and Banking Model for Emerging Markets and an Application to the Philippines
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Monetary and Macroprudential Policy Mix under Financial Frictions Mechanism with DSGE Model: Lessons from Indonesian Experience
Harmanta, Nur M. Adhi Purwanto, Aditya Rachmanto and Fajar Oktiyanto
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Foreword

Our conference theme “The Evolving Role and Limits of Monetary Policy: New Perspectives for Emerging Market Economies” cannot be more relevant given recent global economic developments. No doubt, the recent Global Financial Crisis (GFC) reminded us all of what monetary policy can and cannot do.

We have seen how monetary policy in advanced countries, in particular, has evolved from the conventional use of policy rates to different unorthodoxies including various forms of quantitative easing, credit easing and forward guidance. In turn, these policies have translated into spillovers to emerging market economies (EMEs) through the dynamics of capital flows, interest rates and financial stability fallouts as discussed in the first session on “Monetary policy, volatility of capital flows and asset price bubbles.” Episodes of capital “surges,” “stops,” “flight” and “retrenchment” impact the likelihood of boom and bust in the housing market (Shahrier and Lian). Such episodes and other foreign macroeconomic shocks and factors were found to have affected remittances in the Philippines (Majuca and Dacuycuy), the yield curve in Malaysia (Sharifuddin and Ling) and the neutral real interest rates in emerging markets, particularly in Brazil (Perrelli and Roache). Options and responses of EMEs have been studied, including regional cooperation. Thus, a monetary union, as regime choice, may be a third and effective option to fixed and flexible regimes, especially in times of adversity (McNelis).

In this environment, central banks need to evaluate the effectiveness of their tools amidst pressures to inflation as highlighted in the second session on “Monetary and inflation pressures,” especially since, as assessed by Chen, He, Filardo, and Zhu, the spillover effects of the US monetary policy had sizeable and persistent impact on output growth, inflation and equity prices. Moreover, the nature of the monetary policy response across advanced and emerging market economies may depend partly on the level of financial stress (Floro, Basilio and van Roye).

With the growing risks to financial stability, complications may arise due to the interplay between monetary and macroprudential policies as examined in the third session on “Monetary policy, macroprudential policy and financial stability.” This may depend on the role of the banking sector in transmitting financial sector shocks to the real sector as evaluated in the case of the Philippines (Anand, Deliolo and Peiris) and Indonesia (Harmanta, Purwanto, Rachmanto and Oktiyan). Furthermore, macro-financial linkages play a significant role in economic fluctuations (Kim and Zhu) and there may be systematic asymmetries in monetary transmission between financial crises episodes and normal times (Jannsen, Potjagailo and Wolters).

Looking forward, the fourth session on “Policy discussion on the evolving role and limits of monetary policy: New perspectives for emerging market economies” provided insightful policy discussions on the role, limits and prospects of monetary policy. The roundtable discussion, chaired by Eli Remolona of the Bank for International
Settlements, brought together an excellent mix of central bankers. Ad van Riet (Senior Adviser) of the European Central Bank conveyed that the GFC revealed the shortcomings in the structure of the Eurozone that forced the ECB to deepen its monetary policy toolkit and use non-standard measures to support a sound banking system and secure financial stability. Philip Lowe (Deputy Governor) of the Reserve Bank of Australia discussed that the very low interest rates in combination with open capital accounts, liberalized financial systems, and insufficient government spending have made the task of monetary policy more complicated; and highlighted that the best macroprudential tool to reduce the risk of financial instability at the current juncture is government spending on infrastructure. Meanwhile, John Murray (former Deputy Governor) of the Bank of Canada emphasized that monetary policy cannot solely deliver strong and sustainable economic growth, but has to be complemented by sound fiscal policy, growth-promoting structural reforms and proper financial regulation.

Indeed, the papers and discussions in this conference have not only promoted exchange of ideas on the prevailing concerns with regard to monetary policy but, most importantly, provided practical lessons and widened insights on how challenges on monetary policy could be dealt with. This Conference was truly engaging - from the papers presented to the policy discussions that have touched upon many issues important to monetary policy and financial stability. We are grateful to each of the contributors for the extensive work involved and the quality of the ideas presented. It is our hope that this compilation will prove to be useful for researchers, central bankers and the wider audience.

AMANDO M. TETANGCO, JR.
Governor
3 July 2015
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Opening Remarks

Felipe M. Medalla
Monetary Board Member
Bangko Sentral ng Pilipinas

Good morning and welcome to the 2014 International Research Conference of the Bangko Sentral ng Pilipinas (BSP). The theme of this conference – “the evolving role and limits of monetary policy” – has attracted a great deal of attention since the beginning of the Global Financial Crisis.

Rethinking Monetary Policy

In 2007, the world was hit by what Alan Greenspan described as a “once-in-a-century credit tsunami”\(^1\) that forced a rethinking of monetary policy.\(^2\) For one, how monetary policy interrelates with financial stability has been given due attention. Before the crisis, a common view, which was supported by research,\(^3\) was that achieving price and output stability would promote financial stability. However, the crisis revealed an important limitation of monetary policy – that even when monetary policy successfully achieves price stability, financial stability is not guaranteed. Low and stable rates of inflation may foster asset price bubbles or overly optimistic expectations. Accommodative monetary policy may give incentives for banks to over-leverage and take on more risks. These actions, in turn, may threaten financial stability.

There is now also recognition that financial stability is essential for an effective monetary policy. The fragility of the financial sector can affect the transmission mechanism of monetary policy and its impact on the real economy, and the outlook for price stability. In times of financial instability, attempts to use monetary policy to stabilize inflation may be muted, since linkages from monetary policy to the financial sector and the real economy are disrupted.

The crisis has likewise demonstrated that global factors have become increasingly important in the transmission of monetary policy and in shaping domestic economic outcomes. Changes in foreign monetary policy alter the movement of capital from one country to another, thereby influencing domestic liquidity conditions, the exchange rate, domestic interest rates and market expectations, among others.

Evolving Views on Monetary Policy

Academics as well as policymakers have argued that these developments call for a revamp of monetary policy frameworks. First, questions are being raised as to whether the monetary policy rule has to explicitly include financial stability concerns. However, the relative weight monetary policy should assign to financial stability remains

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1 Alan Greenspan’s testimony before the House of Representative’s Government Oversight Committee on 23 October 2008
Nonetheless, identification of potential conflicts between financial and price stability, and on ways to improve on potential tradeoffs have to be intensified.

Related to the foregoing, the importance of macroprudential policy to complement monetary policy has come to the fore. When monetary policy is constrained to address price stability, targeted macroprudential measures can be tapped to address specific sources of risks.

Second, as global factors have become increasingly important in influencing domestic outcomes, the set of information variables as well as the policy toolkit of central banks should be expanded. A greater understanding of how various aspects of the monetary transmission mechanism are affected by global factors has become necessary to ensure the effectiveness of policy instruments.

Third, there is now greater importance placed on the possibility of multilateral coordination of monetary policies to appropriately internalize spillovers. Such thoughts suggest that monetary policy may need to give due attention to its international ramifications, especially on capital flows and on financial stability in foreign jurisdictions.

These considerations clearly have an important bearing on the future of central banking, in general, and on monetary policy making, in particular.

Monetary Policy Strategy in the Philippines

To put these issues in context, let me now turn to the experience of the Philippines. Throughout the crisis, the primary objective of the Bangko Sentral ng Pilipinas (BSP) remained to be “to maintain price stability”. Nonetheless, financial stability is an important pursuit. Policy instruments were used in increasingly innovative ways, and the BSP policy toolkit was broadened to address evolving economic conditions. This strategy ensures that monetary policy is not overburdened in achieving both price and financial stability.

Among the adjustments in the BSP’s monetary policy instruments include the following:

- Rationalization of reserve requirement policies as befit market conditions;
- Revisions of policies on the use of BSP fixed-term deposits; and
- Participation in the foreign exchange market to dampen exchange rate volatility and accumulation of foreign exchange reserves.

Some non-monetary policy measures implemented by the BSP have proved particularly helpful in maintaining financial stability, to name a few:

- Development of risk assessment tools to monitor developments in the financial and foreign exchange markets for early detection of signs of distress;
- Full adoption of the new capital requirements of Basel III on January 2014;
- Expansion of the definition of real estate exposure to restrain credit growth in the sector as well as conduct stress test to ensure banks have sufficient capital to cover their real estate exposures; and

---

• Formal coordination across government agencies through the creation of the Financial Stability Coordination Council (FSCC) to identify, manage and mitigate the build-up of financial risks emanating from both financial and non-financial sectors of the economy.

The tools implemented and endeavors pursued by the BSP are supported by high-quality supervision, sound regulatory framework and effective enforcement. These are likewise clearly communicated to ensure maximum compliance by banks and appreciation by our stakeholders and the public.

The Conference Sessions

Our two-day conference will touch upon many issues important to monetary policy and financial stability. Papers will review how emerging markets were affected by movements in capital flows, the risks associated with these flows, and how monetary policy responded. There will also be a discussion on the challenges facing central banks and the effectiveness of their available tools during financial crisis. And the interplay between monetary policy and macroprudential policy will be analyzed.

These topics are particularly important as central banks continue to face challenges in monetary policymaking. We have brought together experts with a wide range of backgrounds, including policymakers, and those working in international research institutions and academia, to exchange ideas on these issues. I thank the authors and your respective institutions for your valuable contribution to this research conference.

To top off our two-day conference, we are privileged this year to have a panel discussion comprised of distinguished central bankers – Deputy Governor Philip Lowe of the Reserve Bank of Australia, Former Deputy Governor John Murray from the Bank of Canada, and Senior Adviser Ad van Riet of the European Central Bank. The experience and expertise of these gentlemen in policymaking promise to provide an insightful discussion on the role, limits and future of monetary policy, using the case of their respective economies. Thank you, gentlemen, for gracing the BSP International Research Conference.

I invite all of you to engage yourselves in the sessions as this conference promises to provide a good opportunity to learn and share ideas on the conduct of monetary policy.

Conclusion

As I end, let me refer to Milton Friedman who said that "Only a crisis - actual or perceived - produces real change. When that crisis occurs, the actions that are taken depend on the ideas that are lying around. That, I believe, is our basic function: to develop alternatives to existing policies, to keep them alive and available..."6

Indeed, the recent crisis has brought us challenges, compelling policy-makers to enhance existing policies and expand toolkits. It is my hope that the shared ideas in this conference will further expand our alternatives to existing policies that will reinforce our capacity to deal with future challenges.

Felipe M. Medalla

I wish you well in this Conference and I look forward to a productive and interesting exchange of ideas. Thank you very much for your participation and a pleasant morning to all.
Session 1
Monetary Policy, Volatility of Capital Flows and Asset Price Bubbles
Finding Stability in a Time of Crisis: Lessons of East Asia for Eastern Europe

Paul D. McNelis

This paper examines the options of small open economies in Eastern Europe pegged to the Euro, in a time of crisis. Specifically, should Bosnia and Herzegovina, Bulgaria, Latvia and Lithuania move to full Euro area accession, as Estonia, Slovakia, and Slovenia have done, or follow the examples of Poland, the Czech Republic, and Hungary?

This paper argues that going forward to full monetary union offers benefits over a pure fixed exchange-rate regime. The experience of Hong Kong at the time of the Asian crisis in the late 1990’s illustrates the benefits of monetary union during a time of crisis.

JEL Codes: E52, E62, F41

1 INTRODUCTION

In the course of the Euro Area crisis since 2007, a number of Euro area countries (Cyprus, Ireland, Greece, Italy, Portugal and Spain) have experienced sharp reversals in capital inflows. The reversal of capital flows seen in Europe was part of a broader global development, since a number of non-Euro Area and non-European countries also experienced capital flow reversals in previous decades.

Sharp reversals in capital flows are not new phenomena. Since the 1980’s many countries have experienced sudden stops. Famous episodes are the Exchange Rate Mechanism (ERM) crisis of 1992/1993 in Europe, Mexico in 1994 (the Tequila crisis), Hong Kong, Indonesia, Malaysia, South Korea, Thailand, during the Asian crisis of the late 1990’s (the Asian Flu), and Russia and a number of other countries in 1998 (the “Russian virus”).

The recent crisis in the Euro area, of course, puts the question of full monetary union in center stage for Bosnia and Herzegovina, Bulgaria, Latvia and Lithuania, now pegged to the Euro. While Estonia, Slovakia, and Slovenia have become full members of the Euro area, a number of other countries, such as Poland, the Czech Republic, and Hungary, have not moved forward to Euro area accession by fixing their exchange rates to the Euro.

Clearly, it is in times of crisis that choices about membership in a monetary union are most critical. After all, in normal times, exchange-rate regime choice, while interesting, is not a front and center policy issue. The question facing the four countries pegged to the Euro is simple: should they go forward, follow the lead of Estonia, Slovakia and Slovenia, or take their cues from Poland, the Czech Republic and Hungary?

Like the members of the Euro area, these countries are vulnerable to sudden stops, when collateral constraints become binding in the wake of adverse shocks, or simply due to contagion effects from nearby countries, even when public debt is trivial (as the experience of Hong Kong shows). This paper argues that it is precisely in these

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1 Department of Finance, Graduate School of Business Administration, Fordham University, New York 10019. Email: mcnelis@fordham.edu. McNelis’ research for this project began as a visiting scholar at the Hong Kong Institute of Monetary Research in December 2012. Further research was supported by the Department of Economic Research of the Bank of Portugal in 2013.
times of adversity that it makes sense to be in a monetary union. For these transition economies of Eastern Europe, the monetary union is the Euro area.

The experience of Hong Kong during the Asian crisis of the late 1990's offers important lessons for this issue. Hong Kong has maintained a currency board with the United States dollar since 1984. While Hong Kong is not in a "de jure" monetary union with the United States, it is in a quasi "de facto" monetary union. With large abundant reserve holdings of U.S. dollars, the monetary authority of Hong Kong at the time of the crisis was able to provide to banks and financial markets special funding, much as the Federal Reserve Board provided special funding to financial institutions at the time of the crisis in 2008.

Specifically, Joseph Yam, the head of the Hong Kong Monetary Authority, authorized in 1998 what has been called an "audacious move," the purchase of US$15 billion in stocks amidst the market panic. The measure restored calm, and effectively defended the Hong Kong fixed exchange rate parity against the US dollar. The move was initially criticized as a very unorthodox form of monetary policy but later praised by Alan Greenspan, no less, as a "savvy move" with "exquisite timing".2

The distinguishing feature of the Euro area case is the fact that sudden stops occurred in a set of countries which are part of a monetary union. In this situation, a common central bank conducts a single monetary policy aimed at ensuring broadly similar monetary conditions across participating countries. Under this regime, net private capital outflows are partially offset by the actions of the central bank. This paper explores in greater detail the implications of such a facility for a country experiencing a sudden stop, comparing the adjustment with a country with a fixed exchange rate.

Clearly, what has happened in Spain, Ireland, Greece, Portugal can happen to Eastern European countries. This paper argues that the funding of a monetary union provides an additional effective cushion in times of adversity. This cushion of the additional reserve funding to member countries in a monetary union functions much like the cushion Joseph Yam was to provide Hong Kong markets at the time of the Asian crisis.

This paper does not go into the details of the history of Eastern European countries or the mechanics of Hong Kong monetary system. Rather we start from a relatively simple model of a small open economy subject to occasionally binding credit constraints, and examine adjustment with and without the benefits of a monetary union, when recurring adverse negative shocks make collateral constraints binding, setting off further debt-deflation dynamics. We then simulate the Hong Kong experience, basically that of contagion effects, leading to a collapse of the share market index. We show with the same model how the reserve funding was able to cushion the effects of the adverse contagion effect.

The Hong Kong adjustment, while harsh, to be sure, did not come as a result of high public indebtedness or the need for large scale banking-sector intervention, as in the stressed European countries. But the experience of Hong Kong should serve as an even more significant lesson. Adverse shocks can and do come, even if the fundamental of public sector finances are sound.

This paper makes use of the small open economy model of Mendoza (2010). With the model, we can generate "sudden stop events," generated by normal business

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cycle shocks (to total factor productivity (TFP) and world interest rates) rather than by assumed exogenous contagion effects. However, with the same model, we are able to compare adjustment of a Hong Kong style contagion effect, with and without the benefits of emergency financing.

The model is based on rigorous microfoundations, and avoids a number of ad hoc elements which have been used in alternative frameworks.

Third, the model incorporates important linkages between asset prices, specifically Tobin’s q, collateral values and borrowing constraints, which have played an important role in the recent crisis.

While taking the Mendoza model as the starting point, we make several modifications. We allow for downward nominal wage rigidity since this potentially has important implications for macroeconomic adjustment under fixed exchange rate regimes (Schmitt-Grohe and Uribe (2011)). Second, and more to the point, this paper embeds a central bank funding facility characterizing a monetary union. We switch this feature on and off to explore its effect on macroeconomic adjustment to sudden stops, in the case of binding collateral constraints.

The literature generally follows the Calvo definition in which sudden stops are defined as "large and unexpected falls in capital inflows that have costly consequences in terms of disruptions in economic activity" (Calvo et al. (2004) p.14).

The macroeconomic response of the affected Euro Area economies to the sudden stop events is similar, in some ways, to previous experience elsewhere. This can be seen in Figure 1. In this figure, we follow Mendoza (2010), by looking at the "average" dynamics of key variables before and after the event for a span of five years.3 The year in which the sudden stop starts is denoted t=0, with the level of each variable (except for capital flows and net export ratios) for the preceding year (t=-1) being normalized to unity. The figure shows the average dynamics for all sudden stop episodes found in the data as well as for the Tequila, Asian and Euro Area crises.

Figure 1 shows that the most severe drops took place in Asia. In terms of GDP, consumption and investment, the collapse in the Euro zone was not as severe as the Asian crises. The patterns are similar and the earlier crises in Asia represented signs of things to come elsewhere in the world.

Figure 2 pictures the adjustment of key variables in Hong Kong before and after the Asian financial crisis of 1997. Unfortunately, balance of payments are not available for the period leading up to the crisis in Hong Kong. This figure shows the severe drop in GDP growth at the time of the crisis, by more than 10 percent, along with the drop in export growth, and government spending. This figure also shows the sharp increase in the domestic interest rate relative to the international LIBOR rate, to which the Hong Kong dollar remained pegged. The figure also shows the onset of a period of deflation at the time of the crisis, which lasted for almost a decade.

While adjustment in Hong Kong was indeed harsh, as it is now for Greece, Ireland, Italy, Portugal, and Spain, it could have been worse, much worse, without the financing through dollar reserves. We argue that the same is true for member countries of the Euro area. The message of this paper to Bosnia and Herzegovina, Bulgaria, Latvia

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3 With the exception of capital flow and net export ratios, all variables in the Figure are computed using deviations from a Hodrick-Prescott filter.
and Lithuania is that bad things can happen, in the form of sudden stops, whether generated by adverse business cycle triggering collateral constraints, or by contagion effects (being in the wrong region of the world at the wrong time). Given that bad things can and do happen, it is much better to be in a credible monetary union than not.

This paper proposes that the European crises reflect the debt/deflation mechanism coming from binding collateral constraints, while the Hong Kong crisis, a decade earlier, represents more clearly a contagion effect, more specifically, a case of the “holy trinity” of financial contagion, in that it was fast and furious, came as a surprise, and involved leveraged international creditors operating within a broader region (see Kaminsky et al. (2003)). From the perspective of Bosnia and Herzegovina, Bulgaria, Latvia and Lithuania, does it really matter how the bad news comes? The issue is how they can best adjust to the bad news.

Calvo and Mendoza (2000) rationalize a sudden stop in countries with sound fundamentals, due to the fixed costs of gathering and processing country-specific information within a region where other crises are taking place. This shows how the presence of these costs lead to herding behavior by rational investors. Billio et al. (2005) find empirical evidence for such a contagion effect in Hong Kong during the 1997 financial crisis.

In the next section we lay out the structure of the model, and show how it can be used to simulate endogenous sudden stops coming from binding collateral constraints as well as exogenous stops due to contagion effects. We then discuss the calibration and simulation method. Following this, we examine the behavior of the model with collateral constraints, in which question of monetary union comes to center stage. We then discuss the behavior of the model with contagion effects, for given stochastic shocks to productivity and world interest rates, where there is little or no public debt. We show that the availability of reserve financing in a time of crisis, makes a significant difference.

Figure 1: Macro Dynamics with Sudden Stops (annual)

Source: IMF Balance of Payments Statistics, World Development Indicators, AMECO, Bloomberg. The year in which the sudden stop starts is denoted 0. All series except net trade and capital flows are deviations from a Hodrick-Prescott filter indexed to 1 for t=-1.
2 MODEL

On the theoretical front, during the past decade, sudden stop phenomena have been the subject of different general equilibrium frameworks. Models differ depending on a number of respects such as: single country versus two country, the type of sectoral breakdown (single good versus traded/non-traded split), the type of frictions included (e.g. sticky versus flexible prices and capital adjustment costs), and the type of shocks considered.

Calvo et al. (2004) drew attention to sudden stops arising as a consequence of uncertainty about fiscal or real exchange rate sustainability. This approach was soon challenged by Chari et al. (2005) who argued that sudden stops were simply a consequence of expected negative shocks to real output.

This controversy is mirrored in the theoretical literature. One set of models treats sudden stops as exogenously determined events. Another set of models treats sudden stops as endogenously generated events, or recurring set of events, with the productivity, terms of trade or foreign interest rates as the forcing variables driving the economy.

Braggion et al. (2009) model the sudden stop as an exogenous permanent regime switch from one steady state to another. In the initial state, there is no borrowing constraint on the economy. The sudden stop is then modeled as a shift towards a permanently binding borrowing constraint. Cúrdia (2008) uses the framework of Bernanke et al. (1996) in which the economy faces an external finance premium. The sudden stop takes the form of an exogenous shock to an external financing premium. Unlike Braggion et al. (2009), this shock is not permanent.

Devereux et al. (2006) also examine the role of the external financing premium in the spirit of Bernanke et al. (1996). Unlike Cúrdia (2008), the premium is endogenously determined by the stochastic shocks driving the model (terms of trade...
and world interest rate shocks). They also embed nominal frictions in terms of sticky prices and imperfect exchange-rate pass through.

In contrast with the above approaches, Mendoza and Arellano (2003) and Mendoza (2010) use a small open economy real business cycle framework with financial frictions in the form of collateral constraints on international borrowing, following the specification of Kiyotaki and Moore (1997a). In this framework, shocks take the usual form of recurring productivity, foreign interest rate, and external price changes. Sudden stop phenomena emerge as endogenously recurring, albeit infrequent events, arising when collateral constraints become binding. When the borrowing constraint hits, consumption and investment fall. At the same time, the working capital channel induces firms to reduce inputs, leading to a fall in output. This mechanism is exacerbated by a "debt deflation mechanism" with falls in the q-ratio leading to a further tightening of the borrowing constraint.

2.1 Benchmark Model

Following Mendoza (2010) the small open economy contains a representative firm-household model which produces a single good using three factors of production: labor $L_t$, capital $k_t$ and imported intermediate goods $v_t$. In addition to the usual intertemporal budget constraint, agents are subject to a working capital requirement on labor and intermediate inputs, quadratic adjustment costs for capital accumulation and the usual intertemporal borrowing constraint. In addition, agents are subject to occasionally binding external borrowing constraints.

The representative household optimizes an intertemporal welfare function $V_t$ positively related to consumption $c_t$ and negatively related to labor $L_t$.

In order to ensure stationarity of net foreign assets the welfare function embodies an endogenous discount factor $D_t$:

$$V_t = U[c_t - N(L_t)] + D_t V_{t+1}$$

$$U(\cdot) = \frac{1}{1-\sigma_c} (c_t - N(L_t))^{1-\sigma_c}$$

$$N(L_t) = \frac{1}{\omega} L_t^{\omega}.$$  

The parameters $\sigma_c$ and $\omega$ represent the relative risk aversion coefficient and the Frisch elasticity of labor supply in the labor component of the utility function, $N(L_t)$, respectively. This specification of the utility function, which follows Greenwood et al. (1988), implies that there are no wealth effects on labor supply. This has important implications for the ability of the model to match the response of the economy to sudden stop episodes. As noted by Chari et al. (2005), standard preferences would imply an increase in labor supply (and thus output) following the imposition of a borrowing constraint on an economy. Suppressing the wealth effect on labor supply as done here eliminates this counter factual feature.

The discount factor $D_t$ has the following functional form:

$$D_t = p(c_t - N(L_t))$$

$$p(c_t - N(L_t)) = \exp(-\gamma \ln(1 + c_t - N(L_t))) .$$

Schmitt-Grohe and Uribe (2003) note that endogenous discounting is only one way for closing open economy models. Other ways include a risk premium on foreign debt, an adjustment cost on foreign debt accumulation, and the assumption of complete markets.
The budget constraint for the household is given by the following relation:

\[ c_t + i_t + g_t = y_t - p_t v_t - \varphi (R_t - 1) (w_t L_t + p_t v_t) - q_b^b b_{t+1} + b_t \]  

(5)

where \( y_t \) represents total domestic output at time \( t \), \( c_t \) consumption, \( i_t \) investment, \( g_t \) government spending, \( b_t \) one-period international bonds. The price index \( p_t \) is the cost of the intermediate goods for the firm, \( w_t \) the real wage rate, and \( q_b^b \) the price of international bonds.

The working capital requirement for the representative firm is given by the parameter \( \varphi \) while \((R_t - 1)\) represents the net nominal world interest rate. The price of international bonds is exogenous, with \( q_b^b = 1/R_t \).

In addition to the economy-wide budget resource constraint, the following collateral constraint applies to international borrowing \( b_{t+1} \):

\[ q_b^b b_{t+1} - \varphi R_t (w_t L_t + p_t v_t) + \kappa q_t k_t \geq 0 \]  

(6)

where \( q_t \) is the price of capital, and \( \varphi \) is the working capital coefficient, giving the percent of the wage and intermediate-goods bill which must be financed. As Mendoza (2010) notes, “the collateral constraint implies that total debt, including both debt in one-period bonds and working capital loans for labor and intermediate goods, cannot exceed a fraction \( \kappa \) of the 'marked-to-market' value of capital” (Mendoza (2010), p.1947). As Mendoza also pointed out, this is the standard, widely used form of imposing collateral constraints, due to Kiyotaki and Moore (1997).

Capital accumulation is equal to investment, net of depreciation and adjustment costs:

\[ i_t = \delta k_t + (k_{t+1} - k_t) \left[ 1 + \psi \left( \frac{k_{t+1} - k_t}{k_t} \right) \right] . \]  

(7)

The parameter \( \delta \) is the rate of depreciation and \( \psi \) is the adjustment cost function. The adjustment cost function in turn is quadratic:

\[ \psi \left( \frac{x_t}{k_t} \right) = \frac{a}{2} \left( \frac{x_t}{k_t} \right)^2 \]  

(8)

where \( x_t \) denotes capital accumulation at time \( t \), and \( a > 0 \) is the adjustment-cost parameter.

For simplicity, net capital accumulation \( z_t \) may be expressed in the following way:

\[ z_t = i_t - \delta k_t - \psi \left( \frac{x_t}{k_t} \right) z_t . \]  

(9)

Government spending \( g_t \) is assumed to be unproductive and funded by a time-invariant \textit{ad valorem} consumption tax, \( t_c \). As noted by Mendoza, this tax does not distort the consumption-leisure decision (Mendoza (2010), p. 1952).

Production is based on a constant returns-to-scale Cobb-Douglas function, multiplied by a total factor productivity shock, given by the exponent of \( \varepsilon_t^{\text{A}} \):
\[ y_t = \exp(e_t^A)A k_t^\beta l_t^\alpha v_t^\eta \]
\[ 0 < \alpha, \beta, \eta < 1 \]
\[ \alpha + \beta + \eta = 1 \]
\[ A > 0 \].

2.2 First-order conditions

The first-order conditions for the representative household/firm are obtained by maximizing function \( V_t \) subject to the intertemporal resource constraint given by equation 5, the law of motion of capital in equation 7, and the borrowing constraint in equation 6, with respect to \( c_t, k_t, k_{t+1}, v_t \) and \( b_{t+1} \).

For first-order conditions for consumption and labor (assuming flexible wages), given by \( c_t \) and \( l_t \), we have the following expressions:

\[ \lambda_t = u_c \left(c_t - N(L_t)\right) + \rho_c \left(c_t - N(L_t)\right)E_t[V_{t+1}] \]
\[ -\lambda_t w_t = -u_c \left(c_t - N(L_t)\right)N_t(L_t) - \rho_c \left(c_t - N(L_t)\right)N_t(L_t)E_t[V_{t+1}] \]

where \( \lambda_t \) is the Lagrangian for the resource constraint and \( E_t \) is the expectations operator. The partial derivative of the discount factor with respect to consumption, \( \rho_c \left(c_t - N(L_t)\right) \), has the following form:

\[ \rho_c \left(c_t - N(L_t)\right) = \left(-\frac{\gamma}{1 + c_t - \frac{L_t}{w}}\right) \exp \left[-\gamma \ln \left(1 + c_t - \frac{L_t}{w}\right)\right] \].

Dividing the labor and consumption Euler equations, we obtain the following familiar labor supply/real wage relation:

\[ N_t(L_t) = w_t. \]

The real wage \( w_t \) obeys the following first-order condition:

\[ \lambda_t \left(\exp(e_t^A)F_k(k_t, L_t, v_t) - w_t(1 + \varphi(R - 1))\right) - \mu_t \varphi R_t w_t = 0 . \]

Similarly, for intermediate goods, \( v_t \), the following first-order condition applies:

\[ \lambda_t \left(\exp(e_t^A)F_v(k_t, L_t, v_t) - p_t(1 + \varphi(R - 1))\right) - \mu_t \varphi p_t p_v = 0 . \]

In both of these equations, the variable \( \mu_t \), as mentioned above, represents the Kuhn-Tucker multiplier applied to the borrowing constraint.

When the borrowing constraint does not bind, with \( \mu_t = 0 \), the above first-order condition simply states that the marginal productivity of intermediate goods, multiplied by the marginal utility of income, should be equal to the marginal cost, including working capital costs. The same is true for the marginal product of labor with respect to the real wage \( w_t \) including working capital costs. When the borrowing constraint binds, \( (\mu_t > 0) \), the multiplier acts like a tax on the use of intermediate inputs and labor, inducing firms to use less of them.

The first-order condition for the international bond \( b_{t+1} \) implies the following asset-pricing relation between the price of bonds and the marginal utility of income:

\[ \lambda_t q_t^b = \mu_t q_t^b + D_t \lambda_{t+1} . \]
The condition implies the following law of motion for the marginal utility of income, \( \lambda_t \):

\[
\lambda_t = \mu_t + D_t R_t \lambda_{t+1}.
\] (18)

The gross real interest rate on one-period domestic bonds \( R_b^t \) satisfies the usual condition which links it to the stochastic discount factor:

\[
\frac{1}{R_b^t} = E_t[D_t \lambda_{t+1}].
\]

When the collateral constraint is not binding \( (\mu_t=0) \) the domestic and foreign rates are identical. However, when the collateral constraint binds \( (\mu_t>0) \), a spread between the two rates emerges. This spread is the difference between the effective real interest rate given by \( (R_b^t) \) and the international interest rate \( (R_i) \):

\[
R_b^t - R_i = \frac{\mu_t}{E_t \lambda_{t+1}}.
\] (19)

Optimizing with respect to investment \( k_{t+1} \) leads to the following expression:

\[
D_t \lambda_t \exp(\xi_{t+1}^A) F_k(k_{t+1}, L_{t+1}, \nu_{t+1}) + q_{t+1} \left\{ - \left[ 1 + \Psi \left( \frac{z_t}{k_{t+1}} \right) \right] - z_t \Psi \left( \frac{z_t}{k_{t+1}} \right) \frac{1}{L_{t+1}} \right\} + q_{t+1} \left\{ - \left[ 1 - \Psi \left( \frac{z_{t+1}}{k_{t+1}} \right) \right] + z_{t+1} \Psi \left( \frac{z_{t+1}}{k_{t+1}} \right) \frac{1}{L_{t+1}} \right\} + \mu_{t+1} k_{t+1} \Psi_\lambda \lambda_{t+1} = 0
\] (20)

The symbol \( D_t \) is the discount factor, equal to \( \rho_t (c_i \cdot N(L_i)) \).

To simplify the first-order condition for the capital stock, we first define expected dividends, \( d_{t+1} \), as the expected marginal productivity of capital less depreciation plus the gains in the form of reduced adjustment costs by the higher stock of capital:

\[
d_{t+1} = \exp(\xi_{t+1}^A) F_k(k_{t+1}, L_{t+1}, \nu_{t+1}) - \delta + \left( \frac{z_{t+1}}{k_{t+1}} \right)^2 \Psi_\delta \left( \frac{z_{t+1}}{k_{t+1}} \right).
\] (21)

Tobin’s \( q \) in this model is derived from the familiar asset-pricing formula:

\[
q_t = E_t \left[ \sum_{j=0}^{\infty} \left( \prod_{i=0}^{j-1} \left( \frac{1}{R_{t+1}^{t+1}} \right) \right) d_{t+1+j} \right]
\] (22)

with the discount factor \( R_{t+1}^{t+1} \) defined in the following way:

\[
R_{t+1}^{t+1} = \frac{\lambda_{t+1} - \mu_{t+1} k}{\lambda_{t+1}}.
\] (23)

As equations (22) and (23) make clear, if the borrowing constraint binds (or is expected to bind in the future), the rate at which dividends are discounted will rise. This leads to a decline in the \( q \)-ratio. Since the borrowing constraint itself depends on \( q \), the fall in \( q \) will in turn lead to a tightening of the borrowing constraint, leading to further falls in \( q \). This debt-deflation mechanism is a key feature of the model and plays an important role in driving the macroeconomic response to sudden stops. Furthermore, the debt-deflation mechanism increases the financing cost of working capital, depressing investment, employment and output even more.
2.3 Contagion Effect Model

In the contagion effect, the level of public debt is thus irrelevant. Foreign investors impose a risk premium or wedge between the domestic and foreign interest rate. In this version of the Mendoza model, the Lagrange multiplier, providing a wedge between the domestic and foreign interest rate, $\mu$, is determined by an exogenous stochastic process, and is not affected by the level of international borrowing.

Lim and McNelis (2012) estimated a Bayesian model for Hong Kong, including a stochastic process for the interest rate differential between the Hong Kong dollar and the international US dollar interest rate. We will use the parameters from this estimated process to assess the effects of an exogenous risk premium process, independent of the fundamentals of the economy.

2.4 Downward Nominal Wage Rigidity

Schmitt-Grohe and Uribe (2011) have drawn attention to downward nominal wage rigidity (DNWR) as the key source of nominal frictions in the economy which weakens the ability of the economy to adjust under fixed exchange rate. In their setup, nominal wages cannot adjust (sufficiently) downwards in response to adverse shocks. This implies that exchange rate pegs will lead to higher levels of unemployment on average than a flexible exchange rate regime with an optimal monetary policy. The implied costs are large. On average, the unemployment rate is more than 10 percentage points higher and the welfare cost of a currency peg under this form of rigidity amounts to 4 to 10 percent of consumption. In a complimentary paper, Schmitt-Grohe and Uribe (2013), for this reason, advocate a Euro Area-wide annual inflation rates of 4.3 percent in order to restore full employment to the Euro zone countries over a period of five years. This is more than twice the annual inflation target rate of 2 percent.

Given the importance of DNWR in recent policy discussion of the Euro Area, we embed this feature into our model. We do this by means of an asymmetric Calvo wage setting scheme. We base our modeling of DNWR on the results of Fagan (2013) who analyzed micro data on wage changes for four countries (the US, Germany, Belgium and Portugal). He found that an asymmetric Calvo scheme best matches the cross sectional distribution of wage changes. He also shows that the case of a strictly binding constraint on wage cuts, as in Schmitt-Grohe and Uribe (2011), is a special case of this more general model.

In the asymmetric Calvo mechanism, nominal wages are free to adjust upwards. However, when nominal wages are required to fall, only a fraction of wage setters are free to cut wages, with the remaining fraction leaving their nominal wage unchanged. As in the regular Calvo setup, the optimal real wage rate chosen by those agents free to cut their wages is given by $w^\text{num}/w^\text{den}$, where

$$w^\text{num} = (1 + tc)\lambda_t w_t^{\theta_w} L^{-1}_t + \psi_w^{\frac{D_{\lambda_t+1}}{\lambda_t}} w^\text{num}_{t+1} (1 + \pi)^{\theta_w}, \quad (24)$$

and

$$w^\text{den} = L_t w_t^{\theta_w} \lambda_t + (1 + \pi)^{\theta_w} \psi_w^{\frac{D_{\lambda_t+1}}{\lambda_t}} w^\text{den}_{t+1}. \quad (25)$$

In contrast to Schmitt-Grohe and Uribe (2011), who assume that "world" inflation is zero, we assume an inflation rate of 2 percent, in line with the ECB target for the Euro Area as a whole. This implies that DNWR will be less binding in our case. Our
assumption on world inflation allows us to express the Calvo first-order conditions in terms of real wages as in (24) and (25).\(^5\)

For the economy-wide real wage, we have the following expression:

\[
W_t = \left( \psi_w(s) \left( \frac{w_{t-1}}{1+r_t} \right)^{1-\theta_w} + \left( 1 - \psi_w(s) \right) \left( \frac{\theta_w w_{t-1}^{num}}{\theta_w - 1} \right)^{1-\theta_w} \right)^{1-\theta_w}. \tag{26}
\]

This expression replaces the households’ first-order condition for labor given by (5). The parameter \(\psi_w(s)\) captures the state-contingent degree of DNWR in the economy at time \(t\). It is zero if nominal wages are rising, so that nominal wages are flexible in this case. Where nominal wages are falling, DNWR kicks in and \(0 < \psi_w(s) \leq 1\).

Since we are solving our model using a global solution method, the introduction of this highly nonlinear form of wage setting poses no additional problems apart from adding an additional state variable (the previous period’s wage).

2.5 Funding Facility in a Monetary Union

To capture the differences between a monetary union and a pure fixed-exchange-rate regime, we note that net foreign assets may be decomposed as the sum of two components: private net foreign assets \((b^{PR}_t)\) and central bank balances \((b^{CB}_t)\), with borrowing via the financing facility, which is recorded as a negative value for \(b^{CB}_t\):

\[
b_t = b^{PR}_t + b^{CB}_t. \tag{27}
\]

The borrowing constraint applies now to private net foreign assets:

\[
q_t b^{PR}_{t+1} - \rho_t (w_t L_t + p_t V_t) \geq -\kappa q_t k_t.
\]

To complete the model, we need to specify how the special funding facilities are determined. We assume that these balances follow a linear function of the spread between the domestic and world interest rate:

\[
b^{CB}_t = \Phi (R^D_t - R_t).
\]

As noted earlier, the difference in the interest rate spread comes into play when the collateral constraint becomes binding. In this case, the emergence of a spread will trigger the special facility inflows. Otherwise, when the collateral constraint is not binding, these balances will be zero. The parameter \(\phi\) reflects the elasticity of central liquidity supply to the country in the monetary union. When it is zero, there is effectively no system in place, and the country operates as if it were in a fixed exchange-rate system. As \(\phi\) tends to infinity, liquidity supply becomes infinitely elastic. In this extreme case, private capital outflows in a sudden stop are completely offset by these inflows, so that the external borrowing constraint falls away.

2.6 Stochastic Shock Specification

Both total factor productivity and the gross interest rate \(R_t\) follow exogenous stochastic processes. The total factor productivity shock, given by \(\varepsilon^A_t\), has the following

\(^5\) Specifically, we assume that the world price level evolves deterministically, increasing at a rate of 2% per annum. The Calvo expressions for wages are normally in terms of nominal wages. However, dividing the first-order conditions for the Calvo wage-setting by the deterministic price level allows us to express the Calvo conditions in real terms as in (24) and (25).
specification, with autoregressive coefficient $\rho_A$ and innovation term $\eta^A_t$, normally distributed with mean zero and variance $\sigma^2_A$:

$$
\begin{align*}
\varepsilon^A_t &= \rho_A \varepsilon^A_{t-1} + \eta^A_t \\
\eta^A_t &\sim N(0, \sigma^2_A).
\end{align*}
$$

(28)

The gross real world interest rate has the following process:

$$
\ln(R_t) = \rho R \ln(R_{t-1}) + (1 - \rho_R) \ln(\bar{R}) + \eta^R_t + \rho_{RA} \cdot \eta^A_t.
$$

(29)

For the case of an exogenous risk premium, we specify the following process:

$$
\mu_t = \rho \mu_{t-1} + \eta^\mu_t \\
\eta^\mu_t &\sim N(0, \sigma^2_{\mu}).
$$

(30)

The logarithm of the gross world interest rate is driven by an innovation term which is in part idiosyncratic, represented by $\eta^R_t$, and in part correlated with the innovation term to total factor productivity, $\eta^A_t$, given by the correlation parameter $\rho_{RA}$. We follow Mendoza (2010) in assuming a negative correlation between real world interest rate and productivity shocks for a small open economy. Finally, for the risk premium, we assume that it is exogenous, and unrelated to domestic shocks.

Mendoza (2010) also specifies a stochastic process for the relative price of imported goods. We do not take this approach here in order to limit the size of the model (for computational reasons) and because it is not clear that shocks to intermediate goods prices have played a significant role in the Euro Area crisis or in Hong Kong during the Asian financial crisis. Thus, in our specification, this price grows at the constant annual inflation rate of two percent.

2.7 General Equilibrium and Debt-Deflation Dynamics under Collateral Constraints

The competitive equilibrium is defined by the sequence $\{c_t, L_t, k_{t+1}, b_{t+1}, v_t, i_t\}_{t=0}^{\infty}$ and prices $\{q_t, w_t\}_{t=0}^{\infty}$ such that the representative household maximizes the intertemporal stationary cardinal utility function, given by $1$, subject to constraints $5$, $6$, and $7$, taking as given the price vector $\{w_t, q_t, R_t\}$ and the initial conditions $\{k_0, b_0\}$. In the case of DNWR the first-order condition for labor (14) is replaced by the wage-setting condition (26).

Wages and the price of capital must satisfy the following conditions:

$$
\begin{align*}
&\frac{\partial N(l)}{\partial L_t} = w_t + \psi_w(s) \left( \frac{w_t}{\bar{w}} \right)^{1-\theta_w} + (1 - \psi_w(s)) \left( \frac{\theta_w}{\theta_w - 1} \frac{w_t^{\text{num}}}{w_t^{\text{den}}} \right)^{1-\theta_w} \\
&\frac{\partial i}{\partial k_{t+1}} = \frac{1}{\bar{L}_t} \\
&\bar{L}_t = L_t \\
&\bar{k}_t = k_t.
\end{align*}
$$

(31)

(32)

(33)

(34)

When the collateral constraint binds, $(\mu_t > 0)$, a wedge, in the form of an external financing premium on debt, emerges (19). There is also an external financing premium on working capital.
3 CALIBRATION AND SOLUTION METHOD

3.1 Parameter Values

The period of the model is annual. The parameters we use in our analysis follow closely those used in Mendoza (2010) and appear in Table 1. The additional parameters, beyond those specified by Mendoza, are for the Calvo wage setting and the liquidity facility equations. The intratemporal elasticity of substitution $\theta$ is usually set at 6. The Calvo coefficient (which measures the percentage of wage setters who are unable to change their wages when wages are falling) is set to 0.6 on the basis of estimates reported in Fagan (2013). These parameters generate a deterministic steady state debt/gdp ratio of 86 percent. We also set the annual world inflation rate 2 percent for the Calvo wage-setting equation. The target or funding facility parameter $\phi$ is set to 0.13. This is based on panel data estimates obtained from a regression of such flows on interest rate spreads in the Euro Area. Finally, for the risk premium, these estimates are the median values obtained by Lim and McNelis (2012).

<table>
<thead>
<tr>
<th>Table 1: Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Utility</strong></td>
</tr>
<tr>
<td>$\sigma_c = 2.0$</td>
</tr>
<tr>
<td>$\omega = 1.846$</td>
</tr>
<tr>
<td>$\gamma = 0.16$</td>
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<tr>
<td><strong>Production</strong></td>
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<tr>
<td>$\alpha = 0.592$</td>
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<tr>
<td>$\beta = 0.305$</td>
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<tr>
<td>$\eta = 0.102$</td>
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<td>$A = 7.389$</td>
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<td><strong>Investment</strong></td>
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<tr>
<td>$\delta = 0.088$</td>
</tr>
<tr>
<td>$\sigma = 2.750$</td>
</tr>
<tr>
<td><strong>TARGET system</strong></td>
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<tr>
<td>$\phi = 0.13$</td>
</tr>
<tr>
<td><strong>Borrowing constraint and Govt.</strong></td>
</tr>
<tr>
<td>$\kappa = 0.225$</td>
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<tr>
<td>$\phi = 0.258$</td>
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<tr>
<td>$\tau_c = 0.168$</td>
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<tr>
<td><strong>Wage Setting</strong></td>
</tr>
<tr>
<td>$\Psi_w = 0.60$</td>
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<tr>
<td>$\theta_w = 6.0$</td>
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<tr>
<td><strong>Stochastic Processes</strong></td>
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<tr>
<td>$\rho_A = 0.57$</td>
</tr>
<tr>
<td>$\rho_R = 0.57$</td>
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<td>$\rho_{RA} = -0.98$</td>
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<td>$\rho_\mu = 0.5$</td>
</tr>
<tr>
<td>$\sigma_A = 0.011$</td>
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<tr>
<td>$\sigma_R = 0.012$</td>
</tr>
<tr>
<td>$\sigma_\mu = 0.038$</td>
</tr>
</tbody>
</table>

3.2 Model Solution Method

Solving models with sudden stops is challenging since these models contain important non-linear processes due to borrowing constraints. The current model incorporates the additional non-linearity, in the form of downward nominal wage rigidity. Solution algorithms based on local approximations (perturbation methods such as log-linearization or quadratic approximation around the deterministic steady state) are not suitable in our case. This is because our primary interest is in what happens when the binding borrowing constraint becomes binding. Such points in the state space are typically far away from the deterministic steady state or even the stochastic mean since the constraint binds only occasionally.

We therefore use a global solution technique within a class of global nonlinear methods which takes into account nonlinearities, in the form of zero lower bounds on the interest rate, asymmetries in the DNWR version of the Calvo model, as well as the

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6 See Mendoza (2010), pp. 1951-53 for a fuller discussion of the parameter selections for this model.
occasionally binding collateral constraints. This paper uses the extended path method originally developed by Fair and Taylor (1983).

4 RESULTS WITH COLLATERAL CONSTRAINTS

We illustrate our model’s implications regarding the effects of a monetary union credit facility using a number of different approaches. We take 100,000 annual observations generated by our stochastic simulations and, emulating the empirical literature on sudden stops, identify particular sudden stop episodes. Following the definition provided by Calvo et al. (2004), we specify that the sudden stop be characterized by a large and unexpected reversal of capital flows and be associated with a contraction in output. We identify a sudden stop episode with two restrictions. First, the change in the net exports to GDP ratio is at least two standard deviations above its mean for at least one year during the episode. Secondly, output is at least one standard deviation below its stochastic mean during the episode.

The results of this exercise are presented in Figure 3. We capture the event dynamics by taking the median values for these episodes, with a normalization factor for each variable at unity one period prior to the sudden stop at time t=0, with the exception of net exports which are normalized at zero.

The solid curves represent the effects of sudden stop with binding collateral constraints in the absence of a monetary union, and the broken curves show the adjustment in a monetary union, when the credit facility is available to members of the union.

We see that the effects on GDP, consumption, investment, Tobin’s Q, and of course, the spread, are greatly mitigated. The net export/gdp ratio rises, but less quickly, and is always slightly lower than the net export/gdp ratio without the funding facility. We varied the specification of the shock processes, with greater volatility in productivity in one set of experiments, greater volatility to world real interest rates in others, but the results were substantially the same.

Figure 3: Adjustment to a Sudden Stop with Binding Collateral Constraints
5 RESULTS: CONTAGION EFFECTS

Bad news happens to countries, whether in the form of collateral constraints becoming binding, setting off a debt/deflation mechanism, or in the form of contagion effects, even if a country has a large positive net foreign asset position, as in the case of Hong Kong.

We show in this case, using the same event dynamics as above, the availability of a large reserve fund, to sustain a credible currency board, greatly mitigates the adverse effects of negative shocks, similar to the way the credit facility funds in a monetary union mitigate the effects of the adverse shocks in a monetary union.

Figure 4 pictures the adjustment with and without support of reserve financing (as Joseph Yam provided at the time of the Asian crisis), when the economy is subject to contagion effects. Following the same methodology as above, in Figure 4, we show the process for GDP and the net export/GDP ratio. As before, the base period is $t=-1$. At the time of the crisis, GDP falls over two years, while the net export/GDP ratios start to rise, as a result of the collateral constraint becoming binding, or the contagion effect. The patterns are similar for GDP, but we see that net exports rise faster in the case of the contagion effects.

We see a similar adjustment, even though there is no binding collateral constraint, endogenously triggered by the fall in Tobin’s Q. Instead the rise in the spread in Figure 4 is exogenously imposed through regional contagion effects.

We see that the drop in GDP, consumption, investment, Tobin’s Q are greatly mitigated, as is, of course, the rise in the spread, with the provision of the credit flows. Unlike the case of the monetary union, where the credit flows are automatic, the credit flows in the currency board arrangement come from a deliberate, discrete policy choice. But the effects are the same as the effects of the endogenous credit facility in the monetary union.

Figure 4: Adjustment to Sudden Stops with Contagion Effects
6 CONCLUSION

This paper compares the adjustment following a sudden stop of two types of countries operating with a fixed exchange rate: a monetary union with an integrated monetary policy and financing system, and a pure peg without such a system. We also compared the adjustment of an economy subject to exogenously imposed contagion effects with that of an economy subject to a borrowing constraint triggered by asset-price deflation. We show that a Hong Kong style arrangement with the availability of large reserves, helps cushion the adverse effects of the contagion effect, much the same way as the monetary union cushions the effects when collateral constraints become binding.

The availability of financing in a monetary union greatly mitigates the adverse effects of a sudden-stop episode on GDP, consumption, and, particularly, investment.

Much of the open economy macro research has focused on the fixed vs. flexible exchange rate regime choice. This paper draws attention to the monetary union as an important third option, and highlights the similarities between sudden stop adjustment with collateral constraints and adjustment due to contagion effects, under a monetary union and currency board.

While the Hong Kong experience with contagion effects, of course, has important differences from the current European experiences of binding collateral constraints under high indebtedness, it offers important lessons for the benefits of a credible monetary union. More to the point, sudden stops can take their toll even on economies which are not highly indebted, and where collateral constraints are not binding, as Hong Kong shows. This paper argues that the transition economies of Eastern Europe fixed to the Euro, Bosnia and Herzegovina, Bulgaria, Latvia and Lithuania, can reap the benefits of the wider union credit facilities, much as Hong Kong reaped the benefits of the currency board and ample stock of reserves during the Asian crisis.
References


and policy in general equilibrium, Chapter 7, pp. 335-405. Cambridge University Press.


Discussion

Dr. Maik Wolters found the paper to be highly relevant and timely for Eastern European countries because the decision of joining a currency union is not easy since it is hardly reversible. The comparison to Hong Kong is worthwhile because there are very few historical episodes of how countries within a currency union managed through a financial crisis. The main finding of the paper is that membership in a currency union is desirable in times of crisis because the cost of the crisis can be mitigated. However, it was not clearly discussed whether joining a currency union is a better alternative to having a fixed exchange rate regime with large currency reserves. In addition, simulations for flexible exchange rate regimes, which is also an important alternative, are absent. Dr. Wolters suggested adding a discussion on the disadvantages of joining a currency union (e.g., the possibility of contagion).

One participant mentioned the importance of looking at the drivers of capital inflows, in particular, the dynamics leading to the crisis, and whether capital is invested in equity or in debt. These considerations will have different implications on the vulnerability of a country.

Another participant proposed to include a discussion on how a currency union would work in the presence of asymmetric shocks. In such a circumstance, countries may want to respond independently or differently from each other.

Dr. Paul McNelis mentioned that the paper may have painted a very optimistic picture of a monetary union, but the paper has indicated that the frequency of crisis is actually higher in a monetary union although less severe. Furthermore, accounting for asymmetric shocks could be a way to expand the model, but will make it more complex.

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13 Dr. Maik Wolters of University of Kiel was the discussant of the paper.
Decomposing Capital Flows and Assessing the Impact of Capital Flows on the Asset Markets: Empirical Evidence from the ASEAN-4 Countries

Nur Ain Shahrier and Chuah Lay Lian

International capital flows played an increasingly important role in the business cycles of high-income and middle-income countries, especially during the episodes of financial crises. Undeniably, the benefits of capital inflows are debatable but one main challenge the policy maker has is the liquidity that could potentially cause asset price booms and the creation of asset bubbles. In this context, the first part of the paper decomposes capital flows to ASEAN-4 countries into bank-led, debt-led and equity-led flows, and identifies the periods of “surge”, “stop”, “flight” and “retrenchment”. The second part of the paper establishes the link between the pattern of capital flows and asset price cycles. While findings show that capital flows have a small impact on asset price boom and subsequently the bust of the asset price cycle after eight quarters; it has however, shown that excessive deviations of house prices from its underlying fundamentals cause imbalances in the asset market.

JEL Codes: F3, E6, F5
Keywords: Capital flows, asset bubble

1 INTRODUCTION

Flows in the capital and financial accounts of Asian countries in the recent decade have displayed an unpredictable pattern and painted mixed picture in the balance of payments. Ten years after the Asian Financial Crisis (AFC) 1997/98, private sector external debt repayments are nearing the end. Portfolio inflows, in particular equity inflows started to gain its importance in the Asian countries, providing a source of capital but at the same time raising the risk of a sudden liquidation of non-resident holdings in local equity markets. Since 2000, Asian countries across the board have been major net exporters of capital, in the form of substantial outflows of portfolio debt and equity investment as well as direct investment. The IMF places China, Japan and Singapore as the top three Asian countries that export capital, constituting 28.5 percent of all countries that export capital to the rest of the world, the remainder being major oil exporters, including Russia, Saudi Arabia, Kuwait, United Arab Emirates and Venezuela.

Following the Lehman failure during Global Financial Crisis (GFC) 2008/09 and the implementation of unconventional monetary policy and the introduction of several rounds of quantitative easing (QE) by a few of the advanced economies have led to massive injection of liquidity into the emerging market economies (EMEs). For instance, the Fed’s balance sheet grew by roughly four times between December 2006 and August 2013 (Chart 1). At the same time, Bank of England’s balance sheet expanded by six times while, ECB and Bank of Japan expanded by roughly two times. Cumulatively, global liquidity2 increased from USD7.3 trillion in 3Q 2008 to about USD 10 trillion in 1Q 2013 (Chart 2).

On the contrary, the EMEs including Asia, started to experience faster economic growth (Chart 3) and higher interest rates than in the US, leading to wider interest rate

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1 Economics Department, Bank Negara Malaysia; correspondence: llchuah@bnm.gov.my, ainshah@bnm.gov.my
2 Global liquidity is proxied as GDP-weighted M2 of US, Euro area, Japan and UK.
differentials. These factors along with the QE led to large capital flows into the region since late 2008. For example, Korea received net portfolio inflows of USD149 billion, Malaysia, USD71 billion, and the Philippines, USD19 billion, between 2009 and 1Q 2013. This is also reflected in the rise of international cross border lending to Asia, in tandem with the rise in global liquidity (Chart 4).

Strong capital inflows bring benefits as well as challenges to the emerging economies. The foreign funds are alternative sources of financing in addition to domestic sources. However, one of the substantial challenges to policymakers of the surge in capital inflows is the acceleration in housing prices resulting in bubbles in property markets. In Asia, households’ credit grew at double-digit levels in most economies (Chart 5) and residential property prices in many EMEs have risen significantly (Chart 6).
Policymakers believe that large capital inflows are associated with sharp increases in asset prices and resulting in a higher risk of financial crisis. Works by Krugman (1998), Caballero and Krishnamurthy (2006), Korinek (2010a, b) and Adam et al. (2011) generally provide support to the general view that capital inflows are associated with periods of persistent deviations of prices from their fundamental values. Capital inflows enter the economy and causes financial imbalances by fuelling liquidity which may lead to credit booms and stronger demand for assets. In turn, the higher demand for assets leads to higher asset prices and this makes the financial conditions of the economy appear to be sound as booming conditions are likely to attract new rounds of capital inflows. This circular process which pushes asset prices even higher is building up financial vulnerabilities which at that point in time may not be evident to the policy makers.

Against this backdrop, the central objectives of this paper can be divided into two distinctive parts. Part 2 presents a set of graphical evidence that is related to the profile of capital flows to the ASEAN-4 (Malaysia, Indonesia, Philippines and Thailand). In particular, the first part of the paper shows the: (i) composition of bank-led flows, debt-led flows and equity-led flows into Asean-4 pre- and post-GFC; (ii) period of capital “surge”, “stop”, “flight” and “retrenchment” episodes over the past decades. Part 3 presents empirical evidence on the impact of capital flows on asset market, specifically attempting to answer the questions on (i) the link between capital flows of non-residents and the periods of boom and bust of asset prices and; (ii) the probability of booms and busts in the asset markets as consequences of financial imbalances. In identifying the compositions of capital flows and its relationship with the asset markets, the policy makers will be able to design policies that can dampen the excessive degree of overheating in asset markets and prevent the negative effects from spilling over to the real economy.

2 PROFILE AND THE DECOMPOSITION OF CAPITAL FLOWS TO THE ASEAN-4 COUNTRIES

2.1 Definition and the construction of bank-led flows, debt-led flows and equity-led flows
In this part, we decompose the capital flows into three types: bank-led flows, equity-led flows and debt-led flows. Most of the data is obtained from CEIC and balance of payment accounts of individual countries as shown in Table 1 below.

<table>
<thead>
<tr>
<th>Gross Inflows</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Equity-led Flows</strong></td>
<td></td>
</tr>
<tr>
<td>Direct Investment</td>
<td>CEIC: Financial Account: Direct Investment in Reporting Economy</td>
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<tr>
<td><strong>Debt-led Flows</strong></td>
<td></td>
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<tr>
<td><strong>Banking-Led Flows</strong></td>
<td></td>
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<tr>
<td>Other Liabilities</td>
<td>CEIC: Financial Account: Other Investment: Liabilities: Other Liabilities</td>
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</tbody>
</table>

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<tr>
<th>Gross Outflows</th>
<th>Source</th>
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<tbody>
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<td></td>
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<tr>
<td>Direct Investment</td>
<td>CEIC: Financial Account: Direct Investment Abroad</td>
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<tr>
<td><strong>Debt-led Outflows</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Banking-Led Outflows</strong></td>
<td></td>
</tr>
</tbody>
</table>
The analysis is on a quarterly basis, starting from 1Q 1995 to 1Q 2014. We define the three types of flows as follows:

- **Equity-led flows** = Direct investments + Equity portfolio investments
- **Debt-led flows** (excluding banking flows) = Debt securities in portfolio investments + Other investments pertaining to non-banking sectors (excluding financial derivatives)
- **Bank-led flows** = Currency and Deposits + Loans + Other liabilities (excluding financial derivatives)

### 2.2 Identifying the periods of capital “surge”, “stop”, “flight” and “retrenchment” episodes in the past decades

This paper adopts the Forbes and Warnock (2011) approach, focusing on gross capital flows instead of net capital flows. The use of gross capital flows allows us to differentiate between capital movements that are initiated by the non-residents or foreigners and those by domestic investors. Studies in the literature which focus on net capital flows cannot explain the volatility in capital inflows and outflows, and therefore cannot differentiate the behavioral changes between the domestic and foreign investors.

To identify the prolonged episodes of extreme capital flows, we use quarterly data for gross inflows and gross outflows as described in the previous section. The extreme gross capital flows refer to the period when domestic or foreign investors significantly increase or decrease capital inflows or outflows more than the historical levels (Forbes and Warnock (2011)). These episodes are classified into four types:

- “Surges” – an episode when gross capital inflows increase sharply
- “Stop” – an episode when gross capital inflows decrease sharply
- “Flight” – an episode when gross capital outflows increase sharply
- “Retrenchment” – an episode when gross capital outflows decrease sharply

The periods of surges and stops are typically driven by foreign investors whereas the period of flight and retrenchment are driven by domestic investors (Forbes and Warnock (2011)). To identify these episodes, we first calculate the four quarter moving average sum of gross capital inflows and outflows. The flows are the summation of equity-led, debt-led and bank-led inflows and outflows, respectively. Finally, we calculate the year-on-year change of these sums. Using the following criteria by Forbes and Warnock (2011), we identify the different episodes according to the following criteria:

- The current year-on-year change in the four-quarter moving average of gross capital inflows and outflows is above or below two standard deviations of the historical average; and
- The year-on-year change in the four-quarter moving average of gross capital inflows and outflows is above or below one standard deviation of the historical average and it lasts for all consecutive quarters

Tables 2–5 in the succeeding pages provide the summary of “Surge”, “Stop”, “Flight” and “Retrenchment” episodes in ASEAN-4.
Nur Ain Shahrier and Chuah Lay Lian

### Table 2: Summary of “Surge” Episodes in ASEAN-4

<table>
<thead>
<tr>
<th>“Surge” Episodes</th>
<th>Indonesia</th>
<th>Malaysia</th>
<th>Philippines</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-AFC</strong></td>
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<td></td>
<td></td>
<td>Banking (1Q 1995)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Debt (2Q 1995-1Q 1996)</td>
</tr>
<tr>
<td><strong>Post-AFC</strong></td>
<td>Debt (4Q 1998), Equity (1Q – 2Q 1999)</td>
<td></td>
<td>Debt (1Q-3Q 1999)</td>
<td></td>
</tr>
<tr>
<td><strong>Pre-GFC</strong></td>
<td>Debt (3Q -4Q 2007)</td>
<td>Equity (4Q 2006-2Q 2007)</td>
<td>Equity (1Q-2Q 2007)</td>
<td></td>
</tr>
</tbody>
</table>

### Table 3: Summary of “Stop” Episodes in ASEAN-4

<table>
<thead>
<tr>
<th>“Stop” Episodes</th>
<th>Indonesia</th>
<th>Malaysia</th>
<th>Philippines</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-AFC</strong></td>
<td>Banking (4Q 1996)</td>
<td></td>
<td>Equity (2Q-3Q 1997)</td>
<td>Banking (3Q-4Q 1996), Debt (Q1-Q2 1997)</td>
</tr>
<tr>
<td><strong>During GFC</strong></td>
<td>Equity (1Q 2009), Debt (2009Q2)</td>
<td>Debt (3Q 2008-2Q 2009)</td>
<td>Equity (1Q-2Q 2008), Debt (3Q-4Q 2008)</td>
<td>Equity (4Q 2008), Debt (1Q 2009)</td>
</tr>
</tbody>
</table>
Decomposing Capital Flows and Assessing the Impact of Capital Flows on the Asset Markets: Empirical Evidence from the ASEAN-4 Countries

Table 4: Summary of “Flight” Episodes in ASEAN-4

<table>
<thead>
<tr>
<th>“Flight” Episodes</th>
<th>Indonesia</th>
<th>Malaysia</th>
<th>Philippines</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-AFC</td>
<td>Equity (4Q 1996)</td>
<td></td>
<td>Banking (1Q-2Q 1997)</td>
<td>Banking (1Q 1996)</td>
</tr>
<tr>
<td>During GFC</td>
<td>Equity (1Q 2009), Debt (2Q 2009)</td>
<td>Banking (3Q 2009)</td>
<td>Debt (2Q-3Q 2008)</td>
<td>Banking (3Q 2009), Debt (4Q 2009-1Q 2010)</td>
</tr>
<tr>
<td>Post-GFC</td>
<td>Debt (1Q 2010, 3Q 2011), Equity (4Q 2011), Banking (1Q-2Q 2012)</td>
<td>Banking (1Q 2010, 1Q2014)</td>
<td>Equity (2Q 2012-3Q2012), Banking (1Q 2014)</td>
<td>Banking (1Q 2014)</td>
</tr>
</tbody>
</table>

Table 5: Summary of “Retrenchment” Episodes in ASEAN-4

<table>
<thead>
<tr>
<th>“Retrenchment” Episodes</th>
<th>Indonesia</th>
<th>Malaysia</th>
<th>Philippines</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-GFC</td>
<td>Banking (3Q-4Q 2006)</td>
<td></td>
<td>Debt (1Q 2006)</td>
<td>Banking (1Q 2007)</td>
</tr>
</tbody>
</table>
2.3 Debt-led flows, equity-led and bank-led flows for ASEAN-4 pre- and post-GFC:

2.3.1 Portfolio Debt Inflows

From charts 7-10 (next page), we observe that portfolio debt inflows have been gaining significant momentum and importance in the aftermath of GFC. The gradual shift from equity portfolios to debt instruments reflects the possibility of countries actively financing their fiscal deficits from the domestic debt markets.

- In Malaysia, the highest non-resident holdings prior to GFC (1Q 2002 – 3Q 2008) were in equity instruments (70 percent) followed by the banking instruments (35 percent) and debt instruments (-5 percent). The large liquidation of debt and equity instruments happened in 1Q 2008 – 2Q 2009. The post crisis period (4Q 2008 – 1Q 2014) showed a significant increase of bond holdings to 64 percent while equity holdings declined to 60 percent.

- In Indonesia, there were almost negligible non-resident holdings of debt instruments compared to about 100 percent of equity holdings prior to GFC (1Q 2000- 3Q 2008). During the period of GFC, surprisingly there was no liquidation recorded but significant debt holdings were liquidated in 2Q 2006 in response to 425 basis point hikes in the benchmark interest rate in the earlier period.\(^3\) During the period after the crisis (4Q 2008 – 1Q 2013), there were significant increases of 57 percent in debt holdings while equity holdings dropped to 68 percent.

- In the Philippines, non-resident holdings of debt liabilities prior to GFC (1Q 2000 – 3Q 2008) stood at only 4 percent compared to 91 percent for equity holdings. During the height of the crisis (1Q 2008 – 2Q 2009), there was a significant liquidation of debt holdings relative to equity and banking instruments.

- In Thailand, between 4Q 2008 – 1Q 2009 at the height of the crisis period, there was a significant liquidation of debt instruments. In period post the crisis (1Q 2009 – 4Q 2013) there was a 36 percent decline in equity instruments and an increase in the banking (31 percent) and debt instruments (29 percent).

The significant increase in debt liabilities post-AFC can be attributed to the evolution of local currency bond markets in the Asian capital market. The establishment of the Asian Bond Market Initiative (ABMI) launched by ASEAN+3 in 2004 has encouraged long-term financing, hence removing the double mismatch problems in the bond market that arose during the 1997 Asian Financial Crisis. As of June 2013, Asia’s\(^4\) outstanding local-currency bonds amounted to USD6.8 trillion. While the governments are still the major issuers of debt in Asia (Chan et al., [2010]), the past five years have shown Asian corporations increasingly tapping into the international bond markets. According to Financial Times,\(^5\) Asian borrowers’ corporate debt issuances will exceed North America and Europe combined in 2016 due to strong issuances from corporations in Singapore, Hong Kong, China and India.

In summary, a broad observation from this discussion is that: (i) during the period of the crisis (3Q 2008 – 2Q 2009), there was significant liquidation or withdrawal of debt holdings and; (ii) there has been a visible shift of investors’ appetite from equities to debt instruments post-GFC for the ASEAN-4 countries.

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\(^3\) The interest rate hike was between 2005Q1-2006Q2.

\(^4\) Asia included People’s Republic of China, Hong Kong, China, Indonesia, the Republic of Korea, Malaysia, the Philippines, Singapore, Thailand and Vietnam.

2.3.2 Portfolio Debt Outflows

Charts 11-14 show a mixed profile of portfolio flows across ASEAN-4:

- In Malaysia, the portfolio debt and equity outflows showed an equal contribution of approximately 40 percent to total outflows prior to GFC (1Q 2000 – 1Q 2008). For two quarters prior to the collapse of the Lehman Brothers (1Q 2008 – 2Q 2008), there was significant liquidation of all instruments abroad by Malaysian residents (about 11 percent each).

- In Indonesia, the portfolio debt outflows were the bulk of Indonesia’s total gross outflows both before and after GFC, registering at 55 percent from 1Q 2004- 2Q 2008 and 50 percent between 3Q 2008 – 1Q 2013 respectively. The equity outflows were 41 percent pre-GFC and 18 percent post-GFC. The positive portfolio debt outflows in 1Q 2007, 3Q 2009 and 2Q 2012 showed significant liquidation debt holdings abroad by residents.

- In the Philippines, the outflows prior to the period of AFC (1Q 1995 – 2Q 1997) were mainly bank-led outflows. In the aftermath of AFC, the residents’ portfolio debt holdings abroad had increased significantly to about 50 percent of total gross outflows relative to their equity holdings abroad of only 26 percent and
bank holdings of 24 percent. During 1Q 2008 – 2Q 2008, there was a spike in the liquidation or withdrawal of debt instruments abroad by the Philippine residents, probably due to the anticipation of the crisis in the US and Europe.

- In Thailand, in the period prior to AFC (1Q 1994 - 1Q 1997), there was a portfolio debt outflow of about 14 percent compared to equity outflows of 71 percent and banking outflows of 15 percent. In the aftermath of the crisis (3Q 1997 – 4Q 1999), the bulk of residents' portfolio assets were in banking instruments, either in the form of currency, deposit or loans. The bank-led flows made up almost 100 percent of total gross outflows post-AFC. The positive value of bank-led outflows in the form of currency and deposits indicated that banks were either withdrawing their deposits and currency from other institutions or banks were receiving deposits and currency into their accounts that they entered as assets in the banks’ balance sheets. Unlike pre-AFC, the period prior to GFC (1Q 2000 – 2Q 2008) Thailand experienced 65 percent portfolio debt outflows relative to only 26 percent of equity outflows and 9 percent of banks outflows. During the GFC (3Q 2008), Thailand’s gross outflows showed a big spike, especially in the debt securities, implying the liquidation of debt holdings abroad by Thailand’s residents. In the aftermath of the GFC (4Q 2008 – 1Q 2014), the bulk of Thailand’s gross outflows was in the form of equity flows (58 percent) relative to debt flows (28 percent) and banking flows (15 percent).

Source: BIS Consolidated Banking Statistics, IMF, IFS, BNM staff calculations.
Mitra and Azis (2012) estimated that ASEAN-5 countries have accumulated USD381 billion of portfolio debt assets abroad in 2008 compared to only USD74.3 billion in 2001. This constituted almost 97 percent and 89 percent of their total portfolio investment assets. Meanwhile, the debt assets invested in the ASEAN-5 was only USD12.8 billion in 2008 and USD4 billion in 2001, equivalent to 7.3 percent (2008) and 11 percent (2001) of total portfolio investment.

Across these countries, the two main observations from the capital outflows data are: (i) there was liquidation or withdrawal of debt instruments abroad held by the ASEAN-4 residents at the early stage of GFC (1Q 2008- 3Q 2008) and; (ii) in the post-GFC period, there was an increase in residents’ holdings of portfolio debt assets abroad. These observations appear to be consistent with Mitra and Azis’ (2012) estimation of an accumulation of USD381 billion of portfolio debt assets abroad by the ASEAN-5 countries in 2008 (2001: USD74.3 billion).

2.3.3 Equity Portfolio Trends

Portfolio equity investment inflows are significant flows for the ASEAN-4 countries, particularly, for periods prior to GFC. Between 1Q 2001- 3Q 2008, the portfolio equity investment recorded staggering inflows of 99 percent of total portfolio inflows in Indonesia, 91 percent in Philippines, 76 percent in Thailand and 70 percent in Malaysia. Economic restructuring after the AFC may have contributed to the larger equity market capitalisation in Asia. The total equity market capitalisation in Asia was USD14 trillion at end-2006 which is two and a half times higher than at end-1997. While higher non-resident participation in domestic equity markets allows sovereign borrowers to reduce the amount of foreign-currency risk on their balance sheets, a sudden liquidation of non-resident holdings in local equity markets could generate capital outflows.

As Asian bond markets gained importance among the regional countries, Charts 7-14 show the significant reversal of investors’ appetite, in particular a shift to portfolio debt instruments. The portfolio equity invested in ASEAN-5 countries was only USD12.1 billion in 2008 compared to USD8.2 billion in 2001. This represented a decline of 17ppt. in portfolio equity holdings, from 24.8 percent of total equity security portfolio investments inside and outside ASEAN-5 in 2001 to 7.2 percent in 2008.

In terms of equity outflows, large cumulative equity portfolio investments abroad were registered by residents of Malaysia (1Q 2002 - 1Q 2014) and Thailand during both pre- and post-GFC (1Q 2000 – 1Q 2014). The holdings of equity instruments abroad are second to the holdings of debt instruments for Indonesia and the Philippines. The equity holdings abroad during the pre-GFC period were 41 percent for Indonesia, 48 percent for Malaysia, 26 percent for the Philippines and 65 percent for Thailand. During the post-crisis period, the equity holdings abroad were 18 percent in Indonesia, 50 percent in Malaysia, 39 percent in Philippines and 58 percent in Thailand. The equity holdings abroad could be attributed to the residents’ investment in foreign mutual funds and higher portfolio investment by companies pursuing higher returns. Furthermore, asset management companies and major state sovereign funds could have also diversified their portfolio overseas.

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6 ASEAN-5 comprises of Indonesia, Malaysia, Philippines, Singapore and Thailand.
2.4 Identification of the periods of “surge”, “stop”, “flight” and “retrenchment”

As explained in section 1.2, we have defined these episodes as an increase or decrease in the average year-on-year change of moving average capital inflows that have exceeded two standard deviations or one standard deviation for a few consecutive quarters. The following charts 15-22 show the “surge” and “stop” in the gross capital inflows and “flight” and “retrenchment” in the gross capital outflows.

Chart 15: Periods of “Surge” and “Stop” for Malaysia

Chart 16: Periods of “Retrenchment” and “Flight” for Malaysia

Chart 17: Periods of “Surge” and “Stop” for Indonesia

Chart 18: Periods of “Retrenchment” and “Flight” for Indonesia

Source: BIS Consolidated Banking Statistics, IMF, IFS, BNM staff calculations.
The “surge” episodes pre-AFC is only evident for Thailand and they comprise mainly of bank-led flows and debt-led flows. Post-AFC period, the “surge” episodes for Indonesia and Philippines were mainly debt and equity-led portfolio investments. During the period prior to GFC, the “surge” episodes were seen across all the countries, with the exception of Thailand. The surges for this period were a combination of debt and equity flows.

Unlike the “surge” episodes during pre-AFC which was only evident for Thailand, the “stop” episodes were experienced by all the ASEAN-4 countries. The flows were a combination of debt, equity and banking flows. The “stop” episodes represent the liquidation or withdrawal of domestic assets by non-residents and appear as negative values in the liabilities portion of the balance of payments. However, during the period of GFC and post-GFC, it is evident that these “stop” episodes are led mainly by sharp
decreases in both debt and equity inflows. The sharp decreases in bank-led inflows are more evident for the Philippines and Thailand during the GFC period.

Meanwhile, the “flight” episodes for Thailand and Malaysia were led mainly by banking outflows. This reflects the increased in the holdings of banking instruments abroad by the residents of these countries. On the other hand, Indonesia and the Philippines showed a combination of the three types of different flows. The “retrenchment” episodes are when the residents liquidate or withdraw their holdings abroad. The main driver of such episodes during the pre-GFC until the present period was the sharp decreases in banking and debt inflows.

From the analysis of the “surge”, “stop”, “flight” and “retrenchment” episodes, there are three key findings: (i) the sharp increase in debt-inflows has led to surge episodes post-GFC across ASEAN-4; (ii) the flight episodes in Thailand and Malaysia were mostly in the form of banking-led outflows; and (iii) the retrenchment episodes during the pre- and post-GFC were mostly in the form of bank-led and debt-led outflows for all the ASEAN-4 countries.

3 THE RELATIONSHIP BETWEEN CAPITAL FLOWS AND BOOM-BUST CYCLES OF ASSET MARKETS

The potential link between capital inflows and booms in asset prices is extensively researched using a variety of theoretical models. The mechanics of the theoretical models supported the diverse arguments on the chain of causation and propagating channels of asset price booms. For example, Krugman (1998) develops a simple model where financial intermediaries propagated the asset price booms. In his model, moral hazard encourages financial intermediaries with implicit government guarantees to take excessive risks in lending. The risky lending pushes asset prices and starts circular process in which financial conditions of intermediaries seem better than they actually are and therefore promotes more borrowing and lending that in turn pushes asset prices even higher. This creates a boom in asset prices. Optimistic demand conditions tend to attract inflows which fuels liquidity in the economy and may lead to credit booms and stronger demand for assets. In turn, the higher demand for assets leads to higher asset prices and makes the financial conditions of the economy appear to be sound as booming conditions are likely to attract new rounds of capital inflows.

The main concern is that these capital inflows tend to be temporary as they can reverse due to the changes in external economic conditions, such as the changes in the policy stances of advanced economies. When capital flows reverse suddenly, the boom phase of credit and asset prices may suddenly be turned into a bust phase following asset bubble dynamics. As a result, economies may suffer from serious financial and economic crisis.

While there are many persuasive arguments on the destabilising nature of large capital inflows, it is thus far, according to Reinhart and Reinhart (2008) been “a discussion and some anecdotal evidence suggesting that asset prices boom during capital inflows bonanzas” but robust cross-country empirical evidence is yet to be systematically documented.

Therefore, in Part 3 of this paper we attempt to establish the link between capital flows of non-residents and periods of booms and bust of asset prices for ASEAN-4 countries. In doing so, the policy makers will be able to design policies that can dampen the excessive degree of overheating in asset markets and, therefore, prevent the negative effects of spillovers into the real sectors.
Decomposing Capital Flows and Assessing the Impact of Capital Flows on the Asset Markets: Empirical Evidence from the ASEAN-4 Countries

However, to do this, we need a reliable indicator that takes into account the developments in both stock and property prices, and provides reliable signals for the boom-bust cycles of the asset market. In principle, the analysis and the monitoring of the developments in asset prices for policy purposes will cover three steps. First, is to define and identify the asset price boom and bust periods. Booms and busts are then selected as episodes when constructed asset price index deviates excessively from the threshold values implied by economic fundamentals. The second step aims at finding a relationship between the periods of boom and bust with macro and financial variables such as output gap, house price gaps, credit growth and capital flows. Finally, drawing from the historical relationship between the boom and bust periods, and these indicators, derive the probabilities of the boom and bust for each period.

The structure of Part 3 is as follows. Part 3.1 discusses some stylised trends of asset prices and capital flows for the ASEAN-4 countries. Part 3.2 covers a discussion on methodology of the construction of the asset price index and identification of threshold for signals. Part 3.3 presents a discussion on the results of the panel probit model which is used to map the relationships between the boom-bust periods (identified using constructed asset price index in Part 3.2) with the deviation of the fundamental drivers of asset prices, namely, the output gap, and the house price gap. The paper concludes with a summary of the findings from Parts 2 and 3 and draws some lessons for policy purposes.

Empirical Evidence of the Relationship between Capital Flows, Macro Fundamental Gaps and Asset Prices

3.1 Stylised trends of Capital flows and Asset Price Indices

Charts 23-26 are time plots of the constructed asset price indices for the ASEAN-4 countries with the net capital flows of non-residents. In the case of Malaysia and Thailand, the asset price indices peak prior to the Asian Financial Crisis (AFC) and they plunge after the AFC. For Thailand, the role of capital flows is more evident as the sharp decrease in asset prices coincided with the liquidation of capital by non-residents. A similar pattern of asset price buildup is also seen across the ASEAN-4 countries during periods prior to the GFC. The decline in asset prices also coincides with the liquidation of capital for all countries except Indonesia.
3.1.1 Relationship between Asset Price Gaps and Periods of Capital Surge and Flight

The time plots for periods of capital “surge” and “flight”\(^7\) defined in Part I and asset price gaps are shown in Charts 27-30. The periods of surges of capital flows into Malaysia in 2006/07 were mainly led by equity flows and this was followed by an economic downturn in 2009. There was also similar pattern for the Philippines which experienced a surge in equity flows during the same period. In the case of Thailand and Indonesia, the surge in capital flows occurred earlier in 2005 and these flows were a mixture of equity and debt-led flows. The timing of the surge in capital flows appeared to occur prior to GFC and capital liquidation seemed to happen during the periods of an economic slowdown. For example, Malaysia experienced bank-led outflows in the second half of 2009. The Philippines experienced debt-led outflows in the middle of 2009 when its economy was growing on a slower pace of 1.1 percent.

Furthermore, the timing of the surges in capital flows tends to coincided with the positive build-ups in asset prices. For Malaysia, the asset prices were already building up in the later part of 2006. Similar positive buildups in asset prices were also seen across the other ASEAN countries, where deviations were apparent as early as 2005. On the other hand, the negative asset price gaps, which coincided with the slowdown in economies across the region, occurred during periods of liquidation of capital. Similarly, the Philippines also experienced positive price gaps during the periods when there were surges in debt and equity flows. The subsequent negative price gaps in 2010 appeared to coincide with the period of debt outflows.

In the case of Thailand, the buildup in asset prices before the Asian Financial Crisis matched the period of surges in debt and banking flows, and the bank-led outflows during the mid-1997 were followed by periods of negative asset price gaps.

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\(^7\) Periods of capital surge is indicated as “+1” and periods of capital flight as “-1”.

Source: BIS Consolidated Banking Statistics, IMF, IFS, BNM staff calculations.
3.2 Constructing the Asset Price Index and Defining Asset Boom-Bust Periods

In this section, we focus on some of the preliminary evidence of the identification of periods of excessive asset price leading up to the bust period. In the identification process, asset price misalignments are detected from deviation of a constructed “composite asset price indicator” which comprises of the stock market index and the housing price index. The intention of basing our analysis on a “composite” asset price index is that such an index would contain information on financial asset price movements and be able to signal financial imbalances over time.

Source: BIS Consolidated Banking Statistics, IMF, IFS, BNM staff calculations.
The construction of composite asset price index follows the Conference Board approach where the symmetric growth rates are calculated for both the house price and the stock price indices. The volatilities of the two indices are then calculated from the symmetric growth rates. These indices are combined based on the weights of the inverse volatility of each index. In taking this approach, the index which is more volatile will not dominate the index which is less volatile in the combined composite index. The values of the combined indices are adjusted and standardized according to the average growth trend. After which, the values are converted into an index recursively throughout the sample from the starting value of 100. The index is rebased to 2005 =100.

In the literature, there are several approaches that can be used to identify asset price booms. Borio and Drehmann (2009) define a boom as a period in which the three-year moving average of the annual growth rate of asset prices is greater than the average growth rate or its mean plus a multiple of 1.3 (in an example of a specific case) of the standard deviation of the growth rates. However, Alessi and Detken (2009) take a different approach as they calculate the trend of the price variable using the one-sided Hodrick-Prescott filter and then calculate the gap between the actual values of the price variable and its trend.

In our case, we identify the emergence of an asset price boom as an excessive deviation of the composite asset price index from its long-term trend. The long-term trend is derived from the 2-sided Hodrick-Prescott filter which produces a more reasonable asset price gap estimates compared to its 1-sided filter. The excessive deviation is determined by testing various thresholds that can produce the best signal-to-noise ratio for periods of eight quarters ahead of the decline of a business cycle. In other words, the composite asset price index is expected to have some leading indicator properties that can be used as an early warning indicator to detect an asset price bust.

In line with this, we define a new “boom dummy” \( DUM_t \) as follows:

\[
DUM_t = \begin{cases} 
1 & \text{iff Asset Price Gap}_t > \text{Threshold of Asset Price Gap}_t \\
0 & \text{otherwise} 
\end{cases}
\]

where the signaling horizon is defined as the period within which the indicator would be expected to be able to signal an asset price boom up to eight quarters ahead of a crisis. As such, a signal that is followed by a boom within two years is considered as a “good” signal, while a signal not followed by a crisis within that interval of time is called a “false” signal.

Chart 31 summarises the behaviour of the composite asset price gap and the corresponding boom-bust episodes for Malaysia. Note that the booms seem to be concentrated around three main periods prior to the two major economic downturns. The first period shows a buildup of price gap beginning 1996, which peaked in 4Q 1996. Eventually, the positive gap disappeared when the economy went into a recession in 1Q 1998. The second period shows a buildup starting from 1Q 2007, and a peak at 1Q 2008. This price gap turned negative in 3Q 2008 before the economy went into a recession in 1Q 2009.

The asset prices appear to build up at around similar periods for the ASEAN-4 countries, namely during periods prior to the two major crises, the AFC and the GFC (Chart 32). However, Thailand and Malaysia appeared to show the strongest asset price booms during 1996 while Indonesia experienced a milder boom. As the asset price misalignments were the strongest for Malaysia and Thailand, they also experienced the strongest decline in asset prices during the AFC. A similar asset price gap pattern is also seen during periods leading up to GFC. However, Thailand experienced a longer and
persistent buildup in asset prices which started in 2003 while asset prices in the other countries only started showing positive price gaps in 2006.

3.2.1 Calculating the Noise-to-Signal Ratio for an Identified Threshold Level

We consider a signal for the composite asset price index, $DUM_t$, that takes the value 1 if a crisis is signaled within eight quarters, and 0 otherwise. A crisis signal is detected when this index deviates from its usual values beyond a certain threshold. To define the optimal value of the threshold asset price gaps, we proceed as follows. We consider the following events:

A: The index predicts a crisis and the crisis occurs within eight quarters (good signal)
B: The index predicts a crisis, but no crisis occurs during the signaling period (false crisis signal)
C: The index does not predict a crisis, but a crisis occurs (missed crisis signal or false calm signal)
D: The index does not predict a crisis and no crisis occurs (good signal)

The performance of the index with a predetermined threshold can be summarised in Table 6:

<table>
<thead>
<tr>
<th>Signal issued</th>
<th>Bust within 8 quarters</th>
<th>No bust within 8 quarters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal issued</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>No signal issued</td>
<td>C</td>
<td>D</td>
</tr>
</tbody>
</table>

The performance of the index is measured as the proportion of the false signals to the correct signals. This proportion termed as the noise-to-signal ratio is used to gauge the appropriate thresholds for the indicator. Based on this approach, threshold of 3 percent of the asset price gap gives the lowest noise-to-signal ratio of 0.09 for Malaysia. The thresholds and the noise-to-signal ratios for the other ASEAN countries are shown in Table 7.
Table 7: Asset Price Gap Threshold and Noise-to-Signal Ratio

<table>
<thead>
<tr>
<th>Asset Price Gap Threshold</th>
<th>N-t-S Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 percent</td>
<td>0.09</td>
</tr>
<tr>
<td>0.8 percent</td>
<td>0.21</td>
</tr>
<tr>
<td>1.2 percent</td>
<td>0.17</td>
</tr>
<tr>
<td>1.5 percent</td>
<td>0.49</td>
</tr>
</tbody>
</table>

Chart 33 depicts the setting of the threshold of 3 percent is able to pick up periods of asset price booms which are followed by periods of bust for Malaysia, for example, the index signaled eight periods prior to the recession in 1998. Similarly, there were signals prior to the recession in 2009. The signaling patterns for the other ASEAN countries are depicted in Charts 34-36, where the signals were seen for periods prior to the two major crises, namely the AFC and the GFC.
Decomposing Capital Flows and Assessing the Impact of Capital Flows on the Asset Markets: Empirical Evidence from the ASEAN-4 Countries

3.3 Probit for Panel Data Approach

3.3.1 The Probit Model and Sources of Data

The empirical analysis in this paper adopts the probit estimation technique for panel data. The probit equation takes this general form:

\[ \left( CI_{it} = 1 \right) = \alpha + \beta X_{it} + \epsilon_{it} \]

where \( X_t \) consists of the fundamental variables and \( \epsilon_t \) represents the error term. The fundamental variables include deviations of real and financial variables from its long-term trend namely, the output gap, housing price gap and real effective exchange rate (reer) gap. Other fundamental variables include credit growth, real interest rates and capital flows.

The gross domestic product (GDP), real effective exchange rate (reer), exchange rates, credit growth, interest rates and consumer price indices are obtained from the International Monetary Fund (IMF) database. The house price indices for Indonesia, the Philippines and Thailand are obtained from the Bank of International Settlements (BIS) database. The yearly net capital flows is obtained from the World Bank database and then spliced into a quarterly series using Eviews. All data for Malaysia excluding capital flows data are obtained from Haver Analytics. The capital flows data for Malaysia is also taken from the World Bank database.

Applying probit techniques for quarterly data set from 1Q 1993 to 4Q 2013 enables us to estimate the probability of occurrence of an asset price boom in the next eight quarters. The assessment of whether a boom will occur or not depends on the subjective choice of a threshold that would give a signal of a boom that leads to a bust in the next eight quarters. While, the decision on the threshold is subjective, it is consistent with the literature which describes ways of choosing the “correct” threshold.

3.3.2 Results of the Probit Model for ASEAN-4 Countries

The results from the probit model show that the deviations of fundamental variables from their long-term trend increase the probability of asset price imbalances. In this case, increases in the reer gap, the house price gap and the output gap tend to increase the probability of an asset price misalignment by 0.06, 0.38 and 0.40, respectively, for the ASEAN-4 countries. The results (Table 8) show that the house price gap which is indicative of imbalances in the property sector has the second biggest impact on probability of a downturn in the asset markets in eight quarters going forward.

In addition to the gap variables, the increases in credit growth have a positive and significant effect on the probability of asset price booms. However, the hypothesis that capital flows tend to also increase the probability of asset price booms is proven true in this case, but its impact is found to be very small. The relationship may be weak as the net capital inflows used in the estimation have offsetting effects of capital accumulation and liquidation of assets by non-residents. The negative sign of real interest rates suggests that low interest rates tend to contribute to asset price booms therefore increasing the probability of a bust in asset markets in the next eight quarters.

\[ \text{A threshold is chosen such that the risks of having too many false signals and the risk of missing many crises/busts are balanced.} \]
Table 8: Results of the Panel Data Probit Model for ASEAN-4 Countries

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reer Gap_{i,t}</td>
<td>0.06</td>
<td>0.04</td>
</tr>
<tr>
<td>House Price Gap_{i,t}</td>
<td>0.38</td>
<td>0.00</td>
</tr>
<tr>
<td>Output Gap_{i,t}</td>
<td>0.40</td>
<td>0.01</td>
</tr>
<tr>
<td>Credit growth_{i,t-6}</td>
<td>0.02</td>
<td>0.06</td>
</tr>
<tr>
<td>Real interest rates_{i,t-3}</td>
<td>-0.09</td>
<td>0.04</td>
</tr>
<tr>
<td>Capital inflows_{i,t-5}</td>
<td>0.0002</td>
<td>0.06</td>
</tr>
</tbody>
</table>

McFadden R-squared = 0.49
LPS = 0.31
QPS = 0.20
KS = 0.75

Besides looking at McFadden R-squared as a measure of the fit of the model, we also apply the evaluation procedures suggested by Jacobs et al. (2005). These procedures include the quadratic probability score (QPS), the log probability score (LPS) adopted by Diebold and Rudebusch (1989), as well as the Kuiper’s score (KS) test adopted by Van der Berg et al. (2008). These scores are supposed to indicate the average closeness of the predicted probabilities and the observed realisations measured by the binary variable, “boom dummy” DUM_t. The quality of a model increases when QPS and LPS approaches 0, and KS approaches 1. The probit model produces a QPS of 0.20, LPS of 0.31 and a KS of 0.75.

Chart 37 shows that the probability of an asset price boom for Malaysia peaked at almost 1 in the 1Q 1996, and the highest probability of price booms was seven quarters prior to the decline in growth. The probability peaked again in 2Q 2007, signalling an excessive asset price misalignment six quarters prior to the economic downturn caused by the GFC. Similar probability patterns were also seen across other ASEAN countries.

Chart 37: GDP Growth and Probability of an Asset Price Boom for Malaysia
4 CONCLUSION

There are concerns that capital flows can amplify financial fragility and crisis risk for economies. There are ongoing debates that large capital inflows tend to lead to excessive foreign borrowing and foreign currency exposure, possibly fuelling domestic credit booms and asset bubbles. When capital flows reverse suddenly, a boom stage of credit expansion and asset prices may be turned into a bust stage. Our findings from Part 2 show that (i) the sharp increase in the debt-inflows led to surge episodes post-GFC across the ASEAN-4 and; (ii) the flight episodes in Thailand and Malaysia are mostly in the form of bank-led outflows.

While the analysis in the Part 3 does not differentiate the types of inflows, we attempt to find empirical evidence of the relationship between capital flows and the boom and bust cycle of the asset market. To do so, we construct an asset price composite index which captures the information from the stock and housing markets. An empirical analysis is carried out based on panel data probit model approach. We find that deviation of fundamental variables such as the house price gap contains the most information in explaining the probability of asset price misalignments. While capital flows also tend to increase the probability of asset price booms, the impact turns out to be very small9.

There is also some evidence that the financial imbalances can be driven by excessive credit growth and low real interest rates. The results suggest that policy makers should monitor closely deviations of house prices from their fundamental values and further assess the feedback role of credit in driving the excessive buildups in asset prices.

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9 Further improvements in the study can be made in analysing the types of capital flows (based on the definitions in Part 2 and their relationship with asset price misalignments).
References


Gerdesmeier, D., Reimers, H.E. and Roffia, B. (2011) Early Warning Indicators for Asset Prices (Unpublished manuscript)


Decomposing Capital Flows and Assessing the Impact of Capital Flows on the Asset Markets: Empirical Evidence from the ASEAN-4 Countries

Discussion

Dr. Ruperto Majuca commented that the paper raised many interesting questions. To improve the paper, he suggested to include an analysis of the following: (1) types of flows by debt, equity, bank-led flows and by country, (2) differences and similarities of flows per country, and 3) impact of country-specific institutions and environment on the different types of flows. In addition, the use of structural type of modeling was suggested.

One participant cited the work of Forbes and Warnock to explain unusually large flows, and the primary explanatory factor was the global risk factor – the fundamentals hardly matter. A suggestion was to add in the model an explanatory variable similar to a global risk factor (e.g., VIX). In addition, instead of using a composite index of equity and housing prices, these can be separated because these variables have very different dynamics.

Another participant asked what the author would recommend when capital flows push asset prices up.

One participant noted that unobserved heterogeneity was not accounted for in the paper and suggested the use of logit. In addition, since the paper focused on four states of capital flows, it may be useful to account for the transitions from one state to another. The use of non-parametric means or Markov processes may be considered. Another recommended the use of a panel general method of moments (GMM)-type of estimation procedure to deal with the potential heterogeneity problem.

Dr. Nur Ain Shahrier will consider including a global risk factor in the model. Likewise, it was noted that separating equity and housing prices may be useful since the former tends to move faster than the latter. Different methodologies will be explored to address unobserved heterogeneity.

Furthermore, Dr. Shahrier relates that in order to deal with capital flows, Malaysia mainly uses macroprudential measures, in addition to having large reserves to ensure that the exchange rate remains within a certain bandwidth. Improving infrastructures likewise ensures that the economy is resilient to shocks.

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10 Dr. Ruperto Majuca of De La Salle University was the discussant of the paper.
An Open Economy DSGE Model for the Philippines

Ruperto Majuca and Lawrence Dacuycuy

This paper identifies various model elements to constitute the necessary theoretical core of a dynamic macroeconomic model, estimates impulse responses through advanced techniques and analyses how remittances and key macroeconomic outcomes are affected by various shocks, all of which reflect the state of the art in open economy Dynamic Stochastic General Equilibrium (DSGE) modelling. We augment the existing Open Economy DSGE model of Adolfson, Laseen, Linde, and Villani (2007) by distinguishing the nontraded and tradable sectors, and including remittances. This makes our model more stylized given the fact that the Philippines remains as one of the top remittance-receiving countries in the world.

We estimated the dynamics of various macroeconomic variables after individually considering exogenous shock processes. We focused our analysis on the response of remittances on shock processes. This is an important undertaking because of the role remittances play in stabilizing foreign exchange markets and providing support to economic activities involving households and firms.

JEL Codes: E0, E30, F24, F41

Keywords: Small open economy, DSGE, remittances, Philippines

1 INTRODUCTION

This paper identifies various model elements to constitute the necessary theoretical core of a dynamic macroeconomic model, estimates impulse responses through advanced techniques and analyses how remittances and key macroeconomic outcomes are affected by various shocks, all of which reflect the state of the art in open economy Dynamic Stochastic General Equilibrium (DSGE) modeling. The objective is to set the stage for an estimable DSGE model that hopefully will capture the features and dynamics of the Philippine economy and will prove as the basis for the construction of other models that explore and explain different macroeconomic problems.\(^2\) Integrated into this paper are some of the essential structures characterizing open economy DSGE models that will help explain macroeconomic dynamics and possibly to provide an analytical platform for future forecasting work and counterfactual analyses.

DSGE models are fast becoming the workhorses of modern macroeconomics. Many central banks have their own DSGE models to determine how certain policies or shocks affect the dynamics of key variables of interest. Burriel, Villaverde, and Ramirez (2010) (henceforth referred to as BVR (2010)) developed a medium scale open economy DSGE model for Spain that takes into account immigration and growth issues. Known as MEDEA, the model uses Bayesian methods to estimate the parameters and employs higher-order approximation methods. As noted in BVR (2010), some of the central banks like European Central Bank, Bank of Canada, Bank of Spain, and Bank of Sweden have their own DSGE models. The Philippines’ Central Bank has its own open economy DSGE model also.

\(^1\) School of Economics, De La Salle University – Manila. We would like to thank Jesson Pagaduan and Dustin Ang who both provided research assistance for the empirical requirements of the paper. We would also like to thank URCO for administrative and financial support. We also gratefully acknowledge Dr. Jesper Linde who generously corresponded with us. Of course, the usual disclaimer applies.

\(^2\) A major challenge for macroeconomic modelling is the availability of high-quality data since DSGE requires mapping of observables to model variables which are theoretically easier to handle but pose formidable measurement issues especially for a country such as the Philippines.
As identified in the literature, an interesting field of inquiry concerns the dynamic impact of remittances which are being hailed, partly due to their stability, as a vital anchor and safeguard against unwanted fluctuations. Several authors have started to analyze the consequences of remittance inflows. Mandelman (2011) analyzed the impact of monetary and exchange rate policy under remittance fluctuations using Philippine data. The study analyzes the role of having Ricardian households but stays away from fielding a model with a New Keynesian theoretical core.

As a major source of skilled migrant labour, the Philippines continues to benefit from sustained inflows of remittances. Amounting to billions of dollars per year, remittances are expected to sustain higher levels of household consumption, modify investment patterns and potentially prolong the boom in residential building construction. Despite this, some analysts have observed the heightened appreciation of the Philippine currency and they attribute this to remittances. As a matter of fact, some researchers have pointed out the double-edged nature of remittances in the sense that they may cause Dutch disease which may affect the state of competitiveness of the country’s tradable sectors, and may promote the expansion of our nontradable sector.

Our model generally subscribes to the standard modelling platform that seeks to explain macroeconomic outcomes in a dynamic, general equilibrium setting. The model seeks to embed remittances in an open economy DSGE model by combining useful features found in three important studies written by Adolfson, Laseen, Linde, and Villani (2007) (henceforth referred to as ALLV (2007)), Acosta, Larrey, and Mandelman (2009) (henceforth referred to as ALM (2009)) and some features of BVR. ALLV’s model is an open economy model that incorporates incomplete exchange rate pass-through but largely subscribes to the New Keynesian features while ALM (2009) developed a model that explains how remittances may induce Dutch disease and may lead to economic problems. The critical differences pertain to how nominal rigidities would affect the external and domestic sectors as well.

We modify the model structure by introducing firm heterogeneity, thereby distinguishing the optimal behaviour of nontradable and tradable intermediate and final goods producers and modifying ALLV’s equation on how net foreign assets evolve when remittances are included as part of the model.

Our theoretical core is heavily influenced by New Keynesian theories that feature nominal rigidities aside from the usual components like preference structures, consumption habits, fiscal and monetary authorities, capital adjustment costs. We necessarily include endogenous pricing mechanisms to model rigidities in terms of nominal price adjustments in export, import and domestic production because empirically, they do matter as shown in ALLV (2007). It also takes care of long-term growth through the incorporation of technological change which is seen as a major source of fluctuations. While the Philippines continue to send thousands of workers annually, we do not capture this in the model just like in BVR who introduced population growth.

A clear limitation of our model is the way assumptions were formed about sectoral dynamics and agent heterogeneity. In ALM’s model, for instance, it is clear that the labor market is markedly competitive, allowing the frictionless movement of labor from the tradable to nontradable sectors leading to the same wage. The model also assumes no labor market frictions. However, when no such assumptions are made and heterogeneous agents are introduced, job search becomes a critical model component. In households, it is possible that some members are employed and others are
unemployed. Of those employed, some are working in the tradable sector while the rest are in the non-tradable sector. In this scenario, wages are determined in a game theoretic environment. In some studies like Christiano, Trabandt and Walentin (2011) (henceforth referred to as CTW (2011)) and Zhang (2011), modelling sectoral labor allocation is more involved as it relies on the incorporation of job search to endogenize the selection of household members into the sectors. Wages are also determined through bargaining which may put to question the ability of households to determine the level of wages in the traditional optimization sense (a la Calvo pricing). It also requires entrepreneurs which introduces financial frictions into the model (Villaverde [2012], CTW [2011]). The advantage of such models is that they elevate the status of labor market frictions as an important source of model dynamics.

The model follows an assumption that the Philippine economy is small relative to the rest of the world. It is similar to the treatment in ALLV (2007), BVR (2010) and ALM (2009). The open economy features are modelled by assuming that there is incomplete exchange rate pass-through which is triggered by local currency price stickiness.

We outline the basic structure of the combined ALLV-ALM-BVR model.

i. The presence of a continuum of households who consume domestic and foreign goods, hold non–interest earning assets or money, save and invest in domestic and foreign bonds, supply capital and labor services, determine wages, and receive remittances from close and distant relatives.

ii. To capture labor market rigidities, households are assumed to exercise market power by offering differentiated labor which will be aggregated by a perfectly competitive labor packer. We make a simplified assumption that only wages in the tradable sector are set by households, not wages in the nontradable sector.

iii. There are two sectors, namely tradable and non-tradable sectors. The existence of two distinct sectors implies firm heterogeneity. The final domestic good is manufactured by a competitive final goods producer who optimally sets the demand for intermediate domestic goods produced by monopolistically competitive firms that buy labor and capital services.

iv. There is a firm that buys and imports a homogeneous good that gets converted into final domestic consumption and investment goods.

v. Export firms buy final domestic goods and differentiate them by brand naming. They sell a continuum of export goods to foreign households, the demand for which depends on foreign preferences. Export prices are assumed to be sticky.

vi. Import firms buy a homogeneous imported good and sell a continuum of import goods to domestic households. There is incomplete exchange rate pass-through, indicating that import prices are sticky.

vii. Aside from a tradable sector, the model encompasses a nontradable sector in order to fully understand the mechanism through which remittances would affect exchange rate dynamics, sectoral dynamics and monetary and fiscal policies. Output in this economy is equal to the sum of output in tradable and non-tradable sectors.

viii. There is a monetary authority that sets one-period nominal interest rate through a Taylor rule, an approximation that includes exchange rate, output gap and deviations from inflation targets.

ix. There is a fiscal policy regulator and assume that tax rates including government expenditures are exogenous.

x. Unit roots are assumed to be found in aggregate technology and prices.
The organization of the paper is as follows: Section 2 details the theoretical structure of the model, using and augmenting ALLV (2007) theoretical model by integrating remittances. Section 3 provides a review of key empirical strategies and discusses relevant issues on measurement, estimation feasibility and expected output from simulation exercises that are expected to generate impulse response functions (IRFs). Section 4 discusses how shocks affect macroeconomic outcomes such as remittances and identify the transmission mechanisms at work. The last section concludes and highlights directions for future DSGE research.

2 THE THEORETICAL STRUCTURE OF AN OPEN ECONOMY DSGE MODEL FOR THE PHILIPPINES

The model focuses on the optimal behaviour of households, firms, and monetary authority. Because the proposed model simply incorporates remittances into the ALLV (2007) model, we acknowledge at this point that the latter provides the model structure, thereby allowing us to use notations used in the ALLV (2007) paper.

2.1 The households

There is a continuum of households indexed by \( j \in (0, 1) \). Following ALLV (2007), the representative household’s preferences are described by a utility function that is separable in consumption, non-interest earning assets or real money balances and hours worked.

\[
E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \zeta^c_t \log(C_{j,t} - h^c C_{j,t-1}) + A_q \frac{q_{f,t}}{x_{t,ft}} \frac{(1-\delta_q)}{1-\delta_q} - \zeta^\ell_t A_{\ell} \frac{(1+\delta_{\ell})}{1+\delta_{\ell}} \right\},
\]

(2.1)

where \( h^c \) is the parameter that captures habit persistence in consumption, \( \theta_{\ell} \) is the inverse of labor supply elasticity and \( \ell_{j,t} \) is labor supply.

Following BVR (2010) and ALLV (2007), we included preference shocks to capture changes in valuations between future and present consumption. The shock to labor is supposed to capture changes in labor supply over the business cycle. The laws of motion of the said shocks are represented as follows:

\[
\zeta^c_t = \rho^c \zeta^c_{t-1} + \epsilon^{c,c}_{t}, \\
\zeta^\ell_t = \rho^\ell \zeta^\ell_{t-1} + \epsilon^{\ell,\ell}_{t}.
\]

(2.2)

To ensure consistency with standard open economy models, we assume that within the household, there are two types of labor, namely workers in the tradable and nontradable sectors. We do not model unemployment and other labor market frictions for they necessitate the introduction of bargaining processes and other agents such as employment agencies and entrepreneurs. The ad hoc assignment of workers in the nontradable sector is important because we assume that output in the said sector depends on a linear technology. We assume that there is no perfect mobility, indicating that wages between the two sectors may diverge and assume that only those in the tradable sector can have market power in setting wages. The way wages are determined may run counter to CTW (2011) and Zhang’s game theoretic approach to determine wages through wage bargaining mechanisms.

Aggregate consumption \( C_t \) is a CES composite of tradable and nontradable goods represented by a CES index. In turn, we also define the tradable component of
aggregate consumption in terms of goods bought abroad (imports) and consumption goods produced domestically. Thus,

$$C_t = \left[ (1 - \omega_N)^{1/\eta_c} \left( C_{T,t} \right)^{(\eta_c - 1)/\eta_c} + \omega_N^{1/\eta_c} \left( C_{N,t} \right)^{(\eta_c - 1)/\eta_c} \right]^{\eta_c/(\eta_c - 1)}$$  \hspace{1cm} (2.3)

where $\omega_N$ is the share of nontradables in (tradable plus nontradable) consumption and tradable consumption, and where $\eta_c$ is the elasticity of substitution between tradable and nontradable consumption. $C_{T,t}$ is defined as

$$C_{T,t} = \left[ (1 - \omega_m)^{1/\eta_T} \left( C_{T,t}^d \right)^{(\eta_T - 1)/\eta_T} + \omega_m^{1/\eta_T} \left( C_{T,t}^m \right)^{(\eta_T - 1)/\eta_T} \right]^{\eta_T/(\eta_T - 1)}$$  \hspace{1cm} (2.4)

where $\eta_T$ refers to the elasticity of substitution between domestic and imported consumption goods, $C_{T,t}^d$ is the domestically produced tradable consumption good, and $C_{T,t}^m$ is the imported consumption good.

The demand functions are given by

$$C_{T,t}^d = (1 - \omega_m) \left[ \frac{P_{T,t}}{P_{T,t}} \right]^{-\eta_T} C_{T,t}$$  \hspace{1cm} (2.5)

$$C_{T,t}^m = \omega_m \left[ \frac{P_{T,t}}{P_{T,t}} \right]^{-\eta_T} C_{T,t}$$  \hspace{1cm} (2.6)

$$C_{N,t} = \omega_c \left[ \frac{P_{N,t}}{P_{T,t}} \right]^{-\eta_c} C_{T,t}.$$  \hspace{1cm} (2.7)

There are now two price indexes. One for the CPI price index, which is defined as the minimum expenditure required to buy a unit of consumption good, and another for the tradable good.

$$P_{T,t}^c = \left[ (1 - \omega_N) \left( P_{T,t}^c \right)^{1-\eta_c} + \omega_N \left( P_{N,t} \right)^{1-\eta_c} \right]^{1/(1-\eta_c)}$$  \hspace{1cm} (2.8)

$$P_{T,t}^m = \left[ (1 - \omega_m) \left( P_{T,t}^m \right)^{1-\eta_T} + \omega_m \left( P_{T,t}^{m,c} \right)^{1-\eta_T} \right]^{1/(1-\eta_T)}.$$  \hspace{1cm} (2.9)

Aside from allocating resources to consumption, households invest in state contingent securities and hold government bonds that pay gross nominal interest rate. It is also assumed that households can purchase foreign bonds expressed in terms of domestic currency. Households also make provisions for capital expenditures.

Similar to consumption, investments are also modelled by assuming a CES structure. Following ALLV (2007), it is assumed that total investment is an aggregate of domestic and imported investment goods, thus:

$$I_t = \left[ (1 - \omega_i)^{1/\eta_i} \left( I_t^d \right)^{(\eta_i - 1)/\eta_i} + \omega_i^{1/\eta_i} \left( I_t^m \right)^{(\eta_i - 1)/\eta_i} \right]^{\eta_i/(\eta_i - 1)}.$$  \hspace{1cm} (2.10)
The demand functions are given by

\[ I^d_t = (1 - \omega_i)(\frac{P_t}{P^-_t})^{-\eta_i} I_t \]  \hspace{1cm} (2.11)

\[ I^m_t = \omega_i(\frac{P^m_t}{P^m^- _t})^{-\eta_i} I_t \]  \hspace{1cm} (2.12)

The price index for an investment good is given by

\[ P^t_t = \left(1 - \omega_i\right)(P_t)(1 - \eta_i) + \omega_i((P^m_t)(1 - \eta_i))^{\frac{1}{1 - \eta_i}} \]  \hspace{1cm} (2.13)

The representative household’s budget constraint is similar to ALLV (2007), with the addition of remittances, \( \Xi_t \), as a source of income, thus,

\[ M_{jt+1} + S_t B_{jt+1} + P_t^c C_{j,t} (1 + \tau^c_t) + P_t^l I_{jt} + P_t (a(u_{jt})K_{jt} + P\Phi(\Delta t)) = R_{t-1}(M_{jt} - Q_{jt}) + Q_{jt} + (1 - \tau^t_t)W_{jt}h_{jt} + \]  \hspace{1cm} (2.14)

\[ + (1 - \tau^t_t)R^k_t u_{jt} R_{jt} + R_{t-1}1(\frac{A_{t-1}}{\phi_{t-1}})S_t B_{jt}^1 + \]  \hspace{1cm} (2.14)

\[ - \tau^t_t (R_{t-1} - 1)(M_{jt} - Q_{jt}) + \]  \hspace{1cm} (2.14)

\[ + (R^k_{t-1}(\frac{A_{t-1}}{\phi_{t-1}})S_{t-1}B_{jt}^1 - 1)S_{t}B_{jt}^1 + B_{jt}^1(S_t - S_{t-1}) + TR_t + D_t + \Xi_t \]

where \( P_t \) is the price of the domestic final good, \( P^c_t \) is the price of consumption good, \( P^l_t \) is the price of the final investment good, the difference \( (M_{jt} - Q_{jt}) \) refers to the amount of resources that earn interest income, \( (1 - \tau^t_t)\) represents net profits that go to households, \( u_{jt} \) is the utilization rate that may be increased by households, thereby incurring capital adjustment costs \( a(u_{jt})K_{jt} \) or simply augment existing capital through investments, \( S_t B_{jt}^1 \) is the amount in domestic currency of foreign bonds and \( \phi(\frac{A_{t-1}}{\phi_{t-1}}) \) represents a function that determines the premium associated with foreign bonds. As explained in ALLV (2007) and BVR (2010), given incomplete international markets and the fact that not all idiosyncratic shocks can be insured against, the introduction of the said function is to ensure a well-defined steady state for consumption and assets in the international market (ALLV (2007), p. 181). \( TR_t \) represents lump sum transfers, \( \Xi_t \) pertains to remittances. It is assumed that remittance flows can be tracked to household recipients. We closely follow ALM (2009) specifications on remittance related functions that largely reflect processes associated with the motives of remittance sending agents. Exogenous tax rates on capital, labor income and wage income are given by \( \tau^c_t, \tau^k_t, \tau^w_t \). We assume that wage income earned in the tradable and nontradable sectors are taxed similarly. Interest rates on domestic and foreign assets are given by \( R_{t-1} \) and \( R_{t-1}^{-1} \), respectively.

Following ALM (2009), \( \Xi_t \) is defined as \( P_t^m e (\Sigma^p_t + \Sigma^i_t) + P_t^m \Sigma^i_t, \) where \( \Sigma^p_t = \Sigma^p_1 Y_t^p \) is assumed to be remittances which are procyclical with development in the host country; \( \Sigma^i_t = \Sigma^i_1 \) are remittances which are countercyclical to domestic economy’s development, and serves as insurance against negative economic shocks; and \( \Sigma^i_t = \mu_t I^m_t \) are self-interested remittances motivated by the sender’s desire to invest in the home country, and are assumed to finance a fraction \( \mu_t \) of the imported investment good. As can be seen from the specification, it is clear that no exogenous shocks affect the level and timing of remittances. However, it does not mean that they are not theoretically
plausible. For instance, $\Xi^p_t$ may be affected by host country-specific shocks while $\Xi^c_t$ is affected by destination country-specific shocks.

As is standard in the literature, investment’s law of motion is given by the following

$$K_{t+1} = [(1 - \delta)K_t + Y_tF(I_t, I_{t-1})] + \Delta_t$$

(2.15)

where $\delta$ is the depreciation rate and, $\Delta_t$ is the purchase cost of capital, and

$$F(I_t, I_{t-1}) = \left(1 - S(A_t)\right)I_t, \quad \Delta_t = \frac{I_t}{I_{t-1}}$$

(2.16)

It is clear that when no installation costs are incurred, $F(I_t, I_{t-1}) = I_t$. Based on the way the function is specified, we discount the possibility that there are investment-specific technology shocks which have been established as one of the major sources of fluctuations in the United States (BVR (2010), Greenwood (1997, 2000), Justiniano, Primiceri and Tambalotti (2010)).

We now specify the household’s optimization problem.

$$\max_{c_{jt}, M_{jt+1}, A_t K_{jt+1}, J_{jt}, \xi_{jt}, u_{jt}, b^r_{jt+1}, b^l_{jt+1}, h_{jt}} \sum_{t=0}^{\infty} \beta^t \left\{ c_{jt} \log(C_{jt} - h^{*} C_{jt+1}) ight. $$

$$+ A_{jt} \left( \frac{Q_{jt}}{x_{jt}} \right)^{1 - \frac{q}{a}} - \frac{c_{jt}^\epsilon A_{jt}}{1 + \theta_t} \}

$$+ \nu_t \left[ R_t \left( M_{jt} - Q_{jt} \right) + Q_{jt} + (1 - \tau^k_t)\Pi_t \right.

$$+ (1 - \tau^k_t)W_{jt} - \frac{\theta_{jt}}{1 + \tau^k_t} + \left(1 - \tau^k_t\right)\frac{W_{jt}}{1 + \tau^k_t} h_{jt}$$

$$+ (1 - \tau^c_t)K_{jt+1} + R_{t-1}^{\phi} \Phi \left( \frac{A_t}{\theta_t^{jt+1}}, \theta_t^{jt-1} \right) S_t B^r_{jt+1}$$

$$- \tau^k_t \left( R_{t-1} - 1 \right) \left( M_{jt} - Q_{jt} \right)$$

$$+ \left( R_{t-1}^{\phi} \Phi \left( \frac{A_t}{\theta_t^{jt+1}}, \theta_t^{jt-1} \right) - 1 \right) S_t B^r_{jt+1}$$

$$+ B^r_{jt+1} (S_t - S_{jt-1}) + \left[ TR_t + D_{jt} \right.$$

$$+ \psi_{jt+1} (\psi_{jt+1}^{m,c} (\Xi_{jt} + \Xi_{jt+1}^{c,t}) + P_{jt+1}^{m,c} (\Xi_{jt+1}^{c,t}))$$

$$- \left( M_{jt+1} + S_t B^r_{jt+1} + P^e C_{jt+1} (1 + \tau^c_t) + P^e I_{jt+1} \right.$$$$+ P_{jt+1} (a (u_{jt+1} K_{jt+1} + P^{l,c} A_t))$$

$$+ \omega_t \left[ ((1 - \delta)K_t + Y_t F(I_t, I_{t-1})] + \Delta_t - K_{t+1} \right. \}

(2.17)

The first-order conditions are:

$$\beta E \left[ \frac{\psi_{jt+1} R_t}{\mu_{jt+1} \pi_{jt+1}} - \frac{\psi_{jt+1} \tau_{jt+1} K_{jt+1}}{\mu_{jt+1} \pi_{jt+1}} (R_t - 1) \right] = \psi_{jt+1}$$

(2.18)
\[
\omega_t = \psi_t P_{k,t}
\]
\[
\psi_{z,t}[(1 - \tau^k) r^k_t - a(u_{j,t})] = 0
\]
\[
\beta E \left[ \frac{\psi_{z,t+1}}{\mu_{z,t+1}} \left\{ (1 - \tau^k_t) \frac{R^k_t}{P_{t+1}} u_{j,t} - \frac{P_{t+1}}{P_{t+1}} a(u_{j,t+1}) \right\} \right] + (1 - \delta) P_{k',t+1} \psi_{z,t+1} = \psi_{z,t} P_{k',t}
\]
\[
\beta E \left[ \frac{\psi_{z,t+1}}{\mu_{z,t+1}} \left\{ R^* \Phi \left( \frac{A_t}{z_t}, \phi_t \right) S_{t+1} - \tau^k_{t+1} \left( S_{t+1} - S_t \right) \right\} \right] = \psi_{z,t} S_t
\]
\[
\left( \frac{Q_{1,t}}{P_t} \right)^{-\sigma_q} = (1 - \tau^k) u_t (R_{t-1} - 1)
\]
\[
\frac{\psi_{z,t} P_{t}^l}{z_t P_t} + \psi_{z,t} P_{k',t} Y_t F_t (i_t, i_{t-1}, \mu_{z,t}) + \beta E \left[ \psi_{z,t+1} P_{k',t+1} + Y_{t+1} F_{t+1} (i_{t+1}, i_t, \mu_{z,t+1}) \right] = 0
\]
\[
\frac{\zeta_t}{c_t - b \zeta_{t-1} \mu_{z,t}} - b \beta E_t \frac{\zeta_{t+1}}{c_{t+1} \mu_{z,t+1} - b c_t} - \psi_{z,t} \frac{P_t^e}{P_t} (1 + \tau_t^e) = 0
\]

### 2.2 Labor demand and wage decisions

We follow the usual mathematical structure of how households determine their own wages. Following ALLV (2007) and BVR (2010), we assume that each household is a supplier of differentiated labor service and that only a proportion of these households \((1 - \theta_h)\) can re-optimize every period using Calvo pricing as the endogenous mechanism for modelling wage stickiness. As noted in BVR and McCandless (2008), assumptions on the behaviour of non-optimizing households are critical in determining the dynamics in the labour market.

In the labor market, we assume a competitive labor aggregator or a labor packer who is responsible for aggregating differentiated labor supplied by households, producing a homogeneous good for intermediate firms to use. Following ALLV (2007) and BVR (2010), the CES production function is used. As remarked in McCandless (2008), the nature of the production technology enables household to exercise market power.

Let the production function of the competitive labor packer be

\[
L_t = \left( \int_0^1 \ell_{j,t} \frac{1}{w_t} d j \right)^{\lambda_w}, \quad 1 \leq \lambda_w \leq \infty
\]

where \(\lambda_w\) is the wage mark-up.

Maximizing profits, the labor demand function for each labor type is given by

\[
\ell_{j,t} = \left( \frac{W_{j,t}}{\lambda_w} \right)^{\frac{\lambda_w}{\lambda_w - 1}} L_t
\]

where \(\ell_{j,t}\) is total labour demand.
Aggregate wages follow the following familiar process

$$W_t = \left( \int_0^1 w_{jt} 1^{1-\lambda_w} dj \right)^{1/1-\lambda_w}$$  \hspace{1cm} (2.28)

As noted in BVR (2010) and ALLV (2007), idiosyncratic risk arises because households follow Calvo's pricing mechanism to set wages. In some papers, wage rigidities are modelled as convex adjustment cost for nominal wages (see Zubairy, 2010).

As is standard in the literature, we assume a Calvo-type staggered price setting. Thus, a proportion of households $1 - \theta_h$ will be able to re-optimize per period while the remainder will simply follow rules of thumb. We follow ALLV's wage setting rule for nonoptimizing households where they can only partially index their wages to past inflation and current inflationary targets.

$$W_{jt+1} = \pi_t^{c_w(\pi_{t+1}^{c_w})1-\kappa_w} \gamma_{jt+1} W_{jt}$$  \hspace{1cm} (2.29)

$\kappa_w$ is the indexation parameter. Note that when $\kappa_w = 1$, wages are indexed to past inflation. If a nonoptimizing household cannot optimize its wages in $s$ periods, the wage in period $t + s$ is

$$W_{jt+s} = \left( \prod_{t=0}^{s-1} \pi_{t+t}^{c_w} \right) \left( \prod_{t=0}^{s} \mu_{t+t} \right) W_{jt}^{NEW}$$  \hspace{1cm} (2.30)

Wages are determined by maximizing the following:

$$\max_{W_{jt}^{NEW}} E_t \sum_{s=0}^{\infty} (\beta \theta_h)^s \left( -\frac{\ell_{jt+s}^p}{1 + \theta} \right) W_{jt}^{NEW} L_{jt+s}$$

subject to

$$\ell_{jt+s} = \left( \frac{W_{jt}^{NEW}}{W_{jt+s}} \right)^{1-\lambda_w} L_{jt+s}. $$

Substituting the constraint into the objective function, we have

$$\max_{W_{jt}^{NEW}} E_t \sum_{s=0}^{\infty} (\beta \theta_h)^s \left( -\frac{\ell_{jt+s}^p}{1 + \theta} \right) \left( \frac{W_{jt}^{NEW}}{W_{jt+s}} \right)^{1-\lambda_w} L_{jt+s}$$

$$+ \nu_{jt+s} \left( \frac{1 - \gamma_{jt+s}^p}{1 + \gamma_{jt+s}^d} \right) \left( \prod_{t=0}^{s-1} \pi_{t+t}^{c_w} \right) \left( \prod_{t=0}^{s} \mu_{t+t} \right) W_{jt}^{NEW}$$

$$\times \left( \frac{W_{jt}^{NEW}}{W_{jt+s}} \right)^{1-\lambda_w} L_{jt+s}$$
For households that can optimize, households maximize with respect to $W_{j,t}^{NEW}$. As noted in BVR (2010), these households set the same wage due to complete market, implying that $W_{j,t}^{NEW} = W_t^{NEW}$. The first-order condition is

$$E_t \sum_{s=0}^{\infty} (\beta \theta_h) \ell_{t+s} \left[ -c_{t+s}^{\pi} \ell_{t+s}^{\pi} \right]^{\theta} \lambda_w \left( \frac{W_{j,t}^{NEW}}{W_{t+s}^{NEW}} \right) ^{1-\lambda_w} \frac{1}{W_{t+s}} \lambda_w \left( \frac{W_{j,t}^{NEW}}{W_{t+s}^{NEW}} \right) ^{1-\lambda_w} \frac{1}{W_{t+s}} L_{t+s}$$

$$+ u_t + s \left( 1 - \tau^{\gamma}_{t+s} \right) \left( \prod_{t=0}^{s-1} \frac{\pi^C_{t+t}}{\pi^C_{t-1}} \right) \left( \prod_{t=0}^{s} \frac{\bar{\pi}^C_{t+t}}{\bar{\pi}^C_{t-1}} \right) ^{1-\lambda_w} \left( \prod_{t=0}^{s} \mu_{z,t+t} \right) ^{1-\lambda_w} \frac{1}{W_{t+s}} L_{t+s}$$

Letting $(\prod_{t=0}^{s} \frac{\pi^C_{t+t}}{\pi^C_{t-1}})^{\lambda_w} = \left( \frac{p_{t+s}}{p_{t-1}} \right)^{\lambda_w}$ and $(\prod_{t=0}^{s} \mu_{z,t+t}) = \frac{p_d}{p_{t-1}}$, we have

$$E_t \sum_{s=0}^{\infty} (\beta \theta_h) \ell_{t+s} \left[ -c_{t+s}^{\pi} \ell_{t+s}^{\pi} \right]^{\theta} \lambda_w \left( \frac{W_{j,t}^{NEW}}{W_{t+s}^{NEW}} \right) ^{1-\lambda_w} \frac{1}{W_{t+s}} W_{j,t}^{NEW}$$

$$+ u_t + s \left( 1 - \tau^{\gamma}_{t+s} \right) \left( \prod_{t=0}^{s} \frac{\pi^C_{t+t}}{\pi^C_{t-1}} \right) \left( \prod_{t=0}^{s} \frac{\bar{\pi}^C_{t+t}}{\bar{\pi}^C_{t-1}} \right) ^{1-\lambda_w} \left( \prod_{t=0}^{s} \mu_{z,t+t} \right) ^{1-\lambda_w} \frac{1}{W_{t+s}} L_{t+s}$$

$$E_t \sum_{s=0}^{\infty} (\beta \theta_h) \ell_{t+s} \left[ -c_{t+s}^{\pi} \ell_{t+s}^{\pi} \right]^{\theta} \lambda_w \left( \frac{W_{j,t}^{NEW}}{W_{t+s}^{NEW}} \right) ^{1-\lambda_w} \frac{1}{W_{t+s}} W_{j,t}^{NEW}$$

We can simply write the first-order condition by following Villaverde (2010) and BVR (2010).
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\[ \sum_{s=0}^{\infty} (\beta \theta h)^{s} t_{t+s}^{1+\theta} s_{t+s}^{p} \]

\[ \sum_{s=0}^{\infty} (\beta \theta h) \frac{W_{t}^{\text{NEW}} z_{t+s}^{P} s_{t+s}^{1+\theta}}{S_{t}^{1+\theta}} \left( \frac{p_{t+s}^{\pi e^{-1}}}{p_{t}^{\pi e^{-1}}} \right)^{K_{W}} \left( \prod_{t=0}^{s} \pi_{t+s}^{e} \right)^{1-\kappa_{W}} . \] (2.32)

Given the fact that the fraction \( 1 - \theta h \) of households is able to set their wages optimally and the remaining households can only partially index their wages to the previous period’s wage and current inflationary targets, the wage index evolves as

\[ W_{t} = \left[ \theta h (\pi_{t-1}^{e} \kappa_{W} (\pi_{t}^{e})^{1-k_{W}} W_{t-1})^{1-\lambda_{W}} + (1 - \theta h) \left( W_{t}^{\text{NEW}} \Pi_{t-1}^{1-\lambda_{W}} \right) \right]^{1-\lambda_{W}} . \] (2.33)

2.3 The production and distribution sectors

We follow the usual theoretical structure that will detail the expected behaviour of firms, their optimality decisions and some stylized features of the production sector. Following BVR (2010) and ALLV (2007), we further group firms under two classifications, namely those that produce final and intermediate goods domestically, and those that engage in imports and exports.

2.3.1 Nontradable goods sector

Following ALLV (2007), we have three types of firms. First, as shown above, labor packers use differentiated labour from households to produce a homogenous input good that will be used by a continuum of intermediate goods firms. Intermediate goods firms behave rather monopolistically since they produced differentiated goods that will be utilized or packed by the final goods producer, a competitive firm in the distribution process. For intermediate goods and final goods firms, however, we take into account firm heterogeneity in terms of sectoral affiliation. As an open economy model, the differentiation between tradable and nontrable sectors is critical. For tradable sector firms, they transform inputs into intermediate outputs using labor and capital. However, for nontradable sector firms, only labor services are included as part of the inputs. We also assume that shocks are sector specific, indicating no interaction among firms belonging to different sectors.

2.3.1.1 Nontradable final goods firm

The final goods firm in the nontradable sector uses a CES production function to aggregate differentiated inputs produced by intermediate nontradable goods firms.

Consider an environment wherein firms produce units of homogeneous final good. Following BVR (2010) and ALLV (2007), we assume that there is a continuum of intermediate goods producers which are monopolistically competitive firms. Indexed by \( N_{t} \in (0,1) \), let the production function be represented by \( Y_{N_{t}} \).

\[ Y_{N_{t}} = \left[ \int_{0}^{1} Y_{N_{t}}^{\lambda_{N_{t}}} dN_{t} \right]^{\lambda_{N_{t}}} \] , \( 1 \leq \lambda_{N_{t}} < \infty \) (2.34)

where \( \lambda_{N_{t}} \) is the time varying mark-up in the domestic goods market which is assumed to follow a stochastic process. As explained in ALLV (2007), there is a relationship...
between the stochastic mark-up and the usual specification involving the elasticity between intermediate goods.

The process that generates the observed mark-up is given by

$$\lambda_{N,t} = (1 - \rho_N)\lambda_N + \rho_N \lambda_{N,t-1} + \epsilon_{\lambda,t} \sim (iid)N(0, \sigma_{\lambda,t}^2).$$  (2.35)

Competitive final goods firms minimize costs by deciding on how much of intermediate inputs to use. Equivalently, these firms maximize profits which is just revenue minus costs with respect to intermediate inputs used, that is,

$$\pi_{Nt} = P_{Nt} Y_{Nt} - \int P_{ni,t} Y_{Ni,t} dN_i.$$  (2.36)

As monopolistic firms, they can set prices $P_t(k)$. Competitive final goods producers have access to CRS technology which transform intermediate goods into final goods.

The final goods pricing rule is given by

$$P_{Nt} = \left[ \int_{0}^{1} \frac{P_{Nt-1} Y_{Nt-1}}{N_i} dN_i \right]^{1-\lambda_{N,t}}.$$  (2.37)

while the demand function for firm $k$'s output is given by

$$\frac{Y_{Nt}}{Y_{N,t}} = \left( \frac{P_{Nt}}{P_{N,t}} \right)^{\lambda_{N,t} - 1}.$$  (2.38)

2.3.1.2 Nontradable Intermediate goods producer

To produce a unit of intermediate good, a firm needs labor only. The production function be specified as

$$Y_{Ni,t} = z_{N,t} e_t H_{Ni,t} - z_{N,t} \phi_N$$  (2.39)

where $\phi_N$ represents fixed costs. Let $\frac{z_{N,t}}{z_{N,t-1}} = \mu_{z,t}^N$.

$$\mu_{z,t}^N = (1 - \rho_{\mu_N})\mu_{z,t}^N + \rho_{\mu_N} \mu_{z,t-1} + \epsilon_{\mu,t} \sim (iid)N(0, \sigma_{\mu,t}^2)$$  (2.40)

Firms minimize the following problem subject to the production constraint:

$$\min_{H_{Ni,t}} W_{Nt} R_{\pi}^f H_{Ni,t} + \lambda_{\mathcal{N}} P_{Ni,t} [Y_{Ni,t} - z_{Ni,t} H_{Ni,t} + z_{Ni,t} \phi].$$  (2.41)

Based on the stochastic production function, the marginal products of labor and capital are

$$W_t R_{\pi}^f = \lambda_{\mathcal{N}} P_{Ni,t} z_{Ni,t} \epsilon_{\pi}^N$$  (2.42)

$$mc_t^N = \lambda_{\mathcal{N}} = \bar{w}_t R_{\pi}^f \frac{1}{\epsilon_{\pi}^N}.$$  (2.43)

The nontradable intermediate goods firm follows Calvo pricing, implying that there is a fraction of firms that can set prices optimally.
2.3.2 Tradable goods sector

Similar to nontradable final goods firms, we assume that there is a continuum of intermediate goods producers which are monopolistically competitive firms. Hence,

\[ Y_{T,t} = \left[ \int_{0}^{1} P_{T(h),t} \frac{1}{\lambda_{T,t}} \frac{1}{\lambda_{T,t}} dh \right] ^{(1-\lambda_{T,t})} \]

where \( \lambda_{T,t} \) is the time varying mark-up in the domestic goods market which is assumed to follow a stochastic process. The process that generates the observed mark-up is given by

\[ \lambda_{T,t} = (1 - \rho_{\lambda_{T}}) \lambda_{T} + \rho_{\lambda_{T}} \lambda_{T-1} + \varepsilon_{\lambda_{T,t}} \varepsilon_{\lambda_{T,t}} \sim (iid)N(0, \sigma_{\lambda_{T}}^2) \].

Competitive final goods firms minimize costs by deciding on how much of intermediate inputs to use. Equivalently, these firms maximize profits which is just revenue minus costs with respect to intermediate inputs used, that is,

\[ \max \left( P_{T,t} Y_{T(h),t} - C_{T(h),t} \right) \]

The final goods pricing rule is given by

\[ P_{T,t} = \left[ \int_{0}^{1} P_{T(h),t} \frac{1}{\lambda_{T,t}} \frac{1}{\lambda_{T,t}} dh \right] ^{(1-\lambda_{T,t})} \].

The demand function for firm \( h \)'s output is given by

\[ \frac{Y_{T(h),t}}{Y_{T,t}} = \left( \frac{P_{T,t}}{P_{(T),t}} \right) ^{\lambda_{T,t}} \].

To produce a unit of intermediate good, the tradable goods firm needs to combine capital and labor. The tradable goods production function is specified as

\[ Y_{T(h),t} = z_{T,t}^{1-\theta} e_{T,t}^{T} K_{h,t}^{\theta} H_{h,t}^{1-\theta} - z_{T,t}^{\theta} \phi_{T} \]

where \( \phi_{T} \) represents fixed costs. Let \( \frac{z_{T,t}}{z_{T,t-1}} = \mu_{z,t}T \).

\[ \mu_{z,t} = (1 - \rho_{\mu_{z}}) \mu_{z,t-1} + \rho_{\mu_{z}} \mu_{z,t-1} + \varepsilon_{\mu_{z,t}} \varepsilon_{\mu_{z,t}} \sim (iid)N(0, \sigma_{\mu_{z}}^2) \]

with \( \varepsilon_{\mu_{z,t}} = \varepsilon_{\mu_{z,t}} \sigma_{\mu_{z}}^2 \).

To save on notation, we let \( h \) represent the \( T(h) \) index of tradable goods firm.

Intermediate goods firms in the tradable goods sector thus have the following minimization problem:

\[ \min_{K_{h,t},H_{h,t}} W_{t}^{f} R_{T}^{f} H_{h,t} + R^{K} K_{h,t} + \lambda_{h,t} P_{h,t} \left( Y_{h,t} - z_{T,t}^{1-\theta} e_{T,t}^{T} K_{h,t}^{\theta} H_{h,t}^{1-\theta} - z_{T,t}^{\theta} \phi \right) \]
Based on the stochastic production function, the marginal products of labor and capital are

$$W_tR^f_t = (1-\theta)\lambda_{h,t}P_{h,t}z_t^{1-\theta}e_tK_{h,t}^{\theta}H_{h,t}^{-\theta}$$

(2.51)

$$R^k_t = \theta\lambda_{h,t}P_{h,t}z_t^{1-\theta}e_tK_{h,t}^{\theta-1}H_{h,t}^{-\theta}.$$  

(2.52)

From the first-order conditions, we have

$$\frac{R^k_t}{W_tR^f_t} = \frac{\theta\lambda_{h,t}P_{h,t}z_t^{1-\theta}e_tK_{h,t}^{\theta-1}H_{h,t}^{-\theta}}{(1-\theta)\lambda_{h,t}P_{h,t}z_t^{1-\theta}e_tK_{h,t}^{\theta}H_{h,t}^{-\theta}},$$

implying that

$$r^k_t = \frac{\theta}{1-\theta}wH_{h,t}K_{h,t}^{-1}R^f_t.$$  

(2.53)

Substituting the optimal input demand functions into the linear cost function and differentiating with respect to $Y_t$, we have

$$mc_t = \left(\frac{1}{1-\theta}\right)^{1-\theta}\left(1\right)^{1-\theta}\left(r^k_t\right)^{\theta}\left(W_tR^f_t\right)^{1-\theta}\frac{1}{e_t}. $$

(2.54)

The price setting problem is similar to BVR (2010), ALLV (2007) and Smets and Wouters (2003). Because not all firms can re-optimize each period by adjusting their prices due to staggered pricing, the probability that some firms can adjust is just $(1-\theta_f)$. Following Rubaszek and Skrzypczynski (2008), we have the following:

$$P_{t+1} = (\pi^c_t)^{k_d}(\bar{\pi}^c_{t+1})^{1-k_d}P_t.$$  

(2.55)

If a non-optimizing household cannot optimize its wages during $s$ periods ahead, the wage in period $t+s$ is

$$P_{t+s} = (\prod_{t=0}^{s-1}\pi^c_t)^{k_d}(\prod_{t=0}^{s-1}\bar{\pi}^c_t)^{1-k_d}P_t^{NEW}.$$  

(2.56)

Prices are determined by maximizing the following:

$$\max_{P_t^{NEW}} E_t \sum_{s=0}^{\infty} (\beta\theta_f)^s v_{t+s} \left( \prod_{t=0}^{s-1} \pi^c_t \prod_{t=0}^{s-1} \bar{\pi}^c_t \prod_{t=0}^{s} P^{NEW}_t \right) Y_{t+s}$$

$$- MC_{hs,t+s}(Y_{t+s} - z_{t+s}\Phi).$$  

$$= \max_{P_{h,t+s}} E_t \sum_{s=0}^{\infty} (\beta\theta_f)^s v_{t+s} P_{t+s} \left( Y_{t+s} \left( \frac{P_{h,t+s}}{P_{t+s}} \right)^{1-\lambda_{d,s+1}} \right)$$

$$- MC_{hs,t+s} \left( Y_{t+s} \left( \frac{P_{h,t+s}}{P_{t+s}} \right)^{-\lambda_{d,s+1}} \right) + z_{t+s}\Phi.$$  

(2.57)

Defining $X_{t+s} = (\pi^c_t\pi^c_{t+1}\pi^c_{t+2}\ldots\pi^c_{t+s-1})^{k_d}(\bar{\pi}^c_{t+s}\bar{\pi}^c_{t+s+1}\bar{\pi}^c_{t+s+2}\ldots\bar{\pi}^c_{t+s+s})^{1-k_d}$ and $\bar{p}_t = \frac{P_t^{NEW}}{P_t}$, the FOC with respect to $\bar{p}_t$ is,
\[
E_t \sum_{s=0}^{\infty} (\theta_T)^s P_{t+s} v_{t+s} Y_{t+s} \left[ \left( 1 - \frac{\lambda_{d,t+s}}{\lambda_{d,t+s}-1} \right) X_{t,s} E_T - \frac{\lambda_{d,t+s}}{\lambda_{d,t+s}-1} \right] = 0
\]

which simplifies to
\[
E_t \sum_{s=0}^{\infty} (\theta_T)^s P_{t+s} v_{t+s} Y_{t+s} (X_{t,s} - \lambda_{d,t+s}) \left[ X_{t,s} E_T - \frac{\lambda_{d,t+s} M_{C_{t+s}}}{P_{t+s}} \right] = 0.
\]

Re-substituting back the definitions of \(X_{t,s}\) and \(E_T\), we therefore have
\[
E_t \sum_{s=0}^{\infty} (\theta_T)^s v_{t+s} \left( \frac{P_{t+s}}{P_{t-1}} \right)^{\frac{\lambda_{d,s}}{\lambda_{d,s}-1}} (\pi_T^c \pi_{t+s}^c \pi_{t+s})^{1-\kappa_d} \left( P_{t+s}^c P_{t+s}^c \right) P_{t+s} \left( \lambda_{d,t+s} M_{C_{t+s}} \right) = 0.
\]

Given the fact that the fraction \(1 - \theta_T\) of intermediate goods firms is able to set their prices optimally and the remaining firms can only partially index their wages to the previous period’s wage and current inflationary targets, the wage index evolves as
\[
P_t = \left[ \left( \frac{\xi^d}{P_{t-1} (\pi_T^c \pi_{t+1}^c \pi_{t+2}^c \pi_{t+3}^c)^{1-\kappa_d}} + \int_0^1 (P_{t}^{new})^{1-\lambda_{d,t}} d\xi \right)^{1-\lambda_{d,t}} \right] = \theta_T \left( \frac{\xi^d}{P_{t-1} (\pi_T^c \pi_{t+1}^c \pi_{t+2}^c \pi_{t+3}^c)^{1-\kappa_d}} + \int_0^1 (P_{t}^{new})^{1-\lambda_{d,t}} d\xi \right)^{1-\lambda_{d,t}}.
\]

Hence, the loglinearized Phillips curve for the tradable goods, after putting back the subscript/superscript T to represent the tradable goods sector, is
\[
\hat{\pi}_t^T = \frac{\beta}{1 + \kappa_T \beta} (\hat{\pi}_t^T + \rho_{\pi_T} \hat{\pi}_t^T) + \frac{\kappa_T}{1 + \kappa_T \beta} (\hat{\pi}_{t-1}^T - \hat{\pi}_t^T)
\]
\[
+ \frac{(1 - \xi_T)(1 - \beta T)}{\xi_T(1 + \kappa_T \beta)} (\hat{\pi}_t^T) + \hat{\lambda}_d \frac{\kappa_T \beta (1 - \rho_{\pi_T})}{1 + \kappa_T \beta} \hat{\pi}_t^T.
\]

The counterpart equation for the nontradable goods is similar, with the index replaced by index N, \textit{mutatis mutandis}. Appendix A lists down all the log-linearized equations of the model.

### 2.3.3 Foreign sector

In modelling the foreign sector, we generally follow ALLV (2007) but there is a fundamental difference between their approach and BVR. In the latter, there are final consumption and investment goods producers which are competitive. They source their inputs from a continuum of importing firms that buy goods from abroad.

#### 2.3.3.1 Importing firms

In modelling the foreign sector, we closely follow ALLV (2007) specifically in formulating the respective objective functions and deriving the implied optimal
behaviour of firms that are able to adjust and those that cannot. In BVR, there is a distributor that combines differentiated imported goods to produce the final imported good. These goods come from a continuum of importing firms that buy a foreign homogeneous good.

There are two kinds of importing firms, namely, investment and consumption firms. They essentially buy a homogeneous good at price $P^*_t$. There is incomplete exchange rate pass through to the prices, by assuming that there is local currency price stickiness (ALLV (2007), p. 8).

Following the logic of Calvo pricing, let $(1 - \theta_m)$ be the proportion of consumption good producing-importing firms that can change their prices optimally. Based on ALLV (2007), the reoptimized price is denoted by $P^{m,c}_{new,t}$. However, for a firm that cannot change its prices, its price evolves according to the following rule:

$$P^{m,c}_{t+1} = (\pi_t^{m,c})^{\kappa_m}(\pi_{t+1}^{m,c})^{1-\kappa_m}P^{m,c}_t. \quad (2.60)$$

For a firm that cannot adjust for $s$ periods, the price in $t + s$ is given by $P^{m,c}_{t+s} = (\prod_{t=0}^{s-1} \pi_t^{m,c})^{\kappa_w}(\prod_{t=0}^{s} \pi_{t+s}^{m,c})^{1-\kappa_w}P^{m,c}_{new,t}$.

Thus, the objective function is given by the following:

$$\max_{P^{m,c}_{new,t}} E_t \sum_{s=0}^{\infty} (\beta \theta_m)^{s} v_{t+s} \left( \left( \prod_{t=0}^{s-1} \pi_t^{m,c} \right)^{\kappa_c} \left( \prod_{t=0}^{s} \pi_{t+s}^{m,c} \right)^{1-\kappa_c} \right) P^{m,c}_{new,t} c^{m,c}_{t+s} - S_{t+s} P^{m,c}_{t+s} \left( C^{m,c}_{t+s} - z_{t+s} \phi^{m,c} \right).$$

The final imported good $C^m_t$ is a composite of differentiated imported consumption goods supplied by different firms.

$$C^m_t = \int_0^1 \left( C^{m,c}_{t,s} \right) \frac{1}{\lambda^{m,c}_t} ds \quad C^*_t, 1 \leq \lambda^{m,c}_t < \infty, \quad (2.62)$$

Expectedly, the demand for each firm’s imported consumption goods is shown by

$$C^m_{i,t} = \left( \frac{P^{m,c}_{i,t}}{\pi^{m,c}_t} \right)^{\lambda^{m,c}_t} C^m_t. \quad (2.63)$$

The mark-up is modelled by the autoregressive time varying processes.

$$\lambda^{m,c}_t = (1 - \rho_{\lambda^{m,c}})\lambda^{m,c}_{t-1} + \rho_{\lambda^{m,c}} \lambda^{m,c}_{t-1} + e^{m,c}_{t}, \quad (2.64)$$

Using the demand function $C^m_{i,t}$, the objective function is written as

$$\max_{P^{m,c}_{new,t}} E_t \sum_{s=0}^{\infty} (\beta \theta_m)^{s} v_{t+s} \left( \left( \prod_{t=0}^{s-1} \pi_t^{m,c} \right)^{\kappa_c} \left( \prod_{t=0}^{s} \pi_{t+s}^{m,c} \right)^{1-\kappa_c} \right) P^{m,c}_{new,t} \left( \frac{P^{m,c}_{i,t}}{P^*_t} \right)^{\lambda^{m,c}_t} C^{m,c}_{t+s} - S_{t+s} P^{m,c}_{t+s} \left( C^{m,c}_{t+s} - z_{t+s} \phi^{m,c} \right),$$

$$\max_{P^{m,c}_{new,t}} E_t \sum_{s=0}^{\infty} (\beta \theta_m)^{s} v_{t+s} \left( \left( \prod_{t=0}^{s-1} \pi_t^{m,c} \right)^{\kappa_c} \left( \prod_{t=0}^{s} \pi_{t+s}^{m,c} \right)^{1-\kappa_c} \right) P^{m,c}_{new,t} \left( \frac{P^{m,c}_{i,t}}{P^*_t} \right)^{\lambda^{m,c}_t} C^{m,c}_{t+s} - S_{t+s} P^{m,c}_{t+s} \left( C^{m,c}_{t+s} - z_{t+s} \phi^{m,c} \right).$$
The first-order condition is given by

\[
E_t \sum_{s=0}^{\infty} (\beta \theta_m)^s v_{t+s} \left( \prod_{\pi=0}^{s-1} \frac{p_{m,c}^{\pi+1}}{p_{m,c}^{\pi+1}} \right)^{\frac{1}{1-\kappa_{m,c}}} \frac{\lambda_{m,c}^{\pi+1}}{1+\kappa_{m,c}} C_{m,s}^t p_{m,c}^{t+s} \times \left( \prod_{s=0}^{s-1} \frac{p_{m,c}^{\pi+1}}{p_{m,c}^{\pi+1}} \right)^{1-\kappa_{m,c}} p_{new,t}^{m_c} \right) \frac{\lambda_{m,c}^{\pi+1} \tau_{t+s}}{\tau_t} \right] \right]^{1-\alpha_{m,c}} = 0.
\]

The price index for differentiated consumption goods is given by

\[
p_{m,j}^t = \theta_m \left( \prod_{\pi=1}^{\infty} \frac{p_{m,j}^{\pi+1}}{p_{m,j}^{\pi+1}} \right)^{1-\kappa_{m,j}} \left( \frac{p_{m,j}^{\pi+1}}{p_{m,j}^{\pi+1}} \right)^{1-\kappa_{m,j}} + (1-\theta_m) \left( \frac{p_{m,j}^{\pi+1}}{p_{m,j}^{\pi+1}} \right)^{1-\kappa_{m,j}} \right) \right] \right]^{1-\alpha_{m,j}}.
\]

Following the logic of Calvo pricing, let \(1-\theta_i\) be the proportion of consumption goods producing-importing firms that can change their prices optimally. Following ALLV (2007), the reoptimized price is denoted by \(p_{m,l}^{new,t}\). However, for a firm that cannot change its prices, its price evolves based on the following rule:

\[
p_{m,l}^{new,t} = \left( \frac{\pi_{t}^{m,l}}{\pi_{t}^{m,l}} \right)^{\kappa_{m,l}} \left( \frac{\pi_{t}^{m,l}}{\pi_{t}^{m,l}} \right)^{1-\kappa_{m,l}} p_{m,l}^{new,t}.
\]

For a firm that cannot adjust for \(s\) periods, the price in \(t+s\) is given by

\[
p_{m,l}^{new,t} = \left( \frac{\pi_{t}^{m,l}}{\pi_{t}^{m,l}} \right)^{\kappa_{m,l}} \left( \frac{\pi_{t}^{m,l}}{\pi_{t}^{m,l}} \right)^{1-\kappa_{m,l}} p_{m,l}^{new,t}.
\]

The aggregator function for differentiated investment goods is given by the following:

\[
l_t^M = \left( \int_{0}^{1} l_t^{M,k} \right) \lambda_{dt}.
\]

As a profit-maximizing firm, the demand function for each investment good is

\[
l_t^M = \left( \int_{0}^{1} l_t^{M,k} \right) \lambda_{dt}.
\]
The mark-ups are modeled by the following time varying process.

$$\lambda_{t}^{m,i} = \rho \lambda_{t-1}^{m,i} + \epsilon_{m,i,t}. \quad (2.73)$$

Substituting the demand function, we have

$$\max_{P_{t+1}^{new}} E_{t+\infty} \sum_{s=0}^{\infty} (\beta \theta_{d})^{s} \nu_{t+s} \left( \prod_{t+\tau}^{s} \pi_{t+\tau}^{m,i} \right) ^{\kappa_{m,i}} \left( \prod_{\pi=0}^{s} \bar{\pi}_{t+\tau}^{i} \right) ^{1-\kappa_{m,i}} \left( \frac{P_{t+1}^{m,i}}{P_{t}^{m,i}} \right) ^{\lambda_{t}^{m,i}} l_{t+\tau}^{m} - S_{t+s} P_{t+s}^{*} \left( \frac{P_{t+1}^{m,i}}{P_{t}^{m,i}} \right) ^{\lambda_{t}^{m,i}} l_{t+s}^{m} - z_{t+s} \theta_{m,i}.$$ 

Maximizing yields the following familiar result.

$$E_{t} \sum_{s=0}^{\infty} (\beta \theta_{d})^{s} \nu_{t+s} \left( \frac{P_{t+1}^{m,i}}{P_{t}^{m,i}} \right) ^{\kappa_{m,i}} \left( \prod_{\pi=0}^{s} \bar{\pi}_{t+\tau}^{i} \right) ^{1-\kappa_{m,i}} \left( \frac{P_{t+1}^{m,i}}{P_{t}^{m,i}} \right) ^{\lambda_{t}^{m,i}} l_{t+s}^{m} P_{t+s}^{m,i} = 0. \quad (2.74)$$

The price index for differentiated investment goods is given by

$$P_{t}^{i,j} = \left[ \theta_{i} \left( \left( \pi_{t-1}^{m,i} \right) ^{\kappa_{t}^{i}} \left( \bar{\pi}_{t}^{i} \right) ^{1-\kappa_{t}^{i}} P_{t}^{m,i} \right) ^{1-\lambda_{t}^{m,i}} + \left( 1 - \theta_{i} \right) \left( P_{new,t}^{m,i} \right) ^{1-\lambda_{t}^{m,i}} \right] \left( \pi_{t-1}^{m,i} \right) ^{\kappa_{t}^{i}} \left( \bar{\pi}_{t}^{i} \right) ^{1-\kappa_{t}^{i}}. \quad (2.75)$$

### 2.3.3.3 Exporting firms

Following the logic in ALLV (2007) and BVR (2010), the exporting firms purchase the final domestic good to produce a good differentiated through brand naming. Because of their orientation, the differentiated products are sold to foreign households. Calvo pricing still persist as a way of determining the price that will optimize firm’s profits but export firms remain unable to achieve complete exchange rate pass-through.

Following the logic of Calvo pricing, let \(1 - \theta_{i}^{x}\) be the proportion of consumption good producing-importing firms that can change their prices optimally. Using ALLV (2007) notation, the reoptimized price is denoted by \(P_{new,t}^{x}\).

For firms unable to set their prices optimally in \(t+1\), the evolution of prices in the export sector is given by

$$P_{t+1}^{x} = (\pi_{t+1}^{x} \kappa_{t+1}^{x} \bar{\pi}_{t+1}^{x}) ^{1-\kappa_{t}^{x}} P_{t}^{x}. \quad (2.76)$$
The objective function is
\[ \max_{P_{\text{new},t}} \sum_{s=0}^{\infty} \left( \frac{\beta \Theta_s}{\Phi_s} \right) u_{t+s} \left( \prod_{t=0}^{s-1} P_{t+t} \right)^{\xi_t} \left( \prod_{t=0}^{s} P_{t+t} \right)^{1-\xi_t} \left( P_{t+t} \right)^{\lambda_{s+1}} \left( \frac{P_{t+t}}{P_t} \right)^{\lambda_{s+1}} \left( P_{t+t} \right)^{\lambda_{s+1}} - \frac{P_{t+s}}{S_{t+s}} \left( P_{t+s} - z_{t+s} \Phi^X \right). \] (2.77)

With the demand function specified by
\[ \tilde{X}_{t,t} = \left( \frac{P_{t+t}}{P_t} \right)^{-\lambda_{t+1}} \tilde{X}_t. \] (2.78)

Substituting the demand function into the objective function, we have
\[ \max_{P_{\text{new},t}} \sum_{s=0}^{\infty} \left( \frac{\beta \Theta_s}{\Phi_s} \right) u_{t+s} \left( \prod_{t=0}^{s-1} P_{t+t} \right)^{\xi_t} \left( \prod_{t=0}^{s} P_{t+t} \right)^{1-\xi_t} \left( P_{t+t} \right)^{\lambda_{s+1}} \left( \frac{P_{t+t}}{P_t} \right)^{\lambda_{s+1}} \left( P_{t+t} \right)^{\lambda_{s+1}} - \frac{P_{t+s}}{S_{t+s}} \left( P_{t+s} - z_{t+s} \Phi^X \right). \]

Given that the domestic economy is small enough to influence the foreign economy. We assume that the following functional relationships hold:

\[ I_t = \left( C^x_t \right)^{\eta_{r+1}} \left( C^{t-1} t \right)^{\eta_{r+1}} \] (2.79)

\[ I_t = \left( 1 - \omega_i \right)^{1/\eta} \left( l_{d,t} \right)^{\eta_{r-1}} + \left( \omega_i \right)^{1/\eta} \left( l_{m,t} \right)^{\eta_{r-1}} \] (2.80)

\[ C^x_t = (1 - \omega_i) \left[ \frac{P^x_t}{P_t} \right]^{\eta} C^x_t \] (2.81)

\[ I^x_t = (1 - \omega_i) \left[ \frac{P^x_t}{P_t} \right]^{\eta} I^x_t. \] (2.82)

### 2.4 Relative prices

As ALLV (2007) explained, the consideration of open economy shocks in a DSGE model is important in determining key macroeconomic outcomes, given the possibility that there is a high elasticity of substitution between domestic and imported goods (ALLV (2007)).

\[ \gamma_{t,mc,d} = \frac{P_{t}^{mc,c}}{P_{t}} \] (2.83)

\[ \gamma_{t,mc,d} = \frac{P_{t}^{mc,id}}{P_{t}} \] (2.84)

\[ \gamma_{t,mc,d} = \frac{P_{t}^{mc}}{P_{t}} \] (2.85)

\[ \gamma_{t,mc,d} = \frac{P_{t}^{mc,ld}}{P_{t}} \] (2.86)
2.5 The monetary authority

Monetary policy in the Philippines is conducted independently by the Bangko Sentral ng Pilipinas (BSP), contrary to the European system wherein it is delegated to the European Central Bank. The nominal interest rate follows the Taylor rule:

\[ R_t^\text{c} = \rho R\hat{R}_{t-1} + 1 - \rho_R \left( \hat{\pi}_t^e + \tau_t^e (\hat{\pi}_{t-1}^e - \hat{\pi}_t^e) + \tau_{y_t} \hat{x}_{t-1} + \tau_{\Delta_\pi} \Delta \hat{R}_t + \tau_{\Delta^y} \Delta \hat{y}_t + \varepsilon_{R_t} \right) \]  

where \( \varepsilon_{R_t} \) is interpreted as a random shock to monetary policy.

Log-linearized exchange rate is given by

\[ \hat{x}_t = S_t + P_t^* - P_t^c. \]

CPI inflation rate index is given by the following equation:

\[ \hat{\pi}_t^c = \left( (1 - \omega_N) \left( \gamma_T^c \right)^{(1-\eta_c)} \right) \hat{\pi}_t^T + \left( \omega_N \left( \gamma_N^c \right)^{(1-\eta_c)} \right) \hat{\pi}_t^N. \]  

The deviation of the inflation target from the steady-state inflation rate is assumed to follow the process

\[ \hat{\pi}_t^c = \rho_{\hat{\pi}_t^c} \hat{\pi}_{t-1}^c + \varepsilon_{\hat{\pi}_t^c}. \]  

2.6 The government problem

The budget constraint consists of the level of outstanding debt, the stochastic process that determines government consumption, and taxes and transfers.
\[ P_t G_t + TR_t = R_{t-1}(M_{t+1} - M_t) + \tau^C P_t C_t + (\tau^V + \tau^Y) \frac{W_t}{1 + \tau^V} L_t + \tau^k \left( (R_{t-1} - 1)(M_{t+1} - Q_t) + R^k u_{i,t} K_t \right) + \left( R_{t-1} \Phi \left( \frac{A_{t-1}}{z_{t-1}} \phi_{t-1} \right) - 1 \right) S_t B^*_t + \Pi_t. \] (2.96)

### 2.7 Aggregation

Closing the model requires aggregation conditions for the goods, labor, and import and export markets. We closely follow BVR (2010) and ALLV (2007). We first specify aggregate demand of the domestic final good which is equal to domestic consumption, domestic investment government spending, and exported consumption and investment goods. Aggregate output is given by

\[ Y_t = Y_{T,t} + Y_{N,t} + G_t \] (2.97)

where \( Y_{T,t} = C_t^a + I_t^a + G_t + C_t^x + I_t^x. \)

Formally, it is represented by

\[ C_t^a + I_t^a + G_t + C_t^x + I_t^x \leq z_t^{-1} \epsilon_t K_t^{\theta} H_t^{1-\theta} - z_t \phi - a(u_t) K_t. \] (2.98)

### 2.8 Evolution of net foreign assets

Following BVR (2010) and ALLV (2007), specifying the evolution of the net foreign assets will close the foreign sector. We integrate remittances by following ALM (2009). The balance of payments evolves as

\[ S_t B_{t+1}^* = S_t P_t^C (C_t^x + I_t^x) - S_t P_t^C (C_t^m + I_t^m) + R^*_{t-1} \Phi(a_{t-1}, \phi_{t-1}) S_t B_t^* + \Xi_t \] (2.99)

\[ S_t B_{t+1}^* = S_t P_t^C (C_t^x + I_t^x) - S_t P_t^C (C_t^m + I_t^m) + R^*_{t-1} \Phi(a_{t-1}, \phi_{t-1}) S_t B_t^* + \Xi_t + \Xi_t^m \] (2.100)

\[ a_t = \frac{S_t B_{t+1}^*}{P_t Z_t}, \]

\[ a_t = \frac{S_t B_{t+1}^*}{P_t Z_t}. \]

Divide through by \( P_t Z_t \)

\[ \frac{S_t B_{t+1}^*}{P_t Z_t} = \frac{S_t P_t^C Y_t^*}{P_t z_t} - \frac{S_t P_t^C}{P_t} \left( \frac{C_t^m z_t + I_t^m z_t}{z_t} \right) + R^*_{t-1} \Phi(a_{t-1}, \phi_{t-1}) \frac{S_t B_{t-1}^*}{S_t B_{t-1}^*} \frac{S_t P_{t-1}^C}{P_t z_t} \frac{S_t P_{t-1}^C}{P_t z_t} \frac{S_t P_{t-1}^C}{P_t z_t} \]

\[ + p_{t-1}^{m,c} \left( \Xi_t^p + \Xi_t^c \right) \frac{p_{t-1}^{m,c} z_t}{P_t z_t} + \frac{p_{t-1}^{m,c} z_t}{P_t z_t}. \]

Stationized net foreign assets (NFA) equation:

\[ a_t = (mc_t^{-1} (y_t^{x*})^{-1} + y_t^{z*}) z_t - (y_t^{x*})^{-1} (c_t^m + I_t^m) + R^*_{t-1} \Phi(a_{t-1}, \phi_{t-1}) \frac{a_{t-1}}{P_t z_t} \frac{S_t}{S_t}; \] (2.101)

\[ + \frac{p_{t-1}^{m,c} z_t}{P_t z_t} \frac{p_{t-1}^{m,c} z_t}{P_t z_t}. \]

Totally differentiating, we arrive at:

Linearized equation for NFA:
\[ \hat{a}_t = -y^*\bar{m}c_t^x - \eta f y^*y_t^{x,s} + y^*\hat{c}_t + (c + i_m)\hat{f}_t \]
\[ -c^m(1-\omega_c)(y_t^{c,d})^{-1}y_t^{m,d} + \hat{c}_t \]
\[ + i^m \eta_i(1-\omega_c)(y_t^{i,d})^{-1}y_t^{m,d} + \hat{i}_t \]
\[ + \frac{R}{\pi\mu_x} \hat{a}_{t-1} \]
\[ \text{2.10) } \]

2.9. Loan market clearing

\[ v_t W_t H_t = \mu_t M_t - Q_t \]

Stationarized form:

\[ v_t \bar{w}_t H_t = \frac{\mu_t \bar{m}_t}{\pi_t u_{t}} - q_t \]

2.10 Foreign economy

We consider three foreign economy variables, namely, foreign output, interest rate and inflation rate. Following ALLV (2007), we model the exogenous variables using a VAR process.

\[ F_0 X_t^* = F(L)X_{t-1}^* + \varepsilon_{x^*,t}, \quad \varepsilon_{x^*,t} \sim N(0, \Sigma_{x^*}) \]

3 EMPIRICS OF AN OPEN ECONOMY DSGE MODEL

3.1 Introduction

For several years now, Bayesian methodologies have provided the estimation framework of choice among macroeconomists, especially those who are estimating medium- and large-scale macroeconometric models that do not have explicit closed form solutions.

Deciphering the reasons for this prevalent preference is not hard. Villaverde (2010) highlights some advantages of the Bayesian technique. First, Bayesian techniques generate more relevant and useful estimates. Second, even with limited data points, such techniques utilize what Villaverde (2010) calls pre-sample information which may be hard to incorporate in a frequentist-based approach. In the case of remittances, for instance, one can incorporate microeconomic-based theories in determining priors. Third, Bayesian techniques are capable of estimating many objects of interest, such as the entire distribution of a particular statistic. For instance, suppose we want to measure how remittances affect welfare. Bayesian techniques can give us the entire distribution of such an effect. Fourth, compared with other estimation platforms, Bayesian methods account for the various model elements and not only those confined within equilibrium relationships (Grifolli [2008]). Finally, Bayesian techniques do not prescribe a true model nor try to replicate the frequentist objective of searching for the true parameter value. In this sense, we cannot make an assertion that the DSGE model is outrightly false relative to a `true' model.

In their review of Bayesian techniques for estimating DSGE models, Guerron-Quintana and Nason (2012) (henceforth referred to as GQN (2012)), notes that the Bayesian method does not endorse a particular model as the true model, contrary to other known estimation platforms that subscribe to the classical approach. As explained in GQN (2012), this view is deeply anchored on the likelihood principle which means that the evidence should be provided by the data and that probabilistic statements made
should pertain to the conditional likelihood, not relative to a data generating process (DGP) that is assumed to be true. In fact, Bayesian methods allow the comparison of models based on model fit (Grifollı́ (2008)).

As shown in ALLV (2007) and BVR (2010), open economy DSGEs are described by a complicated and interdependent model structures. The incorporation of such structures necessarily lead to a problem of high dimensionality which is not easily addressed using conventional estimation platforms such as the maximum likelihood estimator (Villaverde (2010)).

In this section, we review existing Bayesian methodologies and examine the feasibility of estimating the base model that may embed remittance shocks in ALLV’s open economy DSGE model. While estimating ‘deep parameters’ remains a key objective, data imperfections prevent us from implementing Bayesian methodologies. Section 3.2 discusses the computational requisites prior to estimating parameters of the model. Section 3.3 discusses how the empirical methodology is applied. Section 3.4 briefly discusses the estimation of the model’s impulse response functions.

3.2 A review of computational requisites

3.2.1 Bayesian methods

Bayesian methods will be used to estimate some of the key parameters of the model. In the literature, Bayesian methods are empirically appealing with the parameters assumed to be random, contrary to the classical assumption that the model is generated by an underlying data generating process (DGP). The objective of classical methods is to estimate unknown parameters that are assumed to be true. Bayesian methods overcome the inherent difficulty of maximum likelihood estimation to include non-sample information and avoid intricacies involved when the distributional assumption is inconsistent with the data. It essentially acts as the bridge between calibration and maximum likelihood (Grifollı́ (2008)). As noted in Villaverde (2010), sometimes it is not interesting to determine the significance of parameter estimates in repeated samples. Bayesian analysis requires the prior distribution, the data and the likelihood function in order to derive the posterior distribution (see GQN).

Formally, consider the vector $\psi$ that stacks up all parameters in the model. The parameter vector may vary across DSGE models due to the imposition of plausible restrictions based on economic theory. The prior density is given by $p(\psi)$. Priors act as weights in the estimation process and helps in the identification of parameters (Grifollı́, 2008). The model implies a likelihood $p(Y^T|\psi) = L(\psi|Y^T)$ for some observed data. The posterior distribution of the vector of parameters is given by

$$p(\psi|Y^T) \propto p(Y^T|\psi)p(\psi).$$

The density of parameters given the data $p(\psi|Y^T)$ can also be written as $p(\psi; Y^T)/p(Y^T)$.

Following Grifollı́ (2008), the posterior density associated with model $M$ is given by:

$$p(\psi_M|Y^T, M) = p(Y^T|\psi_M, M) \times p(\psi_M|M) / p(Y^T|M)$$

where the marginal density $p(Y^T|M)$ equals
To complete the picture, the posterior kernel is given by
\[ p(\psi_M|Y^T,M) = p(Y^T|\psi_M,M)p(\psi_M|M). \]

The posterior distribution for DSGE models is difficult to characterize, thereby necessitating the use of simulation methods to generate draws using the Metropolis-Hastings (MH) algorithm. We use Kalman filter to estimate the likelihood function and the posterior kernel is simulated using the MH algorithm.

### 3.2.2 Estimating DSGE: a general procedure

1. There is a need to stochastically detrend because of the presence of nonstationary prices and technology or productivity shocks. Following ALLV (2007), GQN (2012) and BVR (2010), detrending is usually applied to the first-order and equilibrium conditions.

2. We log-linearized the solution of the DSGE open economy model, duly accounting for non-stationary behavior induced by price level and technological change. We use the first-order Taylor or linear approximation.

3. Following De Jong and Dave (2007) and GQN (2012), equilibrium conditions are portrayed as expectational stochastic difference equations.

4. Consistent with other studies, we specify the prior distributions of a set of estimable parameters. The choice of priors is not a trivial exercise.

5. Determine the likelihood via Kalman filter. In this step, there is a need to utilize tools of state space modeling and filtering theory (Villaverde 2010)). There are two critical components of the state space representation, namely a transition equation relating a state vector to a vector of innovations and parameters, and a measurement equation which, in turn, relates observed variables to shocks. To avoid the problem of stochastic singularity, the number of observed series should be equal to the number of shocks in the model. As mentioned in Villaverde (2010), one needs to determine the set of observed variables because they have implications on inference. In using the Kalman filter, we assume that both the transition and measurement equations are linear and the shocks are normally distributed (Villaverde (2010), p. 17). This necessitates solving the model and approximating the same using a first-order linear approximation.


7. Compute the marginal likelihood numerically.

8. Compute statistics of interest. We are interested in computing the posterior distribution of estimable parameters.

### 3.2.3 The Linearized Model and its solution

The basis of the linearized model is the theoretical model elements identified in ALLV (2007) and section 2. In the said references, the structure of the model consists of first-order optimality conditions, equilibrium conditions, relative prices and shock processes. As explained in BVR (2010) and GQN (2012), since the DSGE model does not have a closed form solution, one needs to determine a model that is linearized around a non-stochastic steady state in order to determine the model solution using linear algebraic solution methods.

Following ALLV (2007), we will also stationarize model variables to account for trends induced by technology or productivity shocks. This is known as stochastic
detrending and it is done by dividing trended real variables by the productivity shock. To implement stochastic detrending, trending real variables are divided by the productivity shock. Nominal wages are divided by the product of the price and productivity shock.

Linearization can be achieved using Uhlig's log-linearization or by way of first-order Taylor approximation. In other studies, higher-order approximations are used to avoid biases that may arise when the valid degree of approximation is not linear.

The solution can be cast as an expectational stochastic difference equation. Largely borrowing from ALLV and GQN, we have the expectational stochastic difference equation as

\[ E_t \left[ G(N_{t+1}, N_t, X_{t+1}, X_t) \right] = 0, \]

where \( X_t \) is the vector of predetermined states and \( N_t \) includes non-predetermined controls. As shown in GQN (2012), the solution of the model takes the form of

\[ X_t = \Psi X_{t-1} + \Phi \xi_t \]
\[ N_t = \Xi X_t. \]

The first is a system of equations that pertain to linear approximate equilibrium decision rules of the state variables. \( \xi_t \) contains the vector of structural innovations in the model.

### 3.3 Bayesian estimation of the model: a roadmap

Bayesian estimation uses the Kalman filter to construct the likelihood of the model. Then priors are proposed because they are used to compute for the posteriors.

#### 3.3.1 Evaluating the likelihood using the Kalman Filter

The solution of a DSGE model is based on the system of log-linearized equations. To be able to estimate the parameters, the likelihood principle should be involved. A necessary step is to be able to evaluate the likelihood function that is based on the solution to the log-linearized system.

To provide an exposition, we use Villaverde (2010), GQN (2012) and De Jong and Dave (2007). For the Kalman filter to work, there are several assumptions, namely, linearity of the transition and measurement equations and normally distributed shocks. The Kalman filter projects the state of linear approximate solution. The filter is useful for evaluating the likelihood because the forecasts are optimal within a class of models.

The starting point is to specify the state-space representation of the solution to the model. Similar to GQN (2012), we have the critical equations.

\[ X_t = GX_{t-1} + He_t, \quad e_t \sim NID(0, I_m), \]
\[ \Psi_t = Q + JX_t + e_{u,t}, \quad e_{u,t} \sim NID(0, \Sigma_u). \]

Following GQN (2012), \( \Psi_t \) corresponds to the vector of observables, \( X_t = [N_t', S_t'] \) simply combines the vectors of non-predetermined variables and states, \( G \) and \( H \) are functions of the structural matrices and \( J \) relates the model’s definitions to the data. As noted in GQN, \( e_{u,t} \) is a measurement error.

We define the following linear projections.
The first is the conditional expectation of $X_t$ given its previous history. The second conditions the mean of the state variable on $Y_t$. The covariance matrix is

$$ p_{t-1|t-1} = E\left[(X_{t-1} - X_{t-1|t-1})(X_{t-1} - X_{t-1|t-1})'\right]. $$

The likelihood of the linearized model, $L(S_{t-1}|\Theta)$ is built up by generating forecasts from the state space system period by period

$$ L(Y_t|\Theta) = \prod_{t=1}^{T} L(Y_t|Y_{t-1}, \Theta). $$

As GQN (2012) states, $L(Y_t|Y_{t-1}, \Theta)$ is the likelihood conditional on the information up to date $t-1$.

The steps are given in GQN (2012), De Jong and Dave (2007) and Villaverde (2010). Closely following GQN, we will simply repeat them here for exposition purposes.

1. Set the conditional forecast of $X_{1|0}$ to zero. The projection $p_{1|0} = GP_{0|0}G + HH'$
2. On the basis of conditional forecasts, compute for the value of $\Psi_{1|0} = JX_{1|0}$, $\Omega_{1|0} = E\left[(\Psi_1 - \Psi_{1|0})(\Psi_1 - \Psi_{1|0})'\right] = J'p_{1|0} + \Sigma_u$.
3. The predictions made in steps 1 and 2 produce the date 1 likelihood. The likelihood for the observable vector conditional on the parameters is given by

$$ L(Y_1|\Theta) = (2\pi)^{-m/2}|\Omega_{1|0}^{-1}|^{1/2}\exp\left(-(1/2)(\Psi_1 - \Psi_{1|0})'\Omega_{1|0}^{-1}(\Psi_1 - \Psi_{1|0})\right). $$

4. Update the date 1 forecasts.

$$ X_{1|1} = X_{1|0} + p_{1|0}\Omega_{1|0}^{-1}(\Psi_1 - \Psi_{1|0}) $$
$$ p_{1|1} = p_{1|0} - p_{1|0}\Omega_{1|0}^{-1}J'p_{1|0} $$

5. Repeat steps 2, 3, and 4 to generate Kalman filter predictions (see GQN)

$$ X_{t|t-1} = X_{t-1|t-1}P_{t|t-1} $$
$$ p_{t|t-1} = Jp_{t-1|t-1}J' + \Psi_{t|t-1} = J'X_{t|t-1} $$
$$ \Omega_{t|t-1} = E\left[(\Psi_t - \Psi_{t|t-1})(\Psi_t - \Psi_{t|t-1})'\right] = J'p_{t|t-1}J + \Sigma_u $$

$$ L(Y_t|\Theta) = (2\pi)^{-m/2}|\Omega_{t|0}^{-1}|^{1/2}\exp\left(-(1/2)(\Psi_t - \Psi_{t|t-1})'\Omega_{t|t-1}^{-1}(\Psi_t - \Psi_{t|t-1})\right) $$

$$ X_{t|t} = X_{t|t-1} + p_{t|t-1}\Omega_{t|t-1}^{-1}(\Psi_t - \Psi_{t|t-1}) $$
$$ p_{t|t} = p_{t|t-1} - p_{t|t-1}\Omega_{t|t-1}^{-1}J'p_{t|t-1} $$

### 3.3.2 Metropolis-Hastings algorithm

As recognized by Grifollı (2008), the MH algorithm allows one to simulate the posterior distribution by generating a Markov chain of samples. Unlike statistical problems wherein the distribution can be easily derived, DSGE models give rise to nonlinear function of deep parameters (Grifollı (2008)). The algorithm is initialized by selecting a starting point which is usually the posterior mode. Then a proposal
parameter vector is drawn from a jumping distribution. Then the acceptance ratio is computed and a rule is proposed in order to set the decision rule on the proposal parameter.

3.4 Model and estimates

3.4.1 Log-linearized equations

As explained in GQN (2012), ALLV (2007) and Villaverde (2010), the solution elements of DSGE models are mostly nonlinear. Closely following ALLV, we have the system of log-linearized equations that form the basis for the estimation procedure. The said log-linearized equations are found in the model block of the DYNARE code of ALLV (2007).

To estimate the impulse response functions, we used DYNARE, a software that specializes in DSGE computation. It is embedded on MATLAB. As shown in the program used by ALLV, the initial step involves the declaration of endogenous and exogenous variables and parameters. The specification of the linearized model comes next. This is the most important component of the DYNARE program. To arrive at a steady state solution, the program requires inputting parameter values. There is a possibility that a steady state may not be found. Then using the Blanchard-Khan procedure, the program now evaluates whether a key condition for computational feasibility and identification is satisfied.

3.4.2 Impulse response functions

Central to DSGE modelling is the co-existence of shocks which may or may not perturb macroeconomic variables. Because of the integrated nature of the model, even a shock in one sector can affect the outcomes in other sectors. There are about 22 shock processes in the model and 8 outcome variables of interest.

In estimating the impact of the shocks, we can include more outcome variables but we decided to focus on the more important ones that provide policy guidance. The outcome variables are: domestic tradable goods inflation, domestic nontradable goods inflation, total remittances, the real wage, consumption, investment, exchange rate and output.

The shock variables are grouped into the following: (a) technology and investment shocks which include tradable and nontradable sector-specific shocks, unit root technology shocks, asymmetric technology shocks and investment-specific shocks; (b) fiscal and monetary policy shocks; (c) substitution elasticity shocks; (d) household preference shocks; (e) foreign variable shocks; (f) price mark-up shocks; (g) trade related variables; and (h) others not elsewhere classified.

One of the most useful results are the impulse response functions, which shows how a certain shock affects outcome variables temporally. Estimated impulse response functions are found in Figures 1 to 22.

4 EXAMINING THE MACROECONOMIC IMPACT ON REMITTANCES

This section focuses on how remittances react to various shocks. For the analyses to be more informative, we will study the respective responses of total remittances and its components. In the model, we did not include shocks to remittances so the objective is to simply understand how shocks affect remittances themselves.
Based on the way we defined total remittances in section 2, we can immediately discern key determinants, namely, domestic output, international output, exchange rate, investment, household’s consumption habits and labor supply preferences, and domestic and foreign inflation, to name a few concrete ones. This implies that when there is a permanent shock to output through an improvement in production processes, remittances will be affected. The introduction of two sectors, the consideration of policy shocks and preference shocks appear to alter remittance behaviour. Based on the way remittances are modelled, we know that remittances respond to domestic conditions and investment opportunities. However, it is safe to presume that the respective components of total remittances will respond to the above-mentioned determinants differently.

Whether such an impact is significant or not, we can appreciate how remittances are affected by a host of economic shocks.

4.1 Impulse response of total remittances

We start by only looking at total remittances. As shown in Figures 1 and 2, sector-specific stationary technological shocks appear to affect remittances differently, with tradable sector shocks being associated with increases in all forms of remittances, including aggregate remittances. Though not substantive an evidence, it plausibly highlights the sensitivity of remittances to improvements in sectoral economic conditions. The more permanent the shock, the higher is the negative impact on remittances. This is the case of unit root technology shocks (see Figure 10) since they induce permanent changes in the level of output. On the other hand, the initial impact of labor preference and asymmetric technology shocks appear to increase remittances. Asymmetric technology shocks relate the level of a given country’s technology to the rest of the world. As shown in Figure 21, a positive shock to labor supply would be expected to boost initial real wages, dampen consumption and boosts investment. Surprisingly, it will reduce output which may partly explain why remittances will decrease.

In terms of fiscal policy variables, an exogenous increase in government spending will reduce remittances. The link between government spending and output is positive and this may partly explain why the initial impact on remittances is negative. Over time, as the impact of the government spending shock diminishes, remittances will be increasing. The immediate impact of shocks to tax rates is insignificant but over time, they induce a downward response from remittances.

Foreign variables also affect remittances. Consider foreign inflation shock. As shown in Figure 13, a positive shock will surprisingly increase remittances. One explanation for this is that the inflation sensitivity of remittances may be dominated by other motivations. It certainly is more favourable in countries where monetary policy aims to maintain price stability. On the other hand, a shock to the domestic inflation target would reduce remittances.

In terms of mark-up shocks, a positive will push remittances upwards while a domestic tradable mark-up results in a negative initial remittance response.

4.2 Impulse response of remittances, by components

As noted in section 2, total remittances have cyclical, procyclical and strategic components. Thus, the analyses will turn out to be more informative than when we simply rely on total remittances.
When there is a positive government spending shock, the initial reaction of counter-cyclical remittances is negative as well as strategic remittances.

Now let us examine how technological shocks affect remittance components. Sector-specific stationary technological shocks appear to have divergent effects on remittance components. A positive shock in the tradable sector appears to induce increases in counter-cyclical and strategic remittances after 7-10 years. On the other hand, if the shock emanates from the nontradable sector, there is a robust positive effect on strategic remittances. Unit root technological shocks robustly cause a decline in counter-cyclical remittances but not in strategic remittances. For asymmetric technology shock, it is clear that the observed increase in total remittances come from its procyclical component. It is also notable that the strategic component will increase remittances after 4 quarters and will sustain its upward trend, thereby compensating the downward trends in procyclical and counter-cyclical remittances.

As expected, a consumption preference shock will reduce counter-cyclical and strategic remittances. Investment specific shocks as shown in Figure 19 indicates that the positive over-all effect on total remittances come consistently from the counter-cyclical and strategic components. Shocks to monetary policy appear to induce an increase in counter-cyclical and procyclical remittance but dampens robustly strategic remittances. In terms of mark-ups, domestic shocks induce a reduction in cyclical remittances but causes an increase in strategic remittances.

5 CONCLUDING REMARKS

In this paper, we augment the existing open economy DSGE model of ALLV (2007) by distinguishing the nontradable and tradable sectors, and including remittances. This makes our model more stylized given the fact that the Philippines remains as one of the top remittance-receiving countries in the world. We estimated the dynamics of various macroeconomic variables after individually considering exogenous shock processes. We focused our analysis on the response of remittances on shock processes. This is an important undertaking because of the role remittances play in stabilizing foreign exchange markets and providing support to economic activities involving households and firms.

While the model appears to capture fairly well some stylized facts, we recognize that there are some inadequacies. First, the paper did not define a stochastic process for remittances. Doing so would allow us to understand how remittance shocks affect key macroeconomic outcomes like labor supply, output, real wages, domestic inflation, elasticity of substitution, real interest rate, to name a few. Second, the impulse response functions, while informative, were based on stochastic simulation methods, not actual data. As mentioned, data transformations must be meticulously mapped against model variables which are not always properly measured. Third, the model made the assumption that while there are two sectors with their own production processes for their respective intermediate goods firms, there is only one real wage which implies total labor was the one considered. Fourth, the model assumes that households have access to capital markets, which may not be reflective of the real situation as other households can be classified as rule-of-thumb households. Fifth, the model does not integrate the financial markets and its various agents, thereby ignoring financial frictions as one probable cause of economic fluctuations.
References


The Log-linearized Model

\[ \hat{\pi}_t^T = \hat{\pi}_t^c + \left( \frac{\beta}{1 + \kappa_T} \right) (\hat{\pi}_{t+1}^T - \rho_a \hat{\pi}_t^c) + \left( \frac{\kappa_T}{1 + \kappa_T \beta} \right) (\hat{\pi}_{t-1}^T - \hat{\pi}_t^c) + \frac{(1 - \xi_T)(1 - \beta \xi_T)}{\xi_T (1 + \kappa_T \beta)} (\hat{m}_c^T) \]

\[ + \lambda d,t - \frac{\kappa_T \beta (1 - \rho_m)}{1 + \kappa_T} \hat{\pi}_t^c \]

\[ \hat{\pi}_t^N = \hat{\pi}_t^c + \left( \frac{\beta}{1 + \kappa_N} \right) (\hat{\pi}_{t+1}^N - \rho_a \hat{\pi}_t^c) + \left( \frac{\kappa_N}{1 + \kappa_N \beta} \right) (\hat{\pi}_{t-1}^N - \hat{\pi}_t^c) + \frac{(1 - \xi_N)(1 - \beta \xi_N)}{\xi_N (1 + \kappa_N \beta)} (\hat{m}_c^N) \]

\[ + \lambda N,t - \frac{\kappa_N \beta (1 - \rho_m)}{1 + \kappa_N} \hat{\pi}_t^c \]

\[ \hat{\pi}_t^{m,c} = \hat{\pi}_t^c + \left( \frac{\beta}{1 + \kappa_{m,c} \beta} \right) (\hat{\pi}_{t+1}^{m,c} - \rho_a \hat{\pi}_t^c) + \left( \frac{\kappa_{m,c}}{1 + \kappa_{m,c} \beta} \right) (\hat{\pi}_{t-1}^{m,c} - \hat{\pi}_t^c) \]

\[ + \frac{(1 - \xi_{m,c})(1 - \beta \xi_{m,c})}{\xi_{m,c} (1 + \kappa_{m,c} \beta)} (\hat{m}_{c,m}^c) + \hat{\eta}_{m,c} - \frac{\kappa_{m,c} \beta (1 - \rho_m)}{1 + \kappa_{m,c} \beta} \hat{\pi}_t^c \]

\[ \hat{\pi}_t^{m,l} = \hat{\pi}_t^c + \left( \frac{\beta}{1 + \kappa_{m,l} \beta} \right) (\hat{\pi}_{t+1}^{m,l} - \rho_a \hat{\pi}_t^c) + \left( \frac{\kappa_{m,l}}{1 + \kappa_{m,l} \beta} \right) (\hat{\pi}_{t-1}^{m,l} - \hat{\pi}_t^c) \]

\[ + \frac{(1 - \xi_{m,l})(1 - \beta \xi_{m,l})}{\xi_{m,l} (1 + \kappa_{m,l} \beta)} (\hat{m}_{c,m}^l) + \hat{\eta}_{m,l} - \frac{\kappa_{m,l} \beta (1 - \rho_m)}{1 + \kappa_{m,l} \beta} \hat{\pi}_t^c \]

\[ \hat{\pi}_t^c = (1 - \omega_c)(\gamma^{c,cd} - (1 - \eta_c) \hat{\pi}_t^c) + (\omega_c)(\gamma^{c,mc} - (1 - \eta_c)) \hat{\pi}_t^{m,c} \]

\[ \hat{\pi}_t^x = \hat{\pi}_t^c + \left( \frac{\beta}{1 + \kappa_x} \right) (\hat{\pi}_{t+1}^x - \rho_a \hat{\pi}_t^c) + \left( \frac{\kappa_x}{1 + \kappa_x \beta} \right) (\hat{\pi}_{t-1}^x - \hat{\pi}_t^c) \]

\[ + \frac{(1 - \xi_x)(1 - \beta \xi_x)}{\xi_x (1 + \kappa_x \beta)} (\hat{m}_c^x) + \hat{\eta}_x - \frac{\kappa_x \beta (1 - \rho_m)}{1 + \kappa_x \beta} \hat{\pi}_t^c \]

\[ \hat{\omega}_t = -\frac{1}{\eta_1} \left[ \eta_0 \hat{\omega}_{t-1} + \eta_2 \hat{\pi}_t^c + \eta_3 \hat{\pi}_t^d + \eta_4 \hat{\pi}_t^{d,+1} + \eta_5 \hat{\pi}_t^{c,-1} + \eta_6 \hat{\pi}_t^c + \eta_7 \hat{\omega}_{t+1} + \eta_8 \hat{\pi}_t^c + \eta_9 \hat{\pi}_t^y + \eta_{10} \hat{\pi}_t^w + \eta_{11} \hat{\pi}_t^p \right] \]

\[ \hat{\epsilon}_{TOTAL,t} = -\left( \frac{1}{\mu_\beta + \beta^2} \right) \left[ -b \beta c \hat{\pi}_{t+1} - b m c \hat{\pi}_{t-1} + b \mu_m (\hat{\mu}_{x,t} - \beta \hat{\mu}_{x,t+1}) \right] \]

\[ +(\mu_x - \beta b)(\mu_x - b)\hat{\psi}_{t,x} + \frac{\tau}{\tau + 1} (\mu_x - \beta b)(\mu_x - b) \hat{\psi}_{t,x} \]

\[ + (\mu_x - \beta b)(\mu_x - b) \hat{\pi}_{t,c}^d + (\mu_x - b)(\mu_x - b) \hat{\pi}_{t,c}^d \]

\[ \hat{\epsilon}_t^d = \eta_c \hat{\pi}_t^{c,d} + \hat{\epsilon}_t \]

\[ \hat{\epsilon}_t^d = \eta_i \hat{\pi}_t^{i,d} + \hat{\epsilon}_t \]

\[ \hat{\epsilon}_t^m = -\eta_c (1 - \omega_c)(\gamma^{c,d} - (1 - \eta_c)) \hat{\pi}_t^{m,d} + \hat{\epsilon}_t \]
\[
\dot{c}_{T,RAD} = \left[ \left( 1 - \omega_m \right)^{1/\eta_T} \left( \frac{c^d}{c} \right)^{(\eta_T - 1)/\eta_T} \right] \dot{c}_T^d
+ \left[ \omega_m^{1/\eta_T} \left( \frac{c^m}{c} \right)^{(\eta_T - 1)/\eta_T} \right] \dot{c}_T^m
+ \omega_N^{1/\eta_T} \left( \frac{c^N}{cT} \right)^{(\eta_T - 1)/\eta_T} \dot{c}_T^N
= \dot{c}_{TOTAL,t} - \left( 1 - \omega_N \right)^{1/\eta_T} \left( \frac{c^{T,RAD}}{cT} \right)^{(\eta_T - 1)/\eta_T} \dot{c}_T^T
\]

\[
\dot{\gamma}_{N,t} = \gamma_{N,t}^* - \left( \dot{\gamma}_T - \dot{\gamma}_T^* \right)
\]

\[
\dot{\gamma}_T = \frac{\gamma_T}{c_T} \left( \gamma_{T,T}^* + \gamma_{T,N,t}^* \right) + \frac{\gamma_N}{y} \gamma_{N,t} \left( \gamma_{N,t}^* + \gamma_{N,t} \right)
\]

\[
\gamma_{T,T}^* - \gamma_{T,N}^* = \gamma_{T,T} - \gamma_{T,N}
\]

\[
\dot{\pi}_t = \left( 1 - \omega \right)\gamma_{T,T}^* + w \gamma_{N,N,t} \gamma_{N,t}^N
\]

\[
\dot{\hat{\kappa}}_t = \left( 1 - \delta \right) \frac{1}{\mu_e} \dot{\kappa}_{t-1} + \frac{1}{\mu_e} \mu_e \left( 1 - \delta \right) \left( \gamma_T^* + \left( 1 - \delta \right) \gamma_{N,N,t}^* + \gamma_{N,N,t} \right)
\]

\[
\hat{\eta}_t = \frac{1}{\sigma_{\eta}} \sigma_{\eta} \left[ \left( 1 - \tau_k \right) \dot{\eta}_t + \left( 1 - \delta \right) \frac{1}{\mu_e} \dot{\kappa}_{t-1} + \frac{1}{\mu_e} \mu_e \left( 1 - \delta \right) \left( \gamma_T^* + \left( 1 - \delta \right) \gamma_{N,N,t}^* + \gamma_{N,N,t} \right) \right]
\]
\[
\hat{m}_{t-1} = \hat{m}_t + \hat{\mu}_t + \hat{\mu}_{x,t} - \hat{\mu}_t
\]

\[
\frac{\mu m}{\pi_{xu}} \hat{\mu}_t = -\frac{\mu m}{\pi_{xu}} \hat{m}_{t-1} + \frac{\mu m}{\pi_{xu}} \hat{\mu}_t + \frac{\mu m}{\pi_{xu}} \hat{\mu}_{x,t} + \bar{q} \hat{q}_t + \bar{v} \bar{\omega} H (\hat{v}_t + \bar{w}_t + \bar{H}_t)
\]

\[
\hat{a}_t = -y^* \hat{m} c_t - \eta_I y^* \hat{c}_t + y^* \hat{\gamma}_t + y^* \hat{\beta}_t + (c^m + \bar{m}) \hat{y}_t^f
\]

\[
- c^m (-\eta_I (1 - \omega_I) (\hat{c}_t - \hat{c}_t) + \hat{\epsilon}_t)
\]

\[
+ (c^m (\hat{c}_t - \hat{c}_t) + \hat{R}_t) + R \frac{\mu m}{\pi_{xu}} \hat{a}_t - 1
\]

\[
y^{mc,t} \hat{r}_{mc,t} + y^{mc,t} \hat{r}_{mc,t}
\]

\[
\hat{R}_t = \frac{\nu R_0}{\nu R + \nu^2}
\]

\[
\hat{R}_t = \hat{\mu}_{x,t} + \hat{\omega}_t + \hat{R}_t^f + \hat{H}_t - \hat{k}_t
\]

\[
\hat{m}_t = \alpha (\hat{\mu}_{x,t} + \hat{\mu}_t - \hat{k}_t) + \hat{w}_t + \hat{R}_t^f - \hat{e}_t
\]

\[
\hat{m}_t^N = \hat{w}_t + \hat{R}_t^f - \hat{e}_t
\]

\[
\hat{y}_t^{c,d} = \omega_c (y^{mc,d}^{(1 - \eta_I)} \hat{y}_{mc,d}^d
\]

\[
\hat{y}_t^{TC,N} = (1 - \omega_N) (y^{TC,Trad} - (1 - \eta_C) \hat{y}_{Trad,N}^N
\]

\[
\hat{y}_t^{Trad,N} = \hat{y}_t^{Trad,N} + \hat{y}_t^{TC} - \hat{y}_t^N
\]

\[
\hat{y}_t^{d} = \omega_d (y^{d})^{(1 - \eta_I)} \hat{y}_{d}^d
\]

\[
\hat{y}_t^{mc,d} = \hat{y}_{t-1}^{mc,d} + \hat{y}_t^{mc,d} - \hat{y}_t^d
\]

\[
\hat{y}_t^{m,d} = \hat{y}_{t-1}^{m,d} + \hat{y}_t^{m,d} - \hat{y}_t^d
\]

\[
\hat{y}_t^{f} = \hat{m}_t^{X} + \hat{y}_t^{X^*}
\]

\[
\hat{y}_t^{mc,t} = \hat{y}_t^{mc,t} + \hat{y}_t^{mc,t} - \hat{y}_t^d
\]

\[
\hat{y}_t^{m,t} = \hat{y}_{t-1}^{m,t} + \hat{y}_t^{m,t} - \hat{y}_t^d
\]

\[
\hat{y}_t^{X^*} = \hat{y}_t^{X^*} - \hat{y}_t^d
\]

\[
\hat{y}_t^{d} = \omega_d (y^{d})^{(1 - \eta_I)} \hat{y}_{d}^d
\]

\[
\hat{y}_t^{mc,t} = \hat{y}_{t-1}^{mc,t} + \hat{y}_t^{mc,t} - \hat{y}_t^d
\]

\[
\hat{m}_t^{c,x} = \hat{m}_t^{c,x} - \hat{y}_t^{X^*} - \hat{y}_t^{mc,t}
\]

\[
\hat{m}_t^{m,i} = -\hat{m}_t^{c,x} - \hat{y}_t^{mc,t}
\]

\[
\hat{m}_t^{m,d} = \hat{m}_t^{c,x} - \hat{y}_t^{X^*} - \hat{y}_t^{mc,t}
\]

\[
\hat{R}_t = \rho_R \hat{R}_{t-1} + (1 - \rho_R) (\hat{y}_t^{c,d} + \hat{y}_t^{mc,t} + \hat{y}_t^{m,i} + \hat{y}_t^{m,d} + \hat{y}_t^{X^*} + \hat{y}_t^{mc,t} + \hat{y}_t^{X^*} + \hat{y}_t^{mc,t})
\]

\[
\hat{R}_t^{TC} = \left((1 - \omega_N) (y^{TC,Trad} - \omega_CI) \right)^{\eta_C} \hat{R}_t^{TC} + \left((\omega_N) (y^{TC,Trad} - \omega_CI) \right)^{\eta_C} \hat{R}_t^N
\]

\[
\hat{R}_t^{Trad} = \left((1 - \omega_m) (y^{Trad,Trad} - \omega_CI) \right)^{\eta_C} \hat{R}_t^{Trad} + \left((\omega_m) (y^{mc,Trad} - \omega_CI) \right)^{\eta_C} \hat{R}_t^{mc}
\]

\[
\hat{y}_{T,t} = \lambda_d \left(1 - \alpha \hat{R}_t + \alpha \hat{R}_t - \alpha \hat{R}_t + \hat{e}_t \right)
\]

\[
\hat{y}_t = \omega_c (y^{c,m})^{(1 - \eta_c)} \hat{y}_t^{mc,t} - \hat{y}_t^{X^*} - \hat{m}_t^{X^*}
\]
\[ \hat{y}_{N,t} = \lambda_N (\hat{A}_{N,t} + \hat{e}_{N,t}) \]
\[ \hat{y}_{N,t} = \hat{e}_{N,t} \]
\[ \hat{A}_t = \frac{\mu_T}{\mu} \hat{A}_{T,t} + \frac{\mu_N}{\mu} \hat{A}_{N,t} \]
\[ \text{rem}_p^t = \xi (\hat{y}_t^* + \tilde{z}_t^* ) \]
\[ \text{rem}_c^t = \eta \hat{y}_t \]
\[ \text{rem}_i^t = i_t \]
APPENDIX B

Figure 1. Impulse responses to a stationary tradable sector-specific technology shock

Figure 2. Impulse responses to a stationary non-tradable sector-specific technology shock
Figure 3. Impulse responses to a monetary policy shock

Figure 4. Impulse responses to an import-substitution elasticity shock (consumption)
Figure 5. Impulse responses to an import-substitution elasticity shock (investment)

Figure 6. Impulse responses to a government spending shock
Figure 7. Impulse responses to a domestic mark-up shock

Figure 8. Impulse responses to a domestic nontradable mark-up shock
Figure 9. Impulse responses to an export mark-up shock

Figure 10. Impulse responses to a unit root technology shock
Figure 11. Impulse responses to a risk premium shock

Figure 12. Impulse responses to a foreign inflation shock
Figure 13. Impulse responses to an inflation target shock

Figure 14. Impulse responses to a foreign interest rate shock
Figure 15. Impulse responses to a consumption tax shock

Figure 16. Impulse responses to a labor tax shock
Figure 17. Impulse responses to an income tax shock

Figure 18. Impulse responses to an investment specific shock
Figure 19. Impulse responses to a consumption preference shock

Figure 20. Impulse responses to a labor supply preference shock
Figure 21. Impulse responses to an asymmetric technology shock


Discussion

Dr. Paul McNelis noted that the model used by the authors is for a large open economy, which would be more appropriate for Euro Area, USA and Japan, but not the Philippines. He further suggested to (1) use a smaller model, (2) present stylized facts on remittances, (3) discuss the policy implications of remittances, and (4) consider using VAR estimation.

In particular, the small economy model of Enrique Mendoza with the addition of a banking sector may be useful. For policy implications, it may be worthwhile to discuss the vulnerability of the banking sector to sharp unexpected changes in remittances and how remittances affect the conduct of monetary policy. Meanwhile, using impulse responses and conditional variance decomposition in VAR may ascertain which shocks are more important at specific times.

One participant commented that there are a number of DSGE models built for small open economies, which the authors could consider. In addition, rather than examining the effects of different economic shocks on remittances; it may be more interesting and useful to know the effects of shocks in remittances on the economy. Moreover, it was suggested that an informal sector be included in the paper.

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3 Dr. Paul D. McNelis of Fordham University was the discussant of the paper.
Flattening Yield Curve amidst Rapid Inflows: The Malaysian Experience

Shakira Teh Sharifuddin and Loke Po Ling

Movements in the yield curve reflect the interplay of monetary policy actions, various macroeconomic conditions as well as the demand and supply conditions in the bond market. We examined the observed periods of flattening of the Malaysian yield curve, paying additional attention to episodes that took place following the active efforts to develop the bond market beginning in the early 2000s as well as the financial liberalisation measures implemented after the Asian Financial Crisis. We also assessed the possible factors that contributed to the compression in yields. The various impacts of increased foreign participation in the domestic bond market were also studied, both qualitatively and quantitatively. Specifically, it was found that foreign participation in the ringgit bond market is statistically significant in determining long-term sovereign yields. Finally, policy implications arising from the flattening yield curve phenomenon in Malaysia were also analysed.

JEL Codes: E44, E58, F21, G15, G18
Keywords: Bond market, yield curve, portfolio flows, foreign investors, emerging markets

1 INTRODUCTION

One of the lessons from past crises affecting emerging markets is the importance of having a sound and relatively deep domestic capital market. As such, there has been a steady trend in emerging market countries, including Malaysia, of embarking on measures towards this direction. Furthermore, as the fundamentals of these economies grow stronger, gradual liberalization of the financial systems has also been implemented. Consequently, as these markets become more developed and more integrated with one another, the dynamics between various events and factors have led to various unique circumstances and phenomena in the domestic capital markets.

In Malaysia, the flattening of the yield curve, particularly the Malaysian Government Securities (MGS) yield curve, or the narrowing in the maturity spread, is an interesting development that has been observed in the ringgit bond market. For the discussion throughout this paper, we define an episode of flattening of the yield curve as a period when the maturity spread for MGS with maturities longer than 5 years narrowed to a point where it was close to zero or turned negative, when the yield curve eventually inverts. These episodes of flattening of the yield curve had been triggered by a confluence of factors. In the early years of the domestic bond market, the levelling of the yield curve was largely driven by domestic factors, particularly domestic monetary policy. More recently, however, as the market became more liberalized, the flattening of the yield curve had been influenced mainly by the increase in foreign investors’

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1 Monetary Policy Department, Bank Negara Malaysia. The authors are grateful to Dr. Norhana Endut, Dr. Mohamad Hasni Sha’ari, Dr. Ahmad Razi Mohd. Ali, Dr. Zarina Zainal Abidin and Mohd Nozlan Khadri from Bank Negara Malaysia, and Ilhyock Shim from the Bank for International Settlements (BIS). The authors would also like to thank participants of the conference “The Evolving Limits of Monetary Policy: New Perspectives from Emerging Market Economies,” organized by the Bangko Sentral ng Pilipinas (BSP) on 28-29 October 2014 for their valuable comments. Also to Roslaini Omar for the assistance in gathering the data for the estimation. Correspondence: shakira@bnm.gov.my, lpling@bnm.gov.my

2 Maturity spread is the difference between the yields of two securities with different maturity, typically measured as the difference between long-term yields and short-term yields.
participation in the ringgit bond market. This was particularly prevalent during periods when there was a surge in portfolio inflows by these investors.

This paper aims to conduct a thorough analysis on the occurrences of flattening yield curve in Malaysia, and the factors driving the phenomenon during each episode. The paper also aims to study the impact of rising foreign participation in Malaysia’s bond market in recent years, from both a quantitative and qualitative perspective. Finally, the paper looks into past policy responses to the phenomenon of the flattening yield curve and considers possible policy options going forward.

Our analyses indicated that the periods of flattening yield curve prior to 2002 were impacted largely by domestic investors’ responses to domestic monetary policy. Following pro-active efforts to develop the ringgit bond market and the implementation of foreign exchange (FX) liberalization measures\(^3\) in the early 2000s, episodes of flattening yield curve were subsequently driven by the surge in portfolio inflows into the domestic bond market. One of the key factors that had attracted portfolio inflows into the ringgit bond market was the large size of Malaysia’s bond market and its advanced development relative to other regional bond markets. Empirically, we found that foreign investors’ participation in the domestic bond market has a statistically significant impact in contributing to the decline in bond yields. We also observed that to date, minimal policy responses were warranted to address the impact of the flattening yield curve in the short-run, but nonetheless, measures to continue to deepen the ringgit bond market should remain.

The remainder of the paper is structured as follows. Section 2 looks at the broad explanations and factors affecting the yield curve. Section 3 discusses Malaysia’s experience with the flattening yield curve phenomenon pre- and post-liberalization, while Section 4 attempts to quantify the impact of rising portfolio inflows and increasing foreign investors’ participation on domestic bond yields. Section 5 lists the policy responses that had been undertaken by Bank Negara Malaysia (BNM) to address the phenomenon and possible measures going forward. Section 6 concludes.

2 OVERVIEW OF FACTORS IMPACTING THE YIELD CURVE

There are three theoretical explanations\(^4\) for the various shapes of the yield curve that could prevail at a point in time. An upward sloping yield curve, a shape that is typically observed, reflects investors’ expectation for the economy to grow in the future, and this is generally consistent with the expectation for higher inflation and interest rates going forward. In addition, the positive slope incorporates the liquidity premium for holding longer-term bonds. A steep yield curve, indicated by a yield spread between long-term yield and short-term yield exceeding that of the historical average, typically occurs after a recession, and suggests that the economy is expected to expand quickly in the future. An inverted yield curve occurs when yields of the longer-term bonds exceed that of the shorter-term bonds, which indicates investors’ expectations for slower economic growth in the future. Numerous works have been published to show the predictive power of an inverted yield curve as an indicator of recessions, particularly in the US, such as those of Estrella and Mishkin (1996), Estrella and Trubin (2006) and Wright (2006). Finally, a flat or a humped yield curve reflects uncertainties over the

\(^{3}\) See Appendix 3

outlook of the economy. A flattening of the yield curve that is caused by a higher increase in the short-end of the yield curve, also known as a ‘bear flattening’, reflects policy tightening or an increase in demand for short-term bonds, whereas a ‘bull flattening’, which is due to yields on the longer-end declining at a larger magnitude relative to the short-end, implies a shift in investors’ preference for longer-term bonds.

While theoretical reasoning helps to explain the shape of the yield curve at a point in time, bond yields, and concurrently the yield curve, are also affected by various factors that could be externally or structurally driven. Analyzing the determinants of government bond yields in the G-7 countries, Hauner and Kumar (2006) showed that capital inflows had contributed to the rising level of liquidity in the sovereign bond market and declining yields. Hol (2006) showed that bond yields in the Scandinavian countries were affected by both domestic macroeconomic as well as international economic conditions.

Of greater interest, the growing presence of foreign investors in emerging markets amidst the liberalisation of exchange control regime also has an impact on how the shape of the yield curve evolves. Earlier studies on emerging market bond yields showed that external factors play an important role in determining the yields’ movements. Baldacci, Gupta and Mati (2008) estimated that emerging markets with larger capital inflows experienced smaller increases in their bond yields during periods even when their fiscal deficits expanded. Hartelius, Kashiwase and Kodres (2008) established that while macroeconomic fundamentals were important, expectations on US interest rates and changes in those expectations were also a key determinant in 33 emerging markets’ bond yields. Moreover, the size and level of development of a country’s debt market also played an integral factor in determining the prevailing form of the yield curve. Comparing the movements of 16 emerging markets’ bond spreads\(^5\) in the 1990s to the period between 1870 and 1913, Mauro, Sussman and Yafeh (2002) showed that changes in spreads in the more recent period – that is, the 1990s, where the markets were more developed, tended to be related to global events. Challe, Le Grand and Ragot (2007) showed that a larger volume of transactions and activities in the bond market\(^6\) pushed both the level and slope of the yield curve.

3 MALAYSIA’S EXPERIENCE WITH THE FLATTENING YIELD CURVE

Since the early 1990s, there have been several episodes where the MGS yield curve moved away from the normal upward sloping curve. During these times, there was a noticeable flattening of the yield curve, and, at times, a brief inversion of the yield curve (Figure 3.1 and Figure 3.2).

In the 1990s to early 2000s, periods where the MGS yield curve flattened were largely driven by domestic factors. Specifically, there were three distinct periods of yield curve flattening: (i) Between 1992 and 1993; (ii) Between 1995 and 1997; and (iii) Between 2000 and 2003\(^7\). In the first two periods, the tightening stance of BNM’s monetary policy resulted in a more marked increase in the short to medium-end of the yield curve compared to the longer-end, thereby lessening the steepness of the yield curve. In the third episode (between 2000 and 2003), there was a shift in investors’ preference towards fixed income investments, particularly long-term MGS, which subsequently resulted in declining long-term yields.

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\(^5\) Argentina, Brazil, Canada, Chile, PR China, Egypt, Hungary, Japan, Greece, Mexico, Portugal, Queensland, Russia, Sweden, Turkey and Uruguay

\(^6\) Panel dataset of 17 OECD countries

\(^7\) During this period, the yield spread spikes momentarily, before resuming its narrowing trend
Figure 3.1: MGS Maturity Spread

MGS Yield Curve
I. (Jan 1992 vs Jan 1993)

Source: Bank Negara Malaysia

Figure 3.2: Periods of Flattening MGS Yield Curve

MGS Yield Curve
II. (May 1995 vs May 1997)

MGS Yield Curve

MGS Yield Curve
IV. (May 2006 vs June 2007)

MGS Yield Curve
V. (Dec 2009 vs May 2010)

MGS Yield Curve
VI. (Dec 2011 vs Apr 2013)

Source: Bank Negara Malaysia
Since the early 2000s, the phenomenon of flattening yield curve in the ringgit bond market has been largely driven by a surge of portfolio inflows into the ringgit bond market (Figure 3.3). Broadly, portfolio flows have contributed to the flattening of the yield curve through two channels. The first is the indirect channel, which normally occurs in the early phase of a portfolio surge. Initially, foreign investors entering the MGS market invest in the short- to medium-term securities. The concentration of foreign funds in securities of short to medium tenures (e.g. 1- to 5-year) subsequently triggers several domestic institutional investors to shift their preference towards longer-tenured securities, which are viewed to be less expensive. Due to the lower level of liquidity in the longer-end of the yield curve, a small increase in demand in longer-term securities often leads to marked decline in yields.

The indirect channel tends to occur within the first few months of a portfolio surge. Over time, as the stream of portfolio flows becomes more sustained, it contributes to the flattening of the yield curve through a more direct channel. As the prices of short- to medium-term securities become more expensive, the demand for MGS eventually becomes more broad-based, with stronger demand for longer-term securities by non-residents. Similarly, the relatively lower level of liquidity in the longer-end of the yield curve magnifies the decline in longer-term yields (Figure 3.4). To date, there are three observable periods that reflect this development: (i) in the first half of 2007; (ii) in the first half of 2010; and (iii) gradually in 2012 through to the first half of 2013. During the first half of 2007, portfolio flows were channeled into all tenures, pushing the entire yield curve below the Overnight Policy Rate (OPR). In line with expectations, the impact of the portfolio flows was more pronounced on the longer-end of the yield curve, thus leading to a flattening yield curve. Similarly, the levelling of the yield curve in 2010 and 2011 was due to a marked increase in demand from foreign investors for longer-term securities. The flattening of the yield curve during these two periods was also affected, in part, by increases in short-term yields following normalization of the Overnight Policy Rate (OPR).

Figure 3.3: Portfolio Inflows into the Bond Market vs Maturity Spread

![Graph showing portfolio inflows into the bond market vs maturity spread](source: EPFR Global; Bank Negara Malaysia)

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8 Bond prices and their prevailing yields have an inverse relationship.
Malaysia’s experience with episodes of flattening yield curve has also been observed in other countries, in both the developed and emerging markets. For example, in the US in 1961, the Federal Reserve (Fed) announced Operation Twist in 1961, which involved planned action by the Fed to flatten the yield curve. This was intended to lower longer-term yields to stimulate investment, while concurrently raising short-term yields to attract foreign capital and strengthen the US dollar (Rampell, (2009)). More recently, this phenomenon has been more prevalent in other emerging markets with relatively developed bond markets, such as Korea, Thailand, Australia, New Zealand and Singapore, which has seen its yield curve flattening in 2007 and 2010 as a result of higher entry of portfolio inflows (Figure 3.5).

Figure 3.5: Maturity Spread* for Selected Countries

Shaded areas indicate periods of flattening yield curve
*10-year yields - 1-year yields
Source: Bloomberg

Figure 3.4: Channels of Inflows into the MGS Market

SOURCE: BANK NEGARA MALAYSIA
3.1 Flattening of the yield curve in Malaysia post-liberalisation: portfolio flows and other factors

Portfolio flows into the domestic market in the 2000s were largely influenced by two key developments in the Malaysian capital markets. Firstly, large-scale efforts were undertaken by BNM and other regulatory authorities to develop the ringgit bond market, resulting in the domestic bond market emerging as one of the biggest and most advanced in the region (Figure 3.6). Secondly, the Malaysian financial system embarked on greater liberalization and deregulation culminating in a series of successive measures\(^9\) in early 2000s, creating a more accessible and integrated financial market in Malaysia. The confluence of these two developments has since led to a rising trend in portfolio inflows into the ringgit bond market, and, concurrently, an increase in the holdings of ringgit debt securities by foreign investors.

Figure 3.6: Size of Local Currency Bond Market as of 1Q 2013 (% of GDP)

![Figure 3.6: Size of Local Currency Bond Market as of 1Q 2013 (% of GDP)](source: Asian Development Bank (ADB) AsianBonds Online)

In addition to the liberalization and development of the domestic bond market, another key factor that contributed towards attracting flows into the domestic bond market was the expectation among foreign investors for ringgit appreciation. Periods of large inflows into the domestic bond market occurred simultaneously with a build-up in investors’ expectation for a sustained strengthening of the ringgit. In addition, the stream of inflows during these periods was partly triggered by investors’ ongoing search for yields due to the high liquidity environment in the advanced economies as well as for portfolio diversification. After the collapse of Lehman Brothers in 2008, the search for yields was further compounded by additional injections of global liquidity brought about by unconventional monetary measures implemented in the major advanced economies. Furthermore, with interest rates in major advanced economies at historical lows, this added further impetus for foreign investors to enter the domestic bond market. In 2011, the onset of the sovereign debt crisis in Europe led to increased interest among investors for emerging market bonds, including ringgit-denominated bonds, further contributing to the decline in long-term yields. Additionally, the gradual implementation of Basel III beginning in 2013 required financial institutions to hold and demand more safe assets, which naturally comprised mainly of government bonds (Iorgova, et al., (2012)), in turn placing further downward pressures on the longer-term yields.

\(^9\) See Appendix 3
The impact of foreign funds on the yield curve was also compounded by several structural issues in the domestic bond market. Despite the rapid growth of the ringgit bond market following large-scale efforts undertaken by BNM, several structural issues in the domestic bond market, at times, led to large magnitudes of inflows to be absorbed quickly by the market. While the private debt securities (PDS) or corporate bond market remains on a gradual expansion path, the Malaysian bond market is still very much a sovereign market and the MGS remains to date, the largest supply of investible bonds in the country. Occasionally, there were significant demand for quasi-government issuances (such as Khazanah bonds as well as those that carry government guarantees), which potentially attracted foreign funds, but the amount of available securities remained small to accommodate a marked and rapid surge of inflows. The limited supply of investible bonds was also exacerbated by the relatively smaller issuances of MGS with maturities exceeding 10 years compared to short- and medium-tenured securities\(^\text{10}\). Consequently, this structural mismatch between demand and supply of ringgit-denominated bonds contributed to the compression of longer-end yields in Malaysia, particularly during periods of large surge of portfolio inflows.

In addition to the limited supply of investible bonds, the large presence of domestic institutional investors such as provident and insurance funds also magnified the impact of yield compression during periods of heavy inflows (Figure 3.7). Firstly, these institutional investors normally adopted a buy-and-hold strategy, which tended to result in a more captive market that could lower the liquidity in the domestic bond market. Consequently, any marked surge of funds in the bond market (such as those coming from portfolio inflows) magnified its impact on yields. Given that these institutional investors were also large holders of MGS and other highly-rated securities\(^\text{11}\), this further widened the mismatch between the market’s demand and supply, especially during periods of large capital inflows.

### 3.2 Potential implications arising from the flattening yield curve and rising foreign participation in the Ringgit bond market

One possible effect of the flattening of the yield curve is the reduced transmission of monetary policy to the longer-end of the yield curve. The outcome of this would lead to an inadequate reflection of the monetary stance in financial prices, particularly for financial instruments whose rates are priced off from sovereign yields. Felman, et al. (2011) highlighted that, to the extent that yield curves are driven by external developments, there is a risk that monetary independence would be reduced. Evidence of this effect was seen in the downward trend of the interest rate swaps\(^\text{12}\) (IRS) (Figure 3.8), even as the OPR was tightened, particularly in 2011. Similarly, in 2007, PDS yields for higher rated bonds\(^\text{13}\) mirrored the flattening movement of the MGS yields, evidenced by its narrowing maturity spread, despite the unchanged stance in monetary policy (Figure 3.9).

\(^{10}\) Efforts to widen the maturity of government securities in Asia in general, have been hampered by a prominent presence of banks which for liquidity management purposes would typically prefer short- to medium-term instruments over longer-term instruments (Goswami and Sharma, 2011).

\(^{11}\) While asset allocations of pension and provident funds are decided by its respective investment panel, given that these institutions are large holders of liabilities (individuals’ contributions) there is still a need for them to apportion a certain amount of their investment portfolio on safer assets such as government securities and higher-rated or government-guaranteed private debt securities.

\(^{12}\) The IRS is one of the determinants of pricing for hire purchase rates.

\(^{13}\) Khazanah bonds, AAA and AA rated PDS
Flattening Yield Curve amidst Rapid Inflows: The Malaysian Experience

Figure 3.7: Breakdown of MGS Holdings

![Graph showing the breakdown of MGS Holdings from 2004 to 2014, categorized by Pension funds (EPF) and others, Insurance, Banking sector, Non-bank financial institutions (Fis), and Foreign investors. Source: Bank Negara Malaysia.]

Figure 3.8: 10-year MGS Yields, IRS and OPR

![Graph showing the 10-year MGS yields, IRS, and OPR from March 1999 to January 2014. Source: Bank Negara Malaysia.]

Figure 3.9: Maturity Spread (MGS, Khazanah* and PDS Yields*)

![Graph showing the maturity spread for MGS, AAA, Khazanah, and PDS yields from March 1999 to March 2014. Source: Bank Negara Malaysia.]

* For Khazanah and PDS yields, maturity spread is calculated as 10-year yields less 3-years.
Where financing is concerned, there was a dual impact of the rising portfolio flows into the bond market. During periods where large portfolio inflows compressed long-term yields downwards, this created an incentive for firms to raise financing through issuances of debt securities given the downward trend of borrowing costs. This was partially reflected in 2007, when there was a marked increase in PDS issuances when long-term PDS yields were on a downward trend (Figure 3.11). Conversely, during periods where there was a noticeable reversal of portfolio flows and the overall volatility in the market was elevated, this brought about difficulty for firms that required financing, as borrowing costs would be at an elevated level (Peiris, 2010). While regulations in Malaysia’s PDS market provided flexibility for firms to plan for their issuances, nonetheless, the swift entry and exit of portfolio flows into the ringgit bond market and its impact on yields presented an additional layer of challenge for prospective PDS issuers.

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PDS issuers in Malaysia have at least six months of grace period to conduct their first issuance, upon receiving approval from the Securities Commission (SC).
4  EMPIRICAL ESTIMATION

The preceding discussions provided indications that the rising presence of foreign investors in the ringgit bond market exerted a strong influence on the decline in long-term yields, subsequently causing the yield curve to flatten. This section attempts to provide an empirical evaluation of the impact of foreign investors’ involvement in the ringgit bond market on longer-term MGS yields.

There are several studies that attempt to quantify the direct relationship between foreign portfolio inflows or foreign investors’ participation and local currency bond yields, both in the developed and emerging markets. Warnock and Warnock (2009) studied the factors contributing to the decline in longer-term yields in the US in the 1990s, and identified that, apart from inflation expectations and volatility, foreign inflows into the US bond market was also statistically significant in lowering the 10-year US Treasury yields. In their estimation using data from 1984 to 2005, 12-month inflows of 1 percent of GDP was associated with a 19-basis point reduction in 10-year Treasury yields. Balakrishnan, et al. (2011) studied the role of non-resident investments in explaining asset price or interest rate movements in emerging market economies. Using a fixed-effect panel data estimation for eight countries, their results showed that, on average, each percentage point increase in non-resident participation reduced long-term bond yields by about 5 basis points. Peiris (2010) also performed a similar estimation, and the results were consistent with those of Balakrishnan, et al. (2011). Additionally, using the GARCH approach, Peiris (2010) also estimated the impact of foreign participation in government bond markets on the volatility of longer-term bond yields in the emerging markets, and found that greater foreign participation did not necessarily result in increased volatility in bond yields and, in fact, could even dampen volatility in some instances. Marcilly (2009) used country specific VAR method to determine the causality between foreign inflows and the local currency of 10-year government bond yields in Indonesia, India, Malaysia and Thailand. The results from the study showed that causality runs mainly from the 10-year yields to the stock of foreign investments in Indonesia and Malaysia. The results also showed that given a shock of 1 percent in foreign investments, the impact on yields would occur two months after the shock, but were nonetheless statistically insignificant.

Our estimation focused on determining quantitatively the impact of foreign investors’ participation in Malaysia on longer-term MGS yields. For this analysis, our dependent variable was the 10-year and the 1-year MGS yields. For completeness, we also performed the estimation on the 10-year maturity spread.

Two types of variables were considered to represent foreign investors’ involvement in the ringgit bond market. The first one was foreign investors’ holdings of ringgit bonds as a percentage of total outstanding bonds. The second possible variable that could be used to reflect foreign participation in the financial market was the non-resident flows on the bond market. As holdings data are stock data, using flows data possibly would allow us to capture the dynamic behavior of portfolio inflows and its impact on yields.

In an attempt to capture the impact of foreign investors’ participation, non-resident holdings data was used. The data on holdings was available on a quarterly basis

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15 Brazil, Indonesia, Korea, Malaysia, Mexico, Poland, Thailand and Turkey
16 Generalised Autoregressive Conditional Heteroskedasticity
17 Vector Autoregression
from 1996, encompassing pre- and post-foreign exchange liberalisation period. In addition, we also performed estimations on portfolio flows by taking the change in non-resident holdings to see if there are any differences in its impact on MGS yields.

4.2 Estimation using non-residents’ holdings of MGS data

For our estimation, we adopted the empirical model used in Warnock and Warnock’s (2009) study on the relationship between international capital flows and US interest rates, and Peiris’ (2010) estimation of foreign participation on local currency bond yields in emerging markets. The model was, however, modified slightly in view of data availability, as well as to incorporate some control variables that are more specific to MGS yields. Our model is written as the following:

\[ r^{LT}_t = \alpha + \beta_1 r^{ST}_t + \beta_2 \pi_t + \beta_3 l_t + \beta_4 g_t + \beta_5 x_t + \beta_6 v_t + \beta_7 f_t \]  

(1)

where \( r^{LT}_t \) denotes the dependent variable, either the nominal 10-year or 1-year MGS yields, \( r^{ST}_t \) is the nominal 3-month Malaysian Treasury bills (MTB) yields (controlling for impact of monetary policy), \( \pi_t \) is rate of inflation (controlling for inflation expectations), \( l_t \) is the turnover ratio of the bond market (controlling for market’s liquidity), \( g_t \) is a measure of the government’s sovereign risks, in this case, the fiscal deficit as a percentage to GDP, \( x_t \) denotes the annual GDP growth, \( v_t \) is the MOVE index (controlling for volatility), and finally, \( f_t \) is foreign investors’ holdings of MGS as a percentage of total MGS outstanding.

From model (1), we expected the nominal 3-month MTB yields, inflation, sovereign risks, economic growth, and the MOVE index to have a positive relationship with the dependent variable. Turnover ratio and foreign investors’ holdings of MGS were expected to show a negative association with the dependent variable. We also postulated that a larger foreign investors’ holdings coefficient on the estimation with the 10-year MGS yields, as the dependent variable relative to the 1-year MGS yields, would support our conjecture that the presence of foreign investors do contribute to the incidence of flattening yield curve.

We ran our initial estimation using the full sample of quarterly data since 1996 on the three dependent variables – MGS 10-year and 1-year yields, as well as the 10-year maturity spread. The estimation results showed that foreign investors’ holding of MGS is statistically significant in determining the level of both the 10-year and 1-year MGS yields. We also observed a larger coefficient for the estimation on the 10-year yields. In addition to foreign investors’ holdings, the liquidity conditions, as represented by the turnover ratio and the 3-month MTB yields were also important determinants of the MGS yields. Additionally, the inflation variable played a role in determining the MGS 1-year yields, implying that inflation expectations affected investors’ sentiments in the short-term.

The results, however, did not appear to be statistically robust and diagnostic checks highlighted the presence of instabilities in the model. From the plot of the 10-

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18 McCauley (2008) cautioned on the use of holdings data as a proxy for foreign investors’ participation. Firstly, biasness issues exist with using foreign holdings data as some domestic agents held local currency securities on behalf of foreign agents. Additionally, a number of foreign investors may avoid investing directly in the local bond market by entering the derivatives market instead.

19 Turnover ratio = MGS turnover / Total outstanding bonds

20 The Merrill Option Volatility Expectations Index (MOVE©) reflects market estimate of future Treasury bond yields volatility.
year MGS yields, it appeared at first glance that there was a structural break at the end of 2001 (Figure 4.1), consistent with the time when BNM and Securities Commission (SC) took aggressive efforts to develop and deepen the domestic capital markets. Statistical analysis also confirmed the presence of a structural break in the data. As such, we re-estimated our model using the sample period beginning in 2002. To take into account the liberalization measures undertaken by BNM in 2004, as well as to ensure econometric robustness, we also re-estimated for the sample period of 2004-2013.

Estimation using the sample data beginning in 2002 and 2004 yielded similar results relative to the estimation using the full sample size (Table 4.1). Foreign investors’ participation in the MGS market, based on the foreign holding of MGS, was statistically significant in determining the level of both the 10-year and 1-year MGS yields. Furthermore, similar to earlier estimation, the coefficient on the 10-year MGS yields estimation was larger than the 1-year MGS yields. A one percentage point increase in foreign investors’ holdings of ringgit bonds (as a percentage of total outstanding bonds) was associated with a 1-basis point decline in the 10-year MGS yields, and a 0.4 basis point decline in the 1-year MGS yields. Consistent with the estimation utilising a longer sample period (1996), liquidity conditions and the short-term MTB yields also had a statistically significant relationship with MGS yields, while inflation had a statistically significant association with the 1-year MGS yields.

### Table 4.1: Summary Regression Results

<table>
<thead>
<tr>
<th></th>
<th>MGS10Y</th>
<th>MGS1Y</th>
<th>MGS10Y</th>
<th>MGS1Y</th>
<th>MGS10Y</th>
<th>MGS1Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>5.952***</td>
<td>0.516***</td>
<td>6.016***</td>
<td>0.564***</td>
<td>6.046***</td>
<td>0.582***</td>
</tr>
<tr>
<td>Control Variable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short-term yields</td>
<td>-0.563***</td>
<td>0.904***</td>
<td>-0.638***</td>
<td>0.862***</td>
<td>-0.572***</td>
<td>0.899***</td>
</tr>
<tr>
<td>Inflation</td>
<td>0.063</td>
<td>0.036***</td>
<td>0.05</td>
<td>0.027</td>
<td>0.068</td>
<td>0.036**</td>
</tr>
<tr>
<td>Liquidity ratio</td>
<td>-1.698***</td>
<td>-0.208</td>
<td>-1.952***</td>
<td>-0.344</td>
<td>-1.814***</td>
<td>-0.282</td>
</tr>
<tr>
<td>GDP</td>
<td>0.066***</td>
<td>0.012</td>
<td>0.0784***</td>
<td>0.019</td>
<td>0.064***</td>
<td>0.012</td>
</tr>
<tr>
<td>MOVE</td>
<td>0.001</td>
<td>-0.0001</td>
<td>0.002</td>
<td>-0.0002</td>
<td>0.002</td>
<td>-0.001</td>
</tr>
<tr>
<td>Fiscal deficit /GDP</td>
<td>0.032**</td>
<td>0.009*</td>
<td>0.035**</td>
<td>0.011**</td>
<td>0.032**</td>
<td>0.008*</td>
</tr>
<tr>
<td>Dummy</td>
<td>-0.16</td>
<td>-0.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dummy*Foreign hdgs.</td>
<td>0.003</td>
<td>0.004</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Foreign participation variable**
- Foreign holdings: -0.008** -0.004*** ~0 ~0 -0.009** -0.005
- Net flows: ~0 ~0
- Sample size: 49 49 49 49 49 49
- Adjusted R-squared: 0.51 0.917 0.56 0.9 0.498 0.918

Note: ***, ** and * denote statistical significance at the 1, 5 and 10 per cent level.
The results from our estimation are in line with the findings of studies by Balakrishnan, et al. (2011) and Peiris (2010). Interestingly, in all the estimations that were done, the coefficient for the liquidity conditions in the bond market was markedly larger than other statistically significant variables, including foreign holdings of MGS. Furthermore, comparing the liquidity coefficient between the estimations on the 10-year and 1-year MGS yields, the coefficient on the long-term yields was also larger than on the 1-year MGS yields. The results, to some extent, reinforced the theoretical channels of transmission that were presented earlier, that liquidity conditions, specifically lower liquidity conditions, magnified the impact of foreign investors’ involvement in the MGS market.

It was also observed from the estimations of the 10-year MGS yields that the coefficient for the 3-month MTB yields had a negative sign, implying that, on average, the short-term rates moved in opposite direction with the long-term MGS yields. This suggested that the policy rate may not be effective in influencing longer-term rates, especially at times of high portfolio inflows. Further discussion on this issue is outlined in the following section. Nevertheless, further investigation needs to be done on the monetary policy transmission in Malaysia to understand the relationship between short-term and longer-term rates.

We should note at this point, however, that while the estimation results of a 1 percentage point increase in foreign holdings of MGS leading to a 1 basis point decline in the 10-year MGS yields was statistically significant, it is not necessarily economically significant. We have to, however, point out that the small coefficient of the foreign holdings could potentially be attributed to the downward bias that is present in the model arising from the endogeneity of the independent variables, as highlighted by Beltran et al. (2013). Nonetheless, while a 1 basis point increase in MGS yields may not seem to be large given the variations in the 10-year MGS yields between 2004 and 2013, the impact could be amplified by the liquidity conditions in the MGS market. This could eventually entail some economic impact.

We also augmented our estimations with two added dimensions. Firstly, we replaced the holdings data with net foreign flows data, by taking the change in non-resident holdings, to see if there were any differences in its impact on MGS yields. Secondly, in recent times, a large portion of the discussion surrounding portfolio flows among policy makers in the emerging market economies has been centered on analysing the impact of a portfolio outflows or reversal on financial markets. The discussion also includes government bond yields, whereby the impact of outflows is generally assumed to be asymmetric relative to inflows. With this in mind, we performed a separate estimation in which we included both a slope and intercept dummy variable to represent periods when there are portfolio outflows from the MGS market.

While our estimation using foreign flows data from 2002 yielded the correct sign, the flows data, nonetheless, did not have a statistically significant association with both the MGS 10-year and 1-year yields. A possible explanation could be the use of quarterly data instead of a higher frequency data, which may have masked or watered down the dynamic behavior of foreign flows and its subsequent impact on MGS yields. Turning to the results of our estimation that incorporated the dummy variables for foreign outflows, both the slope and coefficient dummy variables had a statistically insignificant relationship with MGS yields. This could possibly be due to limited historical
data on periods of outflows to date\textsuperscript{21}. Going forward, it is hoped that with more data and observed periods of outflows, the results would provide deeper insights on the different dynamics and impact that outflows may have on MGS yields.

For robustness and completeness purposes, we also performed the estimation using higher frequency monthly data. Results using the monthly data also showed that foreign holdings are statistically significant in affecting the level of MGS yields. Moreover, estimation using higher frequency monthly data, using monthly net foreign flows figures, also indicated that it is statistically significant in determining the MGS yields. As expected, the coefficient for the liquidity conditions variable was the largest for the estimations, particularly on the 10-year MGS yields (See Appendix 2).

5 POLICY IMPLICATIONS

On the surface, the flattening of the yield curve amidst strong portfolio inflows appears to have affected the monetary transmission to the economy. However, despite the marked decline in longer-term yields during periods of yield curve flattening, higher portfolio inflows did not fully nullify BNM’s ability to influence the economy. Unlike in the US and other economies, where the bulk of financing was sourced from the capital market, financing in Malaysia still relied heavily on bank lending (Figure 5.1). Retail lending rates in Malaysia were mainly influenced by banks’ funding costs – that is, money market rates – which had a higher degree of pass-through to the lending rates (Abdul Majid, 2010). One exception was the decline in hire purchase rates, which were derived from IRS. However, it should be noted that these rates had also been suppressed by the intense competition among banks especially in the car loan market. Balakrishnan, et al. (2011) showed that, based on their estimation, the higher presence of foreign investors did not curtail the effectiveness of the policy rates altogether, as their results showed that more than half of a 25-basis point increase in policy rates was transmitted across the yield curve into longer-term rates.

**Figure 5.1: Financing by Non-Bank Business Sector**

![Graph showing financing by non-bank business sector](image)

Source: Bank Negara Malaysia

There could be significant impact of portfolio reversals on the domestic financial markets, particularly on the level of volatility and its consequential impact to the economy. Due to limited historical data on periods of portfolio outflows, the impact of portfolio outflows remains an ongoing challenge to quantify. It can be postulated,

\textsuperscript{21} Since 2002, only two observable periods of large and sustained outflows have been recorded; during the global financial crisis in 2008 and the recent ‘taper tantrum’ episode in May 2013.
nonetheless, that while the impact of portfolio outflows on sovereign yields would be larger compared to the impact of portfolio inflows amidst increased risks aversion during periods of outflows, the magnitude of the impact would also depend largely on the triggering factors for the outflows in the first place. Nevertheless, at present, there is an adequate demand for ringgit-denominated bonds, particularly from domestic institutional investors to absorb any aggressive sell-off activities from foreign investors during periods of marked reversal. Based on a GARCH analysis, Peiris (2010) estimated that in Malaysia, yield volatility generated from greater foreign participation was partly alleviated by the presence of large domestic institutional investors. Additionally, these periods of reversal had been temporary and the yield curve eventually normalized as negative sentiments in the ringgit bond market improved. Prasad and Rajan (2008) further argued that over the long run, the relationship between yields volatility and foreign participation may be much weaker. They postulated that to the extent that the increase in foreign investors drove up market liquidity and continued to demand strong corporate governance and improved transparency, it would have a mitigating impact on price volatility in the long run.

With regard to capital flow management measures (CFM), Malaysia has not employed any CFMs since the Asian Financial Crisis. Realizing that these inflows can have undesirable impact, including exchange rate overshooting and inflating asset price bubbles, many emerging economies, including regional countries, have deployed various CFMs to mitigate these spillover effects. Nevertheless, market participants remain wary of such possibility in light of this recent trend. The utilization of capital flow management measures (CFM) has not been completely ruled out by policy makers, if warranted by economic conditions.

Going forward, efforts to further deepen the ringgit bond market will remain a priority, firstly to improve the liquidity conditions in the domestic bond market and improving the breadth of the market. This includes increasing the number of investible securities, which is essential in absorbing large streams of portfolio inflows. While steps have been taken to widen the maturity of MGS, more attention should also be given towards deepening the PDS market going forward. Gyntelberg, Ma and Remolona (2005) argued that while, in the past, authorities in Asia had emphasized on expanding the corporate bond market despite the issuances being heavily concentrated on quasi-government issuers or those with government guarantees, this might have been done at the expense of improving transparency and the timeliness of information in the corporate bond market. Expanding the corporate bond market beyond high-rated and government guaranteed securities would spread out the current heavy concentration on MGS yields. Effective March 2015, the inclusion of the Government Investment Issues (GII) into the Barclays Global Aggregate Index will increase the demand for GIIs and could ease the heavy concentration of foreign funds in the MGS market. BNM, together with other institutions such as the Securities Commission (SC), will continue to play an active role in developing the ringgit bond market into a vibrant bond market in the region. Strong infrastructure and regulatory frameworks have been put in place together with various initiatives to promote the further growth of the bond market. Malaysia also participates in regional economic and financial initiatives, such as the Asian Bond

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22 Based on MGS Auction Calendar, see https://fast.bnm.gov.my/fastweb/public/MainPage.do

23 GIIs are debt securities issued by the Government that are in compliance with Islamic Shariah requirements and are an alternative debt instrument for the Government.

24 See Appendix 4
Market Initiative and the Asian Bond Funds,\(^25\) aimed at broadening and deepening the domestic and regional bond markets.

6 CONCLUDING REMARKS

Since 2002, episodes of flattening of the MGS yield curve have been dominated by the surges in portfolio inflows entering the domestic bond market.

We have studied Malaysia’s experience with yields compression, particularly when it was driven by rising portfolio inflows or the growing presence of foreign investors, as well as its implications to the economy. Our analyses suggested that since 2002, periods of flattening yield curve in Malaysia had mainly been led by an increase in portfolio inflows. The fall in longer-term yields is further augmented by some structural issues existing in the ringgit bond market, particularly liquidity conditions, which are natural in a bond market that is still growing, such as Malaysia’s.

In our estimation, we found that a higher presence of foreign investors in the domestic bond market, whether represented by foreign investors’ holdings of debt securities or the level of net portfolio inflows, is statistically significant in contributing to the decline in longer-term yields, by 1 to 2 basis points. The relationship was consistent across different permutation of variables used.\(^26\)

This environment of large and sudden inflows appeared to impact the effectiveness of monetary transmission, as evident from the negative relationship estimated between short-term yields and longer-term yields. Nevertheless, the impact of monetary policy on the economy was not nullified, as financing in the economy still depended largely on bank borrowings, which were priced off the money market rates. Moving forward, however, measures to further deepen the bond market should continue to be introduced to ensure that the market will be able to absorb the demand for ringgit bonds.

In the near term, it would be useful to closely study measures that could specifically address the structural issues in the ringgit bond market. In addition, it would also be worthwhile to look into the asymmetric effect of portfolio inflows and outflows on the sovereign yields, especially at times of heightened volatility in the financial markets.


\(^{26}\) See Appendix 5
References


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# Appendix 1: Description of Data Sources Used in Estimation

<table>
<thead>
<tr>
<th>Variables</th>
<th>Unit</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-year MGS yields</td>
<td>Percent</td>
<td>Bank Negara Malaysia</td>
</tr>
<tr>
<td>5-year MGS yields</td>
<td>Percent</td>
<td>Bank Negara Malaysia</td>
</tr>
<tr>
<td>10-year Private Debt Securities yields</td>
<td>Percent</td>
<td>Bank Negara Malaysia</td>
</tr>
<tr>
<td>- AAA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- AA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-month MTB yields</td>
<td>Percent</td>
<td>Bank Negara Malaysia</td>
</tr>
<tr>
<td>CPI (yoy growth)</td>
<td>Percent</td>
<td>Department of Statistic Malaysia</td>
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<td>Liquidity ratio</td>
<td>Ratio</td>
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<td>GDP (yoy growth)</td>
<td>Percent</td>
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</tr>
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<td>VIX</td>
<td>Index</td>
<td>Bloomberg</td>
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<tr>
<td>MOVE</td>
<td>Index</td>
<td>Bloomberg</td>
</tr>
<tr>
<td>Fiscal deficit</td>
<td>Percent (of GDP)</td>
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</tr>
<tr>
<td>IPI (yoy growth)</td>
<td>Index</td>
<td>Department of Statistic Malaysia</td>
</tr>
<tr>
<td>Debt-to-GDP</td>
<td>Percent</td>
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</tr>
<tr>
<td>Foreign holdings</td>
<td>Percent (of total bonds outstanding)</td>
<td>Bank Negara Malaysia</td>
</tr>
<tr>
<td>Bond flows</td>
<td>RM billion</td>
<td>Bank Negara Malaysia</td>
</tr>
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</table>

# Appendix 2: Summary Regression Results using Monthly Holdings Data

**Summary Regression Results - Monthly**

**Estimation period: 2002M1-2014M6**

<table>
<thead>
<tr>
<th></th>
<th>MGS10Y (1)</th>
<th>MGS1Y (2)</th>
<th>MGS10Y (3)</th>
<th>MGS1Y (4)</th>
<th>MGS10Y (5)</th>
<th>MGS1Y (6)</th>
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<tbody>
<tr>
<td>C</td>
<td>1.241***</td>
<td>0.375***</td>
<td>1.230***</td>
<td>0.298***</td>
<td>1.271***</td>
<td>0.387***</td>
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<tr>
<td>Control Variable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Lagged dependent var</td>
<td>0.793***</td>
<td>0.437***</td>
<td>0.808***</td>
<td>0.573***</td>
<td>0.796***</td>
<td>0.434***</td>
</tr>
<tr>
<td>Short-term yields</td>
<td>-0.094*</td>
<td>0.514***</td>
<td>-0.102***</td>
<td>0.374***</td>
<td>-0.099**</td>
<td>0.517***</td>
</tr>
<tr>
<td>Inflation</td>
<td>0.012</td>
<td>0.025***</td>
<td>0.005</td>
<td>0.016**</td>
<td>0.008</td>
<td>0.026***</td>
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<tr>
<td>Liquidity ratio</td>
<td>-1.117***</td>
<td>-0.104</td>
<td>-1.181***</td>
<td>-0.271</td>
<td>-1.187***</td>
<td>-0.115</td>
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<td>Growth</td>
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<td>0.001</td>
<td>0.002</td>
<td>0.002*</td>
<td>0.002</td>
<td>0.0004</td>
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<tr>
<td>Volatility</td>
<td>~0</td>
<td>-0.001***</td>
<td>~0</td>
<td>~0</td>
<td>~0</td>
<td>~0</td>
</tr>
<tr>
<td>Sovereign risks</td>
<td>0.002</td>
<td>0.001</td>
<td>0.002</td>
<td>0.001</td>
<td>0.002</td>
<td>0.001</td>
</tr>
<tr>
<td>Dummy</td>
<td>0.034</td>
<td>-0.027</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dummy*Foreign hdgs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Foreign participation variable**

<table>
<thead>
<tr>
<th></th>
<th>MGS10Y (1)</th>
<th>MGS1Y (2)</th>
<th>MGS10Y (3)</th>
<th>MGS1Y (4)</th>
<th>MGS10Y (5)</th>
<th>MGS1Y (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign holdings</td>
<td>-0.002</td>
<td>-0.004***</td>
<td></td>
<td>-0.002</td>
<td>-0.002</td>
<td>-0.004</td>
</tr>
<tr>
<td>Net flows</td>
<td></td>
<td></td>
<td>-0.002***</td>
<td>-0.006*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample size</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.82</td>
<td>0.949</td>
<td>0.832</td>
<td>0.939</td>
<td>0.824</td>
<td>0.949</td>
</tr>
</tbody>
</table>
### Appendix 3: List of Foreign Exchange (FX) Liberalization Measures Announced in 2004

<table>
<thead>
<tr>
<th>FX Administration Rules</th>
<th>Liberalisation</th>
</tr>
</thead>
</table>
| **Forward Foreign Exchange Contracts by Residents and Non-Residents** | To allow businesses and individuals to effectively manage their risks; residents and non-residents may enter into forward foreign exchange contracts with licensed onshore commercial and Islamic banks (licensed onshore banks) and approved merchant banks without prior permission of the Controller of Foreign Exchange (the Controller) to buy or sell foreign currency against ringgit or another foreign currency as follows:  
  - Residents are now allowed to enter into forward foreign exchange contracts to hedge the following:  
    a) Foreign currency exposures of permitted overseas investments;  
    b) Payment for permitted overseas investments;  
    c) Repayment of principal and payment of interest for foreign currency credit facilities (onshore or offshore) which are payable within 24 months; and  
    d) Anticipatory receipts from exports and anticipatory payments for import of goods and services, based on the value of export receipts and import payments of the preceding 12 months.  
  - Non-residents are now allowed to enter into forward foreign exchange contracts for the following committed flows of funds:  
    a) Repatriation of investment proceeds from Malaysia; and  
    b) Purchase of ringgit assets in Malaysia. |
| **Maintenance of Foreign Currency Accounts (FCA) by Residents and Conversion of Ringgit into Foreign Currency for Credit into FCA** | The rules on the maintenance of FCA by residents are also liberalised further to facilitate effective cash flow management and to promote business efficiency.  
  - Residents are now free to open FCA with licensed offshore banks in Labuan and overseas banks for any purpose, except for the retention of export receipts. With this flexibility, residents may retain their foreign currency receipts (other than export proceeds) in FCA maintained with licensed onshore banks, licensed offshore banks in Labuan and overseas banks with no overnight limits imposed on these accounts.  
  - Resident companies maintaining FCA with licensed offshore banks in Labuan and overseas banks are required to submit monthly statement, Statement OA, to the Controller.  
  - Residents may also convert ringgit into foreign currency for credit into these FCA maintained with licensed onshore banks, licensed offshore banks in Labuan and overseas banks as follows:  
    a. Any amount for residents (companies and individuals) without any domestic credit facilities;  
    b. Up to RM10 million per calendar year on a corporate group basis by resident companies with domestic credit facilities; and  
    c. Up to RM100,000 per calendar year by resident individuals with domestic credit facilities.  
  - Residents are now free to retain any amount of export receipts in FCA maintained with licensed onshore banks. The limits imposed on export FCAs are, accordingly, uplifted. |
<table>
<thead>
<tr>
<th>FX Administration Rules</th>
<th>Liberalisation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>With the removal of the limits, effectively all FCA maintained with licensed onshore banks (except for FCA for overseas education and employment purposes by residents with domestic credit facilities) are free from any overnight limits.</td>
</tr>
<tr>
<td></td>
<td>• The aggregate overnight limits on FCA for overseas education and employment purposes maintained by residents with domestic credit facilities remain as follows:</td>
</tr>
<tr>
<td></td>
<td>a) US$150,000 for FCA maintained with licensed onshore banks or licensed offshore banks in Labuan respectively; and</td>
</tr>
<tr>
<td></td>
<td>b) US$50,000 for FCA maintained with overseas banks.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Domestic Credit Facilities to Non-resident Controlled Companies (NRCCs)</th>
<th>Liberalisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>The RM50 million limit on extension of credit facilities to a NRCC by residents as well as the 3:1 gearing ratio requirement imposed on NRCC for its domestic borrowing exceeding RM50 million are abolished. With the abolishment, residents are now free to extend any amount of ringgit credit facilities to NRCCs.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Investment Abroad</th>
<th>Liberalisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>As part of efforts to further enhance management of funds and provide diversification of business opportunities, the rules on investment abroad by residents have also been liberalised.</td>
<td></td>
</tr>
<tr>
<td>• Residents with no domestic credit facilities are now free to invest any amount abroad. The investment may be made through the conversion of ringgit or from foreign currency funds retained onshore or offshore. Overseas investment funded by foreign currency borrowing will be limited to only RM10 million or equivalent at any one time.</td>
<td></td>
</tr>
<tr>
<td>• Residents with domestic credit facilities are also free to invest abroad their foreign currency funds maintained onshore or offshore. In addition, they are allowed to convert ringgit into foreign currency up to the following limits for overseas investments:</td>
<td></td>
</tr>
<tr>
<td>a) Up to RM10 million per calendar year by companies on a per corporate group basis; and</td>
<td></td>
</tr>
<tr>
<td>b) Up to RM100,000 per calendar year by individuals.</td>
<td></td>
</tr>
<tr>
<td>For companies converting ringgit for overseas investments, they must have a minimum shareholders’ funds of RM100,000 and must be operating for at least one year. In addition, they may finance overseas investment with foreign currency borrowing up to RM10 million or equivalent at any one time.</td>
<td></td>
</tr>
<tr>
<td>• The limit that can be invested abroad by unit trust management companies is also increased to 30 percent from 10 percent of the Net Asset Value (NAV) attributed to residents. Fund/asset managers may now invest abroad any amount of investment of resident clients without any domestic credit facilities and up to 30 percent of investments by resident clients with domestic credit facilities. The funds may be pooled for investment abroad. Such investments must be in line with the Securities Commission’s prudential guidelines.</td>
<td></td>
</tr>
<tr>
<td>• Resident insurance companies and takaful operators may also invest abroad up to 30 percent, increased from 10 percent, of the NAV of the investment-linked funds that they market. These investments are subject to compliance with prudential insurance and takaful regulations issued by Bank Negara Malaysia.</td>
<td></td>
</tr>
<tr>
<td>• The above flexibilities are subject to prior registration of any overseas investments exceeding the equivalent of RM50,000 with the Controller.</td>
<td></td>
</tr>
</tbody>
</table>
To enhance expediency in managing business in Malaysia, the limit for residents to obtain foreign currency credit facilities from non-residents, licensed onshore banks and licensed merchant banks in Malaysia is increased from the current limit of RM5 million or equivalent.

- Resident companies on a corporate group basis may now obtain foreign currency credit facility up to an equivalent of RM50 million in aggregate.
- Resident individuals are allowed to obtain foreign currency credit facility up to an equivalent of RM10 million in aggregate.
- The above flexibilities are subject to prior registration of any foreign currency credit facility exceeding RM1 million or equivalent with the Controller.
- Residents may prepay their foreign currency credit facilities subject to the registration of such prepayments with the Controller prior to effecting the payments.
- Residents may also utilise up to an aggregate of RM10 million or equivalent of their foreign currency credit facilities to finance overseas investment activities.

In line with the relaxation on residents for retention of export proceeds and overseas investments as well as freedom to obtain domestic credit facilities by NRCC, OHQs may now:

- Retain any amount of export receipts in their FCA maintained with licensed onshore banks;
- Obtain any amount of ringgit credit facilities from domestic sources; and
- Finance their overseas investment activities, including extension of credit facilities to non-residents, by converting up to RM10 million into foreign currency per calendar year if they have domestic credit facilities.

### Appendix 4: List of Bond Market Development Measures

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Initiatives</th>
</tr>
</thead>
</table>
| **Introducing an efficient and facilitative issuance process** | • Release of Guidelines on Offering of PDS - 2000  
• Introduction of a self-registration scheme - 2000  
• Release of Guidelines on the Offering of Asset-Backed Securities (ABS) – 2001  
• Release of Asset Securitisation Report to provide detailed information on ABS issuance including surveys and structures – 2002  
• Introduction of Guidelines on the Offering of Islamic Securities to set common standards between conventional and Islamic PDS – 2004  
• Introduction of a web-based Fully Automated System for Issuing/Tendering (FAST) – 2005 |
| **Broadening the issuer and investor base** | • Universal brokers allowed to trade in the over-the-counter (OTC) bond market - 2002  
• Introduction of a tax-neutral framework and tax deduction on issuance expenses for ABS – 2003  
• Islamic PDS are accorded various tax incentives (e.g. stamp duty waiver, tax deductions on issuance expenses) and a tax-neutral framework – 2003, 2005  
• Multilateral development banks, multilateral financial institutions and multinational corporations are allowed to raise ringgit-denominated bonds - 2004  
• Removal of withholding tax on interest income derived from investments by non-residents in all ringgit-denominated bonds - 2004  
• Allowing a wider group of investors to have access to the information memoranda and trust deeds of ringgit-denominated bond issues database to facilitate decision making – 2005 |
| **Improving liquidity in the** | • Non-financial institutions are allowed to enter into repurchase transactions with financial institutions – 2000 |
Shakira Teh Sharifuddin and Loke Po Ling

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Initiatives</th>
</tr>
</thead>
</table>
| secondary market          | • The Securities Borrowing and Lending Programme is introduced via the Real Time Electronic Transfer of Funds and Securities (RENTAS) system – 2001  
• ISCAP is introduced to facilitate securities lending by major institutional investors to Bank Negara Malaysia for use in market operations – 2005  
• Introduction of callable MGS and MGS switch auction to increase the amount of benchmark securities and further enhance trading in the secondary market – 2006, 2007 |
| Improving price discovery process | • Establishment of Bond Information and Dissemination System (BIDS) as a central information platform to enable reporting of all bond market transactions and wide dissemination of information – 1997 (further information on the Malaysian bond market can be obtained from the following websites: https://fast.bnm.gov.my; http://rmbond.bnm.gov.my; http://iimm.bnm.gov.my)  
• Release of Guidelines on the Registration of Bond Pricing Agencies to provide independent and objective fair value prices, on a daily basis, for all ringgit-denominated bonds traded in the OTC bond market – 2006  
• Daily publication of indicative yield-to-maturity of Government securities (conventional and Islamic) – 2005 |
| Establishing a reliable and efficient benchmark yield | • Introduction of an annual auction calendar for MGS to enhance transparency and facilitate longer-term planning by issuers and market participants – 2000  
• Revision of the principal dealers system every two years – to enhance principal dealers’ function as market makers for benchmark papers – 2006  
• Introduction of profit-based Government Investment Issues – 2005 |
• Introduction of Guidelines on Regulated Short-selling of Securities – 2005 |

Appendix 5: Variables Considered for Estimation

<table>
<thead>
<tr>
<th>Variables</th>
<th>Quarterly</th>
<th>Monthly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent variable</td>
<td>MGS 10-year, 5-year, maturity spread</td>
<td>MGS 10-year, 5-year, maturity spread</td>
</tr>
<tr>
<td>Explanatory variables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short-term rate</td>
<td>3-month MTB, KLIBOR (1-month, 3-month, 6-month, 9-month, 12-month), OPR, MGS 1-year</td>
<td></td>
</tr>
<tr>
<td>Inflation expectations</td>
<td>Annual growth in CPI</td>
<td></td>
</tr>
<tr>
<td>Liquidity</td>
<td>Liquidity ratio, Size of bond market</td>
<td></td>
</tr>
<tr>
<td>Sovereign risks</td>
<td>Debt-to-GDP ratio, Fiscal deficit (as percent of GDP)</td>
<td>Debt-to-GDP ratio, Fiscal balance, EIU</td>
</tr>
<tr>
<td>Volatility</td>
<td>MOVE, VIX</td>
<td></td>
</tr>
<tr>
<td>Growth</td>
<td>GDP, IPI</td>
<td></td>
</tr>
<tr>
<td>Foreign participations</td>
<td>Non-resident holdings of MGS, Bond flows, EPFR flows, change in NR holdings</td>
<td></td>
</tr>
</tbody>
</table>
Discussion

Ms. Danvee Floro commented that the paper provided a comprehensive narrative of the factors that drove the flattening of the Malaysian yield curve. The paper is relevant and provides a timely contribution to the ongoing policy discussions on capital flows and monetary policy.

Several challenges may be encountered in estimating the relationship between foreign bond holdings and nominal yields. One is the presence of two-way causality. It is possible that foreign investors target markets depending on the expected return on their assets. Another challenge is the possibility that long-term yields are affected by unobservable factors which are correlated to both foreign holdings of domestic bonds and long-term yields. To check if any of these is driving the results of the paper, it is recommended to conduct simple endogeneity tests (e.g., Hausman-Wu). If endogeneity is present, then forward-looking variables (e.g., inflation and growth from consensus forecasts) can be used as regressors or instrumental variables technique can be implemented.

Recommendations were given on how to enhance the paper. First, use rolling regression to determine whether the coefficient of foreign inflows is varying over time. Second, use differenced yield data or real interest rates to address non-stationary interest rate data. Third, add a forward rate of the Malaysian ringgit (1-year or 2-year) to examine whether expectations of Malaysian ringgit appreciation affect long term yields. Fourth, test for non-linearity by using threshold models (e.g., foreign holdings may be dependent on the state of risk aversion). Finally, check for long-run relationship between foreign bond holdings and long-term yields by using cointegration models.

One participant commented that foreign participation per se did not cause the decline in the yield curve, but global monetary policy expectations. Since global interest rates have fallen, foreign investors searched for higher yields, which in turn caused the flattening of the yield curve in Malaysia. Another participant asked whether the flattening of the yield curve should be considered a problem.

Ms. Shakira Teh Sharifuddin relayed that a flattening yield curve in Malaysia is a concern to the extent that it may give fiscal authorities the false impression that interest rates are going to remain low for a long time; and therefore, authorities may take spending for granted.

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27 Ms. Danvee Floro of the Bangko Sentral ng Pilipinas was the discussant of the paper.
Time-Varying Neutral Interest Rates in Emerging Markets

Roberto Perrelli and Shaun K. Roache

Emerging markets experienced a sizeable decline in their neutral real interest rates in the decade through mid-2013. In this paper we identify the main factors that contributed to this decline and apply a range of techniques useful for estimating neutral rates in emerging markets using Brazil as a case study. We also assess the implications of incorrectly estimating a time-varying neutral rate using a small structural model with a simple monetary policy instrument rule. We find that policy prescriptions are very different when facing uncertainty of neutral rate and of output gap. Our result contrasts sharply with Orphanides (2002), suggesting that the best response to neutral rate uncertainty is to ensure policy remains highly sensitive to inflation and output variations.

JEL Codes: E1; E4; E5

Keywords: Natural rate of interest, small monetary model, inflation targeting regime

1 INTRODUCTION

Knut Wicksell (1898) was probably the first economist to try and define the neutral real interest rate (henceforth the “neutral rate”). His interpretation was that “(it) is a certain rate of interest on loans which is neutral in respect to commodity prices, and tends neither to raise nor lower them.” The profession still thinks of the neutral rate in a similar way as the interest rate consistent with output at potential and inflation remaining stable. This is not just a theoretical curiosity; the neutral rate is an important operational benchmark against which to measure the stance of monetary policy, playing a pivotal function in some rules-based regimes (Laubach and Williams, 2003).

Policymakers that use some concept of the neutral rate in setting policies face considerable challenges, however. First, the neutral rate cannot be seen nor measured and instead has to be estimated, often with a low degree of confidence. Second, while often thought to reflect slow moving structural factors, notably saving and investment behavior over the medium to long run, neutral rates can and do change. In particular, emerging market economies undergoing rapid structural change may experience large shifts in the neutral rate, further complicating their use as a benchmark for monetary policy.

Our definition of the neutral rate in this paper is based on the nominal policy rate or the targeted interest rate—for some countries, the overnight interbank rate deflated by expected inflation. In other words, we typically focus on the neutral “ex-ante” short-term real rate, recognising that that there is likely to be something of a maturity mismatch between an overnight interest rate and inflation expectations that are often expressed for the coming 12 months. For a few emerging markets, however, the paucity of data requires the use of actual instead of expected inflation and the “ex-post” real rate. It is possible to think of the neutral rate as a short-, medium- or long-run concept (Archibald and Hunter, 2001). We define the neutral rate here to be invariant to

1 Based on “Time-Varying Neutral Interest Rate – The Case of Brazil”, IMF Working Paper 14/84 (May 2014) by the same authors.
2 Email address: rperrelli@imf.org; sroache@imf.org. We would like to express our special thanks to Olivier Basdevant, Andrew Berg, Marcos Chamon, Mercedes Garcia-Escribano, Tommaso Mancini Griffoli, Vikram Haksar, Dong He, Miguel Savastano, Björn van Roye and conference and seminar participants at the Bangko Sentral ng Pilipinas, Brazilian National Treasury, the Brazilian Central Bank, the Hong Kong Institute of Monetary Research, and the IMF for the many insightful comments we have received. The usual disclaimers apply.
both the cycle and factors that do not alter long-term saving and investment patterns. As such, we consider it to be a slow moving benchmark against which to set monetary policy through the business cycle.

In this paper, we infer stylized facts about neutral rates across a large sample of emerging markets and identify factors that may have caused their decline. Our innovation is to contrast a number of well-known statistical and econometric approaches and discuss their suitability for an economy undergoing rapid structural changes. A second contribution is to assess the implications of incorrectly estimating a time-varying neutral rate using a small structural model with a simple monetary policy instrument rule. This is a topic that has attracted scant attention in the literature, with much of the focus previously turned to uncertainty regarding potential output (e.g. Erhmann and Smets, 2003) or the natural rate of unemployment. We recognise that neutral rates and potential output growth are linked, but we find that the policy prescriptions are very different when facing uncertainty of either variety.

The plan of this paper is as follows: Section 2 highlights some stylized facts about the declining neutral rates in emerging markets. Section 3 offers a concise review of the relevant literature. Section 4 presents estimates of the neutral real interest rate from consumption-based models calibrated for Brazil. Section 5 explores several econometric techniques used to generate time-varying estimates of Brazil’s neutral real interest rate. To assess whether these estimates are consistent with theory, Section 6 compares them to those from Section 4 and discusses the implications for monetary policy based on a small macro model calibrated for Brazil. Concluding remarks are provided in Section 7.

2 STYLISTED FACTS ABOUT NEUTRAL RATES IN EMERGING MARKETS

Actual real interest rates are typically thought to fluctuate around the unobservable neutral rate—i.e., the real interest rate compatible with a closed output gap and with stable inflation. In this section, we use this assumption to infer some facts about neutral rates in emerging markets, in terms of how they might have changed, how they co-move, and what might be the common factors that explain such comovement. We use the terms “trend rate” and “neutral rate” interchangeably in this section.

Our first observation is that neutral rates appeared to decline across most emerging markets (henceforth “EMs”) between 2002 and 2011. This is suggested by the steady drop in trend real policy rates (henceforth “trend rates") obtained from the application of statistical filters. In Figure 1 (left panel), the trend is filtered from nominal policy interest rates deflated by prevailing consumer price inflation—hence, this is by construction an “ex post” proxy for the neutral rate that allows us to use a larger sample of countries (some of which do not have a long history of inflation expectation surveys). Brazil’s trend rate has averaged nearly 500 basis points (bps) lower between 2010 and 2013 compared with the average of the previous 4-year period. The only country with a larger drop in the sample was Turkey (around 800 bps). Notwithstanding this sizeable decline, Brazil’s trend real rate remains the highest in our EM sample (Figure 1).

Assuming less than perfect global financial integration, trend real rates in EMs should be determined, in part, by domestic factors, including saving and investment demand, as well as the level of the “world neutral rate” which reflects common factors like “excess” global saving and unconventional monetary policies in the US and Europe (Gourinchas and Jeanne, 2012). Indeed, a simple principal components decomposition of actual (i.e., unfiltered) de-meaned real short-term interest rates for the countries in our
sample and find that two factors explain about 45 percent of the common variation in real rates (not shown).

Figure 1. Emerging Markets: Declines in Neutral Real Interest Rates, 2005–13 1/ (In basis points, based on Hodrick-Prescott trend real policy rates)

Sources: Thomson Datastream, Haver, and authors' calculations
1/ For Turkey, the neutral rate is based on overnight rates until May 2010, and on 1-week repo rates afterwards.

These mechanical approaches can only bring us so far in helping us understand how and why neutral rates may have changed and what, as a consequence, might be the implications for monetary policy. In the next section, we briefly survey the existing literature to provide the foundation for a more comprehensive analytical framework.

3 A BRIEF REVIEW OF THE LITERATURE ON ESTIMATING NEUTRAL RATES

Notwithstanding Wicksell’s (1898) seminal theoretical work and the pivotal role played by the neutral rate in Taylor’s (1993) celebrated monetary policy rule, the econometric literature on this topic has flourished only recently.


For Brazil, Miranda and Muinthos (2003), and Muinthos and Nakane (2006) provide early estimates of the neutral rate, while Neto and Portugal (2009) consider the initial years of the inflation target regime (1999–2005). Since then the Brazilian economy has changed substantially, and so did its neutral interest rate. Perrelli (2012) provides an early attempt to model Brazil’s neutral real interest rate in the post-global financial crisis era. Several works have attempted to explain Brazil’s persistently high levels of interest rates. Arida, Bacha, and Resende (2005), Gonçalves, Holland, and Spacov (2007), and Bacha, Holland, and Gonçalves (2009), worked with the hypothesis that jurisdictional uncertainty on long-term contracts has led to high interest rates—to certain extent, as a
Roberto Perrelli and Shaun K. Roache


4 STRUCTURAL ESTIMATES OF THE NEUTRAL RATE

In this section, we use structural models to assess Brazil’s neutral real interest rate. Our estimates are based on the calibration of the first-order condition for optimal intertemporal consumption of a representative agent. Our calibrations use Brazil’s actual growth rate of per capita income and its volatility, along with a range of behavioral parameters typically adopted in this literature (e.g., Issler and Piqueira, 2000).

We begin by assuming that the representative individual has a constant relative risk aversion (CRRA) utility function given by:

$$u(C_t) = \frac{C_t^{1-\gamma}}{1-\gamma} \quad \text{with} \quad \gamma > 0$$

(1)

where $C$ is per capita consumption, $\gamma$ is the coefficient of relative risk aversion, and $t$ is a time indicator. The consumer maximizes her lifetime utility discounting future consumption by $\beta$, subject to a budget constraint where financial assets $B$ grow as a function of per capita income ($Y_t$), consumption ($C_t$), and the real return on assets ($1+r_t$):

$$\max \sum_{t=0}^{\infty} \beta^t u(C_t) \quad \text{subject to} \quad B_{t+1} = (1+r_t)(B_t + Y_t - C_t).$$

(2)

In the steady state, $Y_t = C_t$ for all $t$ such that the first-order condition can be rewritten simply as

$$(1 + r) = E_t \left[ \frac{\beta \gamma E_t(Y_t)}{Y_t} \right]^{-1}.$$ 

(3)

As equation (3) suggests, the first-order condition can be written in terms of the steady state growth rate of per capita income ($g$), since $Y_{t+1} = (1+g)Y_t$. Assuming log normal $g$, the Euler equation can be approximated as follows:

$$\ln(1 + r^*) \equiv -\ln \beta + \gamma E_t(g) - \frac{1}{2} \gamma^2 \text{var}(g)$$

(4)

where $r^*$ is the neutral rate and $\text{var}(g)$ is the variance of per capita growth.

Equation (4) indicates a positive relationship between the neutral rate and the expected rate of growth of per capita income, consistent with the stylized fact that trend interest rates in advanced economies are lower than in faster growing emerging markets. But while estimating $E_t(g)$ and $\text{var}(g)$ is a relatively easy task, pinning down values for behavioral parameters like $\beta$ and $\gamma$ in rapidly changing emerging markets is more challenging and subject to considerable uncertainty.

In Brazil’s case, we consider the average growth rate and standard deviation of per capita income in two sub-periods (2005-2008 versus 2010-2013), estimated respectively at 3.5 percent and 2.5 percent per annum, and 1.4 percent and 2.8 percent, respectively. For $\beta$ we use values typically adopted in the calibration of Ramsey models—in the range of 0.97 to 0.99—and also used in the literature of other emerging markets (e.g., Fuentes and Gredig, 2008). For $\gamma$, the literature suggests a value in the range of 1 to 2. This exercise then suggests a neutral rate of about 7¼ percent for the period 2005-2008 and 5¾ percent for the 2010–13 years (Table 1).
Structural consumption models provide a solid bridge between theory and practice and deliver plausible results for Brazil. These models can also inform important policy discussions regarding economic growth in emerging economies—faster growth is expected to be matched by higher neutral rates unless behavioral changes provide offsetting effects. In turn, this is related to the patterns of saving and investment—neutral rates in low-saving countries (such as Brazil, Turkey, and South Africa) are typically higher than in high-saving peers (like Indonesia and Malaysia). Therefore, increasing household savings in Brazil would contribute to a lower neutral rate. Last, but not least, the careful calibration of consumption models can deliver results close to those found empirically through the application of model-free methods, such as statistical filters, as we discuss in the next section.

5 ECONOMETRIC ESTIMATE OF NEUTRAL RATES

One drawback of structural models is that their key parameters are not directly observable, while estimates are subject to considerable uncertainty. An alternative approach is to apply a range of econometric techniques to evaluate the likely range for neutral rates.

5.1 Statistical Filters

We use a range of filters which are useful for disentangling the real interest rate cycle from its secular trend—including the Hodrick-Prescott, Ravn-Uhlig, and Christiano-Fitzgerald time-varying filters—to the ex-post real interest rates in a sample of 24 emerging markets. Table 2 shows that for the whole sample, the average filtered interest rate dropped more than 200 basis points, from about 3 percent early in the previous decade to approximately ¾ percent in the four-year period after the global financial crisis.
There are drawbacks to using statistical filters. Most filters are unable to reliably disentangle permanent (or very persistent) and temporary fluctuations. In the case of interest rates, the filtered trend may be identifying extended cyclical variation that may not be driven by an underlying structural shift in saving-investment balances, potential output growth, or consumer preferences. Additional information and structure may be required to identify such cases, including, for example, the behavior of inflation. A second issue is that many two-sided filters suffer from end-point bias, which serves only to reinforce the effect of the current period’s actual interest rate—which may be strongly affected by cyclical conditions—on estimates of the neutral. For these reasons we present a range of alternative econometric methods in the following sub-sections.

### Table 2. Emerging Markets: Estimates of the Ex-Post Neutral Rate from Statistical Filters

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<tbody>
<tr>
<td>Brazil</td>
<td>9.3</td>
<td>8.8</td>
<td>3.5</td>
<td>-575</td>
</tr>
<tr>
<td>Chile</td>
<td>0.8</td>
<td>0.4</td>
<td>1.7</td>
<td>89</td>
</tr>
<tr>
<td>China</td>
<td>4.3</td>
<td>2.8</td>
<td>2.8</td>
<td>-150</td>
</tr>
<tr>
<td>Colombia</td>
<td>0.1</td>
<td>2.1</td>
<td>1.2</td>
<td>101</td>
</tr>
<tr>
<td>Czech Rep</td>
<td>1.2</td>
<td>-0.5</td>
<td>-1.4</td>
<td>-259</td>
</tr>
<tr>
<td>Egypt</td>
<td>4.9</td>
<td>-0.7</td>
<td>-0.6</td>
<td>-552</td>
</tr>
<tr>
<td>Hungary</td>
<td>3.8</td>
<td>2.3</td>
<td>1.8</td>
<td>-204</td>
</tr>
<tr>
<td>India</td>
<td>n.a.</td>
<td>-0.3</td>
<td>-2.9</td>
<td>n.a.</td>
</tr>
<tr>
<td>Indonesia</td>
<td>2.0</td>
<td>0.1</td>
<td>0.9</td>
<td>-113</td>
</tr>
<tr>
<td>Israel</td>
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<td>2.1</td>
<td>-0.4</td>
<td>-425</td>
</tr>
<tr>
<td>Korea</td>
<td>0.7</td>
<td>1.0</td>
<td>0.1</td>
<td>-57</td>
</tr>
<tr>
<td>Malaysia</td>
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<td>0.1</td>
<td>0.8</td>
<td>19</td>
</tr>
<tr>
<td>Mexico</td>
<td>2.2</td>
<td>3.2</td>
<td>0.5</td>
<td>-176</td>
</tr>
<tr>
<td>Pakistan</td>
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<td>-0.3</td>
<td>1.1</td>
<td>-212</td>
</tr>
<tr>
<td>Peru</td>
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<td>1.5</td>
<td>0.7</td>
<td>80</td>
</tr>
<tr>
<td>Philippines</td>
<td>n.a.</td>
<td>2.9</td>
<td>2.1</td>
<td>n.a.</td>
</tr>
<tr>
<td>Poland</td>
<td>4.7</td>
<td>2.1</td>
<td>0.8</td>
<td>-386</td>
</tr>
<tr>
<td>Russia</td>
<td>3.7</td>
<td>0.3</td>
<td>1.1</td>
<td>-255</td>
</tr>
<tr>
<td>South Africa</td>
<td>4.5</td>
<td>2.7</td>
<td>0.3</td>
<td>-422</td>
</tr>
<tr>
<td>Taiwan</td>
<td>1.3</td>
<td>0.8</td>
<td>0.6</td>
<td>-69</td>
</tr>
<tr>
<td>Thailand</td>
<td>-0.1</td>
<td>-0.3</td>
<td>-0.3</td>
<td>-16</td>
</tr>
<tr>
<td>Turkey</td>
<td>6.8</td>
<td>6.5</td>
<td>-1.6</td>
<td>-840</td>
</tr>
<tr>
<td>Ukraine</td>
<td>3.2</td>
<td>-4.4</td>
<td>3.1</td>
<td>-5</td>
</tr>
<tr>
<td>Uruguay</td>
<td>n.a.</td>
<td>-0.5</td>
<td>0.3</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

**Simple EM Average**: 2.9, 1.4, 0.7, -211

Sources: Haver and authors’ calculations
5.2 Yield Curve Models

Interest rates at different maturities across the yield curve add more information to the estimation process, particularly by incorporating market expectations of the path of short-term rates. With “well-anchored” inflation expectations, the average slope of the yield curve should mainly reflect the term premium. When computed over a sufficiently long horizon and between cyclically-equivalent end-points, the average term premium can be considered neutral with respect to the business cycle (Basdevant et al., 2004).

Yields on Brazil’s long-term 10-year local currency sovereign bonds and short-term 3-month swap rates have trended lower during most of the sample period. We estimate the average term premium in Brazil during 2006–13, i.e., the difference in yields between long-term bonds and short-term swaps—to be about 140 basis points with significant cyclical variation (Figure 2). In this framework, a proxy for the neutral rate can be backed out by adding the “excess” term premium—defined as the current term premium minus the sample average—to the trend real short-term interest rate. In the second half of 2013, for example, the trend real interest rate in Brazil floated around 3.4 percent, while its “excess” term premium averaged 110 basis points. Hence, this approach suggests an estimate of Brazil’s neutral real interest rate around 4½ percent during that reference period.

Figure 2. Brazil: Slope of the Yield Curve, 2006–13
(Yields in percent; slope of the yield curve in basis points)

5.3 State Space Models

This methodology relies on the identification of cyclically-neutral positions to anchor the average term premium, which may be difficult to verify in such a short sample period. Given the limited experience of emerging market economies with the duration of business cycles under inflation target regimes, the results are subject to uncertainty.
The state space framework is well-suited to estimating neutral rates since it explicitly takes account of latent (unobservable) variables. The most simple application assumes that short-term and long-term nominal interest rates are determined by a common unobservable time-varying neutral rate, inflation expectations, and idiosyncratic shocks. The long-term rate is also explained by a term premium.

We apply this approach to Brazil by estimating a system of four equations using monthly data: two signal (observable) equations, and two state (latent) equations. The signal equations for the short-term rate (5) and the long-term rate (6) are estimated as functions of the 12-month ahead expected inflation ($E_t(\pi_{t+12})$), the output gap ($Y_{gap_t}$), the 3-month ($US3m_t$) and 10-year ($US10y_t$) yields on U.S. Treasury securities (to capture interest rate parity issues), the Brazilian 5-year CDS ($BRCDS_t$) spreads (as a gauge for shifts in sovereign risks), and the neutral real interest rate $r^*_t$.

The output gap is calculated as as the difference between the central bank’s Economic Activity Index (IBC-Br)—a high-frequency real-time gauge of GDP—and an estimate of its trend using a standard filter. We use the yields on 10-year local currency sovereign bonds for the long-term interest rate and the 3-month swap rate for the short-term rate. We also control for the time-varying term premium $\alpha_t$ in the long-term rate equation:

$$r_{t,short} = \rho_0 E_t(\pi_{t+12}) + \rho_1 Y_{gap_t} + \rho_2 US3m_t + r^*_t$$

$$r_{t,long} = \beta_0 E_t(\pi_{t+12}) + \beta_1 US10y_t + \beta_2 BRCDS_t + \alpha_t + r^*_t.$$  

State equation (7) models $r^*$ as a random walk, while state equation (8) assumes the term premium follows a stationary AR(1) process:

$$r^*_t = r^*_{t-1} + \epsilon_{1,t}$$

$$\alpha_t = \gamma_0 + \gamma_1 \alpha_{t-1} + \epsilon_{2,t}.$$  

A Kalman-filtered neutral rate calculated from the estimates of this model (Table 3 and Figure 3) has declined over the past decade, albeit with significant cyclical variation, ranging between 3 and 5 percent over the last two years. The model estimates are determined mainly by expected inflation, long-term U.S. Treasury yields, and Brazil’s CDS spreads:

<table>
<thead>
<tr>
<th>Signal equation:</th>
<th>Expected inflation</th>
<th>Output gap</th>
<th>U.S. 3-month yields</th>
<th>U.S. 10-year yields</th>
<th>CDS spreads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short-term rate</td>
<td>0.721</td>
<td>0.028</td>
<td>0.112</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.24)***</td>
<td>(0.04)</td>
<td>(0.14)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-term rate</td>
<td>1.421</td>
<td></td>
<td></td>
<td>0.779</td>
<td>0.490</td>
</tr>
<tr>
<td></td>
<td>(0.56)***</td>
<td></td>
<td></td>
<td>(0.22)***</td>
<td>(0.17)***</td>
</tr>
</tbody>
</table>

Sources: BCB, Thomson Datastream, Haver, and authors’ calculations.
1/ Standard errors in parenthesis: * significant at 10 percent; ** significant at 5 percent; and *** significant at 1 percent.
5.4 Fundamentals-based Regression Models

Stronger macroeconomic fundamentals may help to explain the decline in emerging market neutral rates over the past decade. In this section we estimate two models that try to decompose changes in the neutral rate by fundamental determinants following Bernhardsen and Gerdrup (2007) and Goldfajn and Bicalho (2011).

5.4.1 Long-Run Equilibrium Real Interest Rate

The long-run equilibrium real interest rate is estimated as a function of productivity, inflation outcomes, external vulnerability, sovereign creditworthiness, and financial deepening. Specifically, the control variables are:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productivity growth</td>
<td>Annual growth rate of output per employed person;</td>
</tr>
<tr>
<td>Inflation gap</td>
<td>Difference between the actual 12-month consumer’s inflation rate (IPCA) and</td>
</tr>
<tr>
<td></td>
<td>the center of the Brazilian Central Bank’s (BCB) inflation target band;</td>
</tr>
<tr>
<td>Inflation surprise</td>
<td>Difference between the one-year ahead expected inflation (from the BCB</td>
</tr>
<tr>
<td></td>
<td>Focus survey) and the actual inflation outcome;</td>
</tr>
<tr>
<td>Sovereign risk</td>
<td>5-year credit default swap (CDS) spreads;</td>
</tr>
<tr>
<td>Public indebtedness</td>
<td>Ratio of net public debt to GDP;</td>
</tr>
<tr>
<td>Financial deepening</td>
<td>Domestic credit to the private sector as a percent of GDP;</td>
</tr>
<tr>
<td>Global interest rates</td>
<td>3-month and 10-year yields on U.S. Treasury securities.</td>
</tr>
</tbody>
</table>
The coefficient on private credit-to-GDP ratio should be negative because financial deepening that reflects an increased supply of savings (foreign or domestic) should lower the neutral rate. The coefficients on sovereign risk and public indebtedness are expected to be positive. The interest parity condition implies a positive coefficient on global interest rates. Better inflation performance—smaller inflation gaps and inflation surprises—should lower the neutral rate. Higher productivity growth should increase the demand for funds and raise the neutral rate. Our econometric estimates are largely consistent with these priors, fit the data well, and pass the usual diagnostic tests (Table 4). We find three main domestic reasons for the fall in the neutral rate: lower public debt, reduced sovereign risk, and an increased supply of saving that has translated into financial deepening (together, the green bars in Figure 4). In contrast, inflation performance has not made a major contribution to a lower neutral rate, at least since 2007 due, in part, to an inflation gap that has not narrowed over recent years, while inflation surprises have been largely asymmetric (on the upside)—see Roache (2014).

Lower global interest rate contributed about 200 basis points to the decline in Brazil’s neutral rate during 2010–13 relative to their average contribution in 2005–08. According to this approach, the long-run equilibrium real interest rate in Brazil was running between 2½ and 3 percent by mid-2013.

Figure 4. Brazil: Determinants of Long-Run Equilibrium Real Interest Rate, 2005–13
(Contributions to the equilibrium real interest rate, in percentage points, excluding the intercept)

Sources: BCB, Thomson Datastream, Haver, and authors’ calculations
In this section we use a small rational expectations model to better understand the policy implications of a changing neutral rate. The aim is to identify how monetary policy settings might respond to a changing neutral rate, but also to assess what happens if policymakers "get it wrong"; in other words, the implications of a policy error made on the basis of an incorrect assessment of the neutral rate.

Previous research has focused more on incorrect estimates of potential output. Orphanides (2002) suggests that when policymakers make systematic errors estimating potential output, activist policy rules can lead to worse outcomes, notably higher output gap and inflation variability. Uncertain neutral rates have also been shown to affect macroeconomic outcomes and optimal monetary policy design. Orphanides and Williams (2007) show that, like potential output, uncertainty about neutral rates and resulting (unintentional) policy errors using Taylor-type rules increase growth and inflation variability. They suggest that the optimal policy rule, in the face of such uncertainty, should exhibit more sensitivity to inflation and output than if the neutral rate was known with certainty. They also suggest that a difference rule in which policy responds to changes in inflation and output (or unemployment) can remove the feedback of policymaker misperceptions of the neutral rate to the economy. Taylor and Williams (2010) also advocate a rule that removes the influence of the estimated neutral rate on policy rate settings. Specifically, they suggest that optimal policy should show greater inertia with the interest rate from the previous period serving as the "steady state" benchmark (in place of an estimate of the neutral rate), while still responding to inflation and output gaps.
Our model is based on the framework described by Berg, Karam, and Laxton (2006) and includes four structural equations that link output, inflation, and policy interest rates. Specifically, the four equations include: (1) an aggregate demand or IS curve that relates the level of real activity to expected and past real activity, the real interest rate, and the real exchange rate; (2) a price-setting or Phillips curve that relates inflation to past and expected inflation, the output gap, and the exchange rate; (3) an uncovered interest parity condition for the exchange rate, with some allowance for backward-looking expectations; and (4) a rule for setting the policy interest rate as a function of the output gap and expected inflation.

\[ y_t - y^*_t = \beta_{ld} \text{gap}_{t+1} + \beta_{lag} (y_{t-1} - y^*_{t-1}) - \beta_r (r_{t-1} - r^*_{t-1}) + \beta_z (z_{t-1} - z^*_{t-1}) + \epsilon_t^y \]  

\[ \pi_t = \alpha_{ld} \pi_{4,t-1} + (1 - \alpha_{ld}) \pi_{4,t-1}^* + \alpha_{gap} (y_{t-1} - y^*_{t-1}) + \alpha_z (z_{t-1} - z^*_{t-1}) + \epsilon_t^\pi \]  

\[ z_t = \frac{z^*_t}{t-\frac{1}{4}} (r_{t-1} - r^{US}_t - \rho_t) + \epsilon_t^z \]  

\[ z_{t+1}^e = \delta z_{t+1} + (1 - \delta) z_{t-1} \]  

\[ i_t = \gamma_{lag} i_{t-1} + (1 - \gamma_{lag}) \left[ r_{t+1}^* + \pi_{4,t} + \gamma_x (\pi_{4,t+4}^* - \pi_{t+4}^*) + \gamma_{gap} (y_t - y^*_t) \right] + \epsilon_t^i \]  

Where:
- \( y_t \equiv \text{log output in period } t \)
- \( y^*_t \equiv \text{log potential output in period } t \)
- \( y_t - y^*_t \equiv \text{output gap in period } t \)
- \( \pi_t \equiv \text{annualized quarter-on-quarter change in the log price index in period } t \)
- \( \pi_{4,t} \equiv \text{inflation target in period } t+4 \text{ (set at 4½ percent)} \)
- \( \pi_{t+4}^* \equiv \text{log equilibrium real bilateral exchange rate versus the U.S. dollar in period } t+1 \)
- \( r_{t-1}^* \equiv \text{log real bilateral exchange rate versus the U.S. dollar in period } t \)
- \( r_{t-1} \equiv \text{log real bilateral exchange rate versus the U.S. dollar in period } t \)
- \( r_t^* \equiv \text{expected (model consistent) real exchange rate in period } t \)
- \( r_t^{US} \equiv \text{United States short-term real interest rate in period } t \)
- \( \rho_t \equiv \text{country-specific risk premium in period } t \)
- \( r_{t+1}^* \equiv \text{true} \text{ neutral real interest rate in period } t \)
- \( r_{t+1}^{**} \equiv \text{policymakers estimate of the neutral real interest rate in period } t \)
- \( i_t \equiv \text{nominal policy rate in period } t \)
- \( \epsilon_t^\gamma \equiv \text{idiosyncratic output shock in period } t \)
- \( \epsilon_t^\pi \equiv \text{idiosyncratic inflation shock in period } t \)
- \( \epsilon_t^z \equiv \text{idiosyncratic exchange rate shock in period } t \)
- \( \epsilon_t^i \equiv \text{idiosyncratic policy interest rate shock in period } t \)

We start the model in its steady state, when policymakers accurately identify the constant neutral rate (i.e., \( r^{**} = r^* \)), the output gap is closed (\( y = y^* \)), and inflation is at the target (\( \pi = \pi^* \)). The parameters for the model \( \theta_{lead}, \theta_{lag}, \theta_z, \alpha_{lead}, \alpha_{gap}, \alpha_z, \delta, \gamma_{lag}, \gamma_n \), and \( \gamma_{gap} \) have been approximately calibrated to Brazil over the 2000Q1 to 2012Q2 period and are provided in the appendix. The inflation target is equal to the mid-point of the Central Bank of Brazil’s target range of 4½ percent ± 2 percent.

Our focus is on a changing neutral rate and our first scenario considers an unanticipated decline in the neutral rate \( r^* \) that is correctly identified by policymakers.
Throughout this period, all other shocks are set to zero to isolate the impact of the change in $r^*$. In particular, we consider a gradual 3½ percentage point decline in the neutral rate to 3 percent over a period of eight years, keeping $r^* = r^{**}$. We contrast this with two alternative scenarios in which policymakers “get it wrong”. We implement a change in the neutral rate without changing any of the other steady-state values in the model, including potential output. As the Euler condition shows, there is a strong link between the neutral rate and potential output growth. We justify our focus only on a changing neutral rate in two ways: $r^*$ can change for a constant potential growth rate due to consumer preferences; and we want to ease the comparison with the previous literature (e.g., on potential output uncertainty) which largely kept the assumed neutral rate unchanged.

In the second scenario, we assume that policymaker beliefs are lagging. Specifically, we assume that policymakers believe the neutral rate is following the same downward trajectory as the true neutral rate, but with a two-year lag. This seems a reasonable assumption. Policymakers will often change their beliefs about important structural variables such as the neutral rate and subsequent policy settings only slowly over time (see for example Sack and Wieland, 2000). At the same time, the neutral rate itself is likely to change only gradually, suggesting long lags in learning. We do not model policymaker beliefs explicitly—as done in Orphanides and Williams, 2007—and instead adopt the heuristic approach to their formation of simply assuming that they decline gradually over time.

In our third and final scenario, we assume that policymakers believe that the neutral rate is falling at a faster rate than is actually occurring. At some point, at least in the simple model above, this error will be recognized—it is easy to show that at a steady state with $r^{**} < r^*$ inflation will be persistently above target by the quantity $\gamma (\pi - \pi^*)$, implying that a rational inflation-targeting central bank will eventually fully learn about the neutral rate.

![Figure 5. Small Model: Scenarios for Neutral Rates (percent)](source)

Source: Authors’ calculations

To implement the two scenarios in which policymakers hold mistaken beliefs, we need to break the link between the policymaker’s expected inflation ($\pi_{4,t+4}$) that is determined by (9) and (10) and current policy settings in (12). The standard model (9)-
(12) would imply inconsistent behavior on the part of policymakers as they set policy on the basis of \( r^{**} \) and project future inflation on the basis of \( r^* \), where \( r^{**} > r^* \). In other words, they would recognize, yet ignore, their own mistake. One way to achieve this is to assume that the policymakers’ horizon, in an environment of higher neutral rate uncertainty, shrinks to the point that they act only on the basis of observable variables. We implement this assumption by setting the policy rule to target the gap between current (observable) inflation and the inflation target. This means the policy rule (12) becomes:

\[
i_t = \gamma_{\text{lag}} i_{t-1} + \left( 1 - \gamma_{\text{lag}} \right) \left[ r^{**}_t + \pi_{\text{ex}}^4_t + \gamma_{\pi} \left( \pi_{\text{ex}}^4_t - \pi^*_t \right) + \gamma_{\text{gap}} \left( y^*_t - y^*_t \right) \right] + \epsilon_t^j
\]

(13)

The results of these simulations are shown in Figure 6. In the first scenario, where \( r^{**} = r^* \), a small negative output gap emerges and inflation falls slightly below the target mid-point. This outcome is due to policy inertia causing the policy interest rate to move sluggishly, with the speed of policy adjustment reflected in the value of \( \gamma_{\text{lag}} \) in (13).

Outcomes are worse when policymakers make mistakes. In the second scenario, the immediate effective tightening in monetary policy caused by inertia is now compounded by policy being set on the basis of an incorrect neutral rate \( r^{**} > r^* \). Over the first year, the real interest rate gap \( r - r^* \) rises by about 50 basis points and this inadvertent monetary tightening results in a modestly negative output gap. The interest rate gap increases by a further 50 basis points in the second year, while the output gap continues to widen modestly. At the same time, inflation falls persistently, but modestly, below the target. The interest rate gap peaks at about 110 basis points during the third year of the mistake, before \( r^{**} \) begins to converge to \( r^* \).

In the third scenario, policy loosens as policymakers mistakenly set \( r^{**} < r^* \). Over the first year of the mistake, the interest rate gap declines by about 20 basis points and the output gap rises, but very modestly. The interest rate gap peaks during the fifth year of the mistake at about 130 basis points reflecting, in part, the very gradual nature of the change in neutral rates.

The striking aspect of these results is that the adverse outcomes are modest given the size of the mistake (measured as \( r^{**} - r^* \)). In scenarios two and three, the output gap peaks at about -0.5 and 0.5 percentage points, respectively. Similarly, inflation diverges from the target by about 0.7 percentage points (in opposite directions) in both scenarios. The reason is that policymakers are continuing to follow their own rules at the same time as mistakenly estimating the neutral rate. This means that policymakers are partly correcting their own mistake in each quarter.

To illustrate, consider the third scenario where \( r^{**} < r^* \). As monetary policy becomes stimulative, the output gap widens, and inflation rises above target; policymakers will perceive this to be a positive output shock (i.e., in equation (9), \( \epsilon^j > 0 \)). In response, they will partially undo the policy rate reductions triggered by their downward revision of \( r^* \), with the strength of the policy reaction condition by the parameters in the policy rule (13). Over time, policymakers will likely learn that their estimate \( r^{**} \) is incorrect. So long as they retain their initial policy rule, the ongoing policy response to perceived output shocks will prevent the actual interest rate gap (defined as the actual real interest rate \( r \) less the true neutral rate \( r^* \) or \( r - r^* \)) from diverging too far away from zero.
Figure 6. Falling Neutral Real Interest Rates in a Small Monetary Model: Scenarios (percent)

Scenario 1: Output Gap (percent)

Scenario 2: Output Gap (percent)

Scenario 3: Output Gap (percent)

Source: Authors’ calculations

Figure 7. Scenario 3: Actual Real Interest Rate Gaps Under Different Policy Rules

Neutral rate mistake \( (r^{**} - r^*) \)

'Actual' real rate gap \( (r - r^*) \) - policy rule 1

Actual real rate gap \( (r - r^*) \) - policy rule 2

Source: Authors’ calculations.

Note: Policy rule 1 assigns coefficients \( \gamma_{lag} = 0 \), \( \gamma_{\pi} = 3 \) and \( \gamma_{ygap} = 3 \). Policy rule 2 assigns coefficients \( \gamma_{lag} = 0 \), \( \gamma_{\pi} = 0.01 \) and \( \gamma_{ygap} = 0.01 \).
Figure 7 shows real interest rate gaps from policy rules with different parameters. Policymakers with loss functions that are highly sensitive to both output and inflation gaps (in Figure 7 this is policy rule 1 with very high values for $\gamma_\pi$ and $\gamma_{ygap}$) will react sharply to the outcomes of their mistaken estimate $r^{**}$. In turn, this results in an interest rate gap that hardly diverges from zero. In contrast, policymakers that attach a much lower weight to output and inflation gaps (in Figure 7 this is policy rule 2 with low values for $\gamma_\pi$ and $\gamma_{ygap}$) instead implicitly attach a much higher weight to their estimate of the neutral. (Note that the interest rate gap $r - r^*$ in this case is somewhat different from the neutral rate estimate gap $r^{**} - r^*$ because actual real rates are calculated using one quarter ahead inflation.)

This analysis clearly highlights the inherent risks for policymakers when the neutral rate appears to be shifting significantly. The most important risk is that policymakers attach a higher weight to anchoring current policy settings on the basis of their estimate of the neutral and less weight on output and inflation gap outcomes. This is consistent with the findings of Orphanides and Williams (2007), and Taylor and Williams (2010). It is well known that uncertainty about state variables (in this case the neutral rate) does not affect the optimal policy feedback rule—see Smets (2002) for an exposition.

However, a simple linear decision rule of the form $i_t = -Fx_t$, where $x_t$ is a vector of state variables (such as output gaps and inflation) is not certainty equivalent as shown by Söderlind (1999). This means that the efficient policy rule coefficients will depend on the covariance of the predetermined variables in the model, including $r^*$. In other words, if uncertainty about $r^*$ increases during its transition to a new steady state, policymakers should maintain their current rule or even increase their activism and respond more forcefully to output and inflation gaps, thereby reinforcing the self-correcting mechanism.

7 CONCLUDING REMARKS

A battery of empirical and semi-structural techniques suggest that neutral rates in emerging markets have declined since over the past decade with a particularly large fall in our case study of Brazil.

For the sample period covered in this paper, our econometric results suggest that global real interest rates have pushed down neutral rates in emerging markets but domestic factors have also been important (at least in Brazil), particularly: an increase in the supply of saving (reflected in swift financial deepening); declining public debt; and lower sovereign risk. At the same time, we find that there has been substantial cyclical variation in the estimates of equilibrium (or neutral) short-term interest rates, reflecting factors such as domestic and world output gaps.

The good news is that high levels of uncertainty regarding the true neutral rate need not complicate policymaking too much. On the basis of small macromodel simulations calibrated for Brazil, we find that the costs of incorrectly estimating the neutral rate, in isolation, are likely to be low. This is because standard monetary policy instrument rules provide a self-correcting mechanism that ensures mistakes are partly corrected. The intuition is clear—an activist policy rule will ensure that policymakers respond symmetrically to observable outcomes, whether they are due to output and inflation shocks or incorrectly estimated neutral rates. This guarantees that actual real
interest rates are never too far away from the “true” neutral rate, thereby minimizing the variability of output and inflation gaps.

Our result contrasts sharply with Orphanides (2002) who showed that, in the presence of an incorrectly estimated level of potential output, activist policy rules can exacerbate output and inflation gap variability. However, it is consistent with Orphanides and Williams (2007), and Taylor and Williams (2010) in that the best response to neutral rate uncertainty is to ensure policy remains highly sensitive to inflation and output variations. The main risk in updating assumptions about the neutral rate is that policy becomes less activist and more focused on “targeting the neutral rate,” which would amplify the costs of mistakes.
References


Discussion

The paper presented different methodologies on how to measure the natural rate of interest, both from theoretical and empirical perspectives. The different approaches used to calculate the natural rate of interest resulted in different estimates. An interesting outcome is that the cost of making mistakes in estimating the natural interest rate, in terms of output gap and inflation outcomes, was estimated to be very small.

While Dr. Björn van Roye agreed that measuring the natural rate of interest is very important for monetary authorities because it helps determine the monetary stance, he gave several recommendations to enhance the paper. First, a fully structural model for Brazil may be set up and the outcomes may be compared with filter techniques. Second, the analysis on the cost of making mistakes in estimating the natural rate of interest may be deepened. Third, advanced economies may be included in the principal components analysis. Fourth, the role of central bank credibility and inflation targeting vis-à-vis the equilibrium rate in Brazil may be discussed.

One participant asked whether there has been research on targeting the natural interest rate instead of the output gap or inflation. Another participant commented that the observation that the real interest rate cannot be far from the neutral interest rate may not be applicable for developing countries. For the Philippines, in particular, there are structural factors that have stronger effects on the real interest rate.

One participant mentioned that the conclusion on the low cost of making mistakes in estimating the neutral rate goes against the theoretical premise. In addition, central bank mistakes have important implications on expectations and the central bank’s credibility.

Dr. Roache emphasized that the neutral interest rate should be an input to policy rule, but should not be targeted by the central bank. In addition, structural factors can indeed affect the neutral interest rate. Finally, the simple model used in the paper assumes that the central bank will continue to follow its policy rule, thus, cost will be small even with incorrect estimates of the neutral rate.

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3 Dr. Bjorn van Roye of the European Central Bank was the discussant of the paper.
Session 2
Monetary Policy and Inflation Pressures
Global Impact of US Monetary Policy at the Zero Lower Bound

Qianying Chen, Andrew Filardo, Dong He and Feng Zhu

This is a study of the cross-border effects of US monetary policy at the zero lower bound on 17 major advanced and emerging economies. We evaluate various channels of international transmission of US monetary policy both before and after the zero lower bound on the nominal interest rate became binding in late 2008. We estimate a global vector error-correcting macroeconometric (GVECM) model to assess the impact of US monetary policy on various measures of economic activity in these economies, approximating the unconventional policy measures implemented by the Federal Reserve with two types of shadow federal funds rates developed by Lombardi and Zhu (2014) and Wu and Xia (2013). The analysis suggests that US monetary stimulus in the crisis period had sizeable domestic effects. Our counterfactual simulations support the view that, domestically, US monetary policy prevented recessions in 2011 and 2012, and has prevented deflation since 2010. For the other economies, the spillover effects from US monetary policy had in many cases a sizeable and persistent impact on output growth, inflation and equity prices. US monetary policy also led to US dollar depreciation, putting strong appreciation pressures on many currencies (eg the Brazilian real, Indian rupee, Indonesian rupiah and Korean won), and to a diverse set of monetary policy responses in the emerging economies.

JEL Codes: E43, E44, E52, E65, F42, F47.
Keywords: Unconventional monetary policy; quantitative easing; central bank balance sheet; shadow interest rate; spillover; global VAR (GVECM)

1 The study is incorporated in “Financial Crisis, US Unconventional Monetary Policy and International Spillovers”, IMF Working Paper 15/85 (April 2015), by the same authors.

2 We thank Tracy Chan and Mario Morelli for excellent data and graph assistance. The views expressed here belong to the authors alone and do not necessarily represent the views of the Bank for International Settlements (BIS), the Hong Kong Monetary Authority (HKMA) or the International Monetary Fund (IMF).

Email: Qianying Chen (IMF): QChen2@imf.org; Andrew Filardo (BIS): Andrew.Filardo@bis.org; Dong He (HKMA and Hong Kong Institute for Monetary Research): dhe@hkma.gov.hk; Feng Zhu (BIS): Feng.Zhu@bis.org.
Discussion

Dr. Shaun Roache mentioned that the paper is one of the first attempts to investigate the impact of quantitative easing (QE) on a comprehensive set of countries. The key conclusions of the paper include: First, the US zero lower bound exerted significant appreciation pressures on the exchange rates of emerging market economies (EMEs). Second, growth and inflation in a number of countries grew as a result of the zero lower bound. Third, the US monetary policy shock is more statistically significant during the global financial crisis (GFC) period.

He raised several issues: (1) over-parameterization of the model; (2) cointegration of the variables in the error correction model; (3) use of one versus different measures of the shadow rate (e.g., the 1-year and 2-year swap rates); and (4) use of exchange rate pressure versus use of reserve accumulation and exchange rate changes, separately.

In response, Dr. Feng Zhu agreed that the model was over-parameterized. Some variables were already taken out of the model to further increase the accuracy of the estimates. Tests for multiple cointegrated relationships were likewise implemented. Moreover, the shadow rate used in the paper is similar to forward rates.

\[3^\text{Dr. Shaun K. Roach of the International Monetary Fund was the discussant of the paper.}\]
The Responsiveness of Monetary Policy to Financial Stress: A Dynamic Panel Threshold Analysis

Danvee Floro¹, Joselito Basilio² and Björn van Roye³

We examine the nature of monetary policy's response to increases in financial stress across a panel of advanced and emerging economy central banks by employing a dynamic panel threshold methodology. We also allow for switches between regimes according to an estimated threshold value of financial stress. First, we find that the negative impact of financial stress on interest rate setting is more pronounced when financial stress is low for both advanced and emerging market central banks. Second, advanced economy central banks react to output developments countercyclically regardless of the financial cycle. Third, we find strong evidence of a shift to countercyclical monetary policy responses to financial stress and business cycle fluctuations for emerging market countries in the low-stress regime.

JEL Codes: E31, E44, E52, G15
Keywords: Financial stress, monetary policy, Taylor rule, threshold panel regression

1 INTRODUCTION

The belief that central banks respond to financial stress, causing them to deviate from simple monetary policy rules, is already well-documented in the literature (Cecchetti, 2008, Lowe and Borio (2002), Borio (2014)). Historically, central banks mostly implemented expansionary monetary policy following an exogenous financial shock. In fact, a growing body of empirical research has demonstrated that monetary policy reacts to movements in and volatility of financial market variables (e.g., exchange rate or stock market volatilities) in a systematic manner through a decrease in interest rates (see Bernanke and Gertler (2001)). However, there is more controversy on what the policy response is when financial stresses are at "low" levels, i.e., when they are only starting to build up. Not surprisingly, there is more divergence in policy actions at this phase of the financial cycle. Bayoumi et al. (2014) note that emerging market economies (EMEs) put significant weights on financial imbalances in their monetary policy decisions before the great financial crisis. By contrast, advanced economies (AEs) before the crisis justify expansionary monetary policy following moderate asset price movements only to the extent that they affected the inflation (and output) outlook, similar to a "benign neglect" notion. Past evidence before and after the crisis thus clearly make the case that monetary policy responds asymmetrically to financial imbalances (see for example, Schmidt-Hebbel and Muñoz, 2012a). Insofar as simple monetary rules are concerned, financial stability concerns add a challenging dimension to the debate on whether central banks should take into account the phase of the financial cycle when responding to fundamental macroeconomic variables such as inflation or output. Drehmann et al. (2012) provide evidence that not all growth recessions coincide with high financial stress episodes. This is most obvious for the recession in the early 2000s, during which the financial cycle was expanding. Therefore, it would be interesting from both a research and policy perspective to examine whether financial stress developments exert an asymmetric influence in central banks' growth objectives.

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² University of Illinois at Chicago / Bangko Sentral ng Pilipinas
³ European Central Bank
In this paper, we quantify central banks’ monetary policy response to financial stress depending on the latter’s varying degrees of intensity. We aim to shed light on two important questions: 1) Is there a threshold level by which monetary policy responds directly to financial stress? and 2) Given that financial stress has significant output loss effects, do central banks behave asymmetrically to output when financial markets are calm and when financial turmoil is very high? We answer these questions by employing a regime-dependent econometric framework, where the behavior of monetary policy is allowed to switch between regimes according to an estimated threshold value of financial stress. Although there has already been a growing literature on non-linear monetary policy rules augmented with financial stress using threshold models, worldwide evidence based on a panel context require further validation. We aim to fill this important gap in the literature by providing cross-country knowledge of a potential non-linear relationship between monetary policy decisions and financial instability across a set of 22 central banks around the world for the period 1996 to 2013 on a quarterly basis, by extending the Taylor (1993) rule specification with a financial stress indicator (FSI, henceforth) estimated by a dynamic threshold methodology in a panel setting. In addition, we estimate a shorter sample that includes Euro area financial stress and policy variables. Non-linearity enters our model through the estimation of a threshold variable for financial stress for which interest-rate setting behavior may change between regimes. Lastly, we focus on the differences between AEs and EMEs, paying attention to the heterogeneity by which their central banks apply or do not apply rules-based monetary decisions in the face of an exogenous financial market shock.

The paper is organized as follows: Section 2 provides a literature review on previous work done on this subject, Section 3 lays out the econometric methodology employed, Section 4 presents the data, Section 5 discusses the estimation results, and robustness tests, and Section 6 concludes.

2 LITERATURE REVIEW

Existing empirical evidence points to a non-linear relationship between monetary policy and financial stress, suggesting that linear specifications may be too simplified after all. Baxa et al. (2013) analyze the interest-rate setting behavior of four major AE central banks in the face of financial stress using time-varying parameter estimations and find a substantial easing of monetary policy settings during “high” financial stress periods. Similarly, Martin and Milas (2011) show in the case of the UK, that the Bank of England reacted more strongly to financial stress during the crisis, relative to previous financial stress periods. They also find a breakdown of the Taylor (1993) rule starting 2007. Mishkin (2009) argues that financial stress enters the central banks’ policy loss function non-quadratically when increased uncertainty in financial markets is present. In the case of the European Central Bank (ECB), Milas and Naraidoo (2012) investigate how the ECB sets interest rates in the context of both linear and nonlinear policy reaction functions. Their findings reveal a shift from inflation targeting to output stabilisation and a shift from an asymmetric policy response to financial conditions at high inflation rates to a more symmetric response irrespective of the state of inflation during the 2007-2009 financial crisis. Jawadi et al. (2014) estimate non-linear monetary policy rules for Brazil and China, using a smooth transition regression model and find that considerations about the output gap and the real effective exchange rate (in the case of Brazil), and the inflation rate (for China) explain the non-linear adjustment of the central bank rate. Still on the EME case, Fouejiu (2012) expand the number of countries to include Chile, the Czech Republic, Mexico, Poland and Malaysia, among others in both a single-unit and panel regression setting. Focusing on the idiosyncratic differences between the interest rate reaction function of inflation and non-inflation targeters, he finds that inflation targeting countries seem to respond more
symmetrically to financial imbalances, which runs counter to the widely accepted belief that in an inflation-targeting regime, monetary policy does explicitly or directly respond to developments in the financial sector.

In more recent years though, a small strand of research on non-linear monetary policy rules has started to focus on threshold effects of financial stress on central banks' interest rate decisions. Regressions involving threshold variables consider switches between regimes which capture the potential state-dependent nature of say, interest rate adjustment. As a result, monetary policy behavior is examined in two or more separate regimes, whose potential nonlinear feature is defined by the state of the threshold variable at each point in time. Sznajderska (2012) investigate whether the reaction function of the National Bank of Poland (NBP) is asymmetric according to the level of inflation gap and the level of output gap. Threshold models in the spirit of Hansen (1999) are applied, and the estimations of an asymmetric Taylor rule seem to indicate that the NBP reacts slightly more strongly to the level of inflation and the level of economic activity when they are relatively high. Bunzel and Enders (2010) find out strong evidence of threshold behavior of the Federal Reserve in a number of time periods between 1965 and 2007. Among others the authors present a model where the central bank is active when the inflation is higher than the interim threshold and when the output gap is negative.

Meanwhile, empirical papers dealing with the threshold effects of financial stress make the conjecture that the effects of financial stress on macroeconomic variables are in fact asymmetric across the financial cycle. To illustrate, van Roye (2014) considers a threshold vector autoregression method to analyze the impact of financial stress on the short-term rate and economic activity for Germany. He finds overwhelming evidence of a nonlinear dampening effect of financial stress on economic activity and on the short-term rate only during high stress periods. Vasicék (2012) estimates separate threshold regressions of Taylor rule fundamentals augmented with financial stress for Hungary, Poland and the Czech Republic, his results reveal that the Czech National Bank and the NBP adjust interest rates downwards when financial stress is high and that monetary policy does not respond to an increase in inflation in the presence of heightened financial instability. In contrast, the Hungarian National Bank raises interest rates when financial stress is above its estimated threshold, reinforcing the claim that central banks do have asymmetric preferences when financial stress is "low". Nevertheless, evidence based on a panel context across a wider group of central banks remains missing in the literature.

3 METHODOLOGY

The starting point of our analysis is the specification of a linear Taylor rule equation (Taylor, 1993), which basically captures the reaction function of short-term nominal interest rates against some growth indicator, the inflation rate, and the inclusion of the lagged value of the short-term nominal interest rate to characterize the interest-rate smoothing feature of monetary policy. We assume a simple, forward-looking rational expectations interest rate rule as in Clarida et al. (1998, 2000) where we let \( i^*_{jt} \) be the interest rate determined by the following policy rule:

\[
i^*_{jt} = \beta_g g_{j,t+1} + \beta_\pi \pi_{j,t+1} + \ldots\tag{1}
\]

Schmidt-Hebbel and Muñoz (2012b) also used forward-looking variables in their estimation of Taylor rule coefficients for AEs and EMES.
Interest rate smoothing consists of the following

\[ i_{jt} = \rho_1 i_{jt-1} + (1 - \rho_1) i^*_t. \]  

(2)

Plugging (1) into (2)

\[ i_{jt} = \rho_1 i_{jt-1} + (1 - \rho_1) \left( \beta_g g_{j,t+m} + \beta_\pi \pi_{j,t+n} \right) \]  

(3)

(N.B. \( i^*_t \) = nominal interest rate at time t for economy j; \( g_{j,t+m} \) = growth rate at time \( t+m \) of economy j; \( \pi_{j,t+n} \) = inflation rate at time \( t+n \) of economy j; and \( \rho_1 \) = central bank smoothing parameter)

where the dependent variable \( i^*_t \) is the policy interest rate of country j at time t. The error term \( \mu_t \) is assumed to be i.i.d. The regressors \( g_{j,t+m} \) and \( \pi_{j,t+n} \) are GDP growth and the inflation rate, respectively. We use the growth rate instead of the usual output gap which is most commonly found in empirical papers on the Taylor rule due to the lack of a consistent and uniform measurement methodology at least for our heterogeneous sample. Nevertheless, Coibion and Gorodnichenko (CG, 2012, henceforth) find that policy rates respond more to output growth rather than the output gap, and that this type of responsiveness helps more in “restoring determinacy for plausible inflation responses.”

It is by now common in the monetary policy rule literature to include a smoothing parameter, \( \rho_1 \) on the interest rate as shown in specification in (3). The smoothing parameter accounts for the observed practice by most central banks of smoothing changes in interest rates, which is characteristic of policy inertia. CG (2012) notes that interest rate smoothing has the potential benefit of reducing financial sector instability because of the increased predictability of interest rates, while at the same time reducing the likelihood of rapid policy reversals, thereby helping establish credibility for the central bank.  

In line with the empirical literature on the effect of financial variables on interest-rate rules, we augment equation (3) with the financial stress index (FSI) across our panel dataset in the following form:

\[ i_{jt} = c + \rho_1 i_{jt-1} + (1 - \rho_1) \left( \beta_g g_{j,t+m} + \beta_\pi \pi_{j,t+n} \right) + \beta_F SFI_{j,t+k} + \mu_{jt} \]  

(4)

where equation (4) allows for the direct effect of the parameter \( \theta_\beta \) on monetary policy decisions. In particular, we assume that \( FSI \), just like the lagged policy interest rate, enters the central bank’s policy rule as a potential factor in explaining the deviation of central banks from the implied interest rate. Therefore, the financial stress indicator is not part of the central bank’s standard loss function, i.e. growth and inflation, which are enclosed within the square brackets. In a sense, one could interpret the coefficient of \( \theta_\beta \) as the degree to which the central bank views the cost of financial instability in terms of output and inflation that might dampen monetary policy’s price stability objective. Thus, estimating Taylor rules augmented with the FSI using (4) assumes that central banks respond to an increased financial stress in a linear fashion. This assumption, however, is no longer valid when considering the presence of a quadratic loss function of the central bank according to the intensity of financial stress in the system. Such asymmetry is shown empirically by Aguiar and Martins (2008), Castro (2012), Surico (2003) and Gerlach and Lewis (2011) for the Euro area, and Cukierman and Muscatelli (2008) for the financial stress index's use ``...may be optimal when policymakers are uncertain about the quantitative effects of policy changes...'' and that "it gives policymakers more control over long-term interest rates via the expectations channel". In econometric terms, the presence of a smoothing parameter solves two problems in the regression analysis. First, the inclusion of a lagged dependent variable as an explanatory variable reduces, if not, eliminates the problem of serial correlation. This, in turn, eliminates the need to include auto-regression techniques in some cases.
US and the UK. Therefore, estimating a reaction function such as that of equation (4) can thus lead to misleading results. On the other hand, nonlinear threshold regression models offer an intuitive way to model empirically the state-dependent nature of interest-rate adjustment to financial imbalances, as these models allow for the determination of a financial stress trigger variable.

3.1 The econometric methodology

We follow Hansen’s (1999) testing and inference techniques for static threshold panel regressions and introduce a dynamic version in the spirit of Kremer et al. (2013). Consider now the general representation of the dynamic panel threshold regression model:

\[ i_{jt} = c + X_{jt}\gamma + \beta^L d_{jt} I(q_{jt} \leq \chi) + \delta I(q_{jt} \leq \chi) + \beta^H d_{jt} I(q_{jt} > \chi) + \mu_{jt} \]  

(5)

where \(X_{jt}\) denotes the vector of exogenous and endogenous regressors for country \(j\) at time \(t\), \(d_{jt}\) is the set of exogenous, regime-dependent variables, and \(I()\) is an indicator function taking the value of 1 if the value \(q\) is below the threshold variable \(\chi\), and zero otherwise. We then consider values of \(q\) below \(\chi\) as those belonging to a "low" stress regime, and values of \(q\) above \(\chi\) representing the "high" stress regime. The threshold model described above offers a clear advantage over the existing approaches to modeling non-linear monetary policy rules, such as assuming specific functional forms of asymmetric monetary policy rules, (e.g. squaring the value of the FSI variable). Since the loss function of monetary authorities is not directly observable, employing statistical techniques to determine the trigger variable that enables potential asymmetries in monetary policy may be a preferred strategy instead of relying on a specific functional form of the model in (4).

We proceed with the estimation of equation (5) sequentially as follows: As in Kremer et al. (2013), we first remove the country-specific fixed effects through the use of forward orthogonal deviations transformation of the variables in the model as proposed by Arellano and Bover (1995). Using this method, each variable is transformed by subtracting the average value of future observations. This ensures an absence of serial correlation of the transformed errors. Second, we follow mainly Hansen and Caner’s (2004) approach in employing IV estimation to account for the endogeneity that is mostly present in a forward-looking Taylor rule specification due to the correlation between the future observations of the inflation rate and the error term in the reaction function. Hence, we use as instruments the period \(t\) up to period \(t-2\) of the inflation rate. In the third step, we replace the values in equation (5) by the fitted values from the reduced form regression in step 1 and estimate this equation this time with the fitted values via least squares for different values of the regime-dependent variable \(q\).

Finally, the threshold variable \(\chi\) is chosen as the value which best minimizes the sum of squared residuals, \(S()\). In particular, we choose \(\chi\) such that \(\chi = \arg\min S(\chi)\). After choosing our threshold value, we then proceed to re-estimate equation (5) via Generalized Method of Moments (GMM) with heteroskedastic and autocorrelation-consistent standard errors and we use the same instruments from our first-stage regression. Following Hansen (1999), we make the restriction that each regime contains at least five percent of the total number of observations.

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6 We thank Alexander Bick for making the MATLAB Code for the panel threshold estimation available online. The code for the panel threshold regression can be downloaded at http://www.public.asu.edu/~abick/}
As we are concerned mainly on the threshold effects of financial stress on monetary policy rules, we take the benchmark case where the FSI is both the regime-dependent regressor, $q$, and the threshold variable, $\chi$, in order to analyze the monetary policy behavior during the “low” and “high” stress regimes. In addition to the benchmark model just described, we test for threshold effects of the FSI on the monetary policy response to business cycle fluctuations, as proxied by real GDP growth. Our prior is that a positive relationship between nominal policy interest rates and real GDP growth in both a “low” and “high” financial stress regime is characteristic of countercyclical monetary policy, which also means that the central bank is leaning against boom cycles and spurring growth during bust cycles.

4 THE DATASET

We built a unique balanced panel database of 22 central banks from AEs and EMEs for the period 1996:Q2 to 2013:Q3 (Table A1). The choice of the starting period of estimation sample hinged mainly on data availability of the policy variables at a quarterly frequency. The countries in our sample consist of 10 AEs (Australia, Canada, Japan, South Korea, Norway, Sweden, Switzerland, United States and United Kingdom) and 12 EMEs (Brazil, Czech Republic, Colombia, Croatia, Hungary, Lithuania, Malaysia, Peru, the Philippines, South Africa, and Thailand). In addition, we estimate panel threshold regressions for a shorter sample, from 2002:Q1-2013:Q3, this time including the Euro area. Estimating a shorter sample period would allow us to control for the influence of heterogenous monetary policy frameworks that characterized most emerging market countries in the late 1990s and early 2000s. It may be recalled that it is roughly around 2002 that monetary policy in most sample countries in our sample have accorded to a modern policy framework, i.e. a floating exchange rate and low inflation regime.

Our dependent variable is the end-quarter value of the short-term nominal interest rate, and for the explanatory variables, we have the quarterly averages of the inflation rate (measured as the year-on-year change on the CPI) and the GDP growth rate (measured as the year-on-year change on real GDP). Using end-quarter values of the short-term interest rate ensures that the information coming from the regressors (i.e. inflation, growth and the FSI) were available to the policymakers at the time of the interest rate decision. Data were sourced from the Organization for Economic Cooperation and Development (OECD) database for AEs including South Africa and Brazil, and the International Financial Statistics (IFS) database of the International Monetary Fund (IMF), as well as central bank websites for the non-OECD countries and EMEs. Finally, our main variable of interest, the FSI (measured in quarterly averages), is taken from Dovern and van Roye (2014), who developed a single aggregate measure of return volatilities of stocks, bank stocks and foreign exchange. The FSI is basically a sum of the standardized values of three sub-indices:

- Banking-related sub-index components: the inverted term spread (the difference between short-term and long-term government bonds), TED spread (the difference between interbank rates and the yield on Treasury bills), banking beta (a measure of the correlation of banking stock returns to total returns in line with the CAPM)

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7 We follow the classification of advanced and emerging economies from the Penn World tables version 7.1.
8 Basilio (2013) used this database to study the cross-sectional determinants of the inflation coefficients in each of the country’s estimated Taylor rule equations. The original dataset consisted of an unbalanced panel of 40 central banks but our sample was limited by data availability on a balanced panel basis.
9 The short-term nominal interest rate would typically be an interest rate closely related to the official policy rate.
The Responsiveness of Monetary Policy to Financial Stress: A Dynamic Panel Threshold Analysis

- Securities-market-related sub-index components: corporate bond spread (the difference between corporate bonds and long-term government bond yields), corporate credit spread, CDS on the corporate sector; housing spread; government bond spreads;

- Foreign-exchange-related sub-index: the time-varying volatility of monthly changes in REER, from the GARCH (1,1) model.

<table>
<thead>
<tr>
<th>Table A1. Descriptions of Data</th>
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<tr>
<td><strong>Country</strong></td>
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<tr>
<td>Advanced Countries</td>
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<td>Australia</td>
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<td>Denmark</td>
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<td>Euro area</td>
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<td>Emerging Countries</td>
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<td>Peru</td>
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N.B. disc = discount rate, mnr = money market rate, rp = repurchase agreement rate, st = short-term bond rate, depo = deposit rate, bank = bank rate.
An advantage of using a continuous-variable, single composite index is that it is able to capture how financial stress evolved in a given period while quantifying the severity and magnitude of various stress events, as opposed to binary variables representing a "stress" or "no stress" event (Baxa et al. (2013), and Illing and Liu (2006)). Empirical papers on this indicator typically place special interest in increases in the FSI as such index provides information on the potential disruptions in financial markets (see for example, Proaño et al. (2014), Davig and Hakkio (2010) Mallick and Sousa (2013) and Cardarelli et al. (2011)). Specifically, an increase in the index implies heightened uncertainty in financial markets, i.e. an increase in the volatility of equity and foreign exchange returns and yields.\(^\text{10}\)

Figure 1 illustrates the unfolding of events that caused upward movements in the FSI from the period 1996 - 2013 for the 22 countries in the sample. We point out the sharp spikes in the FSI which coincide with five major episodes of heightened financial stress. The first was the Asian financial crisis which peaked in the fourth quarter of 1998, along with the Russian debt crisis in the third quarter of the same year and the associated default of the large hedge fund Long Term Capital Management in 1997-1998. Meanwhile, a spike in the FSI around the first quarter of 2000 reflected the burst of the dotcom bubble, which was characterized by an overall increase in financial stress in many countries around the world. Since then, financial stress has been relatively stable in the last five years leading up to the height of the global financial crisis in the third quarter of 2008. Financial stress then reached its peak levels during the global financial crisis in 2008, as nearly all indicators from all market segments point to a sharp increase in financial stress in almost all countries (Dovern and van Roye, 2014).

Figure 1. The Financial Stress Index in 22 Countries, 1996-2013

Suffice it to say, these financial stress episodes were met with strong, albeit varied monetary policy responses from among the countries in the sample and across time. For instance, in the Asian financial crisis, countries such as Indonesia, Malaysia and Thailand pursued tight monetary and fiscal policies in order to prevent a further decline in their exchange rates and to reign in capital outflows. In other words, monetary policy was procyclical in EMEs in the 1990s until the early 2000s. Starting in 2000, a lot of these EMEs adopted a more flexible monetary policy framework, (e.g. inflation targeting),

\(^{10}\) According to Baxa et al. (2013), the interpretation of the movements in this index should proceed with caution. Variables not included in the FSI but highly correlated with the sub-components of the FSI causes the indicator to increase.
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which was subsequently followed by a general decline in policy interest rates. On the other hand, AEs went into a tightening phase in the run-up to the bursting of the dotcom bubble (Figure 2), after which interest rates were lowered in order to prevent their economies from plunging into a recession.

Figure 2. Average Financial Stress and Monetary Policy in Advanced Countries, 1996-2013

Source: authors’ own estimates

The global financial crisis of 2008-2009 has undoubtedly brought sizeable financial market shocks that greatly challenged the way the norms by which monetary policy should respond to financial instability. AE central banks responded by implementing of massive conventional and unconventional policy measures to calm the financial market volatility. Quite remarkably, EME central banks also loosened monetary policy (Figure 3) in order to prevent a further decline in economic growth due to lower external demand from the crisis-hit AEs. This was a turnaround from the previous monetary policy response of EMEs during the Asian financial crisis and Russian debt crisis in the late 1990s, where policy settings were instead tightened considerably at the peak of financial stress.

Figure 3. Average Financial Stress and Monetary Policy in Emerging Market Countries, 1996-2013

Source: authors’ own estimates
An examination of simple statistical relationships provides further insights into the relationship between the Taylor rule variables and financial stress in a panel setting. Tables A2 and A3 present the pairwise correlations of all policy variables in the Taylor rule augmented with the FSI for each country group. The main difference between these two is the positive (negative) correlation of the FSI with policy interest rate in the case of the EMEs (AEs), with correlations being significantly different from zero in each case. In general, we observe a significant negative correlation between the FSI and growth, suggesting that countries experiencing increased financial stress tend to experience output loss as well. Meanwhile, a high and positive correlation with inflation indicates that in countries with increased financial market volatility, inflation expectations tend to be unanchored. The correlation of inflation and growth with monetary policy all have the expected signs and are significant at the percent level.

### Table A2. Bi-variate correlations, Advanced and Emerging Market Countries 1996Q2-2013:Q3

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<th>Policyt</th>
<th>Inflationt+2</th>
<th>Inflationt</th>
<th>Growtht</th>
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<tbody>
<tr>
<td>Policyt</td>
<td>1.00</td>
<td>0.374*</td>
<td>0.367*</td>
<td>0.323*</td>
<td>-0.139*</td>
<td>-0.197*</td>
</tr>
<tr>
<td>Inflationt+2</td>
<td>0.692*</td>
<td>1.00</td>
<td>0.717*</td>
<td>0.308*</td>
<td>0.002</td>
<td>-0.122</td>
</tr>
<tr>
<td>Inflationt</td>
<td>0.718*</td>
<td>0.754*</td>
<td>1.00</td>
<td>0.121*</td>
<td>-0.011</td>
<td>-0.114*</td>
</tr>
<tr>
<td>Growtht</td>
<td>-0.262*</td>
<td>-0.115*</td>
<td>-0.221*</td>
<td>1.00</td>
<td>-0.458*</td>
<td>-0.421*</td>
</tr>
<tr>
<td>FSIt</td>
<td>0.137*</td>
<td>0.012</td>
<td>0.088*</td>
<td>-0.432*</td>
<td>1.00</td>
<td>0.747*</td>
</tr>
<tr>
<td>FSI_{t-1}</td>
<td>0.094*</td>
<td>-0.020</td>
<td>0.046</td>
<td>-0.425*</td>
<td>0.762*</td>
<td>1.00</td>
</tr>
</tbody>
</table>

(1) Lower triangular matrix: Emerging market economies simple correlations; Upper matrix: Advanced country correlations.
(2) Correlations statistically significant at 5 pct. with asterisk.

### Table A3. Bi-variate correlations, Advanced and Emerging Market Countries 2002Q1-2013:Q3

<table>
<thead>
<tr>
<th></th>
<th>Policyt</th>
<th>Inflationt+2</th>
<th>Inflationt</th>
<th>Growtht</th>
<th>FSIt</th>
<th>FSI_{t-1}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policyt</td>
<td>1.00</td>
<td>0.481*</td>
<td>0.398*</td>
<td>0.272*</td>
<td>-0.134*</td>
<td>-0.192*</td>
</tr>
<tr>
<td>Inflationt+2</td>
<td>1.00</td>
<td>0.696*</td>
<td>0.355*</td>
<td>-0.232*</td>
<td>-0.185</td>
<td></td>
</tr>
<tr>
<td>Inflationt</td>
<td>0.560*</td>
<td>0.733*</td>
<td>1.00</td>
<td>0.217*</td>
<td>-0.071</td>
<td>-0.190*</td>
</tr>
<tr>
<td>Growtht</td>
<td>-0.111*</td>
<td>0.143*</td>
<td>-0.041</td>
<td>1.00</td>
<td>-0.544*</td>
<td>-0.518*</td>
</tr>
<tr>
<td>FSIt</td>
<td>0.124*</td>
<td>-0.052</td>
<td>0.147*</td>
<td>-0.477*</td>
<td>1.00</td>
<td>0.751*</td>
</tr>
<tr>
<td>FSI_{t-1}</td>
<td>0.085*</td>
<td>-0.091*</td>
<td>0.033</td>
<td>-0.491*</td>
<td>0.758*</td>
<td>1.00</td>
</tr>
</tbody>
</table>

(1) Lower triangular matrix: Emerging market economies simple correlations; Upper matrix: Advanced country correlations.
(2) Correlations statistically significant at 5 pct. with asterisk.
Taking stock of the anecdotal and statistical evidence presented above, a natural follow-up analysis would be to detect any regime shifts in the FSI and the associated changes in the conduct of monetary policy. Before estimating the model in (5), we employ the stationarity test of Choi (2001), which is based on a combination of p-values of the test statistic for a unit root in each cross-sectional unit (we perform an Augmented Dickey-Fuller test with two lags for each unit). The null hypothesis that all time series have a unit root (the alternative of which is that a fraction of the sample is stationary) is rejected for all our variables.

5 ESTIMATION AND INference RESULTS

5.1 The FSI as threshold variable and regime-dependent regressor

We now modify the FSI-augmented Taylor rule equation in (4) and apply the dynamic panel threshold model given in (5) as follows:

\[ i_{jt} = c + \rho_i i_{j,t-1} + (1 - \rho_i) (\beta_y g_{j,t+m} + \beta_{\pi} \pi_{j,t+n}) + \beta_b^{FSI} FSI_{j,t+k} I(\hat{FSI}_{j,t+k} \leq \chi_f) + \beta_g^{FSI} FSI_{j,t+k} I(\hat{FSI}_{j,t+k} > \chi_f) + \mu_{jt} \]

where \( FSI_{j,t+k} \) is both the regime-dependent regressor and the threshold variable with \( \chi_f \) threshold being assumed to be exogenous. We impose the same exogeneity assumption on the lagged interest rate, \( i_{j,t-1} \) and the growth rate, \( g_{j,t+m} \). Due to the forward-looking nature of inflation in our model, inflation enters our model endogenously and we set \( n = 2 \).\(^{11}\) Meanwhile, we set \( m = 0 \) and \( k = 0 \), as we assume that monetary authorities react immediately to financial stress (Mishkin, 2009).

Table 1 presents the benchmark results of the threshold regression model for the worldwide sample, AEs and EMEs. The first row of the table displays the estimated FSI thresholds and the corresponding 95 percent confidence intervals enclosed in brackets. A robust finding is that the regime change is identified for high levels of financial stress for all country groups and across different time periods, with roughly 80 to 85 percent of the observations falling within the "low" stress regime. Proaño et al. (2014) found similar patterns on the FSI as their threshold variable in their estimation of debt on growth, with debt-to-GDP ratio and the FSI as the regime-dependent variables. Averaging out the 22 countries in the sample period yielded a threshold estimate of around 0.66, while splitting the sample according to the two country groups revealed a higher threshold value for AEs compared to EMEs. Given an estimate \( \hat{\chi}_f \), Figure 4 plots the likelihood ratio for every \( \chi_f \) as well as the critical value for the 95 percent confidence interval, as shown by the green line. The set of all feasible \( \chi_f \)'s for which the true threshold value is indeed \( \chi_f \) are the values below this line. For the worldwide and EMEs sample, the range of feasible thresholds are quite wide, at (-1.823, 1.67) and (-1.479, 1.728), respectively. For AEs, the threshold is highly significant, with the global minima confined to a tighter range.

We now begin with the interpretation of the slope parameter estimates of our dynamic panel threshold model. Our main interest lies in the coefficients \( \beta_b^{FSI} \) and \( \beta_g^{FSI} \), which represent the marginal impact of financial stress for the two stress regimes and are shown in the second row of Table 1. Our estimates strongly suggest that financial stress has a statistically significant and asymmetric influence on monetary policy behavior for AEs. The same holds true for EMEs and for the worldwide sample when considering the post-2001 period. Note that the sign and magnitude of \( \beta_b^{FSI} \) and \( \beta_g^{FSI} \) hinges

\(^{11}\) Batini and Nelson (2001) show from their baseline model that \( t=2 \) is the optimal targeting horizon. We nevertheless tested the model for different values of \( n \), but this did not significantly change the results.
mainly on the level of FSI. For the 1996-2013 period, we find that the marginal impact of financial stress on AE central banks' policy interest rates when financial stress is "low" is negative and significant. In the "high" stress regime, financial stress has virtually no effect on AEs' interest rate setting with the coefficient $\beta_{bH}^H$ being close to zero. This result corroborates existing empirical findings of a generally negative reaction of AE monetary authorities to financial stress, but we provide new evidence that monetary policy may actually be reacting to financial stress only up to a certain point, after which the latter no longer exhibits any systematic impact on interest-rate setting behavior (Figure 4). Meanwhile, we find statistically insignificant effects of financial stress on EME central banks' interest rate setting in both regimes.

Table 1. Dynamic Panel Threshold Model
Dependent Variable: Policy rates

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_{bL}$</td>
<td>-0.037</td>
<td>-0.071</td>
<td>0.096</td>
<td>-0.136</td>
<td>-0.069</td>
<td>-0.177</td>
</tr>
<tr>
<td></td>
<td>(0.093)</td>
<td>(0.026)</td>
<td>(0.178)</td>
<td>(0.039)</td>
<td>(0.029)</td>
<td>(0.079)</td>
</tr>
<tr>
<td>No. of Obs.</td>
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<td>618</td>
<td>720</td>
<td>909</td>
<td>464</td>
<td>477</td>
</tr>
<tr>
<td>$\beta_{bH}$</td>
<td>-0.070</td>
<td>-0.009</td>
<td>-0.047</td>
<td>-0.116</td>
<td>-0.009</td>
<td>-0.122</td>
</tr>
<tr>
<td></td>
<td>(0.068)</td>
<td>(0.036)</td>
<td>(0.172)</td>
<td>(0.172)</td>
<td>(0.042)</td>
<td>(0.083)</td>
</tr>
<tr>
<td>No. of Obs.</td>
<td>208</td>
<td>82</td>
<td>120</td>
<td>172</td>
<td>53</td>
<td>87</td>
</tr>
<tr>
<td>Control Variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\rho$</td>
<td>0.792</td>
<td>0.932</td>
<td>0.770</td>
<td>0.854</td>
<td>0.93</td>
<td>0.836</td>
</tr>
<tr>
<td></td>
<td>(0.058)</td>
<td>(0.016)</td>
<td>(0.058)</td>
<td>(0.028)</td>
<td>(0.012)</td>
<td>(0.036)</td>
</tr>
<tr>
<td>$\beta_{\pi t+2}$</td>
<td>0.317</td>
<td>0.148</td>
<td>0.336</td>
<td>0.243</td>
<td>0.100</td>
<td>0.244</td>
</tr>
<tr>
<td></td>
<td>(0.105)</td>
<td>(0.036)</td>
<td>(0.098)</td>
<td>(0.051)</td>
<td>(0.049)</td>
<td>(0.052)</td>
</tr>
<tr>
<td>$\beta_{a}$</td>
<td>-0.039</td>
<td>0.037</td>
<td>-0.068</td>
<td>-0.003</td>
<td>0.020</td>
<td>-0.006</td>
</tr>
<tr>
<td></td>
<td>(0.019)</td>
<td>(0.010)</td>
<td>(0.026)</td>
<td>(0.017)</td>
<td>(0.011)</td>
<td>(0.022)</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.325</td>
<td>0.362</td>
<td>0.429</td>
<td>-0.190</td>
<td>0.527</td>
<td>-0.449</td>
</tr>
<tr>
<td></td>
<td>(0.246)</td>
<td>(0.101)</td>
<td>(0.026)</td>
<td>(0.160)</td>
<td>(0.145)</td>
<td>(0.266)</td>
</tr>
</tbody>
</table>

I. Robust standard errors in parentheses, 95 pct. confidence intervals in brackets.
II. Each regime contains at least 5 pct. of all observations (Hansen, 1999). The endogenous variable $\pi_{t+2}$ is instrumental $\pi$ by to $\pi_{t-2}$.
Figure 4. The likelihood ratio for different FSI threshold values

Source: authors’ own estimates
Turning to the point estimates for the policy variables, the smoothing parameter $\rho_1$ and the 2-period ahead inflation coefficient $\beta_{\pi+2}$, were significant and had the expected signs. On the other hand, the coefficient of growth $\beta_g$ is positive (negative) and significant for AEs (EMEs), indicating a somewhat procyclical monetary policy of EMEs in response to growth. This is supported by similar empirical findings by Vegh and Vuletin (2012) and Coulibaly (2012).

We note the absolute size of the estimates of the smoothing parameter for the AE group, $\rho_1 = 0.93$ which suggests a relatively greater degree of interest rate smoothing in this sub-group.\textsuperscript{12} Baxa et al. (2013) suggest that a higher (lower) coefficient value of $\beta_g$ and a lower (higher) value of $\rho_1$ could be interpreted as the central bank adjusting rates substantially (gradually) in response to financial stress due to fears of destabilizing financial markets resulting from sudden changes in interest rates. The positive association between financial stability concerns and a high degree of interest-rate smoothing is echoed by the findings of Agenor et al. (2013), who simulate a dynamic stochastic general equilibrium model augmented with financial frictions (i.e., credit growth and loan spread volatility). They further show that the gains to reducing financial market volatility through monetary policy easing become smaller as the financial instability indicator shock gets bigger, if interest rate smoothing is high. We also highlight the relatively bigger (absolute) size of the parameters for inflation for EMEs compared to that of AEs, indicating the higher price stability focus of the former.\textsuperscript{13}

We then proceed to analyze the results for the 2002-2013 sample, which now includes the Euro area (Table 1).\textsuperscript{14} The point estimates of the threshold as well as the 95 confidence interval for the worldwide sample and EMEs are considerably lower in the shorter estimation sample with the exclusion of the Asian, Russian and the dotcom bubble crises (1996-2001). Meanwhile, the threshold for AEs is expectedly higher at 0.996, indicating that the financial cycles of AEs and EMEs exhibit different patterns.\textsuperscript{15} As previously mentioned, the existence of a negative threshold effect of financial stress on AE central banks’ interest-rate setting only at the "low" stress regime is robust across different time periods as well as to the inclusion of additional control variables. Meanwhile, the interest rate response of EME central banks to an increase in financial stress is this time negative and significant, with around 85 percent of all the observations of this sub-group belonging to the "low" stress regime. Similar to AEs, the interest rate response of EMEs appears to be less negative but statistically insignificant when the intensity of financial market turmoil is high. Taking stock of the results from the two estimation periods, it appears that the direct response of monetary policy to different financial stress regimes transitioned post-2001, becoming relatively more symmetric compared to the full sample period. The less negative coefficient of $\beta_g$ in the shorter sample compared to the full sample could also suggest that monetary policy has become less procyclical in the shorter sample period. Our findings are generally in line with these observations.

\textsuperscript{12} Basilio (2013) obtained similarly high estimates of the smoothing parameter for individual regressions of the Taylor rule on AEs such as the US, UK, Canada, Australia, Denmark, and Sweden and a relatively higher $\rho_1$ for panel regressions on five advanced economies (USA, UK, Canada, Norway, and Australia) compared to panel regressions on 23 EMEs.

\textsuperscript{13} In Hofmann and Bogdanova (2012), policy rule parameters are reported for both advanced economies and emerging market economies. They find a lower range of inflation coefficients for advanced economies (0.0 to 2.2) compared to that of emerging economies (0.9 to 2.75). Estimates are based on the policy rule $i_t=\rho_1i_{t-1} + (1-\rho_1)\pi_t + \rho_1\pi_{t-1} + \alpha+\beta_0(\pi_t-\pi^*)+\beta_gx_t+e_t$. The equation is estimated by non-linear least squares for all possible combinations of different inflation and output gap measures. The pooled sample is over the period 2001:Q1 to 2012:Q1 for EMEs and 2001:Q1 to 2008:Q1 for AEs.

\textsuperscript{14} We report only the the regression output for the sample that includes the Euro area for the 2002-2013 period, as removing it does not change the main results.

\textsuperscript{15} See for example, Balakrishnan, et al. (2009), Belke and Klose (2010) and Dovern and van Roye (2014).
with Takats (2012), Coulibaly (2012) and Vegh and Vuletin (2012), who document an increasingly countercyclical monetary policy in EMEs since the start of 2000s.

5.2 Real GDP as the regime-dependent variable and the FSI as the threshold variable

Next, we examine the non-linear influence of financial stress on the responsiveness of monetary policy to business cycle fluctuations, as proxied by real GDP growth. As already mentioned in the introduction, the fact that not all economic downturns coincide with “high” financial stress regimes has important policy implications. If policymakers tend to “overreact” to financial market developments, causing them to lose responsiveness to their growth objectives, then monetary policy would tend to become procyclical down the road. Procyclical policies have the undesirable effect of deepening economic downturns, which, in turn, could lead to severe losses in output and employment (Borio and Lowe, 2002). Hence, it would be a worthwhile exercise to see the extent of the responsiveness of monetary policy to its growth objectives in a low-stress and high-stress regime. We estimate the following specification:

\[
i_{jt} = c + \rho_i i_{j,t-1} + (1 - \rho_i) [\beta_{g} g_{jt} FSI_{j,t+k} I(FSI_{j,t} \leq \chi_f) + \beta_{b} \pi_{j,t+2} + \beta_{b} FSI_{j,t} + \mu_{jt}] + \delta_{1} I(FSI_{j,t} > \chi_f) + \beta_{b} FSI_{j,t} + \mu_{jt}
\]

where the real GDP growth, \(g_{jt}\) is the regime-dependent regressor and \(FSI_{j,t}\) at time \(t\) is the threshold variable. The other parameters and variables remain the same as before except that in this specification, we add \(\beta_{b} FSI_{j,t}\) additional exogenous regressor.

Table 2 reports the threshold regression model as described by equation 7. Except for the worldwide sample, the threshold estimates across different time periods remained unchanged as to the preceding results in Table 1. The evidence of a threshold effect seems to be stronger for AEs, as the shape of the likelihood ratio is more V-shaped with a clearly defined global minima. Going back to Table 2, the first three columns which show the result for the 1996-2013 sample indicate that for the worldwide sample, the average central bank increases its responsiveness to output growth only when financial stress is high. Meanwhile, AE central banks' average response to output is symmetrically countercyclical. In particular, the average AE central bank increases (decreases) policy interest rates when output is growing (declining), regardless of whether the economy is in a low-stress or high-stress regime. In stark contrast, EME central banks' monetary policy response to output is highly procyclical when the financial cycle is in a calm state. In times of extreme financial market turmoil, EMEs do not respond to output developments at all.

The results for the 2002-2013 sample reveal that both AE and EME central banks' reaction to output growth is that of a uniform increase in policy interest rates at low levels of financial stress, but the reaction becomes insignificant when financial stress exceeds the upper threshold. Empirical evidence from Kontonikas et al. (2014) also find an insignificant reaction of the Fed output developments in times of high financial stress. A noteworthy result, though, is the change in the sign or direction of responsiveness (relative to that in the 1996-2013 period) of EME central banks to output growth, which implies a shift to countercyclical behavior post-2001.
Danvee Floro, Joselito Basilio and Björn van Roye

Table 2. Dynamic Panel Threshold Model
Dependent Variable: Policy rates

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
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<tbody>
<tr>
<td>( \chi_f )</td>
<td>0.044</td>
<td>0.744</td>
<td>0.324</td>
</tr>
<tr>
<td></td>
<td>[-1.823, 1.673]</td>
<td>[-0.649, 1.013]</td>
<td>[-1.479, 1.728]</td>
</tr>
<tr>
<td>Output Growth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \beta_{t+2} )</td>
<td>-0.028</td>
<td>0.046</td>
<td>-0.068</td>
</tr>
<tr>
<td></td>
<td>(0.028)</td>
<td>(0.010)</td>
<td>(0.034)</td>
</tr>
<tr>
<td>No. of Obs.</td>
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<td>677</td>
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<tr>
<td>( \beta_t )</td>
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<td>0.040</td>
<td>0.005</td>
</tr>
<tr>
<td></td>
<td>(0.023)</td>
<td>(0.016)</td>
<td>(0.038)</td>
</tr>
<tr>
<td>No. of Obs.</td>
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<td>163</td>
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<td>Control Variables</td>
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<td></td>
<td></td>
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<tr>
<td>( \rho )</td>
<td>0.800</td>
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<td>0.769</td>
</tr>
<tr>
<td></td>
<td>(0.049)</td>
<td>(0.015)</td>
<td>(0.056)</td>
</tr>
<tr>
<td>( \beta_{t+2} )</td>
<td>0.296</td>
<td>0.149</td>
<td>0.338</td>
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<tr>
<td></td>
<td>(0.091)</td>
<td>(0.036)</td>
<td>(0.096)</td>
</tr>
<tr>
<td>( \beta_t )</td>
<td>-0.000</td>
<td>-0.017</td>
<td>-0.094</td>
</tr>
<tr>
<td></td>
<td>(0.046)</td>
<td>(0.027)</td>
<td>(0.126)</td>
</tr>
<tr>
<td>( \delta )</td>
<td>0.249</td>
<td>0.314</td>
<td>-0.257</td>
</tr>
<tr>
<td></td>
<td>(0.228)</td>
<td>(0.106)</td>
<td>(0.497)</td>
</tr>
</tbody>
</table>

I. Robust standard errors in parentheses, 95 pct, confidence intervals in brackets.
II. Each regime contains at least 5 pct. of all observations (Hansen, 1999). The endogenous variable \( \pi_{t+2} \) is instrumental \( \pi_t \) by to \( \pi_{t-2} \) .

5.2.1 Monetary Policy Response during the 2008 crisis period and beyond

So far, the main takeaway from the evidence presented suggests that the direct and indirect (through output growth) responsiveness of monetary policy to financial stress mostly occurs when the latter is below a threshold level. On the other hand, there does not seem to be a clear and significant pattern of monetary policy responsiveness when financial market stress is very high. Considering that the global financial crisis is one in which exceptional monetary policy actions were conducted under a high-stress regime, we conducted a threshold regression on a much shorter sample period starting from 2008:Q1 up until 2013:Q3. Table 3 shows that the threshold values remained virtually the same for AEs, but this time significantly lower for EMEs compared to the 1996-2013 and 2002-2013 sample periods. The finding of monetary policy unresponsiveness to financial stress and growth in the high-stress regime still holds in the shorter sample period for both AEs and EMEs. This brings to mind several factors that might have come into play. McGettigan et al. (2013) find out, for example, that AEs and EMEs have become somewhat less countercyclical coming into the global financial
crisis and attribute the likely effects of AE central banks’ high reliance on long-term rates as a policy tool, as well as forward guidance and quantitative easing measures. On the part of EMEs, the global commodity price shock of 2008 may have placed a bigger weight on EME central banks’ reaction functions, despite the financial market turmoil spurred by the Lehman Brothers collapse which happened in parallel around the third quarter of 2008. The sharp increase in international commodity prices led to intense inflationary pressures in most EMEs, but as this was a supply-side shock, immediate monetary policy action was not warranted. By early 2009, inflation appeared to reach a peak and started to fall, and the spillover effects of the global financial crisis started to dampen the growth outlook prospects. However, inflation was still high in AEs so that there was less room for EMEs to loosen monetary policy, and less need, from an inflation viewpoint (McGettigan et al. 2013). Coulibaly (2012) noted that in 2013, several EMEs tightened monetary policy or refrained from loosening it further partly because of concerns over capital outflows, despite weak domestic economic growth coupled with increased financial stress.

<table>
<thead>
<tr>
<th>Table 3. Dynamic Panel Threshold Model</th>
<th>All Countries</th>
<th>Advanced Countries</th>
<th>Emerging Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threshold Estimate</td>
<td>(2008-2013)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$X_f$</td>
<td>0.688</td>
<td>0.743</td>
<td>-0.273</td>
</tr>
<tr>
<td></td>
<td>[-0.067, 1.451]</td>
<td>[0.725, 0.774]</td>
<td>[-1.397, 2.162]</td>
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<td>Financial Stress Control Variables</td>
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<td>0.174</td>
</tr>
<tr>
<td></td>
<td>(0.040)</td>
<td>(0.042)</td>
<td>(0.112)</td>
</tr>
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<td>No. of Obs.</td>
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<td>200</td>
<td>195</td>
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<td>$\beta^H_b$</td>
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<td>-0.023</td>
<td>-0.045</td>
</tr>
<tr>
<td></td>
<td>(0.042)</td>
<td>(0.016)</td>
<td>(0.056)</td>
</tr>
<tr>
<td>No. of Obs.</td>
<td>103</td>
<td>53</td>
<td>113</td>
</tr>
</tbody>
</table>

I. Robust standard errors in parentheses, 95 pct. confidence intervals in brackets
II. Each regime contains at least 5 pct. of all observations (Hansen, 1999). The endogenous variable $\pi_{t+2}$ is instrumental $\pi_t$ by $\pi_{t-2}$.
Lastly, the coefficients $\beta_g, \beta_\pi, \beta_b$ can be thought of as short-run coefficients, measuring the immediate response (within the year) of policy interest rates to a one-percent increase in inflation, the growth rate and the financial stress level below and above the thresholds, respectively. In the context of the Taylor rule principle, i.e. that the response of monetary policy to a one percent increase in inflation is more than one-for-one, it would be interesting to look at the long-run responses of the coefficients mentioned above and examine whether our estimations of a non-linear Taylor rule augmented with threshold values of the FSI indeed produce long-run coefficients of monetary policy on inflation that exceed unity. Davig and Leeper (2007) point out that it is only in the long run that monetary policy adjusts to satisfy the Taylor rule principle. We compute the long run responsiveness of monetary policy to inflation, and growth as $\frac{\beta_\pi}{1-\rho_1}$ and $\frac{\beta_g}{1-\rho_2}$, respectively. For the estimations of equations 5 and 6, the Taylor principle is strongly satisfied.

5.3 Caveats and Robustness

We examine the robustness of our benchmark model to alternative specifications by conducting a sensitivity analysis. For the sake of brevity, we do not list the detailed regression results. They are, however, available on request. Our results in equations 6 and 7 are robust to dropping one variable at a time. In particular, we exclude two sets of countries, those with the highest and those with the lowest FSIs over time. Excluding South Korea (highest FSI over time) and the U.S. (lowest FSI over time) one at a time had no significant effect on our baseline results. Exclusion of these two countries together only marginally changed the coefficients. Nevertheless, it is important to stress that these exclusion exercises are conducted for robustness purposes only and have limited value in our analysis. The results are also robust to the inclusion of additional explanatory variables. In particular, we include dummy variables for the Asian financial crisis and the global financial crisis one at a time and together at the next step. This did not change the sign nor the magnitude of our results across different time periods and specifications.

Furthermore, the results remain robust even if we replace the U.S., U.K. and Euro area policy rates with the "shadow policy rates" data series of Wu and Xia (2014), which allow for the quantification of the stance of monetary policy in the zero lower bound environment and in the presence of unconventional monetary policy actions.

Finally, we note that a limitation in our study is that within a Taylor rule framework, the role of monetary policy instruments are not explicitly captured. To be specific, changes in reserve requirements, which play an important role in some EMEs, and balance sheet policies of AE central banks are not taken into account. The fact that AE central banks’ balance sheets have more than doubled in the last ten years could have further eased monetary policy by more than what is reflected in the Taylor rule equation. On our findings of countercyclicality, it is worthwhile to keep in mind that the zero lower bound AE interest rates during the global financial crisis might have influenced EME central banks to ease or increase policy interest rates more than they could have done otherwise. An investigation of long-run relationships, which is beyond the scope of this paper, would be helpful in this regard.\footnote{Takats (2012) underscored the point that prolonged ZLB AE interest rates might complicate countercyclical monetary tightening in the future.}
6 CONCLUDING REMARKS

In this paper we investigate whether the direct and indirect responsiveness of monetary policy to financial stress switches as the economy moves from a low financial stress regime to a high financial stress regime for a relatively wide sample of AEs and EMEs. We do that by employing a nonlinear, dynamic panel threshold regression model applied within a Taylor rule-based framework. We present strong evidence of policy switches driven by the intensity of financial stress across a wider set of AE and EME central banks. Overall, our results suggest the following: First, for AE central banks, the negative impact of financial stress on interest rate setting is more pronounced when financial stress is low, with this effect dissipating entirely as the economy moves toward a high-stress regime. This finding partly reflects AEs' inability to generate negative real interest rates in the zero lower bound, hence an increased preference for interest rate smoothing. Yet, for EME central banks, financial stress only figures significantly in EMEs' reaction functions in the post-2001 estimation period. In fact, the interest rate reaction is similar to AE central banks: loosening monetary policy in response to an increase in the FSI in the low-stress regime, with no statistically significant effect of financial stress at the high-stress state. This suggests that the shift to the adoption of flexible exchange rate regimes and more credible monetary policy frameworks (e.g. inflation targeting) that most EMEs adopted post-2001 could have partly contributed to the change in the monetary policy response to financial stress. Third, AE central banks react to output developments countercyclically regardless of whether the economy is in a low or high financial stress regime. EMEs and AEs, on the other hand, responded to output in a uniformly countercyclical manner only when financial stress is low. Similar to monetary policy's direct responsiveness to financial stress at the high-stress regime, we do not find a statistically significant relationship between monetary policy and growth when financial stress exceeds a threshold.
References


The Responsiveness of Monetary Policy to Financial Stress: A Dynamic Panel Threshold Analysis


Discussion

Dr. Dennis Mapa cited the objectives of the paper: first, to determine whether there is a threshold level by which central bank monetary policy responds to financial stress; and second, to determine whether central banks behave asymmetrically when the financial stress is in high or low regime.

Due to the complexity of steps that had to be undertaken to derive the threshold value, a more transparent explanation is warranted. The choice of the threshold value is crucial since results will depend on it. Analysis could be enhanced by setting a rule on selecting the threshold value and comparing the threshold value across economies and periods. The comparison will provide robustness check whether the results remain with a shift in the threshold value.

In addition, reverse causality may be an issue since the financial stress index was constructed from several indicator variables, some of which may be influenced by the interest rate. It was uncertain if the index was causing the interest rate or vice versa. Additional analysis on this possibility may be warranted.

One participant recommended to group the EMEs into those with large current account surplus and large current account deficit. Another participant raised the possibility that the monetary policy responses of Asian economies during the 1997 Asian Financial Crisis were actually responses to the IMF program.

Dr. Björn van Roye replied that it would be interesting to go deeper into cross-country differences, especially for EMEs. Since some economies were under the IMF program during the Asian Financial Crisis, this may explain the difficulties in explaining the responses of these economies during the said crisis. Finally, he gave assurance that reverse causality is not present in the model.

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\[\text{Dr. Dennis Mapa of the University of the Philippines was the discussant of the paper.}\]
Session 3
Monetary Policy, Macroprudential Policy and Financial Stability
Estimating Macro-financial Linkages in Asia

Hoon Kim and Feng Zhu

The recent global financial crisis and the Great Recession have highlighted the importance of macro-financial linkages. The crisis has also revealed how little we knew about the interactions between financial sector developments and real activity, which have been essential to the transmission of financial shocks to business cycles. In this paper, we use two approaches to investigate macro-financial linkages in Asian economies. First, we employ frequency-domain techniques to study the relationship between financial variables (credit and asset prices) and real activity across the entire frequency range, estimating cross-spectral density, coherency, gain, phase-to-frequency ratio, and frequency-specific coefficients of correlation and regression. Second, we estimate country-specific Bayesian vector autoregressive (BVAR) models to study the interactions between financial and macro variables, and we evaluate the impact of financial sector shocks on real activity.

We find that long-term financial sector developments contribute to trend growth, but real GDP growth affects equity prices and bank lending mainly at the business-cycle and higher frequencies. The business-cycle link between output growth and bank lending growth is weak, in contrast to its link with equity prices. In addition, macro-financial linkages change over time and differ significantly across the emerging Asian economies, which might be attributed to the rather different levels of financial sector development and to distinct policy and institutional frameworks. Nevertheless, macrofinancial linkages play a significant role in economic fluctuations in the region.

Keywords: Asset price, Bayesian VAR, business cycle, credit, frequency-domain method, macrofinancial linkage, financial cycle.
Discussion

Dr. Nur Ain Shahrier noted the importance of macro-financial linkages in light of the global financial crisis. It is important to identify and examine the interactions between financial sector developments and real sector activities, in particular the impact of financial sector shocks to business cycles. To evaluate the interactions between financial and macro variables, cross-spectral density and Bayesian vector autoregressive (BVAR) models were used. The cross-spectral density was used over simpler methods such as the Hodrick–Prescott (HP) filter in order to distinguish the long-run from short-run developments. The BVAR models were used to overcome data dimensionality problem that is common to traditional VAR models.

Three main findings were identified. First, in the long run, financial sector developments, especially growth in bank lending, are associated with economic growth. Second, there is strong interaction between financial and economic cycles. Third, in emerging Asia, financial shocks that originated from equity and house prices have considerable contribution to business cycles and real activity.

While detailed examination of macro-financial linkages were provided, greater discussion on policy implications of results and on the role of monetary policy in minimizing adverse impacts of external shocks to the economy are warranted. A limitation of the study is the orthogonality assumption that shocks are independent from one another. In reality, shocks may be related to each other.

One participant took note of the conclusion that credit shocks did not have substantial effects on output and recommended additional discussion on transmission mechanism working through output. Another participant asked how financial sector developments contributed to long-term growth.

Dr. Feng Zhu mentioned that the extent of how credit shocks affect inflation and output may depend on how liquidity is used. One possibility is that the expansion in liquidity is not accompanied by an expansion in supply, which would result in liquidity going to the demand side that prompts price increases but not output growth. Furthermore, financial market developments can be considered an addition to capital, which increases potential output and, therefore, long-term growth.

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1 Nur Ain Shahrier of Bank Negara Malaysia was the discussant of the paper.
Monetary Policy during Financial Crises: Is the Transmission Mechanism Impaired?\textsuperscript{1}

Nils Jannsen\textsuperscript{2}, Galina Potjagailo\textsuperscript{3}, Maik H. Wolters\textsuperscript{4}

We study the effects of monetary policy on output during financial crises. We use a large panel of advanced and emerging economies and we interact financial crises dummy variables with key macroeconomic variables in a panel VAR. Taking a sample from the mid-1980s to today, we find that an expansionary monetary policy shock is very effective in raising GDP during the recessionary period of a financial crisis. The effect is stronger than in non-crisis times. In contrast, during the recovery period of a financial crisis, monetary policy has a very small effect on GDP. These differences can be explained by a confidence channel: during the joint occurrence of a recession and a financial crisis an expansionary monetary policy shock increases consumer confidence, while it has no effect on confidence during the following recovery. Other variables like credit, housing prices and exchange rates can at most partially explain differences in transmission.

JEL Codes: C33, E52, E58, G01
Keywords: Monetary policy transmission, financial crisis, financial stability, state-dependence, panel VAR

1 MOTIVATION

The recent financial crisis and Great Recession led many central banks to conduct massive monetary expansions with the aim of tranquilizing financial markets, boosting economic growth and stabilizing prices. Despite very low policy rates and a variety of expansionary unconventional policy actions, GDP growth remained unexpectedly low in many countries during the years following the crisis. For example, forecasts by the OECD over predicted growth rates during the Great Recession and the following recovery (Pain et al. (2014)). One possible explanation is that the persistently adverse impact of the crisis was underestimated so that despite effective and highly expansionary monetary policy GDP growth remained lower than expected (see e.g. Mishkin (2009)). A second possibility is that monetary policy transmission was less effective in spurring GDP growth compared to non-crisis times (see e.g. Krugman (2008)).

In view of this, we study whether monetary policy transmission differs around financial crisis and non-crisis times. This question is of high relevance for monetary policy makers: if effective, monetary expansions can be used as an important tool to shield the economy from large recessions that often come along with severe financial crises. If, however, monetary policy transmission is impaired during and after financial crises, monetary expansions that are needed to bring GDP growth rates back to normal levels are very large. This could either exclude monetary policy completely from the set of stabilizing policy tools or lead to a new trade-off for central banks between stabilizing output in the short run and the risk of causing financial instability that leads to more volatile output in the medium run.

\textsuperscript{1} Preliminary work in progress
\textsuperscript{2} Kiel Institute for the World Economy
\textsuperscript{3} University of Kiel
\textsuperscript{4} University of Kiel and Kiel Institute for the World Economy
2 LITERATURE

Theoretical predictions on the effectiveness of monetary policy during financial crises are mixed. Some models predict monetary policy to be more effective in financial crises through the “financial accelerator”, i.e. the ability of monetary policy to lower the external finance premium by increasing the net worth and the collateral of creditors through higher asset prices and by stimulating credit supply. As credit and collateral constraints are more likely to be binding during recessions and financial crises, the financial accelerator should be larger during these episodes and monetary policy thus more effective (Bernanke et al., (1999), Christiano et al., (2004)). In contrast, other contributions question monetary policy effectiveness during financial crises as these episodes are typically characterized by large increases in uncertainty and losses of confidence. High uncertainty can lead to lower investment via real-option effects: investors wait and postpone investment decisions until more information arrives and uncertainty is at least partially resolved (see e.g. Bernanke (1983); Dixit and Pindyck (1994), Bloom (2009)). If, in addition, firms and consumers lose confidence in their business and employment prospects during a financial crisis, monetary policy makers may further lose the ability to stimulate borrowing, investment and spending on durables with lower interest rates (Morgan, (1993)). Thus, expansionary monetary policy might have weaker effects during a financial crisis, as compared to “normal” recessions. On the other hand, those monetary policy measures that aim at stabilizing financial markets might be all the more effective after financial crises if they are able to restore the credit channel of monetary policy.

Similar to the theoretical explanations described above, results from empirical papers are divided regarding the asymmetry of monetary policy effectiveness during recessions and expansions, and during financial crises and normal times. Weise (1999), Garcia and Schaller (2002), Peersman and Smets (2002) and Lo and Piger (2005) find that monetary policy is more effective during recessions than expansions, while more recent papers by Tenreyro and Thwaites (2013) and Caggiano et al. (2014) find the opposite. The empirical literature on monetary policy transmission during financial crises is small – mainly due to weak data availability on financial crisis episodes. A few papers focus on the US and on specific aspects of financial crises like increases in financial stress or uncertainty. While these are certainly important characteristics of financial crises, they can also increase in periods not associated with a financial crisis as for example following the terrorist attacks of 9/11. The results of this literature are also mixed: Hubrich and Tetlow (2012) and Aastveit et al. (2013) find that effects of monetary policy shocks are weaker at high levels of financial stress and uncertainty, while Zheng (2013) and Dahlhaus (2014) find the opposite. Kannan et al. (2009) and Bech et al. (2014) follow a different approach and use comprehensive measures of financial crises episodes such as the one of Laeven and Valencia (2013). Both contributions apply event studies and find that monetary policy is more effective in reducing duration and in stimulating recovery growth rates of recessions that are accompanied by financial crises. Finally, Ciccarelli et al. (2013) focus on the 2009 financial crisis and recursively estimate a panel VAR for euro area economies. They find that monetary policy had stronger effects on output during the financial crisis and that this amplification operated through the credit channel.
3 METHODOLOGY AND DATA

We estimate an interacted panel VAR (IPVAR) for 21 advanced economies and, in an alternative specification, for 45 OECD and emerging market economies over the period 1984Q1 to 2013Q4. Our dataset covers 47 financial crisis episodes, among which 20 occurred in advanced economies and 27 in emerging economies. The baseline PVAR includes real GDP, consumer prices and the short-term interest rate as endogenous variables. In alternative specifications additional endogenous variables such as banks’ credit to the private sector, house prices, exchange rates, share prices and a consumer confidence indicator are added to the PVAR in order to examine the transmission mechanism of monetary policy in greater detail. Potential asymmetries in monetary transmission are captured by augmenting the PVAR with an exogenous dummy variable for financial crises and, alternatively, with dummy variables that distinguish between recession and expansion periods in and outside of financial crises.

Data sources for the endogenous variables are mainly the OECD Economic Outlook, the OECD Main Economic Indicators, IMF Financial Statistics Database and the Bank for International Settlements. Data on financial crisis episodes are taken from Laeven and Valencia (2013), which use the narrative approach for identification. Recession episodes are identified by the Bry-Boschan algorithm for quarterly data.

By using the panel VAR methodology, we are able to include a large number of historical financial crisis episodes in the data set, which increases the estimation precision relative to single-country VARS. At the same time, the inclusion of interaction terms allows us to detect systematic asymmetries in monetary transmission between financial crisis episodes and normal times, over many economies and different historical financial crises. The IPVAR is estimated with OLS and fixed effects. In the baseline estimation, monetary policy shocks are identified via a Cholesky identification scheme, ordering the short-term interest rate last in the PVAR. As a robustness check, identification will also be carried out with sign restrictions, by restricting the reactions of consumer prices and the short-term interest rate during the first two quarters after the shock, while remaining agnostic about the reactions of output.

4 RESULTS

We find that monetary policy has a somewhat larger effect on GDP during financial crises; in particular GDP reacts faster to monetary policy shocks as compared to non-crisis episodes. When we differentiate between recessionary and expansionary periods within financial crises, it becomes obvious that the effectiveness of monetary policy differs sharply in these two sub-periods. While monetary policy has large effects on GDP in recessionary periods, which usually take place at the beginning of a financial crisis, monetary policy has hardly any effect on GDP in expansionary periods of financial crises, which usually take place at later stages of financial crises.

Having established these stylized facts, we analyze the transmission channels that lead to these results. First, we disentangle changes in policy transmission, i.e. the effects of the interest rate on inflation and output, and changes in systematic policy reactions, i.e. reactions of the interest rate to lags of the interest rate and output and

Panel VARs have also been applied in other empirical applications with the aim to increase estimation precision and to detect common country dynamics. See Goodhart and Hofmann (2008), Assenmacher-Wesche and Gerlach (2008), Gambacorta et al. (2012), Towbin and Weber (2012), Sà et al. (2014) and Georgiadis (2014). The latter three studies also include interaction terms into the panel VAR.
inflation. To do so, we construct counterfactual scenarios, in which we use monetary policy parameters estimated during normal times and use them together with the transmission parameters during financial crises. We find that larger effects of monetary policy on output during the recessionary part of financial crises are not driven by changes in systematic monetary policy, but by changes in monetary policy transmission. Second, we add to our PVAR model measures of banks’ credit to the private sector, share prices, house prices, exchange rates, and a consumer confidence indicator as additional endogenous variables. We find that our results on differences in monetary policy transmission between financial crises and normal times, and between recessions and expansions can be explained by the confidence channel. Consumer confidence and share prices react more strongly to monetary policy shocks during recession phases of financial crises as compared to both expansionary periods of financial crises and expansionary periods in non-crisis times. By contrast, we do not find a particular role for the credit channel of monetary policy.

5 OUTLOOK

This paper presents preliminary results and we plan to extend our analysis in various directions. To further investigate the transmission channel of monetary policy during financial crises, we plan to add additional variables into our empirical investigation – such as consumption, housing and non-housing investment and net trade instead of aggregate GDP. As far as data availability allows it, we will also try to include measures of risk premia and of fiscal policy. We also want to conduct additional robustness checks. First, we want to allow for heterogeneity in slopes across countries in the PVAR, which is a less restrictive approach than the fixed effect estimator. Second, we want to use sign restrictions as an alternative identification method for monetary policy shocks. In this, we hope to resolve the price puzzle that is present in our recursively estimated results. We also hope to account for unconventional monetary policy measures by imposing sign restrictions on the reactions of monetary aggregates. Alternatively, we want to incorporate unconventional monetary policy into our analysis by using data on shadow interest rates instead of money market rates for the US, the UK and for Eurozone countries.
References


Discussion

Ms. Shakira Teh Sharifuddin noted that the paper provided a better understanding of the dynamics of transmission mechanism during different phases of financial crisis in advanced and emerging market economies. Periods were classified into non-financial crisis and financial crisis. The financial crisis period is further broken down into recession and recovery periods. There were two main takeaways from the paper. First, monetary policy shocks have the greatest impact on growth during the recessionary period of a financial crisis. Second, consumer confidence and share prices have strong reactions to monetary policy shocks during the recessionary period.

Recommendations on how to enhance the paper were provided. First, dividing the paper into subsections for each financial crisis period may provide better structure to the discussion. Second, more analysis on the difference in the magnitude of response to shocks by advanced and emerging markets may be provided. Third, the contribution of external factors during the recovery period, especially for emerging markets may be considered. Fourth, discussion on policy implications may be included. Finally, robustness checks and controls for unconventional monetary policy, exchange rate, financial market openness, and financial stability may be added.

One participant remarked that when economic recovery is fragile, the central bank has to be committed to maintain public confidence. In addition, low confidence, collapsed credit and broken transmission mechanism make monetary policy ineffective during recessions and financial crises.

Another participant noted that the cause of the financial crisis (decline in liquidity, banking crisis or collapse in stock prices) will determine the appropriate monetary policy response needed to address the crisis. One participant likewise mentioned that identification of financial crisis may not be simple because some were followed by a debt crisis that turned into a currency crisis. Moreover, distinction between bank-based and non-bank based financial systems must be made.

Dr. Maik Wolters mentioned that going forward, greater analysis on consumer confidence channel and communication of monetary policy will be provided. Furthermore, the effects of external shocks on emerging markets’ consumption, investment and exports will be included. Analysis may also be extended towards sovereign debt and currency crises.

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6 Ms. Shakira Teh Sharifuddin of Bank Negara Malaysia was the discussant of the paper.
A Credit and Banking Model for Emerging Markets and an Application to the Philippines

Rahul Anand, Vic Delloro and Shanaka Jayanath Peiris

The paper develops a small open economy New Keynesian DSGE model with financial frictions and an active banking sector for emerging markets, in order to understand the role of banking intermediation in the transmission of monetary impulses, and to analyze how shocks that originate in credit markets are transmitted to the real economy. The DSGE model builds-in many of the features of emerging markets such as rigidities in interest rate pass-through, “financial accelerator” effects and foreign currency borrowing by firms, a credit supply channel, as well as impact of conventional and unconventional monetary policies. The analysis delivers the following results. First, the presence of financial frictions amplifies the magnitude and the persistence of transitory shocks. Second, market power of monopolistic banking sector amplifies the business cycle. However when interest rates are sticky, banking system attenuate the response to shocks. Third, the tightening of credit markets (modeled by a persistent negative shock to bank capital) can have substantive effects on the economy. Fourth, when the central bank resorts to using non-monetary tools, there is a larger contraction in output and consumption as compared to traditional monetary tightening (operating through nominal interest rate changes). These results are driven by the two channels through which the financial sector interacts with the real economy – the financial accelerator channel, which establishes a link between the balance sheet of the firms (borrowers) and the real economy; and the banking channel, which creates a feedback loop between the real and the financial side of the economy through the bank’s balance sheet.

1 INTRODUCTION

The global financial crisis has amply demonstrated that the performance of the real side of the economy is closely linked to the disturbances in the financial sector. Shocks originating in the credit markets have resulted in substantial loss of output and large-scale unemployment. Inter-bank markets froze; credit became extremely costly, and at times totally unavailable. Tighter credit conditions not only exacerbated, but also protracted the crisis. Realizing that the recovery of the real economy depends crucially on the smooth functioning of the financial sector, central banks have taken substantive measures to unclog the credit markets. To analyze and understand these linkages better, it is imperative to develop a dynamic stochastic general equilibrium (DSGE) model with macro-financial linkages and an active banking sector.

The importance of financial shocks in terms of how they affect the real economy has long been realized (Fisher, 1933), but most of the general equilibrium models developed to study macro-financial linkages have focused only on the demand side of the credit markets. These models have abstracted from modeling the banking sector explicitly, and assume that credit transactions take place through the market (thereby not assigning any role to financial intermediaries such as banks). The growing

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1 Rahul Anand is a senior economist at the IMF, Vic Delloro was seconded in the IMF resident representative office in the Philippines and is Bank Officer V from the Bangko Sentral ng Pilipinas, and Shanaka J. Peiris is the IMF resident representative to the Philippines.

2 Bernanke, Gertler and Gilchrist (1999) and Iacoviello (2005) have introduced credit and collateral requirements to analyze the transmission and amplification of financial shocks.
importance of banks in the modern financial system and the current crisis has demonstrated that the role of financial intermediation cannot be overlooked, and we need to model the supply of credit to understand business cycle fluctuations better. Also, modeling credit supply is essential to study the transmission of shocks originating in the credit markets.

The objective of this paper is to develop a small open economy New Keynesian model with financial frictions and an active banking sector for emerging markets, in order to understand the role of banking intermediation in the transmission of monetary impulses, and to analyze how shocks that originate in credit markets are transmitted to the real economy. The model developed is used to analyze issues related to monetary transmission and financial stability. We specifically look at (1) the monetary transmission mechanism in the presence of banking sector and financial frictions; (2) the role of banks in propagation of macroeconomic shocks; (3) the effects of a tightening of credit conditions; and (4) the effects of non-standard monetary policy tools.

The credit and banking DSGE model builds-in many of the features of emerging markets that tend to be bank dominated and prone to surges in capital flows. To be concrete, we consider the example of the Philippines to inform the specification of the model but the characteristics of the model are quite general to emerging markets particularly emerging Asia. First, we allow rigidities in the pass through of policy or money markets interest rates to retail (deposit and lending) rates as observed in the Philippines. Second, surges in portfolio flows and liquidity can affect the net worth or leverage of firms that determine the “external” finance premium and demand side “financial accelerator” effects. Moreover, considering that corporates in emerging market economies tend to also rely on foreign currency external borrowing in addition to domestic bank borrowing, exchange rate and world interest rate fluctuations through their effect on balance sheets can play an important role (Krugman, 1999, Aghion et al., 2001). Third, bank capital and financial stability concerns could impact the supply of credit as experienced during the global crisis. Another major contribution of this paper is to incorporate features to study the transmission mechanism of non-conventional monetary policy tools. Unlike most models available in the literature, we consider the use of reserve requirements on bank deposits that are frequently used in many emerging Asian economies including the Philippines. Finally, we assess the use of liquidity requirements on banks or equivalently shocks to the share of government debt securities held by banks that could be related to other factors such as portfolio shifts of non-resident investors in local currency government securities markets that have gained in importance.

We extend the small open economy DSGE model of Anand, Saxegaard and Peiris (2010) to include an active banking sector along the lines of Gerali and others (2010). Anand and others (2010) have shown that a model with financial frictions, modeled with a financial accelerator mechanism similar to Bernanke, Gertler and Gilchrist (1999), improves the model’s ability to capture the macro dynamics observed in India. The banking sector is modified to include the non-monetary tools frequently used by central banks in emerging Asia. We depart from Iocaviello (2005) and Gerali et al. (2010) in modeling financial frictions, that we only introduce the balance sheet effects for firms. Though such frictions may be an important feature of households’ balance sheets in advanced economies and some emerging markets, they have played a relatively secondary role in the Philippines for now and are excluded for parsimony.

We introduce a banking sector which operates under a monopolistically competitive environment. Banks are modeled as comprising of three parts, two “retail branches” and one “wholesale” unit. The two retail branches provide differentiated
loans to entrepreneurs (loan branch) and raise differentiated deposits from households (deposit branch). These branches set rates in a monopolistic competitive fashion, subject to adjustment costs. The wholesale unit manages the capital position of the group and, in addition, raises wholesale loans and wholesale deposits. Banks combine deposits from the household and borrowing at interbank market with the bank capital to produce loans. While using deposits to make loans, banks observe cash reserve ratio (keeping a fraction of deposits in liquid form, which do not earn any interest) and statutory liquidity ratio (investing a fraction of deposits in government t-bills) imposed by the central bank or fixed exogenously. Cash reserve ratio requirements and statutory liquidity ratio requirements leave banks with fewer resources to lend. Both these factors increase the marginal cost of producing loans and affect the real side of the economy, through the borrowing costs of the firms. Bank capital is accumulated in each period out of retained earnings, and banks pay a quadratic cost if they deviate from the capital/loan requirement set by the central bank. Accumulation of bank capital from retained earnings creates a feedback loop between the real and the banking sector in the economy. As macroeconomic conditions deteriorate, profits of banks are affected negatively, and this weakens the ability of banks to raise new capital. Depending on the nature of the shock, this may force banks to cut down lending, or demand a higher price for credit, giving rise to the “credit cycle” observed in the recent recession episodes.

The paper is organized in five sections. In the next section, we present some empirical facts to further motivate the analysis, and also review the relevant literature. In Section 3, we develop a small open economy New Keynesian model with financial frictions and an active banking sector, which forms the basis of further analysis. In Section 4 we analyze the impulse responses. Section 5 concludes.

2 STYLIZED FACTS AND RELATED LITERATURE

We begin by presenting some basic stylized facts about the growing importance of macro-financial linkages and the banking sector in the Philippine economy and then look at the monetary policy practices in the Philippines. We also review the recent attempts at introducing banking sector in traditional DSGE models.

Household debt in the Philippines is relatively low compared to corporate debt and corporates still predominantly rely on bank borrowing to finance investment, although capital markets are starting to play a greater role. While Philippine companies finance the majority of their investment using retained earnings and bank finance, the share of external financing to GDP is more than double bank credit reflecting the importance of capital market financing and foreign debt financing. As a result, the Philippines’s corporate sector is exposed to global financing conditions, though the share of foreign currency denominated debt has fallen.

Capital inflows to the Philippines have surged since the beginning of 2010. There have been two other major episodes of capital inflows to the Philippines and emerging Asia more generally over the past two decades. The first episode began in the early 1990s and ended abruptly with the 1997-98 Asian financial crisis; the second began in the early 2000s and again ended abruptly with the global financial crisis. What is striking about the current episode is that surge in capital inflows to the Philippines has been predominately portfolio inflows to peso-denominated securities and other inflows to the non-financial private sector. This pattern in similar to the rest of emerging Asia, where portfolio flows have driven equity prices higher and local currency government bond yields lower. In addition, the increase in other liabilities has raised corporate leverage in a number of countries though less than Asian crisis levels (AREO 2014).
In the Philippines, the empirical relationship between non-FDI capital inflows and domestic demand is strong. The main channel through which the relationship seems to work is by reducing the cost of equity finance and expanding bank credit to the non-financial private sector.\textsuperscript{3} The impulse responses of Bayesian VARs show that non-FDI flows expands both private consumption and fixed investment, with a greater response of investment as expected.\textsuperscript{4} Easier external finance conditions enhance the borrowing capacity of corporates and expand the volume of bank and foreign debt financing resources available to them. Capital flows also tend to lower market interest rates and lead an expansion of credit possibly reflecting a search for yield and weakening of lending standards.

The Philippines shifted to an inflation targeting regime in 2002 (see Guinigundo, 2010). To achieve the inflation target, the BSP uses a suite of monetary policy instruments in implementing the desired monetary policy stance. The reverse repurchase (RRP) or borrowing rate is the primary monetary policy instrument of the BSP. Other monetary policy instruments include (a) increasing/decreasing the reserve requirement; (b) encouraging/discouraging deposits in the special deposit account (SDA) facility by banks and trust entities of BSP-supervised financial institutions; (c) adjusting the rediscount rate on loans extended to banking institutions on a short-term basis against eligible collateral of banks' borrowers; and (d) outright sales/purchases of the

\textsuperscript{3} Conceptually, the real cost of equity (i.e. the implied rate of return required by investors) is equal to the sum of the risk-free interest rate and equity risk premium. At a time of capital inflows, the relative appeal of capital investment increases, making it easier for firms to borrow from banks based on their greater net worth.

\textsuperscript{4} Government bond yields and real estate prices could also be an important transmission channel of capital flows and driver of domestic demand in EM Asia and the Philippines, although the historical analysis using BVARs did not show a significant impact.
BSP’s holding of government securities. Policy rates are supposed to anchor money market rates and Treasury bill/bond (T-bill) yields that act as benchmarks for deposit and loan rates. However, a recursive VAR shows that the transmission of the RRP to lending rates is imperfect and that the secondary market 91-day t-bill rates, foreign portfolio inflows, U.S. interest rates and the SDA rate could have a larger impact and explanatory power. In such an environment, allowing for interest rate rigidities and divergence of markets rates from policy rates would be important to take into account.\(^5\) The weak interest rate and credit channel may also explain the use of non-traditional monetary policy tools such as reserve requirements to carry out monetary policy operations. The BSP also merged its liquidity requirements that prescribed a level of liquid assets predominately government securities with the reserve requirement in 2012 but the share of bank assets held in debt securities remain significant.\(^6\) Thus, shocks to the share government debt securities held by banks as a result of policy or sudden changes of foreign participation in the bond market could be an additional source of fluctuations.

Figure 2. Dynamics of Market and Retail Interest Rates

Peiris (2012) also shows a similar imperfect pass-through of policy rates to deposit rates in the Philippines.

\(^5\) Peiris (2012) also shows a similar imperfect pass-through of policy rates to deposit rates in the Philippines.

\(^6\) The BSP unified the existing statutory reserve requirement and liquidity reserve requirement into a single set of reserve requirement as well as discontinued the renumeration of the unified reserve requirements in 2012.
Despite their relevance for policy making, most of the general equilibrium models generally lack interaction between financial markets and the real economy. Though a long tradition in economics starting from Irving Fishers' (1933) debt deflation explanation of the Great Depression; most of the theoretical works focused on partial equilibrium analysis till the seminal paper by Bernanke and Gertler (1989). They used information asymmetry in credit markets and monitoring costs to establish a link between the financial sector and the real economy. They showed that in such a setting, the borrowing costs of firms depend on the strength of their balance sheets (net worth). Bernanke, Gertler and Gilchrist (1999), Kiyotaki and Moore (1997) and Carlstrom and Fust (1997) have demonstrated that the presence of financial frictions amplify the magnitude and the persistence of macroeconomic shocks. Gertler, Gilchrist and Natalucci (2007) and Eleckdag, Justiniano and Tchakarov (2005) extended the framework to small open economies. Iocaviello (2005) introduced the collateral constraints tied to real estate values of the firms and household level nominal debt to study the linkages between financial frictions and real economy. However all these models have used financial frictions on the firm/household side (or demand side of the credit market). All these models assume that credit transactions take place through markets, and do not assign any role to financial intermediaries such as banks. Also, they do not include the credit supply channel.

Recently there has been increasing interest in introducing a banking sector in dynamic models. The present crisis has underscored the need to model the supply side of credit markets to understand better the linkages between the financial sector and the real economy. In order to introduce the supply side of credit markets, researchers have followed three major approaches to model banking sector - (i) Perfectly competitive banks with banking costs; (ii) Monopolistically competitive banks and; (iii) Risky banks with inter-bank lending. All these models try to generate a spread between the lending and deposit rates which adjusts along the cycle, establishing a link between the banking activity and the real economy.

It is commonly referred to in the literature as a “Financial Accelerator”.

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7 It is commonly referred to in the literature as a “Financial Accelerator”.

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Bangko Sentral ng Pilipinas
In models with perfectly competitive banks, banking (producing loans, deposits, bank equity etc.) is a costly activity which requires resources. Costs of banking activities create a spread between lending and deposit rates (Edward and Vegh, 1997; Benes et al., 2009; Cúrdia and Woodford, 2009; Goodfriend and McCallum, 2007; and Christiano et al., 2009). Models with monopolistically competitive banks use the market power of banks to generate a spread between the deposit and lending rates, which adjusts along the cycle, thus affecting the real side of the economy (Gerali et al., 2010; Huelsewig and Wollmershauser, 2009; and Sudo and Ternishi, 2009). Risky banks and inter-bank lending models assume that banks operate under perfectly competitive markets and the production of loans is separate from the production of deposits. Banks rely on inter-bank lending and there is an endogenous probability of default by firms and banks. This probability of default induces a financial accelerator in these models as the rate of default is countercyclical (de Walque et al., 2009; and Gertler and Kiyotaki, 2009).

In this paper we follow Gerali et al. (2010) to introduce the banking sector in a model with financial frictions. Banks in our model operate in a monopolistically competitive environment and set deposit and lending rates. A wedge is created between the two rates as a result of the market power of banks. We model financial frictions a la Bernanke, Gertler and Gilchrist (1999).

3 THE MODEL

We build on the model of Anand, Saxegaard and Peiris (2010) and include a banking sector on the lines of Gerali and others (2010). The basic structure of model consists of four kinds of agents – households, entrepreneurs, capital producers and retailers. Households consume a composite of domestic and imported goods and provide labor. They have access to foreign capital markets and make deposits with the banks. Households are the owner of banks and retail units. Entrepreneurs produce intermediate goods using labor and capital purchased from the capital producers. They finance the acquisition of capital partly through their net worth and partly through borrowing domestically (from banks) and from abroad. Banks raise deposits from households and give out loans to entrepreneurs. They operate in a monopolistically competitive environment – setting interest rates on deposits and loans to maximize profits. Banks combine deposits from the household and borrowing at inter-bank market with the reinvested profits (bank capital) to make loans to entrepreneurs. Entrepreneurs operate under perfect competition and sell their product to retailers who differentiate them at no cost and sell them either in domestic market or export overseas. Retailers operate in a monopolistically competitive environment and face a quadratic adjustment costs in changing prices a la Rotemberg (1982). Capital producers use a combination of existing capital stock and investment good purchased from retailers and abroad to produce capital. The market for capital, labor and domestic loans are competitive. The model is completed with a description of the fiscal and monetary authority.

In order to provide a rationale for monetary stabilization policy, three sources of inefficiencies are included in the model: (a) monopolistically competitive retail market; (b) sluggish price adjustment in retail sector and (c) capital adjustment costs. In addition sluggish interest rate adjustments and bank capital adjustment costs are the other sources of inefficiencies in the model. While relatively simple, the framework captures many of the rigidities which previous studies have found are important to describe the dynamics in the data and serves as a useful starting point for developing a credit and banking model for emerging markets.
3.1 Households

The economy is populated with a continuum of infinitely lived households with preferences defined over consumption, $C_j(t)$ and labor effort $L_j(t)$. The objective of household is to maximize the expected value of a discounted sum of period utility function given by

$$E_0 \sum_{t=0}^{\infty} \beta^t U_j(C_j(t), L_j(t)) \quad \beta \in (0,1), U' > 0, U'' < 0$$

(1)

where $\beta$ is the discount factor and $U$ is a period utility function. We include the habit persistence according to the following specification

$$U_j(C_j(t), L_j(t)) = \zeta_{C,j}(1-b) \ln(C_j(t) - bC_{j-1}) - \frac{\zeta_{L,j}}{\psi} L_j(t)$$

(2)

where $C_{j-1}$ is lagged aggregate consumption and $b \in (0,1)$. $\zeta_{C,j}$ and $\zeta_{L,j}$ are preference shocks to the marginal utility of consumption and the supply of labor respectively. Note that in symmetric steady-state $C_j(t) = C_{j-1}$, the marginal utility of consumption is independent of the habit persistence parameter $b$. The aggregate consumption bundle $C_j(j)$ consists of domestically produced goods, $C_{H,j}(j)$ and an imported foreign good, $C_{F,j}(j)$ and is given by
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\[ C_t(j) \equiv \left[ \frac{1}{\eta} \left( C_{H,j}(j) \right)^{\eta-1} + \left( 1 - \alpha \right) \frac{1}{\eta} \left( C_{F,j}(j) \right)^{\eta-1} \right]^{\frac{1}{\eta}} \]  

(3)

where \( C_{H,j}(j) \) is an index of consumption of domestic goods given by the constant elasticity of substitution (CES) function

\[ C_{H,j}(j) = \left( \int_0^1 C_{H,j}(s)^{\frac{\varepsilon_j}{\varepsilon_j-1}} ds \right) \]  

(4)

where \( s \in [0,1] \) denotes the variety of the domestic good. Parameter \( \eta \in [0, \infty] \) is the elasticity of substitution between domestic and foreign goods and \( \varepsilon_j > 1 \) is the elasticity of substitution between the varieties produced within the country. \( \alpha \in [0,1] \) can be interpreted as a measure of home bias.

We assume that households have an access to foreign financial markets or nominal contingent claims that span all relevant household specific uncertainty about future income and prices, interest rates, exchange rates and so on. As a result each household face the same intertemporal budget constraint

\[ P_t C_t(j) + e_t B_t^f(j) + P_t \tau_t(j) + P_t D_t(j) = e_t B_t^f(j) \int_0^1 \Pi_t'(s)ds + W_t L_t(j) \]

\[ + t_{t-1}^d P_t D_{t-1}(j) + \int_0^1 (1 - \omega_b^t) P_t \Pi_t^b(i)di, \forall t \]

(5)

where \( B_t^f \) is the net holding of foreign currency one period bond that matures in period \( t \), paying a gross interest rate of \( i_t^f \). Households make deposit \( D_t \) with financial intermediary. Deposits pay the gross interest of \( i_t^d \) set by deposit banks between \( t \) and \( t+1. \)

\[ \int_0^1 \Pi_t'(s)ds \] represents nominal profit from the ownership of domestic retail firms and

\[ \int_0^1 (1 - \omega_b^t) P_t \Pi_t^b \] is the dividend earned from the ownership of banks. \((1 - \omega_b^t)\) is the exogenously set dividend rule. \( \tau_t \) is the lump sum tax in the economy and \( W_t \) is the nominal wage rate. \( P_t \) is the CPI index given by

\[ P_t = \left[ \alpha \left( P_{H,j} \right)^{-\eta} + (1 - \alpha) \left( P_{F,j} \right)^{-\eta} \right]^{\frac{1}{\eta}} \]

(6)

where \( P_{H,j} \) is the domestic price index given by

\[ P_{H,j} = \left( \int_0^1 P_{H,j}(s)^{1-\varepsilon_j} ds \right)^{\frac{1}{\varepsilon_j}} \]

(7)
and $P_{F,t}$ is the price of the imported goods.\(^8\)

Households choose the paths of $\{C_t(j), L_t(j), D_t(j), B^t_{t+1}(j)\}_{t=0}^{\infty}$ to maximize expected lifetime utility given by equation (1) subject to the sequence of constraints given by equation (5) and the initial value of $B^t_0$.

Ruling out Ponzi type schemes, we get the following first-order conditions

$$
\frac{(1-b)\zeta_{C_t}}{C_t(j) - bC_{t-1}} = \lambda_t P_t 
$$

(8)

$$
\zeta_{L_t} L_t(j)^{\nu-1} = \lambda_t W_t
$$

(9)

where $\lambda_t$ is the lagrange multiplier associated with the budget constraint. The first-order conditions are given by

$$
1 = (i_t') E_t \left\{ \rho_{t,t+1} \left( \frac{P_t}{e_{t+1}} \right) \right\} 
$$

(10)

$$
1 = (i_t') E_t \left\{ \rho_{t,t+1} \left( \frac{P_t}{e_{t+1}} \right) \right\} 
$$

(11)

where $\rho_{t,t+1} = \frac{\lambda_t}{\lambda_{t+1}} = \frac{\zeta_{C_t}(C_{t+1}(j) - bC_t)}{\zeta_{C_j}(C_t(j) - bC_{t-1})}$ is the stochastic discount factor.

Up to a log-linear approximation equations (10) and (11) imply, $E_t \ln(e_{t+1}/e_t) \approx i_t' - i_t'$. The optimum allocation of expenditure between domestic and imported goods is given by

$$
C_{H,t}(j) = \alpha \left( \frac{P_{H,t}}{P_t} \right)^{-\eta} C_t(j)
$$

(12)

$$
C_{F,t}(j) = (1-\alpha) \left( \frac{P_{H,t}}{P_t} \right)^{-\eta} C_t(j)
$$

(13)

and the demand for each variety of domestic goods is given by

$$
C_{H,t}(s) = \alpha \left( \frac{P_{H,t}(s)}{P_{H,t}} \right)^{-\eta} C_{H,t}(j)
$$

(14)

### 3.2 Bank

Banks intermediate all financial transactions between the agents in the model. We model banks as monopolistically competitive at the retail level. They hold some market power in conducting their intermediation activity, which allows them to set deposit rates and lending rates. This setup allows us to study how different degrees of interest rate pass-through affect the transmission of shocks. We can think of each bank

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\(^8\)We assume that the price of imported goods is set in the same manner as the domestic prices in the exporting country i.e. the price of imports adjust sluggishly and is given by an equation similar to equation (46).
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\(i \in [0,1]\) in the model as composed of three parts - two retail branches and one wholesale branch. The retail branches raise differentiated deposits from the household and provide differentiated loans to entrepreneurs. The wholesale unit manages the capital position of the group and in addition raises wholesale loans and wholesale deposits in the inter-bank market.

Following Gerali et al. (2010), we assume that units of deposit and loan contracts bought by households and entrepreneurs are a composite CES basket of slightly differentiated products – each supplied by a branch of a bank \(i\) – with elasticities of substitution equal to \(\varepsilon^d_i\) and \(\varepsilon^l_i\), respectively. We assume that each household (entrepreneur) has to purchase a deposit (loan) contract from each single bank in order to save (borrow) one unit of resources.\(^9\) This assumption is similar to the standard Dixit-Stiglitz framework for goods markets.

Given the Dixit-Stiglitz framework, demand for an individual banks’ deposit contract depends on the interest rate charged by the bank relative to the average rates in the economy and is given by

\[
D_i(i) = \left( \frac{i^d(i)}{\bar{i}^d} \right)^{\varepsilon^d} D_i
\]

where \(D_i\) is the aggregate demand of deposits and \(i^d(i)\) is the deposit interest rate faced by each deposit bank \(i \in [0,1]\).\(^10\) \(\bar{i}^d\) is the aggregate (average) deposit rate and is defined as

\[
i^d = \left( \int_0^1 \left( i^d(i) \right)^{\varepsilon^d+1} di \right)^{1/\varepsilon^d+1}.
\]

Similarly the demand for loans facing bank \(i\) is given by

\[
L_i(i) = \left( \frac{i^l(i)}{\bar{i}^l} \right)^{\varepsilon^l} L_i
\]

where \(L_i\) is the aggregate demand of loans and \(i^l(i)\) is the loan interest rate faced by each lending bank \(i \in [0,1]\).\(^11\) \(\bar{i}^l\) is the aggregate (average) lending rate and is defined as

\[\text{\(^9\) Though this assumption may seem unrealistic, it is just a useful modeling device to capture the existence of market power in the banking industry. A similar approach has been adopted by Benes and Lees (2007). Arce and Andres (2009) set up a general equilibrium model featuring a finite number of imperfectly competitive banks in which the cost of banking services is increasing in customers’ distance. Mandelman (2009) set up a model with segmented banking sector where collusive pricing decisions give rise to the market power.}

\[\text{\(^10\) Aggregate deposit demand is given by } D_i = \left( \int_0^1 \left( D_i(i) \right)^{\varepsilon^d} di \right)^{1/\varepsilon^d+1}.
\]

\[\text{\(^11\) Aggregate loan demand is given by } L_i = \left( \int_0^1 \left( L_i(i) \right)^{\varepsilon^l} di \right)^{1/\varepsilon^l+1}.
\]
\[ i_t^d = \left( \frac{1}{0} \left( i_t^d (i) \right)^{-\varepsilon_t^d} \right)^{1/\varepsilon_t^d} \]  

(18)

3.2.1 Retail Banking

Retail banking takes place in a monopolistically competitive setting. There is a continuum of two types of retail branches – deposit branch and loan branch.

3.2.1.1 Deposit Branch

Each deposit branch collects deposit \( D_t(i) \) from households and passes it on to the wholesale branch which pays them a rate \( i_t^s \). Also, we assume that there is a quadratic adjustment cost of intertemporally varying the deposit interest rate. This rigidity allows an interest rate spread that evolves over the cycle. We assume adjustment costs à la Rotemberg (1982), given by

\[ Ad_t^d (i) = \frac{\phi_t^d}{2} \left( \frac{i_t^d (i) - i_t^{d-1}}{i_t^{d-1}} - 1 \right)^2 D_t \]

where \( \phi_t^d > 0 \) is a cost adjustment parameter. The optimization problem of the saving bank is to choose the retail deposit interest rate \( i_t^d (i) \) to maximize

\[ \text{Max} E_0 \sum_{t=0}^{\infty} \beta^t \left[ i_t^d D_t(i) - i_t^d (i) D_t(i) - Ad_t^d (i) \right] \]

subject to

\[ D_t(i) = \left( \frac{i_t^d (i)}{i_t^d} \right)^{\varepsilon_t^d} D_t \]

In symmetric equilibrium, the first-order condition of this optimization problem gives the optimal deposit interest rate

\[ \frac{1 + \varepsilon_t^d}{\varepsilon_t^d} i_t^d = i_t^s - \frac{\phi_t^d}{\varepsilon_t^d} \left( \frac{i_t^d}{i_t^{d-1}} - 1 \right) i_t^d + \beta \frac{\phi_t^s}{\varepsilon_t^d} \left( \frac{i_t^{d+1}}{i_t^{d-1}} - 1 \right) i_t^{d+1} D_t^{d+1} / D_t \]  

(19)

Thus, the deposit rate is a mark down of the wholesale deposit rate and expected future gain of adjusting the deposit rate. With fully flexible rates, \( i_t^d \) is determined as a static mark-down over the wholesale deposit rate

\[ i_t^d = \frac{\varepsilon_t^d}{1 + \varepsilon_t^d} i_t^s \]  

(20)

3.2.1.2 Loan Branch

Each retail branch obtain wholesale loan \( L_t^d (i) \) from the wholesale unit at the rate \( l_t^h \). We assume that there is a quadratic adjustment cost of intertemporally varying
the lending rate. This rigidity allows an interest rate spread that evolves over the cycle. We assume adjustment costs à la Rotemberg (1982), given by

\[ Ad^j_t(i) = \frac{\phi_j}{2} \left( \frac{i^j_t(i)}{i^b_t(i)} - 1 \right)^2 \]

where \( \phi_j > 0 \) is a cost adjustment parameter. The optimization problem of the lending bank is to choose the retail lending rate \( i^j_t(i) \) to maximize

\[ \text{Max}_{i^j_t} \sum_{t=1}^{\infty} \beta^t \left[ L^d_t(i) + \phi_j \left( \frac{i^j_t(i)}{i^b_t(i)} - 1 \right)^2 \right] \]

subject to

\[ L^d_t(i) = \left( \frac{i^j_t(i)}{i^b_t(i)} \right)^{-c_i} L^d_t(i) \]

In symmetric equilibrium, the first-order condition of this optimization problem gives the optimal deposit interest rate

\[ i^d_t = \frac{\epsilon_i^j}{\epsilon_i^b} i^b - \frac{\phi_j}{\epsilon_i^b} \left( \frac{i^j_t(i)}{i^b_t(i)} - 1 \right) \left( \frac{i^j_t(i)}{i^b_t(i)} - 1 \right) + \beta \frac{\phi_j}{\epsilon_i^b} \left( \frac{i^j_t(i)}{i^b_t(i)} - 1 \right) \left( \frac{i^j_t(i)}{i^b_t(i)} - 1 \right) \frac{L^d_t}{i^d_t} L^d_{t+1} \] (21)

Thus, the lending rate is a mark up over the wholesale loan rate and expected future gain of adjusting the lending rate. With fully flexible rates, \( i^d_t \) is determined as a static mark-up over the wholesale loan rate –

\[ i^d_t = \frac{\epsilon_i^j}{\epsilon_i^b} i^b \] (22)

### 3.2.2 Wholesale Branch

Wholesale branch gets the deposits from the deposit branch. In order to study the effect of non-traditional monetary policy interventions, we introduce two such tools. We assume that wholesale branch meets the cash reserve ratio (CRR) and the statutory liquidity ratio (SLR) imposed by the central bank.\(^{12}\) The latter can also be thought of as an exogenously determined share of deposits in government securities that is susceptible to changes investor and bank sentiment. Central bank varies these requirements to control credit supply by changing the availability of resources available with the banks to make loans. Let \( \alpha^d_t \) is the CRR and \( \alpha^d_t \) is the SLR requirements. Then wholesale branch keep \( \alpha^d_t D_t(i) \) in the form of cash and keep \( R^b_t = \alpha^d_t D_t(i) \) in the form of government securities.\(^{13}\) It earns an interest of \( i^d_t \) on the government securities. The wholesale branch combines net worth or bank capital \( Z_t(i) \) with the remaining available deposit \((1 - \alpha^d_t - \alpha^d_t) D_t(i)\) and inter-bank loans, \( B^D_t(i) \), to make wholesale loans \( L^d_t(i) \).

---

\(^{12}\) CRR is the portion of deposits that banks are required to keep in the form of cash. SLR is the portion of bank holdings kept in the form of liquid government securities.

\(^{13}\) Since CRR does not earn any profits and SLR earns a lower profit than lending in the market.
Since wholesale branch can finance their loans using either deposits or bank capital they have to obey a balance sheet identity:

\[ L_d(i) = (1 - \alpha_i^d - \alpha_i^d)D_i(i) + B_{i}^{ib}(i) + Z_i(i). \] (23)

As two sources of finance are perfect substitutes from the point of view of the balance sheet, we introduce some non-linearity (i.e. imperfect substitutability) in order to pin down the choices of the bank. We assume that there exists an (exogenously given) capital-to-assets (i.e. leverage) ratio \( \kappa^b \) for banks. In particular, the bank pays a quadratic cost whenever the capital-to-assets ratio \( (Z_i(i)/L_d(i)) \) moves away from \( \kappa^b \).

This modeling choice provides us a shortcut to study the implications and costs of regulatory capital requirements and also gives bank capital a key role in determining the conditions of credit supply.

Bank capital is accumulated each period out of retained earnings according to

\[ Z_i(i) = (1 - \delta^b)Z_{i-1}(i) + \omega^b\Pi_{i-1}^b(i) - m_i \] (24)

where \( \Pi_{i-1}^b(i) \) is overall bank profits made by the three branches of bank \( i \) in nominal terms, \( (1 - \omega^b) \) summarizes the dividend policy of the bank, and \( \delta^b \) measures resources used in managing bank capital and conducting overall banking intermediation activity. \( m_i \) is a mean zero shock to the bank capital. Since we assume that bank capital is accumulated out of retained earnings, the model has built-in feedback loop between the real and the financial side of the economy. As macroeconomic conditions deteriorate, banks profits are reduced, weakening their ability to raise new capital. Depending on the nature of the shock, it may result in the reduction of amount of loans banks are willing to give, thus exacerbating the original contraction.

The dividend policy is assumed to be exogenously fixed, so that bank capital is not a choice variable for the bank. The problem for wholesale branch is to choose loans \( L_d(i) \), deposits \( D_i(i) \), and interbank borrowing \( B_{i}^{ib}(i) \) so as to maximize profits subject to the balance sheet constraint given by equation (23) and \( R_i^b = \alpha_i^d D_i(i) \)

\[ \max_{L_d(i), D_i(i), B_{i}^{ib}(i)} E_0 \sum_{r=0}^{\infty} \beta^r \left[ i_d^b L_d(i) + i_d^b R_{i}^{ib}(i) - i_i D_i(i) - i_b B_{i}^{ib}(i) - Z_i(i) - \frac{\phi_z}{2} \left( \frac{Z_i(i)}{L_d(i)} - \kappa^b \right)^2 \right] \]

where \( i_d^b \) - the wholesale deposit rate and \( i_i^b \) - the wholesale loan rate are taken as given.\(^{14}\) \( \phi_z \) is the cost of bank capital adjustment parameter. In a symmetric equilibrium, the first-order condition gives

\(^{14}\) Banks value the future stream of profits using the households discount factor since they are owned by households.
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\[ i_t^b = i_t - \phi_Z \left( \frac{Z_t}{L_t^d} - \kappa^b \right) \left( \frac{Z_t}{L_t^d} \right)^2 \]  
\[ i_t^s = (1 - \alpha^s_t - \alpha^d_t) i_t + \alpha^s_t i_t^l . \]  

The above equations state a condition that links the rate on wholesale loans to the policy rate \( i_t \) and the leverage of the banking sector \( \frac{Z_t}{L_t^d} \) and wholesale deposit rate to the policy rate, t-bill rate and reserve requirements, \( \alpha^s_t \) and \( \alpha^d_t \).

It highlights the role of bank capital and reserve requirements in determining the credit supply conditions. As long as there is a spread between lending and the policy rate - the bank would like to make as many loans as possible, increasing the leverage and thus profit per unit of capital. On the other hand, when leverage increases, the capital-to-asset ratio moves away from \( \kappa^b \) and banks pay a cost, which reduces profits. So, the banks’ problem is to choose an optimal level of loans such that the marginal cost of reducing the capital-to-asset ratio exactly equals the spread between (wholesale) deposit and lending rate.

The spread between the wholesale lending rate and the policy rate is inversely related to the overall leverage of the banking system - in particular, when banks are scarcely capitalized and capital constraints become more binding (i.e. when leverage increases) margins become tighter.

Overall profits of bank \( i_t \) are the sum of earnings from the wholesale unit and the retail branches. After deleting the intra-group transactions, profits is given by

\[ \Pi^b_t(i) = i_t^s D_t^l(i) - i_t^d(i) D_t^s(i) - \alpha^d_t D_t^s(i) - \phi_Z \left( \frac{Z_t(i)}{L_t^d(i)} - \kappa^d \right)^2 Z_t(i) \]  

3.3 Production Sector

3.3.1 Entrepreneurs

We model the behavior of entrepreneurs as proposed by Bernanke, Gertler and Gilchrist (1999). We follow the modeling framework of Gertler, Gilchrist and Natalucci (2007) and Elekdag, Justiniano and Tchakarov (2005) while introducing financial accelerator i n an open economy context. Entrepreneurs combine labor hired from households with capital purchased from the capital producers, to produce intermediate goods in a perfectly competitive setting. They are risk neutral and have a finite horizon for planning purposes. The probability that an entrepreneur will survive until the next period is \( \nu_t \), so that the expected live horizon is \( \frac{1}{1 - \nu_t} \).

The number of new entrepreneurs entering the market each period is equal to the number of entrepreneurs exiting, implying a stationary population. To get started, new entrepreneurs receive a small transfer of funds from exiting entrepreneurs.

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15 This assumption ensures that entrepreneur’s net worth (the firm equity) will never be enough to fully finance the new capital acquisition.
At the end of each period $t$, entrepreneurs purchase capital $K_{t+1}$, to be used in the subsequent period at a price $q_t$. They finance capital acquisition partly through their net worth available at the end of period $t$, $n_{t+1}$, and partly through borrowing domestically and through raising foreign currency denominated debt. Total borrowing $B_t$ is given by

$$B_t = q_t K_{t+1} - n_{t+1} \quad (28)$$

where $q_t$ is the real price per unit of capital. Fraction of loan raised domestically $B^d_t$ is exogenous to the model and is given by $\omega$. Thus, $B^d_t = \omega(q_t K_{t+1} - n_{t+1})$ and $B^e_t = (1 - \omega)(q_t K_{t+1} - n_{t+1})$ where $B^e_t$ is the amount of loans raised abroad.

Entrepreneurs use units of $K_t$ capital and $L_t$ units of labor to produce output $Y_t^W$, using a constant returns to scale technology

$$Y_t^W \leq \theta_t K_t^\phi L_t^{1-\phi}, \quad \phi \in (0,1) \quad (29)$$

where $\theta_t$ is a stochastic disturbance to total factor productivity. Entrepreneur maximizes profits by choosing $K_t$ and $L_t$ subject to the production function given by equation (29).

First-order conditions for this optimization problem are

$$W_t = (1 - \phi)P_{H,t}^W \frac{Y_t^W}{L_t} \quad (30)$$

$$r_{K,t}^* = \frac{P_{H,t}^W}{P_t} (\phi) \frac{Y_t^W}{K_t} \quad (31)$$

where $P_{H,t}^W$ is the price of the wholesale good and $r_{K,t}^*$ is the marginal productivity of capital.\(^{16}\) The expected marginal real return on capital acquired at $t$ and used in $t+1$ yields the expected gross return $E_t(1 + r_{K,t+1}^k)$, where

$$E_t(1 + r_{K,t+1}^k) = E_t \left[ \frac{r_{K,t+1}^* + (1 - \delta)q_t}{q_t} \right] \quad (32)$$

and $\delta$ is the rate of depreciation of capital and $r_{K,t+1}^*$ is the marginal productivity of capital at $t+1$.

Following Bernanke, Gertler and Gilchrist (1999), we assume that there exists an agency problem which makes external finance more expensive than internal funds. While entrepreneurs costlessly observe their output, which is subject to random outcomes, banks cannot verify output outcomes costlessly. After observing the outcome, entrepreneurs decide whether to repay their debt or to default. If they default, banks audit the loan and recover the outcome less the monitoring costs. This agency problem makes loans riskier and banks charge a premium over the lending rate.

\(^{16}\) Since the firms are perfectly competitive, $P_{H,t}^W = MC_t^W$. 

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Thus, entrepreneurs’ marginal external financing cost is the product of the gross premium and the gross real opportunity cost of funds that would arise in the absence of capital market frictions.

Therefore, the expected marginal cost of borrowing, $E_i f_{t+1}$, is given by

$$E_i f_{t+1} = (1 + \Gamma_i) \left\{ \Theta \left( \frac{n_{t+1}}{q_i K_{t+1}} \right) \sigma E_i \left[ \frac{i_t}{\pi_{t+1}} \right] + \Theta \left( \frac{n_{t+1}}{q_i K_{t+1}} \right) (1 - \sigma) E_i \left[ \frac{i_t}{\pi_{t+1}} \frac{RER_{t+1}}{RER_t} \right] \right\} \quad (33)$$

where $\Theta$ is the gross finance premium which depends on the size of the borrower’s equity stake in the project (or, alternatively, the borrowers’ leverage ratio). $\Gamma_i$ is the shock to the cost of borrowing, $\pi_t = \frac{P_t}{P_{t-1}}$, is the gross domestic inflation and $\pi_t^* = \frac{P_t^*}{P_{t-1}}$, is the gross world inflation. $RER_t$, is the real exchange rate defined as

$$RER_t = \frac{e_t P_t^*}{P_t} \quad (34)$$

We characterize the risk premium by $\Theta$ by $\left( \frac{n_{t+1}}{q_i K_{t+1}} \right)^{\sigma}$, where $\sigma$ represents the elasticity of external finance premium with respect to a change in the leverage position of entrepreneurs. As $\left( \frac{n_{t+1}}{q_i K_{t+1}} \right)$ falls, entrepreneur relies on uncollateralized borrowing (higher leverage) to a larger extent to fund his project. Since this increases the incentive to misreport the outcome of the project, the loan becomes riskier and the cost of borrowing rises. Entrepreneurs’ demand for capital depends on the expected marginal return and the expected cost of borrowing. Thus, demand for capital satisfies the following optimality condition

$$E_i (1 + r_{t+1}) = (1 + \Gamma_i) \left\{ \Theta \left( \frac{n_{t+1}}{q_i K_{t+1}} \right) \sigma E_i \left[ \frac{i_t}{\pi_{t+1}} \right] + \Theta \left( \frac{n_{t+1}}{q_i K_{t+1}} \right) (1 - \sigma) E_i \left[ \frac{i_t}{\pi_{t+1}} \frac{RER_{t+1}}{RER_t} \right] \right\} \quad (34)$$

Above equation provides the foundation for the financial accelerator. It links entrepreneurs’ financial position to the marginal cost of funds and, hence, to the demand for capital. Also, movements in the price of capital, $q_{t+1}$, may have significant effects on the leverage ratio. In this way the model captures the link between asset price movements and collateral stressed in the theory of credit cycles (Kiyotaki and Moore, 1997). At the beginning of each period, entrepreneurs collect their returns on capital.

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17 We assume that law of one price holds for each of the differentiated goods.

18 Though the behavior described above is true for an individual entrepreneur, we appeal to the assumptions in Bernanke, Gertler and Gilchrist (1999) that permit us to write it as an aggregate condition. See Bernanke et.al. (1999) and Carlstrom and Fuerst (1997) for details. It implies that gross finance premium may be expressed as a function of aggregate leverage ratio, i.e. it is not entrepreneur specific.
and honor their debt obligations. Aggregate entrepreneurial net worth evolves according to

\[ n_{t+1} = V_t + (1 - V_t)H_t \]  

where \( V_t \) is the net worth of the surviving entrepreneurs carried over from the previous period, \( 1 - V_t \) is the fraction of new entrepreneurs entering and \( H_t \) (which is exogenous in the model) are the transfers from exiting to newly entering entrepreneurs. \( V_t \) is given by

\[
V_t = \left( 1 + r^k_t \right) q_{t-1}K_t - \left( 1 + \Gamma_t \right) \Theta \left( \frac{n_t}{q_{t-1}K_t} \right) \left[ i_{t-1} \right] \left( \sigma \left( q_{t-1}K_t - n_t \right) \right)
\]  

\[
- \left( 1 + \Gamma_t \right) \Theta \left( \frac{n_t}{q_{t-1}K_t} \right) E_t \left[ \frac{i_{t-1} RER_t}{\pi_t RER_{t-1}} \right] \left( 1 - \sigma \right) \left( q_{t-1}K_t - n_t \right) \right].
\]

As equations (35) and (36) suggest, the principal source of movements in net worth stems from unanticipated movements in returns and borrowing costs. In this regard, unforecastable variations in asset prices, \( q_t \), is the main source of fluctuations in \( (1 + r^k_t) \). On the cost side, unexpected movements in inflation and exchange rates are the major sources of fluctuations in the net worth. An unexpected deflation or depreciation, for example, reduces entrepreneurial net worth, thus enhancing the financial accelerator mechanism. Entrepreneurs going out of business at time \( t \) consume and transfer some funds to new entrepreneurs out of the residual equity \( (1 - \nu) V_t \). Thus consumption by entrepreneurs are given by

\[
C^e_t = (1 - \nu) \left( V_t - H_t \right) \]  

3.3.2 Capital Producers

Capital producers combine the existing capital stock, \( K_t \), leased from the entrepreneurs to transform an input \( I_t \), gross investment, into new capital \( K_{t+1} \) using a linear technology.\(^{19}\) We assume that capital producers face a quadratic adjustment costs given by

\[
\frac{\kappa \left( I_t - \delta \right)^2}{2 \delta} K_t.
\]

where \( \kappa \) is the capital adjustment cost parameter. The aggregate capital stock evolves according to

\(^{19}\) This setup follows Bernanke et al. (1999) and assumes that capital producers rent the capital stock from entrepreneurs and use it to produce new capital. Since this takes place within the period we assume that the rental rate is zero.
A Credit and Banking Model for Emerging Markets and an Application to the Philippines

\[ K_{t+1} = (1 - \delta)K_t + \zeta_{t, I}I_t - \left( \frac{\kappa}{2} \left( \frac{I_t}{K_t} - \delta \right) \right)^2 K_t \]  \hspace{1cm} (38)

where \( \zeta_{t, I} \) is a shock to the marginal efficiency of investment (Greenwood et al. 1988).

Gross investment consists of domestic and foreign final good and we assume that it is the same aggregation function as the consumption basket

\[ I_t = \left[ \frac{1}{\eta} \left( I_{H, t} \right)^{\eta-1} + (1 - \alpha) \frac{1}{\eta} \left( I_{F, t} \right)^{\eta-1} \right]^{\eta-1} \]  \hspace{1cm} (39)

Optimal demand for domestic and imported investment is given by

\[ I_{H,t} = \alpha \left( \frac{P_{H,t}}{P_t} \right)^{-\eta} I_t \]  \hspace{1cm} (40)

\[ I_{F,t} = (1 - \alpha) \left( \frac{P_{F,t}}{P_t} \right)^{-\eta} I_t \]  \hspace{1cm} (41)

Price of investment is the same as the domestic price index given by equation (6).

Capital producing firms maximize expected profits

\[ \text{Max } E_t \left\{ q_t \left[ \zeta_{t, I}I_t - \left( \frac{\kappa}{2} \left( \frac{I_t}{K_t} - \delta \right) \right)^2 K_t \right] - I_t \right\} \]

and the first-order condition for the supply of capital is given by

\[ q_t \left[ \zeta_{t, I} - \kappa \left( \frac{I_t}{K_t} - \delta \right) \right] = 1 \]  \hspace{1cm} (42)

3.3.3 Retailers

There is a continuum of retailers \( s \in [0,1] \). They purchase wholesale goods at a price equal to the nominal marginal costs, \( MC_t^W \) (the marginal cost in the entrepreneurs’ sector) and differentiate them at no cost.\(^{20}\) They sell their product in a monopolistically competitive domestic and export market. Final domestic good, \( Y_t^W \), is a CES composite of individual retail goods

\[ Y_{H,t} = \left( \int_0^1 Y_{H,t}(s)^{\frac{1}{\varepsilon}} ds \right)^{\frac{1}{\varepsilon-1}} \]  \hspace{1cm} (43)

\(^{20}\) Entrepreneurs sell their goods in a perfectly competitive market so \( P_{H,t}^W = MC_t^W \). Retail sector is defined only to introduce nominal rigidity into the economy. Since they differentiate goods costlessly, the marginal cost of producing final goods is same as \( MC_t^W \).
Corresponding price of the composite consumption good, $P_{H,t}$, is given by equation (7). Demand facing each retailer can be written as

$$Y_{H,t}(s) = \left( \frac{P_{H,t}(s)}{P_{H,t}} \right)^{-\varepsilon_t} Y_{H,t}$$  \hspace{1cm} (44)

For simplicity we assume that the aggregate export demand function is given by

$$Q_t^X = \left( \frac{P_{X,t}}{P_t} \right)^{-\zeta_t}, \zeta_t > 0$$  \hspace{1cm} (45)

where $P_{X,t} = eP_{H,t}$ is the price of exports, $P_t$ is the world price index and $Q_t^X$ is the total exports. $\zeta_t$ is the price elasticity of exports.

### 3.3.4 Price Setting by Retailers

Following Ireland (2001) and Rotemberg (1982), there is sluggish price adjustment to make the intermediate goods pricing decision dynamic. This ensures that monetary policy has real effects on the economy. Following Julliard et al. (2004), we assume that retailers face an explicit cost of price adjustment measured in terms of intermediate goods and is given by

$$\frac{\theta_d}{2} \left[ \frac{P_{H,t}(s)/P_{H,t-1}(s)}{\pi} - 1 \right]^2 (Q_t^d + Q_t^e)$$

where $Q_t^d$ is the total domestic demand, $\theta_d \geq 0$ is the parameter determining the cost of price adjustment relative to last period’s price level and $\pi$ is the steady state inflation. Following Saxegaard (2006b), real profits are given by

$$\Pi_t = \left[ \frac{P_{H,t}(s)}{P_t} - \frac{MC_i}{P_t} \right]^e Q_t^e + \left[ e_iP_{X,t}(s)/P_t - \frac{MC_i}{P_t} \right]^e \left( P_{X,t}(s)/P_X - 1 \right)^2 (Q_t^d + Q_t^e)$$

where $e_i$ is the nominal exchange rate, expressed as the domestic currency price of foreign currency.\(^{21}\) Note also that we allow for a shock to the elasticity of substitution between differentiated goods $\varepsilon_i$, which determines the size of the markup of intermediate good firms. Alternatively, the shock to $\varepsilon_i$ can be interpreted as a cost-push shock of the kind introduced into the New Keynesian model by Clarida, Gali and Gertler (1999).

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\(^{21}\) An increase in $e_i$ implies depreciation of the domestic currency.
The optimal price setting equation for domestic good (non-tradable good) can then be written as:

\[ P_{H,t} = \frac{\varepsilon_t}{\varepsilon_t - 1} MC_{W,t} - \frac{\vartheta_d}{\varepsilon_t - 1} P_t \pi_{H,t} \left[ \frac{\pi_{H,t}}{\pi} - 1 \right] \]

\[ + \frac{\vartheta_d}{\varepsilon_t - 1} P_tE_t \left\{ \rho_{t+1} Y_{H,t+1} Y_{H,t} \left[ \frac{\pi_{H,t+1}}{\pi} - 1 \right] \right\} \]

(46)

where \( \pi_{H,t} = P_{H,t} / P_{H,t-1} \), is the domestic price inflation.

We have used the fact that all retailer firms are alike to impose symmetry and we assume that the law of one price holds in the export market so that \( P_{X,t} = P_{H,t} / \varepsilon_t \).

Above equation reduces to the well known result that prices are set as a markup over marginal costs if the cost of price adjustment, \( \vartheta_d = 0 \). In general however, the goods price will follow a dynamic process and the firm's actual markup will differ from, but gravitate towards the desired markup. Profits from retail activity are rebated lump-sum to households (i.e. households are the ultimate owners of retail outlets).

### 3.4 Central Bank and Government

#### 3.4.1 Central Bank

We assume that the central bank adjusts the interbank rate, \( \hat{i} \), in response to deviations in inflation and output from their steady state values. The monetary policy evolves according to the following Taylor-type-policy rule

\[ \log\left( \frac{\hat{i}}{i} \right) = \rho_i \log\left( \frac{i-1}{i} \right) + \rho_{\pi} \log\left( \frac{\pi_i}{\pi} \right) + \rho_{\pi} \log\left( \frac{\pi_i}{\pi} \right) + \varepsilon_{i,t} \]

(47)

where \( \rho_i \) and \( \rho_{\pi} \) are the weights on inflation and output gap assigned by the policy makers,\(^{23}\) \( \rho_i \) represents the Central Banker's preference for interest rate smoothing. \( \pi, \pi \) and \( i \) are the steady state values of output, inflation and nominal interest rate. \( \varepsilon_{i,t} \) is a monetary policy shock to capture unanticipated increase in the nominal interest rate.

#### 3.4.2 Government

The fiscal authority is assumed to purchase an exogenous stream of the final good \( G_i \), which is financed by levying lump-sum tax on households, and issuing

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\(^{22}\) We assume that price of imported goods are set in the similar function. So the price setting equation for the price of imported good is given by a similar expression with \( \pi_{M,t} \), import price inflation, in place of \( \pi_{H,t} \), and \( \vartheta_d \) in place of \( \vartheta_d \).

\(^{23}\) We include an interest rate smoothing parameter in our monetary policy rule as the benefits of such smoothing are well documented in the literature (see, e.g., Lowe and Ellis, 1997; Sack and Wieland, 1999). Various authors have argued that moving interest rates in small steps increases its impact on the long-term interest rate; it also reduces the risks of policy mistakes and prevents large capital losses and systemic financial risks. Mohanty and Klau (2004) find that all emerging market central banks put substantial weight on interest rate smoothing. Clarida et al. (1998) find that central banks of advanced economies also put a large weight on interest rate smoothing.
securities held by the banks. For simplicity we assume that the fiscal authority has no access to international capital markets. Its period by period budget constraint is given by

$$G_t + \left(1 + \frac{i_{t-1}}{\Pi_t}\right) R_{t-1}^b = \tau_t + R_t^b$$

(48)

Government buys both domestic and foreign final goods and we assume that it is the same aggregate function as the consumption basket

$$G_t \equiv \left[ \frac{1}{\gamma} \left(G_{H,t}\right)^{\gamma-1}\alpha + \left(1 - \alpha\right) R_t^F \right]^{\gamma-1}$$

(49)

Optimal demand for governments’ domestic and imported consumption is given by

$$G_{H,t} = \alpha \left(\frac{P_{H,t}}{P_t}\right)^{\gamma} G_t$$

(50)

$$G_{F,t} = (1 - \alpha) \left(\frac{P_{F,t}}{P_t}\right)^{\gamma} G_t$$

(51)

3.5 Market Clearing and Aggregation

Domestic households, exiting entrepreneurs, capital producers, government and rest of the world buy final goods from retailers. The economy wide resource constraint is given by

$$Y_{H,t} = C_{H,t} + C_{H,t}^e + I_{H,t} + G_{H,t} + Q_t^X = Q_t^d + Q_t^X$$

(52)

where

$$Q_t^d = C_{H,t} + C_{H,t}^e + I_{H,t} + G_{H,t}.$$  

(53)

The national income accounting equation is given by

$$P_t^* ZZ_t = P_t (C_t + C_t^e + I_t + G_t) + P_{t X} Q_t^X - P_{t F} Q_t^M + \frac{g_{dt}}{2} \left[ \frac{P_{H,t}}{P_{H,t-1}} \Pi - 1 \right] P_{H,t} Y_{H,t}$$

where $Q_t^M$ is the total imports and $ZZ_t$ is the real GDP.

Markets for loan and deposits clear –

$$D_t = L_t^d = B_t^d.$$  

(54)

Funds in the inter-bank market must implicitly balance at the end of each period:

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24 Following Bernanke et al. (1999) we ignore monitoring costs in the general equilibrium.
The model allows for non-zero holdings of foreign currency bonds by households and foreign currency denominated debt by entrepreneurs. In particular, it is well known (see inter alia Schmitt-Grohe and Uribe, 2003) that unless adjustments are made to the standard model, the steady state of a small open-economy model with foreign currency bonds will depend upon initial conditions and will display dynamics with random walk properties. In particular, if the domestic discount rate exceeds the real rate of return on foreign currency bonds, then domestic holdings of foreign currency bonds will increase perpetually. Beyond the obvious conceptual problems of such an outcome, our analysis is constrained by the fact that the available techniques used to solve non-linear business cycle models of the type considered here are only valid locally around a stationary path.

Fortunately, a number of modifications to the standard model are available which enable us to overcome this issue. In this paper, we follow Schmitt-Grohe and Uribe (2003) and specify a foreign debt elastic risk-premium whereby holders of foreign debt are assumed to face an interest rate that is increasing in the country's net foreign debt. In particular, \( i^f_t \), the interest rate at which households and entrepreneurs can borrow foreign currency equals the exogenous world interest rate plus a spread that is a decreasing function of economy's net foreign asset position:

\[
 i^f_t = i^w_t - \chi_d \left[ \frac{(B^f_t + L^f_t)/P^* - \delta_t}{\Omega} \right] \frac{(B^f_t + L^f_t)/P^* - \delta_t}{\Omega}
\]

where \( \chi_d \) is a parameter which captures the degree of capital mobility in the market for foreign-currency borrowing and lending by households and \( \Omega \) is the steady-state value of exports. As in Schmitt-Grohe and Uribe (2003) we include the steady-state level of debt so that the risk-premium is nil in steady state. Note that under perfect capital mobility (\( \chi_d = 0 \)), the country would face an infinite supply or demand of foreign capital and the model would not have a well-defined steady state. As Kollmann (2002) points out, the model in this case becomes a version of the permanent income theory of consumption, with non-stationary consumption and net assets.

### 3.6 Specification of the Stochastic Processes

Our model includes fifteen structural shocks: three shocks to technology and preferences \( \theta_t, \tilde{C}_{C,t}, \tilde{C}_{L,t} \), three foreign shocks to world interest rates, world inflation, and the price elasticity of exports \( \pi^*, i^*, \tilde{\chi}^* \), two shocks to investment efficiency and firms’ markup \( \tilde{\chi}_{I,t}, \tilde{\chi}_{E_t} \), two financial shocks to the cost of borrowing by entrepreneurs and the survival rate of entrepreneurs \( \Gamma_t, V_t \), a monetary policy shock, a government spending shock \( \tilde{\epsilon}_{i,j}, \tilde{G}_t \), a shock to CRR \( \alpha^f_t \), a shock to SLR(\( \alpha^d_t \)) and a shock to back capital \( m_t \). Apart from monetary policy shock, \( \tilde{\epsilon}_t \), which is a zero mean i.i.d. shock with a standard deviation \( \sigma_t \), the other structural shocks follow AR(1) processes:
\[ x_t = (1 - \rho_s) x + \rho_s x_{t-1} + \varepsilon_{xt} \]

where \( x_t = \{ \theta_t, \xi_{C,t}, \xi_{L,t}, \sigma_t^*, \iota_t^*, \iota_t^*, G_t, \Gamma_t, \varepsilon_t, \xi_{L,t}, \alpha_t^d, \alpha_t^l, \nu_t, m_t \} \), \( x \geq 0 \) is the steady-state value of \( x_t \), \( \rho_s \in (-1,1) \), and \( \varepsilon_{xt} \) is normally distributed with zero mean and standard deviation \( \sigma_{xt} \).

### 3.7 Calibration

Parameter selection for the model is a challenging task. There is no consensus on the values of some parameters, and for the banking parameters no corresponding estimates are available in the literature. Moreover, most of the parameters used in the literature are based on micro data from advanced countries. Hence, our approach is three pronged. We calibrate the parameters in the model that determine the steady state based on findings from previous studies on emerging markets and historical data for the Philippines. For calibrating the parameters which determine the dynamic properties of the model away from the steady state we use the values estimated in Anand et al. (2010) for an Asian emerging market. While for banking sector parameters we calibrate them to match historical averages.

The appropriate value of the Frisch elasticity \( (1/\psi) \) is both important and controversial. The range of values used in the literature goes from 0.25 to 1.\(^{25}\) For our benchmark case we assume it to be 0.66 \( (\psi = 1.5) \). The substitution elasticity between imported and domestically produced goods is set at 1.5 (Saxegaard, 2006a), while the elasticity of substitution of exports, \( \zeta^* \), is set to 4.89, a value consistent with the steady state export to GDP ratio.

Following Christensen and Dib (2006), the steady state leverage ratio of entrepreneurs, \( K/N \), is set to 0.5. The probability of entrepreneurial survival to next period, \( \nu \), is set at 0.98. Following Anand et al. (2010) we set elasticity of external finance premium with respect to firm leverage \( \sigma^* \) equal to 0.0566.\(^{26}\)

For calibrating parameters which determine the dynamic properties of the model we follow the estimates of Anand et al. (2010). The habit persistence parameter, \( b \), is set to 0.4986. Price adjustment costs of domestic goods and price adjustment costs of imported goods are set to 118.22 and 100.043 respectively. Capital cost adjustment cost is set equal to 23.008. Monetary policy parameters are chosen as \( \rho_i = 0.8, \rho_{\pi} = 2, \rho_y = 0.01 \) which are in the range of values commonly used in the literature.

For the banking parameters, no corresponding estimates are available in the literature. The parameters \( \varepsilon^d \) and \( \varepsilon^l \) that measure the degree of monopoly power of deposit and lending banks are set equal to 31.12 and 2.51, respectively. These values are chosen to match the historical averages of deposit and loan rates, \( i^d \) and \( i^l \). The parameter \( \sigma^d \) is set at the value 0.035, that ensures that the steady state value ratio of

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\(^{25}\) Christiano, Eichenbaum and Evans (1996) estimate it to be 0.25 while Rotemberg and Woodford (1997) estimate it to be 0.40. Blundell and MaCurdy (1999) estimate the intertemporal elasticity of labor supply to be in the range of \( (0.5, 1) \).

\(^{26}\) This is slightly below the estimate of 0.066 for Korea in Elekdag et al. (2005) and somewhat higher than estimate in Dib et al. (2008) for Canada.
bank capital to total loans is exactly 0.10. We follow the estimates of Gerali et al. (2010) for setting the adjustment cost parameters for interest rates and bank capital to loan ratio. Cost of adjusting interest rates, \( \phi_i \), and \( \phi_l \), are set equal to 20 while the cost of bank capital adjustment, \( \phi_Z \), is set equal to 10.

We calibrate the shocks’ process parameters using values estimated in Anand et al. (2010). The parameter of credit tightening process is calibrated using the estimated values in Gerali et al. (2010). Since there are no parameter estimates available in literature on non-monetary policy interventions, we choose the values of AR(1) coefficients at 0.99.

4 IMPULSE RESPONSE

The objective of this paper is to study the monetary transmission mechanism in the presence of financial frictions and financial intermediation. We are also interested in understanding how shocks in the financial sectors are transmitted to the real economy and to study the transmission mechanism of non-standard monetary policies. In comparison to traditional DSGE models, our model has two additional channels for the transmission of shocks – the financial accelerator channel (credit demand channel) and the banking channel (credit supply channel). Our aim is to study how these channels affect the transmission of shocks.

A useful way to illustrate the importance of financial accelerator is to consider the impulse response functions when the financial accelerator is present and when it is not. Therefore, we analyze the impulse responses of key macroeconomic variables to the structural shocks in two models: (1) the full model with banking sector and financial frictions (baseline hereafter), and (2) a model with only banking sector (no-FA model, hereafter).

In order to understand the role of banking sector, we compare our baseline model against a number of models where we shut down one feature of the model at a time: (1) a model where we shut down the bank capital channel; i.e. a model with a simplified balance-sheet for banks, including only deposits on the liability side (no-BK model, hereafter)\(^{30}\); (2) a model where we also remove stickiness in bank interest rate setting and allow for flexible rates (no-BK-FR model, hereafter)\(^{31}\); and (3) a model with perfectly competitive banks, i.e. a single interest rate model with financial frictions (no-B model, hereafter).\(^{32}\) Strictly speaking even though we can not compare the impulse responses of our baseline model with that of no-B model, it is instructive to plot them to understand how the presence of banks affect the business cycle.

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\(^{27}\) Steady state capital to loan ratio is set to 0.1 which is consistent with the regulatory capital requirements for banks in the Philippines (slightly higher than imposed by Basel II).

\(^{28}\) We do a simple OLS to get this coefficient.

\(^{29}\) no-FA model is obtained by setting the elasticity of the external finance premium with respect to firm leverage, \( \sigma' \), equal to zero, but keeping all other parameters same as in the baseline model.

\(^{30}\) To obtain no-BK model, we set the cost of bank capital adjustment, \( \phi_Z \), equal to zero and rebate the banking profit to households in a lump-sum fashion.

\(^{31}\) To get the no-BK-FR model, we set the costs to change rates \( \phi_i \) and \( \phi_l \) equal to zero in the no-BK model model.

\(^{32}\) We set \( \sigma' = \sigma^d = 0 \) in the no-BK-FR model. Then we set the elasticities of loan and deposit, \( \sigma^l \) and \( \sigma^d \) equal to infinity. The steady state values of the two models differ as the effective lending rate and deposit rate faced by the agents are not the same. Also, absence of banks implies that there is no CRR or SLR requirement.
We use a monetary policy shock and productivity shock to explore the effects of financial frictions and financial intermediation on the transmission of shocks. We then look at a shock to bank capital (which can be considered as reflecting tightening credit conditions) to understand how shocks originating in the credit market affect real variables. To analyze non-standard monetary policy transmission mechanism, we focus on shocks to cash reserve ratio and shocks to the statutory liquidity ratio.

4.1 Monetary Policy Shock

The transmission of monetary shock is studied by analyzing the impulse responses to a 100 bps increase in the policy rate \((i_t)\). Due to the presence of multiple channels, the overall effect on the transmission mechanism of monetary policy could in principle be ambiguous (Gerali et al. 2010). In order to understand the importance of financial frictions we plot the responses of baseline and no-FA model in Figure 4.

Figure 5 plots the responses of baseline, no-BK, no-BK-FR and no-B model to see how the presence of banking sector impinges on the transmission of shock. Each variable’s response is expressed as the percentage deviation from its steady state, with the exception of rate variables, which are in percentage points.

In all these models, increase in the nominal interest rate raises the cost of domestic borrowing for consumers and therefore leads to a contraction in consumption. It also raises the demand for domestic bonds, and thus appreciates the domestic currency, while the net worth of entrepreneurs declines because of the declining return to capital and higher real interest costs associated with existing debt (debt-deflation effect). Output contracts both as a result of decreased domestic demand and a result of decreased competitiveness following the appreciation of the real exchange rate. The contraction in demand in turn leads to a fall in inflation. In the baseline model, bank loan rates and deposit rates increase less than the policy rate reflecting the imperfect pass-through of lending rates.

As evident from Figure 4, presence of financial frictions results in the amplification of the shock. Reduction in output, consumption, investment, net worth and capital is much larger under the baseline model as compared to the no-FA model. In the presence of a financial accelerator, the external finance premium increases as a result of the decline in the net worth and rising leverage. This pushes up the real borrowing cost for entrepreneurs, putting downward pressure on investment and the price of capital which further reduces the net worth. This reduction in net worth leads to a further increase in the cost of borrowing (the premium goes up), thus reducing capital, investment and output further (second round effects). This mechanism amplifies the magnitude and the persistence of transitory monetary policy shocks as evident from the impulse responses.

Each variable’s response is expressed as the percentage deviation from its steady state level. Interest rates are shown as absolute deviation from steady state. Baseline model represents the complete model with financial frictions and banking sector. no-FA model is obtained by setting the elasticity of the external finance premium with respect to firm leverage \(\sigma\) equal to zero, but keeping all other parameters same as in the baseline model. So it represents a model without financial frictions.
Figure 5 gives an indication of how the presence of banking sector may affect the transmission of monetary shock. Comparing no-B model with no-BK-FR model highlights the role of imperfect competition in the credit market. As we can see, market power of banking system increases the volatility of real variables. Market power of banks result in higher lending rates (as lending rate is a mark-up over the policy rate) increasing the cost of borrowing for the firms. Due to financial accelerator, external finance premium goes up, reducing the net worth further and forcing the firms to borrow more from banks at an increasingly higher cost. This mechanism results in the amplification of the monetary shock. Our result is similar to Mandelman (2009), where market power of banks result in the amplification of the shocks.

However, when we compare the baseline model with no-B model, we find that the presence of banking sector attenuates the response of monetary shock. This result is driven by the stickiness in interest rate setting, which prevents banks to fully pass on the

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As no-BK-FR model add a simplified banking sector to the no-B model. In no-BK-FR model, only bank’s market power channel is present (as both the bank capital channel and sticky interest rates channel are shut).
policy rate increase to retail rates. Borrowing costs faced by the firms is lower than no-B case and therefore response of output, investment and capital is muted. Thus, the presence of banking sector with sticky interest rates has a dampening effect of policy shock on output, investment, capital and net worth. Gerali et al. (2010) has also found similar attenuating effect of the banking system in the presence of sticky bank rates.

Presence of bank capital in our model seems to have virtually no effect on the dynamics of the real variables. This partly reflects the use of rather small value of the capital cost adjustment parameter in this exercise. As an example, our calibration implies that a reduction of the capital-to-asset ratio by half (from its steady state value of 10 percent) would increase the spread between wholesale loan rates and the policy rate by only 20 basis points.

Figure 5. Impulse Responses to 100 Bps Contractionary Monetary Policy Shock (Baseline model, no-BK model, no-BK-FR model and no-B model)

Note: Each variable’s response is expressed as the percentage deviation from its steady state level. Interest rates are shown as absolute deviation from steady state. Baseline model represents the complete model with financial frictions and banking sector. In no-BK model we shut down the bank capital channel. We set the cost of bank capital adjustment, $\phi_Z$, equal to zero and rebate the banking profit to households in a lump-sum fashion. no-BK-FR model, also shuts down the sticky interest rate channel. It is obtained
by setting $\phi_i$ and $\phi_j$ equal to zero in the no-BK model model. To obtain no-B model, we set $\alpha^L = \alpha^D = 0$ and the elasticities of loan and deposit, $\epsilon^L$ and $\epsilon^D$ equal to infinity. no-B model is a single interest rate model with financial frictions but no banking sector. The steady state values of the two models differ as the effective lending rate and deposit rate faced by the agents are not the same. Since the steady-state under the two models is different, this plot is only instructive.

4.2 Technology Shock

The transmission of a technology shock is studied by looking at the impulse responses coming from the same set of models described in the previous subsection. Figure 6 plots the responses of baseline and no-FA model. Figure 7 plots the responses of baseline, no-B and no-BK-FR model to see how the presence of banking sector impinges on the transmission of shock. Each variable’s response is expressed as the percentage deviation from its steady state, with the exception of rate variables, which are in percentage points.

In all these models, negative technology shock decreases the return to capital and thus leads to decrease in investment and output. At the same time, negative productivity shock increases firms’ marginal costs and thus increases inflation. The lower return to capital, and higher inflation, has opposite effects on net worth, but in our model the negative impact of the lower capital return to capital dominates. Higher inflation and domestic interest rates result in real appreciation thereby decreasing the demand for exports, which lead to further output contraction. Monetary policy responds to the increase in inflation by raising the policy rate, and therefore decreasing loans, aggregate demand and output further.

Figure 6 shows that the financial accelerator has less of an impact following a negative shock to technology. When the financial accelerator is active, the fall in net worth pushes up the risk premium faced by entrepreneurs and leads to a larger response of investment and capital. While output is somewhat more volatile when the financial accelerator is present, the impact is significantly less than following a shock to monetary policy.

Figure 7 gives an indication of how the presence of banking sector may affect the transmission of productivity shock. Comparing no-B model with no-BK-FR model indicates that the presence of monopolistic banking system amplifies the propagation of the shock. Similar to monetary policy shock, market power of banks result in higher lending rates (as banks apply a mark-up to the inter-bank rate) resulting in higher borrowing costs for the firms which in the presence of financial accelerator leads to a an increase in external finance premium, thus reducing capital, investment and output further. This mechanism results in the amplification and persistence of the negative shock. Again our result is similar to that of Mandelman (2009).

However, in the presence of sticky interest rates, banking sector attenuates the response of the technology shock (comparing baseline with no-B model). Since bank rates are sticky, increase in the retail rates are much less than the policy rate. Thus the borrowing cost for firms increase by less in the presence of sticky interest rate setting banks. Thus, the presence of banking sector with sticky interest rates has a dampening effect of policy shock on output, investment, capital and net worth.

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34 Similar to monetary policy shock, bank capital have virtually no effect on real variables, so we do not present the impulse responses.
Figure 6. Impulse Responses to a 1 percent Negative Shock to Technology (Baseline model and no-FA model).

Note: Each variable’s response is expressed as the percentage deviation from its steady state level. Interest rates are shown as absolute deviation from steady state. Baseline model represents the complete model with financial frictions and banking sector. no-FA model is obtained by setting the elasticity of the external finance premium with respect to firm leverage, $\sigma$, equal to zero, but keeping all other parameters same as in the baseline model. So it represents a model without financial frictions.
Figure 7. Impulse Responses to a 1 percent Negative Shock to Technology
(Baseline model, no-B model and no-BK-FR model)

Note: Each variable’s response is expressed as the percentage deviation from its steady state level. Interest rates are shown as absolute deviation from steady state. Baseline model represents the complete model with financial frictions and banking sector. To obtain no-BK-FR model first we shut down the bank capital channel. We set the cost of bank capital adjustment, $\phi_Z$, equal to zero and rebate the banking profit to households in a lump-sum fashion. Then we also shut down the sticky interest rate channel. It is obtained by setting $\phi_l$ and $\phi_i$ equal to zero in the no-BK model model. To obtain no-B model, we set $\alpha^l = \alpha^d = 0$ and the elasticities of loan and deposit, $\varepsilon^l$ and $\varepsilon^d$ equal to infinity. no-B model is a single interest rate model with financial frictions but no banking sector. The steady state values of the two models differ as the effective lending rate and deposit rate faced by the agents are not the same. Since the steady-state under the two models is different, this plot is only instructive.
4.3 The Effects of a Tightening of Credit Conditions

Starting in the summer of 2007, financial markets all across the globe fell under considerable strain. The initial deterioration in the U.S. sub-prime mortgage market quickly spread across other financial markets. Banks, in particular, suffered losses from write-offs and increasing funding difficulties. A number of them were forced to recapitalize and improve their balance sheets. In addition financial intermediaries tightened credit standards for the approval of loans. Against this background, policymakers were particularly concerned with the impact that a restriction in the availability and cost of credit might have on the real economy. Our model is well suited to analyze the effects of a tightening in credit conditions on the real activity. We carry out this exercise by implementing a persistent contraction in bank capital \( z \).\(^{35}\) The shock is calibrated in a way such that it determines a fall of bank capital by 5 percent on impact. In the exercise, we assess the role of the adjustment costs on the bank capital/asset ratio by computing the impulse responses under different calibration of the parameter \( \phi_z \). We consider as benchmark a value of 10, and then a higher one, corresponding to 15, and a lower one equal to 5. Figure 8 presents the impulse response of macro variables to a negative shock to bank capital \( z \).

By construction, the credit tightening brings about a fall in bank capital. In order to compensate for the loss in equity, banks increase the rate on deposits to attract them and increase their liability. At the same time, they increase the rates on loans to increase profits. This pushes up the costs of borrowing for entrepreneurs, reducing their net worth, which in turn decreases the demand for capital, leading to a decline in investment and output. Since banks try to re-build their capital, the spread increases.

The higher the cost of adjusting the bank capital ratio, the larger is the increase in the lending rates, resulting in larger decline in net worth, demand for capital, investment and output. Output contracts on impact only when the adjustment cost is sufficiently large. With high adjustment costs, spread between wholesale loan and wholesale deposit rates increase; bank profits increase and compensates for the fall in equity. The bank capital-loan ratio converges faster to its steady state. Response of consumption depends on the size of the adjustment cost. Gerali et al. (2010) have also found similar results.

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\(^{35}\) Similar to Gerali et al. (2010) we model the credit condition tightening as a simple negative shock to the bank capital.
Figure 8. Impulse Responses to a Negative Shock to Bank Capital (Baseline model with different bank capital adjustment costs)

Note: Each variable’s response is expressed as the percentage deviation from its steady state level. Interest rates are shown as absolute deviation from steady state. Low BK cost model has bank capital adjustment cost, $\phi_Z = 5$ while High BK cost model has bank capital adjustment cost, $\phi_Z = 15$.

4.4 Unconventional Monetary Policies

Next we analyze the monetary transmission mechanism associated with non-monetary tools generally employed by the central banks in emerging markets. Policymakers resort to cash reserve requirements generally for two reasons – to control inflation by soaking up liquidity (or decreasing aggregate demand) and mitigate financial stability risks by retarding credit growth. Statutory liquidity requirements were used for similar reasons in the Philippines as well as possibly to create a captive source of
financing and keep borrowing costs low for the government. While liquidity requirements are no longer used for monetary policy purposes, the impact of shocks to the share of government securities held by banks could mimic the likely counterpart impact of sudden shifts in non-resident holdings of government securities. While analyzing the effect of these non-monetary policy tools, we assume that the central bank keeps the policy rate unchanged.

4.5 **Shock to Cash Reserve Requirement**

We present the impulse response of macroeconomic variables to a positive shock in CRR (increase in CRR by 50 bps) in Figure 9. The policy achieves its intended objective of reducing inflation. Since banks have less credit available to lend, they increase the lending rate. This results in higher borrowing costs for entrepreneurs, causing net worth to decline. Also a decline in inflation results in higher debt repayment which also reduces the net worth of the firms. It puts downward pressure on the demand for capital, resulting in the decline of investment and output. The financial accelerator mechanism results in further reduction in investment and output. Since banks are left with less credit to meet the loan requirements, they have to tap additional deposits and also use bank capital. Deposits go up. Since the bank’s profitability goes down they use their bank capital to meet the demand for loans, resulting in a worsening of their balance sheet. Lowered economic activity results in lower wage income and lower dividend income for the households. This reduces their consumption demand. Also as households shift to deposits, their current consumption demand is further reduced.

4.6 **Shock to Statutory Liquidity Ratio**

We present the impulse response of a positive shock to SLR (increase in SLR by 50 bps) or the share of government securities held by banks in Figure 10. Banks are forced to lend to the government at a lower than the lending rates and possibly below the market rate (since they only earn the t-bill rate). In order to maximize their profits, banks raise the lending rates. Higher lending rates and declining inflation leads to an increase in the borrowing costs for the firms. Thus even though the policy rate is unchanged, borrowing costs for the firms go up. This sets in the financial accelerator mechanism, leading to contraction in output, investment and consumption. Since in our model the government has a balanced budget, increased t-bill holdings in each period result in lowering of t-bill rates, which further reduces the profits of banks. This does not have to be the case in an emerging market and t-bill rates could rise with budget deficits and/or non-resident sales of government securities to domestic banks but that would still be contractionary as foreign borrowing costs would rise as debt increases. Lowered economic activity results in lower wage income and lower dividend income for the households. This reduces their consumption demand. Also as households shift to deposits, their current consumption demand is further reduced.
Figure 9. Impulse Responses to a Positive Shock to Cash Reserve Ratio (CRR)

Note: Each variable’s response is expressed as the percentage deviation from its steady state level. Interest rates are shown as absolute deviation from steady state. We assume that the central bank does not change the policy rate while changing the reserve requirements i.e. $i_t = i_{t-1}$. 
We have examined monetary and productivity shocks to understand the role of the banking sector and financial frictions in the transmission of shocks and their effect on the real economy. Results are similar to those of Mandelman (2009) in terms of amplification of shocks when the interest rates are flexible. However, when rates are sticky, our results are comparable to Gerali et al (2010), where the presence of banking sector attenuates the shocks. A similar attenuator effect arises also in Andres and Arce (2009) and Aslam and Santoro (2008). Our model also suggests that using non-traditional monetary tools may result in larger volatility than using a traditional monetary tightening.
5 CONCLUSIONS

The global crisis has amply demonstrated that financial shocks can have a significant effect on the real economy. Macro-financial linkages have become the focus of attention in both academia and central banks. This crisis has also highlighted the need of introducing banking sector (credit supply channel) in a standard DSGE model with financial frictions (credit demand channel) to study and analyze shocks emanating in the credit markets.

The aim of this paper has been to develop a small open economy model with financial frictions and a banking sector to understand the role of financial intermediation in the transmission of shocks, and to analyze the effects of credit market shocks on the real economy. The model includes a financial accelerator mechanism similar to that proposed by Bernanke et al. (1999). Banks are modeled as monopolistically competitive optimizing units. They combine deposits with the bank capital (accumulated out of retained earnings) to make loans while meeting the capital-asset requirement. We have introduced cash reserve ratio (CRR) and statutory liquidity ratio (SLR) in the model to study the non-monetary policy tools used by central bank in emerging markets.

Our analysis suggests that the presence of financial frictions result in the amplification and persistence of shocks, while the presence of monopolistic sticky interest rate setting banking sector attenuates the effect of shocks. However, if interest rates are flexible, market power of banking system results in the amplification of shocks. Other results suggest that tightening of credit markets (a negative shock to bank capital) have substantive effects on the economy, and when the central bank resorts to using non-monetary tools and/or results in domestic banks holding a greater share of government securities, there is a larger contraction in output and consumption as compared to traditional monetary tightening (operating through nominal interest rate changes). The results are driven by the fact that we have two channels through which the financial sector interacts with the real economy. The banking sector affects the real economy through the credit supply channel. Presence of banks creates a wedge between the policy rate and rates which are relevant for the decision making of each agent in the economy, modifying the response of real variables. The financial accelerator mechanism works by altering the cost of borrowing faced by the firms.

The model developed in this paper can be used extensively to analyze several issues related to financial sector and financial stability. Since the model includes bank capital channel, our model is well suited to study the effects of bank recapitalization programs.

Our model with reserve requirements can be used to study the macro-economic consequences of using different policy tools and to rank them as well as to study the welfare costs of various financial frictions and financial under-development. It can also be extended to study the welfare costs of various rigidities in the financial markets. By estimating the parameters of the model using Bayesian techniques we can use it to study the optimality of monetary policy in the Philippines and emerging markets, in general. Also, it can then be used to assess the relative importance of shocks in explaining business cycle fluctuations in the Philippines.
References


A Credit and Banking Model for Emerging Markets and an Application to the Philippines


Discussion

Dr. Harmanta commented that the paper followed recent methods and techniques common in DSGE modeling with financial frictions. The Gerali et al. (2010) model with a banking sector and financial frictions was augmented by adding interbank borrowing operations. It was assumed that entrepreneurs could borrow from both domestic and foreign sources to finance needed capital.

Several recommendations were given to enrich the paper. First, the mechanism for the interbank market may be described in detail. Second, incorporating the probability of default in the interbank market may provide a mechanism to simulate the effects of financial crisis. Third, a discussion on the dynamics of domestic and foreign loans may be warranted. This is important for countries with companies that finance a fair amount of their investment from capital market and foreign debt financing because the corporate sector will be exposed to global financing conditions. Such is the case for the Philippines. Fourth, household debt must be modeled so that the effect of rationing consumption loan when they are growing too high can be examined. In addition, households can be differentiated into patient (saving) and impatient (borrowing). Fifth, a hybrid New Keynesian Phillips Curve (NKPC) can be used to combine both forward and backward looking components of inflation formation. In the Indonesian case, the weight of backward looking component in the formation of inflation is still relatively high, around 0.5 to 0.6.

Finally, macroprudential policy can be endogenized in the model. For instance, Indonesia uses a small-scale semi-structural DSGE model, incorporating both monetary policy (Taylor Rule) and macroprudential policy (LTV Rule) endogenously. In addition, parameter calibration can be combined with Bayesian estimation to better capture the dynamics of the Philippine economy.

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36 Harmanta of Bank of Indonesia was the discussant of the paper.
Monetary and Macroprudential Policy Mix under Financial Frictions Mechanism with DSGE Model: Lessons from Indonesian Experience

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In this research a DSGE model is developed for the small open economy of Indonesia, complemented with the inclusion of financial frictions in the form of collateral constraints amongst households and a financial accelerator amongst entrepreneurs. The model demonstrates that shocks in the banking sector, for instance raising the CAR requirement, impacts the real sector through the credit channel, which undermines GDP and lowers the rate of inflation. The financial accelerator mechanism in the model evidences procyclicality in the financial system to economic conditions.

The simulations also show that a policy mix of monetary and macroprudential policy not only achieves sustainable GDP and stable inflation but also helps to control consumption, thereby reducing demand for imported goods. Coupled with stable exports, a slowdown in imports will have a favourable effect on the current account.

JEL Codes: E32, E44, E52, E58
Keywords: Monetary policy, DSGE with banking sector, macroprudential policy

1 INTRODUCTION

The array of economic and financial crises that have plagued economies around the world over the past few decades has shown that macroeconomic instability stems primarily from shocks in the financial/banking sector, which is highly procyclical. Agung (2010) stated that the level of procyclicality in the financial sector of Indonesia is categorised as high. This is evidenced by the pace of real credit growth that exceeds GDP during a period of expansion and a decline that far surpasses that of GDP during a contractionary phase. The high level of procyclicality in the banking sector of Indonesia demands synergy between monetary policy and macroprudential policy in order to mitigate excessive economic fluctuations (the business cycle) and the financial cycle.

Monetary policy has the potential to support financial system stability through its ability to influence financial conditions and behaviour on financial markets through its transmission to the balance sheets of companies and banks as well as their appetite for risk. Similarly, conditions in the financial system also have the potential to affect monetary stability. Bernanke and Gertler (2001) stated that aggressive monetary policy

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does not provide any significant benefits in terms of controlling asset prices because financial variables have inherently large volatility, which requires a set of policy instruments to achieve price stability and financial market stability. An economic model is used to assist Bank Indonesia in terms of formulating policy to stabilise prices and financial markets, which is able to simulate the effects of monetary policy and macroprudential policy on the financial/banking sector and economy as a whole that provides the best coordination and combination of monetary policy and macroprudential policy.

The goal of this research is to develop a DSGE model, complemented by the inclusion of the banking sector, to accurately simulate monetary and macroprudential policy. Furthermore, the benefits of the research are as follows:

- As a tool to assist monetary and macroprudential policymaking at Bank Indonesia.
- As a step towards competence building in the development of a DSGE model to simulate diverse monetary and macroprudential policy in the development of a core model in the Forecasting and Policy Analysis System (FPAS) of Bank Indonesia looking ahead (pursuant to best practices from advanced countries that have adopted a core model based on DSGE)

One component rarely found in models used by a central bank, primarily for the period before the global financial crisis in 2007-2008, is a financial sector with the inclusion of financial frictions. This is particularly unfortunate because the macroprudential policy transmission mechanism depends heavily on the characteristics of the financial sector. As cited by Roger and Vicek (2011), the inclusion of the credit channel and the presence of financial intermediation in the macroeconomic model used by a central bank help explain the dynamics of the business cycle that is influenced by financial sector procyclicality. In addition, they also emphasized the importance of modelling household balance sheets as well as the effect of durable assets, like housing, on the transmission of macroeconomic policy. Recently, after the global financial crisis, financial frictions feature is used by most DSGE models as well as macroprudential policy transmission.

2 MODELLING FINANCIAL FRICTIONS IN THE DSGE MODEL

Based on existing literature, there are two main approaches to include financial frictions in the DSGE model: the financial accelerator approach and the collateral constraints approach. Each approach has its own set of strengths and weaknesses that continue to evoke debate among economists, in academia and central bankers alike. Introducing the banking sector into the DSGE model provides an additional method to model financial frictions, particularly those related to the cost of intermediation.

The basic assumption of the financial accelerator approach is the presence of asymmetric information between lenders and borrowers that results in an external finance premium, which illustrates the difference between the cost of borrowing and the cost of using internal funds. The external finance premium is determined by the net worth of the borrower and determines the size of the loan that can be approved. Net worth is defined as the value of assets owned by the borrower subtracted by the amount of outstanding debt. When an economy is experiencing an expansionary phase, the net worth of borrowers also increases due to greater credit worthiness and a lower external finance premium. In contrast, when an economy contracts, lower net worth decreases credit worthiness and exacerbates the cost of borrowing. The countercyclical dynamics of the external finance premium is a mechanism that amplifies the response of GDP and investment to a shock. For example, the initial response of GDP to a
technological shock will be amplified by rising asset prices that emerge due to that shock. Soaring assets prices will raise the net worth of borrowers and lower the external finance premium, which will ultimately boost investment. The financial accelerator approach helps explain the magnitude of change in investment and a hump-shaped output response to moderate changes in interest rates. In this model, the financial accelerator is modelled on entrepreneurs who loan the product of their capital investment to intermediate goods producers in order to produce intermediate goods.

Similar to the financial accelerator approach, the basic mechanism of the collateral constraint approach is a shift in asset prices that interact with imperfections in the credit market and amplify the response to a shock. Notwithstanding, departing from the financial accelerator approach, the net worth of borrowers will directly influence the size of loan approved but not through its effect on the external finance premium. Lenders require collateral when extending a loan in order to provide incentives to borrowers to repay their outstanding loans. Durable assets like land, housing and capital goods are typically used as collateral. In this case, collateral constraints are applied to impatient households that borrow from a bank with collateral in the form of housing to offset their consumption, housing investment, tax payments as well as repaying debt from the previous period. When an economy is experiencing an episode of expansion, housing prices of impatient households tend to increase, thereby increasing the size of loans received, boosting household consumption and catalysing economic growth. In contrast, when an economy contracts, asset prices of impatient households decline, thereby reducing the amount of bank loans and tempering household consumption, thereby triggering a deeper contraction in the economy. Such conditions explain the phenomenon of procyclical financial frictions on the economy of Indonesia.

Financial system procyclicality is the propensity of the financial system to stimulate faster economic growth during an expansionary episode and suppress the economy during a contractionary phase. Procyclical behaviour causes the financial system to exacerbate macroeconomic instability through the creation of fluctuations in output. Borio et al. (2001) stated that although financial friction is the primary mechanism stemming from procyclicality, the response elicited from market participants is not proportional in terms of evaluating risk, which in turn amplifies procyclicality. Consequently, in general, procyclicality is compounded by interaction between the business cycle, financial cycle and the behaviour of economic agents to risk. Interaction between the three cycles, which move in the same direction and mutually reinforce one another, is what creates financial sector procyclicality. In the majority of emerging market countries, like Indonesia, managing financial system procyclicality fundamentally involves managing banking sector procyclicality because the domestic economy depends heavily on the banking sector as the main source of investment financing. Therefore, controlling banking sector procyclicality has important implications in terms of creating and maintaining macroeconomic stability.

Macroprudential policy instruments aim to prevent or alleviate the effects of financial system procyclicality. Instruments like the loan-to-value ratio, countercyclical capital requirement and time-varying reserve requirement function through the balance sheet of the banking sector or the borrower. Consequently, this means that explicitly modelling financial friction and the balance sheet of the banking sector is imperative in order to simulate the transmission mechanism of macroprudential policy instruments.

Gerali et al. (2010) developed a DSGE model that included the banking sector, which was subsequently used as the basis of model development to simulate macroprudential policy at a number of central banks. The resultant model was a DSGE model for a closed economy with credit market friction in the form of borrowing
constraints and a banking sector that operated under monopolistic competitive conditions. The model is populated with agents that function as lenders (patient households) and borrowers (impatient households and entrepreneurs). Both borrower agents face borrowing constraints in the form of collateral constraints à la Iacoviello (2005), linked to the assets held (housing in the case of impatient households and capital goods for entrepreneurs). The bank balance sheet is modelled on term deposits and capital on the liabilities side and loans receivable on the assets side. Banks accumulate capital through retained earnings and are required to meet the Capital Adequacy Ratio (CAR) determined by the central bank. It is assumed that banks have market power in terms of accruing and allocating funds, and banks set differing interest rates for loans extended to impatient households and entrepreneurs. Stickiness is also assumed to occur between bank retail interest rates and the dynamics of the policy rate.

The model of Gerali et al. (2010) was estimated using the Bayesian approach with data from the euro area. That model is applied to understand the distinction between financial friction and financial intermediation in determining the dynamics of the business cycle, in particular relating to how monetary policy transmission to the real sector is influenced by financial friction and financial intermediation. Furthermore, Angelini et al. (2010) also applied that model to investigate the additional procyclicality caused by the implementation of Basel II compared to Basel I. In 2011, Angelini et al. reapplied the Gerali model to study interaction between monetary policy and macroprudential policy.

3 CHARACTERISTICS OF THE INDONESIAN ECONOMY AND BANKING SECTOR

The economy of Indonesia has demonstrated constant growth over the past decade, with average GDP for the period 2001-2012 achieving 5.42 percent. The economy has continued to expand, peaking in 2011 when growth of 6.49 percent (yoy) was realised. This is an impressive achievement when compared to neighbouring countries that were blighted by the global crisis in 2007-2008.

On the demand side, the economy of Indonesia is buoyed by private consumption with a 55.42 percent share of total GDP, followed by investment accounting for 27.44 percent (Table 1). Tenacious domestic consumption and a growing share of exports due to strong demand from leading trade partners like China and India, especially for commodities and mined products, provide an important contribution to economic growth. The expanding share of investment from year to year spurs economic
development and advancement by creating employment opportunities and income, thereby maintaining the level of public consumption.

On the production side, the economy of Indonesia is underpinned by the manufacturing industry that accounts for the largest share of GDP, followed by the trade, hotels and restaurants sector. Greater domestic consumption and stronger export demand from export partners has catalysed growth in a variety of economic sectors.

Rising incomes coupled with low inflation and interest rates have also stimulated growth in production sectors, like construction and transportation. Other sectors experiencing rapid growth include the financial sector, leasing and services as well as the services sector. Growth in those sectors helped raise total GDP to 6.23 percent in 2012.

An assumption made when modelling the banking sector in the DSGE model by a number of central banks is that banks have market power in terms of accumulating and disbursing funds, thus banks also have the power to determine lending rates and deposit rates. Moreover, a body of empirical research in Indonesia has corroborated the same conclusion. One such piece of research was conducted by Purwanto (2009), who concluded that the dynamics of bank interest rate spread (defined as the difference between the interest rate charged on loans minus the interest paid on deposits) is predominantly influenced by the level of concentration in the banking industry in Indonesia. In that research, the Herfindahl-Hirschman Index is used to measure the level of concentration in the banking industry. Based on the empirical model using monthly (panel) data for individual banks from January 2002 to April 2009, it was concluded that during the aforementioned period a narrower spread was the result of increased competition in the banking sector due to increased market share of the majority of banks accompanied by a diminishing market share of the largest banks. Those results are congruous with other research using the Structure-Conduct-Performance approach that links market concentration and market power to the setting of interest rates (Berger et al. (2004)).

Additionally, in the DSGE models developed by a number of central banks, stickiness is also assumed to occur between the bank retail interest rate and the policy rate. From a theoretical perspective, banks prefer not to frequently adjust interest rates when consumer demand is inelastic in the near run due to the high switching costs involved (Calem et al. (2006)) or because of the fixed cost (menu cost) associated with adjusting interest rates (Berger and Hannan, 1991). Another theoretical argument proposed by economists is the importance banks placed on maintaining loyal relationships with their customers through interest rate smoothing to protect the consumer from fluctuations in the market (policy) rate. This enables banks to set high interest rates even when the policy rate is low (Berger and Udell (1992)).

In simple terms, a rigid near-term bank retail rate response to the dynamics of the policy rate has been discussed in previous research conducted by Harmanta et al. (2012). An impulse response analysis of the bivariate VAR system6 showed that the short-term response of the bank retail rate to changes in the BI (policy) rate is limited, especially for rates on consumer loans. The response of the deposit rates and lending rates offered to the corporate sector are more or less the same. Although the magnitude is not as small as the response of the rate on consumer loans, the level of stickiness is similarly high.

6 Each respective VAR system is established based on exogenous variables, namely the size of the reserve ratio for VAR of the deposit rate; and the magnitude of capital, risk-weighted assets (risk-based balanced sheet by total credit), and the size of loans disbursed for VAR of the lending rate.
### Table 1. Growth of GDP Component of Indonesia (percent)

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Source: Indonesia Statistics Bureau

### Table 2. Share of GDP Component of Indonesia (percent)

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Source: Indonesia Statistics Bureau
4 THE BANKING SECTOR DSGE MODEL

The model developed in this research is based on the banking sector DSGE model refined by Harmanta et al. (2012), which itself was expanded based on the model of Gerali et al. (2010) that includes a banking sector under a New Keynesian DSGE Model framework à la Christiano et al. (2005). In this context, a financial accelerator is added to the 2012 DSGE model à la Bernanke et al. (1999), which was subsequently modified by Zhang (2010). The main modification to this model compared to the previous research of Harmanta et al. (2012), is the inclusion of financial frictions, namely collateral constraints on households and a financial accelerator on entrepreneurs. Additionally, the model also simulates default by entrepreneurs that prevents them repaying the loan to the bank. Banks also bear risk due to the presence of asymmetric information concerning the repayment capacity of the entrepreneur, which in this model will affect the level of bank profit generated and, ultimately, bank capital. Bank capital in this model also functions as a buffer stock against the unexpected realization risk of aggregate returns on capital from the entrepreneur, which subsequently influences the capital adequacy ratio and forces the bank to manage its asset portfolio. The model assumes a small open economy and includes the government to enrich the simulations of macroprudential policy. The standard features of the DSGE model, for instance habit persistence in terms of consumption, the adjustment cost related to adjusting investment, the modelling of sticky prices and sticky wages are also included in the model developed in this research. The complete model schematic is presented in Figure 2.

In the model there are two groups of households, namely patient and impatient households. The difference between the two agents lies in the discount factor, where the value of the discount factor of patient households is higher than that of impatient households. Due to the higher discount factor, patient households consider future consumption important, thereby avoiding spending their income in the current period and tending to save at a bank in the form of term deposits. These agents also consist of bank owners and retailers, thereby receiving revenue from the profits of banks, domestic retailers, importer retailers and exporter retailers. Conversely, impatient households tend to consume in the current period and consequently have to borrow from banks. In addition to spending in the form of consumption, both types of households also invest in housing and pay taxes to the government.

Another agent, entrepreneur, leases capital to intermediate goods producers after purchasing from capital goods producers. Intermediate goods producers produce homogeneous intermediate goods using capital goods (capital) leased from entrepreneurs and employ workers from patient households and impatient households. Homogeneous intermediate goods produced by intermediate goods producers are subsequently sold to domestic retailers for the domestic market and exporting retailers for the international market, which are transformed into differentiated goods. Final goods producers act as aggregators, amalgamating intermediate differentiated goods from the domestic market purchased from domestic retailers with international intermediate differentiated goods purchased from importing retailers.

In the model, there are capital goods producers and housing producers who utilise goods produced by final goods producers in order to produce capital goods (capital) and housing, consecutively, applying technology and incurring an investment adjustment cost. The adjustment cost enables the prices of capital goods and housing to differ from the prices of consumer goods.
There are two types of financial instrument offered by banks to economic agents in the model: savings accounts (term deposits) and loans/credit. Households face borrowing constraints when borrowing funds from a bank. Borrowing constraints correlate to the value of collateral held, namely the stock of housing. Meanwhile, extending credit to entrepreneurs is determined by the bank’s expectations concerning the return on capital of the entrepreneur that affects the expected net worth of the entrepreneur.

The banking sector operates under monopolistic competitive conditions, where a bank sets its deposit rates and lending rates to maximise profit. Total loans extended by a bank are offset by the term deposits accumulated and the bank’s capital. Capital in this research is a risk-free asset and part of the bank’s assets, as modified from Gerali et al. (2010).

4.1 Households and Entrepreneurs

Patient households maximise their utility function based on their desired level of consumption $c_t^P$, their rest time (outside working time $n_t^P$) and housing assets $\chi_t^P$ with a discount factor $\beta_P$.

$$\max_{c_t^P(1), \chi_t^P(1), n_t^P(1)} \sum_{t=0}^{\infty} (\beta_P)^t \epsilon_{u,t} \left[ \frac{(c_t^P(i) - \xi_{t-1}^P)^{1-\sigma_c}}{1-\sigma_c} + \epsilon_{\chi_t} \chi_t^P(i)^{1-\sigma_{\chi}} \right]$$

$$- \epsilon_{n,t} \frac{n_t^P(i)^{1+\sigma_n}}{1+\sigma_n}.$$  

(1)
The parameter, $\xi$, is the level of external habit formation and $\varepsilon_{u,t}$, $\varepsilon_{x,t}$, $\varepsilon_{n,t}$ is the intertemporal shock, housing preference and labour preference with dynamics, AR(1), and an error term, i.i.d.

Patient households receive income from the provision of labour to entrepreneurs $W_e n_t^p$, income from term deposits $(1 + r_{t-1}^p)d_{t-1}$ and dividends from their company $\Pi_t^p$. Income is subsequently used to pay taxes $T_t^p$, fund consumption, purchase housing assets and save the remainder in the form of term deposits $d_t$. Therefore, the budget constraints faced by patient households are as follows:

$$P_t c_t^p(i) + P_{x,t} \left( c_t^p(i) - (1 - \delta_x) x_{t-1}^p(i) \right) + d_t(i) = W_t n_t^p(i) + (1 + r_{t-1}^p) d_{t-1} - T_t^p + \Pi_t^p.$$  \hfill (2)

In terms of budget constraints, the variables, consumer spending and housing assets, are respectively multiplied by the price to obtain their nominal value. Parameter $\delta_x$ is the level of depreciation of housing assets owned by the households.

From the objective function and budget constraints of patient households mentioned previously is obtained a solution to the equation that can explain the level of consumption of patient households, which is determined by the lending rate, tax payable on the deposit rate as well as the rate of inflation, and can be expressed as follows:

$$-\left( -\frac{\sigma_c}{1 - \xi} (e_t^p - \dot{e}_t^p) \right) + \dot{\varepsilon}_u - \frac{\sigma_c}{1 - \xi} (e_t^p - \dot{e}_t^p) + \dot{\varepsilon}_u - \dot{\varepsilon}_x = \frac{\beta_p r_t^D}{\pi} (1 - \alpha_t^D) r_t^D - \dot{\pi}_{t+1}.$$  \hfill (3)

Meanwhile, the accumulation of housing by patient households is calculated by solving the objective function and budget constraints, which are determined by the deposit rate, tax payable on the deposit rate, the rate of inflation, housing prices as well as expected houses prices looking forward, and can be written as follows:

$$\frac{\beta_p (1 - \delta_x)}{(1 - \beta_p (1 - \delta_x))} \left[ -(1 - \alpha_t^D) \dot{\pi}_t + E_t(\hat{\pi}_{t+1}) + E_t(\hat{\pi}_x + \hat{\pi}_t) + \dot{\varepsilon}_u + \dot{\varepsilon}_x \right]$$

$$- \sigma_x \dot{x}_t^p = \dot{\pi}_t + \dot{\pi}_x.$$  \hfill (4)

The size of the term deposits saved by patient households at a bank is determined by the level of profit received, the return on term deposits in the previous period, wages earned from working, the level of consumption as well as level of housing investment, and can be expressed as follows:

$$\frac{d\dot{\pi}}{d_t} = \frac{(1 - \alpha_t^W)(1 + r^p)}{\pi} \frac{\ddot{\pi}}{\dot{y}} \left( \ddot{d}_{t-1} - \ddot{\pi}_t + \ddot{\pi}_{t-1} \right) + (1 - \alpha_t^M) \frac{\ddot{\pi}_t}{\dot{y}}$$

$$- \frac{\dot{x}_t \hat{x}_t \dot{y}}{\dot{y}} \left( \dot{\pi}_x + \dot{\pi}_t \right) + (1 - \delta_x) \frac{\dot{x}_t \hat{x}_t \dot{y}}{\dot{y}} \left( \dot{\pi}_x + \dot{\pi}_{t-1} \right)$$

$$- \frac{\dot{x}_t \hat{x}_t \dot{y}}{\dot{y}} \left( \dot{\pi}_x + \dot{\pi}_{t-1} \right) \left( \ddot{\pi}_t + \ddot{\pi}_{t-1} \right).$$  \hfill (5)
Meanwhile, impatient households also have a utility function consisting of the same variables as patient households as follows:

\[
\begin{align*}
\max_{c_t^i, x_t^i, n_t^i, b_t^i} & \sum_{t=0}^{\infty} (\beta_t)^t \left\{ \left( c_t^i(i) - \xi c_{t-1}^i \right)^{1-\sigma_c} + \epsilon_{u,t} \frac{1}{1-\sigma_c} + \epsilon_{x,t} \frac{1}{1-\sigma_x} \right\} \\
& - \frac{n_t^i(i)^{1+\sigma_n}}{1+\sigma_n}
\end{align*}
\]

To fund their spending, in addition to income earned from providing labour \( W_t n_t^i \), impatient households also borrow from banks \( b_t^i(i) \). Consequently, impatient households are also liable to repay their loans from the previous period \( (1 + r_{t-1}^{BI}) b_{t-1}^i(i) \) to the lender. The budget constraint of impatient households is as follows:

\[
P_t c_t^i(i) + P_{X,t} \left( x_t^i(i) - (1 - \delta_x) x_{t-1}^i(i) \right) + (1 + r_{t-1}^{BI}) b_{t-1}^i(i) = W_t n_t^i(i) + b_t^i(i) - \tau_t^i(i).
\]

Through borrowing to fund their consumption, total loans that can be obtained by impatient households are limited by the value of housing assets owned multiplied by the current loan-to-value ratio, \( m_t^i \), in effect.

\[
(1 + r_t^{BI}) b_t^i(i) \leq m_t^i E_t [(1 - \delta_x) x_t^i(i)].
\]

From a microeconomic perspective, the value of \((1 - m_t^i)\) can be interpreted as the proportional cost of collateral repossession for the bank in the event of default. From a macroeconomic standpoint, the value \( m_t^i \) determines the total loans offered by a bank to households for a specific value of housing asset owned. It is assumed that variation in the LTV ratio is independent of the decision of each respective bank and is a stochastic exogenous process, the dynamics of which enable us to study credit-supply restrictions on the real sector from the economy.

From the aforementioned objective function and budget constraints of impatient households is obtained a solution to the equation that can explain the level of consumption of impatient households, which is determined by the wages earned from providing labour, loans from a bank, the interest rate on consumer loans, rate of inflation, housing prices as well as housing stock, and can be written as follows:

\[
\frac{c_t^i y_t^i}{\bar{y}} = \left(1 - \alpha_{NW} \right) \frac{\bar{W}_t n_t^i}{\bar{y}} (\bar{\omega}_{t,t} + \bar{n}_t^i) \\
+ \frac{b_t^i}{\bar{y}} \left( \bar{\omega}_{t,t} - \frac{1 + r_{t-1}^{BI}}{\pi} \left( \bar{b}_{t-1}^i - \bar{\pi}_t + \bar{\pi}_{t-1} \right) \right) \\
- \frac{\chi_t^i y_t^i}{\bar{y}} \left( \bar{\chi}_t^i + \bar{\pi}_{X,t} - (1 - \delta_x) \left( \bar{\chi}_{t-1}^i + \bar{\pi}_{X,t-1} \right) \right).
\]

Meanwhile, the accumulation of housing by impatient households is calculated by solving the objective function and budget constraints, which are determined by the LTV ratio, housing prices, the interest rate on consumer loans as well as the rate of inflation, and can be expressed as follows:
The size of loan borrowed by impatient households from a bank is determined by the LTV ratio, expected housing prices, expected inflation, housing stock as well as the interest rate on consumer loans, and can be written as follows:

$$
\hat{b}_t^l = \hat{m}_t^l + \hat{b}_{X,t+1} + \hat{n}_{t+1} + \hat{\chi}_t^l - \hat{\tau}_t^{BI}
$$

$$
\hat{b}_t^l = \hat{m}_t^l + \hat{b}_{X,t+1} + \hat{n}_{t+1} + \hat{\chi}_t^l - \hat{\tau}_t^{BI}
$$

The utility function of entrepreneurs is based on the return on capital that determines the level of income and loan repayment capacity to a bank or international lender. Consequently, the profit realisation of entrepreneurs can be expressed as follows:

$$
V_{t+1} = \int_{\omega_{b}^{l,b}}^{\infty} \omega R_{t+1}^{K} p_{K,t} K_{t}^{l} f(\omega) d\omega - \left(1 - F(\tilde{\omega}_{b}^{L,b})\right) (1 + r_t^{BE}) b_t^E.
$$

The variable, $\omega$, is the idiosyncratic shock faced by an entrepreneur and $\tilde{\omega}_{b}^{L,b}$ is the threshold that determines whether the entrepreneur will default ($if \omega < \tilde{\omega}_{b}^{L,b}$) or repay the loan ($if \omega > \tilde{\omega}_{b}^{L,b}$) with a log-normal probability of default $F(\tilde{\omega}_{b}^{L,b})$.

A financial contract between a bank and entrepreneur will occur if the bank, at a minimum, can receive an expected return equal to the opportunity cost. In this model, a loan to an entrepreneur is a loan unit, which already incorporates a minimum target loan rate of the wholesale unit, therefore the size of the opportunity cost incurred by the bank is equal to the funding rate determined by the wholesale unit, more specifically $R_{b}^{P}$. The prime lending rate determined by the wholesale unit already includes a markup that takes into consideration stickiness, as well as the probability of default of the entrepreneur, $F(\tilde{\omega}_{b}^{L,b})$, based on bank expectations concerning the return on capital of the entrepreneur. If the entrepreneur is unable to repay its liabilities pursuant to the financial contract and therefore experiences default, the bank will incur a monitoring cost and foreclose on the assets of the entrepreneur, which can be expressed as $(1 - \mu^m)\omega R_{t+1}^{K} p_{K,t} K_{t}^{l}$, while an entrepreneur that has defaulted receives nothing. A financial contract between a bank and entrepreneur must satisfy the following requirements:

$$
V_{t+1} = \int_{\omega_{b}^{l,b}}^{\infty} \omega R_{t+1}^{K} p_{K,t} K_{t}^{l} f(\omega) d\omega - \left(1 - F(\tilde{\omega}_{b}^{L,b})\right) (1 + r_t^{BE}) b_t^E
$$
Subject to:

\[
(1 - F\left(\omega_t^{(a)}\right))(1 + r_t^{be})b_t^{E} + (1 - \mu^m) \int_{0}^{\omega_t^{(a)}} \omega E_t R_{t+1}^K P_{K_t} f(\omega) d\omega = (1 + R_t^b)b_t^{E}.
\]

The left-hand side of the equation shows the expected gross rate of return of the loan lent to the entrepreneur and the right-hand side indicates the opportunity cost of the bank. Parameter, \(\mu^m\), is the monitoring cost of the bank in the event of default, the value of which increases as the bank verifies and monitors the remaining project after default. The probability of default \(F\left(\omega_t^{(a)}\right)\) of an entrepreneur is the cumulative distribution function, while \(f(\omega)\) is the probability distribution function. Where \(\omega_t^{(a)}\) is the expected threshold (ex-ante). Adhering to the concept proposed by Zhang (2010), the difference between the expected threshold \((\omega_t^{(a)})\) and realised threshold \((\omega_t^{(b)})\) (which can be interpreted as the prediction error of the bank) will indicate the difference between expected income and realised income, which represents the portion of the cost borne by the bank.

The solution to the equation above is the relationship between corporate leverage \(K_t = \frac{P_{K_t} R_{K_t}}{N_t}\) and the external finance premium \(s_t^{EI} = \frac{E_t(1 + R_{t+1}^b)}{(1 + R_t^b)} f(K_t) = f\left(\frac{P_{K_t} R_{K_t}}{N_t}\right)\).

An increase in the expected discounted return to capital will reduce the expected probability of default, thus the entrepreneur could take on more debt and expand his/her business. That mechanism is known as the financial accelerator because in the event of a positive shock that raises the net worth of the business, then the resultant healthier balance sheet will bolster investment to expand the business and reduce the external finance premium.

The evolution of ex-ante threshold to ex-post threshold is a function of expected return to capital and the realised return to capital and can be expressed as follows:

\[
\omega_t^{(b)} = \frac{E_t(1 + R_{t+1}^b)}{(1 + R_t^b)} \omega_t^{(a)}.
\]

4.2 Producers

Intermediate good producers operate in a perfectly competitive market and have an objective function to maximise profit, which is the difference between the products sold and the cost of capital and labour as follows:

\[
\max_{P_{w,t}} E_t \sum_{s=0}^{\infty} (\beta_r \theta_r)^s \left\{ p_{w,t+s}(j) y_{w,t+s}(j) - \left( \left( w_{p,t+s}(j) n_{p,t+s}(j) + w_{l,t+s}(j) n_{l,t+s}(j) + z_{t+s}(j) K_{t+s}(j) \right) \right) \right\}
\]

where \(P_{w,t}\) is the price of the product made and \(y_{w,t}\) is the homogenous intermediate product made using the following production function:
\[ y_{W,t}(i) = A_t[u_t(i)k_t(i)]^\alpha \left( n_{P,t}(i) \right)^{\mu_t} \left( n_{L,t}(i) \right)^{1-\mu_t} \]  

(18)

where \( A_t \) is total factor productivity, \( u_t \in (0, \infty) \) is the level of capital utilisation, \( k_t \) is capital stock, \( n_{P,t} \) is the labour input of patient households and \( n_{L,t} \) is the labour input of impatient households.

There are three other types of producers in the model, namely capital goods producers, housing producers and final (consumption) goods producers. Capital goods producers operate in a perfectly competitive market and utilise consumer goods to produce capital goods. In addition, capital goods producers also use old capital goods that do not depreciate, \((1 - \delta_k)k_{t-1}\), to sell to entrepreneurs, which can be expressed as follows:

\[ k_t = (1 - \delta)k_{t-1} + \varepsilon_{k,t} \left( 1 - \frac{1}{2} \kappa_k \left( \frac{i_{k,t}}{i_{k,t-1}} - 1 \right)^2 \right) i_{k,t} \]  

(19)

where \( \varepsilon_{k,t} \) is the variable shock that has the dynamics, AR(1), with an error i.i.d. Old capital goods of the entrepreneur are directly transformed into new capital goods, while the transformation of consumer goods into capital goods is subject to a function of the adjustment cost \( S_k = \left( \frac{k_t}{k_{t-1}} \right) \) that has the following characteristics:

\[ S_k(1) = S_k'(1) = 0; S_k''(1) = \kappa_k > 0. \]  

(20)

In a steady state, there is no adjustment cost and as the level of utilisation of consumer goods moves farther away from the steady state, the adjustment cost increases.

The objective function of capital goods producers is to maximize

\[ \max_{k_t} \sum_{s=0}^{\infty} (\beta_p)^s \left( P_{k,t+s}k_{t+s} - (P_{k,t+s}(1 - \delta)k_{t+s-1} + P_{t+s}i_{k,t+s}) \right). \]  

(21)

Housing producers act in a similar way to capital goods producers, namely:

\[ \chi_t = (1 - \delta_\chi)\chi_{t-1} + \varepsilon_{\chi,t} \left( 1 - \frac{1}{2} \kappa_\chi \left( \frac{i_{\chi,t}}{i_{\chi,t-1}} - 1 \right)^2 \right) i_{\chi,t}. \]  

(22)

The function of the adjustment cost also has similar characteristics as capital goods producers:

\[ S_\chi(1) = S_\chi'(1) = 0; S_\chi''(1) = \kappa_\chi > 0. \]  

(23)

The objective function is to maximize

\[ \max_{\chi_t} \sum_{s=0}^{\infty} (\beta_p)^s \left( P_{\chi,t}\chi_t - (P_{\chi,t}(1 - \delta_\chi)\chi_{t-1} + P_t i_{\chi,t}) \right). \]  

(24)

Final goods producers are agents that combine goods from domestic retailers \( y_{H,t}(j_H) \) and retailers of imported goods \( y_{F,t}(j_F) \) to make a final product that is subsequently sold on a perfectly competitive market. The production function of final goods producers is as follows:
\[ y_t = \left[ \eta^{1+\mu} y_{H,t}^{1+\mu} + (1-\eta)^{1+\mu} y_{F,t}^{1+\mu} \right]^{1/\mu} \]  

(25)

where \( \eta \) is the home bias parameter and \( \mu \) determines the elasticity of substitution between domestic and foreign goods. Optimisation of the objective function of final good producers will produce an equation of demand for domestic goods \( (y_{H,t}) \), demand for imported goods \( (y_{F,t}) \) and the price (final) of consumer goods \( (P_t) \) as follows:

\[ y_{H,t} = \eta \left( \frac{P_{H,t}}{P_t} \right)^{-\frac{1}{\mu}} y_t \]  

(26)

\[ y_{F,t} = (1-\eta) \left( \frac{P_{F,t}}{P_t} \right)^{-\frac{1}{\mu}} y_t \]  

(27)

\[ P_t^{-\frac{1}{\mu}} = \eta(P_{H,t})^{-\frac{1}{\mu}} + (1-\eta)(P_{F,t})^{-\frac{1}{\mu}}. \]  

(28)

Demand for imported (foreign) goods \( (y_{F,t}) \) is determined by the import price relative to the price of the final goods. Similarly, demand for domestic goods \( (y_{H,t}) \) is determined by the domestic price relative to the price of the final goods. Meanwhile, the price of final goods \( (P_t) \) is determined by the domestic price and import price.

### 4.3 Retailers

Retailers in the model include domestic retailers, exporting retailers and importing retailers. Domestic retailers purchase undifferentiated intermediate goods from entrepreneurs, convert them into differentiated goods and sell them to final good producers. Exporting retailers purchase undifferentiated intermediate goods from entrepreneurs, convert them into differentiated goods and sell them to the international market. Importing retailers purchase undifferentiated goods from the international market, convert them into differentiated goods and sell them to final good producers. Prices are determined at the three agents according to the sticky price model à la Calvo, where in each period, only a portion of retailers re-optimise their prices, while the remainder adjust price based on the level of inflation in the previous period (backward looking).

For domestic retailers that re-optimise prices, prices are determined by \( P_{H,t} = P_{H,t-1} \pi_{t-1} \). Therefore, aggregate prices at period \( t \) can be calculated using the following function:

\[ P_{H,t} = \left( \theta_H \left( P_{H,t-1} \pi_{H,t-1} \right)^{1-\epsilon_H} + (1-\theta_H) \left( P_{H,t}(i) \right)^{1-\epsilon_H} \right)^{1/\epsilon_H}. \]  

(29)

The final log-linearization of the first-order condition (FOC) of the objective function of domestic retailers indicates the NKPC equation of inflation where domestic prices are determined by self-expectations, both backward and forward, in addition to being determined by the price of intermediate goods, which can be written as follows:

\[ \hat{\pi}_{H,t} = \frac{1}{1+\beta_p} \hat{\pi}_{H,t-1} + \frac{\beta_p}{(1+\beta_p)} (\hat{\pi}_{H,t+1}) + \frac{(1-\beta_p \theta_H)(1-\theta_H)}{(1+\beta_p) \theta_H} \left( \hat{P}_{W,t} \right). \]  

(30)

For importing retailers that do not re-optimise, prices are determined by \( P_{F,t} = P_{F,t-1} \pi_{t-1} \). Similarly, aggregate prices at period \( t \) can be calculated using the following function:
\[
P_{F,t} = \left( \theta_F(p_{F,t-1} \pi_{F,t-1})^{1-\epsilon_F} + (1 - \theta_F)(p_{F,t}(i))^{1-\epsilon_F} \right)^{\frac{1}{1-\epsilon_F}}. \tag{31}
\]

The final log-linearization of the first-order condition (FOC) of the objective function of importing retailers is NKPC as follows:

\[
\pi_{F,t}^* = \frac{1}{1 + \beta_p} \pi_{F,t-1}^* + \frac{\beta_p}{1 + \beta_p} (\pi_{F,t+1}^*) + \frac{(1 - \beta_p \theta_P)(1 - \theta_P)}{(1 + \beta_P) \theta_P} (\bar{s}_t + \hat{p}_{F,t}^*). \tag{32}
\]

From the equation above, it can be seen that import price inflation is determined by self-expectations, both backward expectations and forward, in addition to being determined by international prices.

Exporting retailers purchase domestic undifferentiated goods, provide branding and sell to the international market at a price \(P_{H,t}^*\), expressed in a foreign currency. It is assumed that prices denominated in a foreign currency are sticky. The demand equation for export goods is as follows:

\[
y_{H,t}^* = \left( \frac{P_{H,t}^*}{P_{R,t}^*} \right)^{-(1+\mu_{H^*})} \frac{\mu_{H^*}}{\mu_{H^*}} y_{R,t}^* \tag{33}
\]

where \(y_{H,t}^*\) indicates the output of the retailer that is defined as follows:

\[
y_{H,t}^* = \left( \frac{P_{H,t}^*}{P_{R,t}^*} \right)^{-(1+\mu_{H^*})} \frac{\mu_{H^*}}{\mu_{H^*}} y_{R,t}^* \tag{34}
\]

and \(P_{H,t}^*\) as

\[
P_{H,t}^* = \left( \int_0^{P_{H,t}^* (y_t^*)^{1+\mu_{H^*}} d_j^* } \right)^{-\mu_{H^*}}. \tag{35}
\]

Furthermore, it is assumed that international demand is given by:

\[
y_{H,t}^* = (1 - \eta^*) \left( \frac{P_{H,t}^*}{P_{R,t}^*} \right)^{-(1+\mu_{H^*})} \frac{\mu_{H^*}}{\mu_{H^*}} y_{H,t}^*. \tag{36}
\]

Similar to other retailers in the model, prices are determined by exporting retailers referring to the standard scheme of Calvo, where the probability of adjusting the price is \((1 - \theta)\) and the probability of not re-optimising prices is \(\theta\). For exporting retailers that do not re-optimise, prices are determined by the function \(P_{H,t}^* = P_{H,t-1}^* \pi_{H,t-1}^*\). Therefore, the aggregate price at time \(t\) is calculated using the following function:

\[
P_{H,t}^* = \left( \theta_H^* (p_{H,t-1}^{\pi_{H,t-1}})^{1-\epsilon_H} + (1 - \theta_H^*) (p_{H,t}(i))^{1-\epsilon_H} \right)^{\frac{1}{1-\epsilon_H}}. \tag{37}
\]

The final log-linearization of the first-order condition (FOC) of the objective function of exporting retailers indicates that export price inflation is determined by self-expectations, both forward and backward, as well as determined by the price of intermediate goods and the exchange rate, which can be expressed as follows:

\[
\pi_{H,t}^* = \frac{1}{1 + \beta_p} \pi_{H,t-1}^* + \frac{\beta_p}{1 + \beta_p} (\pi_{H,t+1}^*) + \frac{(1 - \beta_p \theta_H^*)(1 - \theta_H)}{(1 + \beta_p) \theta_H} (\bar{r}_{W,t} - \bar{s}_t). \tag{38}
\]
4.4 Bank

Banks play an important role in the financial intermediation process in the model. The only financial instruments available to patient households are bank term deposits and the only financial instrument available to impatient households and entrepreneurs is to borrow through a bank loan. We slightly modified the preliminary model developed by Gerali et al. (2010) in terms of the financial intermediation process, namely that agents in the new model have access to international sources of financing. Only the government, however, has access to external sources of finance in order to simplify the model.

The model developed in this research has the capacity to simulate default that could occur when an entrepreneur fails to repay his/her debt to the bank, which involves the bank bearing the risk of asymmetric information regarding the repayment capacity of the entrepreneur. Such conditions affect the size of bank profit that will subsequently determine bank capital. Risk sharing by a bank is possible because the model has two threshold values, namely $\omega^L_i$ that is the ex-ante threshold based on bank expectations regarding the return on capital of the entrepreneur, as well as threshold $\omega^B_i$ which is ex-post or the actual return on capital of the entrepreneur. The difference between the expected and realised return on capital of the entrepreneur will determine bank capital that functions as a buffer stock against the unexpected realisation of aggregate return on capital of the entrepreneur, which will subsequently affect the capital adequacy ratio of the bank and compel the bank to manage its asset portfolio.

Pursuant to the approach taken by Gerali, we also assume that banks have market power in terms of accumulating and allocating funds, thus giving the bank the power to set the lending rate and deposit rate. In addition, stickiness is also assumed to affect the retail lending rate when linked to the dynamics of the policy rate. In this model the bank balance sheet is more detailed compared to the model developed by Gerali with the inclusion of risk free assets and reserves on the assets side of the bank balance sheet. This is in accordance with the (aggregate) balance sheets of the banking industry in Indonesia that continue to enjoy an abundance of excess liquidity in the form of Bank Indonesia Certificates (SBI) and tradeable government securities (SBN). This is an important inclusion to the model considering that the condition of excess liquidity can determine the transmission of monetary and macroprudential policy.

<table>
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<tr>
<th>Table 3. Bank Balance Sheet</th>
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<tr>
<td><strong>Assets</strong></td>
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<tr>
<td>Total Loan</td>
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<tr>
<td>Risk Free Asset (SBI and SBN)</td>
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<tr>
<td>Reserve</td>
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</tbody>
</table>

Each bank in the model contains three units, namely two retail units and one wholesale unit. The first retail unit is responsible for disbursing different loans to impatient households and to entrepreneurs, while the second retail unit is responsible for accumulating term deposits from patient households.

Each wholesale unit operates under a perfectly competitive market and functions to manage the balance sheet of the bank as follows:

$$RF_t + B_t = (1 - \Gamma_t)D_t + K^b_t$$  \hspace{1cm} (39)
where $RF_t$ is risk-free assets, $B_t$ is total loans extended by the bank, $D_t$ is total deposits accrued, $\Gamma_t$ is the reserve ratio set by the bank and determined by the reserve ratio requirement set by the central bank and $K_t^b$ is bank capital.

Figure 3. Bank’s Financial Intermediation Process

It is assumed that banks do not have access to external financing, hence the only way a bank can augment its capital is through retained earnings:

$$K_t^b = (1 - \delta^b)K_{t-1}^b + w_t^b$$  \hspace{1cm} (40)

where $j_t^b$ is total profit generated by the three bank units, $(1 - w_t^b)$ is the portion of bank dividend allocation and $\delta^b$ is the resources invested to manage bank capital. Dividends are assumed to be exogenous and fixed, therefore bank capital is not variable option for the bank. Comprehensively, the utility function of the wholesale unit is as follows:

$$\max \left\{ \frac{\beta F_t}{A_t} \right\} \sum_{s=0}^{\infty} \gamma_t^{s} \left[ \Gamma_{t+s} D_t - \Delta \Gamma_{t+s+1} D_{t+s+1} + (1 + r_{t+s})R_{t+s} \\
- RF_{t+s+1} + (1 + R_{t+s}^b)B_t + B_{t+s+1} + D_{t+s+1} \\
- (1 + R_{t+s}^d)D_{t+s} + \Delta K_t^b + 1 \\
- K_{t+s}^b - \frac{1}{2} \left( \frac{K_{t+s}^b}{\omega_{t+s}^b B_t} - v_{b,t+s} \right)^2 \right\}$$  \hspace{1cm} (41)

subject to

$$RF_t + B_t = (1 - \Gamma_t)D_t + K_t^b$$  \hspace{1cm} (42)

where $\rho_t^d$ is the stochastic discount factor, $R_t^b$ is the wholesale lending rate, $R_t^d$ is the wholesale deposit rate and $r_t$ is the policy rate of the central bank. The first-order condition (FOC) of the objective function of the wholesale unit illustrates the equation that determines the lending and deposit rates offered by the loan unit and deposit unit:

$$R_t^b - r_t = -\left( \frac{\omega_t^b}{\omega_t^b B_t} \right) K_t^b \left( \frac{K_t^b}{\omega_t^b B_t} - v_{b,t} \right) \left( \frac{K_t^b}{\omega_t^b B_t} \right)^2$$  \hspace{1cm} (43)

$$\Gamma_t (1 - \Gamma_t) = R_t^d.$$  \hspace{1cm} (44)

Under conditions where $\text{CAR} = \frac{K_t^b}{\omega_t^b B_t} = v_{b,t}$ then $R_t^b = r_t$. Meanwhile, under conditions where $\text{CAR} > v_{b,t}$, then a bank will react to lower CAR by increasing the
allocation of loans $B_t$ (decreasing $R_t^d$), thus the level of CAR will approach the statutory minimum, $\text{CAR} \approx \nu_{p,t}$.

Under conditions where reserve requirement, $RR = \Gamma_t = 0$, then $\frac{\Delta \Gamma_t}{\Delta R_t} = 1$, while under conditions where $RR > 0$ then a bank will endure an increase in opportunity cost when extending funds, hence the bank will react to lower that cost by reducing total deposits, equivalent to decreasing $R_t^d$.

In addition, we added an ad hoc equation to explain the dynamics of the reserve ratio selected by a bank. Previously we set the dynamics of the reserve requirement ratio ($\Gamma_t^r$) determined by the central bank as follows (in the form of log linearization):

$$\Gamma_t^r = \rho_t \Gamma_{t-1}^r + \hat{e}_{t^r}.$$  

The reserve requirement ratio subsequently determines the magnitude of excess reserves ($\hat{e}_t^r$), which is set by a bank as follows:

$$\hat{e}_t^r = \rho e \hat{e}_{t-1}^r + (1 - \rho e) \Gamma_t^r + \hat{e}_{t^r}.$$  

And the dynamics of reserves are as follows:

$$\hat{e}_t^r = \rho e \hat{e}_{t-1}^r + (1 - \rho e) \Gamma_t^r.$$  

In this model, the level of market power ascribed to a bank is determined by the magnitude (steady state value) of demand elasticity for deposits and loans alike. A lower absolute value of elasticity indicates the more monopolistic power of a bank. It is assumed that credit (savings) extended to (acquired from) households and entrepreneurs is in the form a composite Constant Elasticity of Substitution (CES) of several slightly differentiated products offered by a bank branch, $j$, with an elasticity of substitution equal to $\epsilon_{t}^{bh}$, $\epsilon_{t}^{be}$ and $\epsilon_{t}^{d}$. The three values of elasticity will determine mark-up (for credit) and mark-down (for savings/deposits) set by a bank when determining interest rates. In other words, the value of elasticity determines spread between the policy rate and lending rate (and deposit rate). It is assumed that the three values of elasticity are stochastic and changes that occur in the three values can be interpreted as changes in the spread of bank retail interest rates that occur outside the sphere of monetary policy. The demand for credit from entrepreneurs ($b_{t}^{E}$) and impatient households ($b_{t}^{I}$) can be expressed as follows:

$$b_{t}^{I}(j) = \left( \frac{r_{t}^{bh}(j)}{r_{t}^{bh}} \right)^{-\epsilon_{t}^{bh}} b_{t}^{I}$$  

$$b_{t}^{E}(j) = \left( \frac{r_{t}^{be}(j)}{r_{t}^{be}} \right)^{-\epsilon_{t}^{be}} b_{t}^{E}.$$  

While the demand for deposits ($d_t$) from patient households can be written as follows:

$$d_{t}(j) = \left( \frac{r_{t}^{d}(j)}{r_{t}^{d}} \right)^{-\epsilon_{t}^{d}} d_{t}.$$  

The loan unit receives wholesale loans, $B_t$, from the wholesale unit at a rate of interest, $R_t^w$, and then extends the loan to households and entrepreneurs applying two different levels of mark-up. In order to apply stickiness and investigate the implications of imperfect bank pass-through, it is assumed that each respective bank faces a quadratic adjustment cost when adjusting its lending rate. The size of that cost is
determined by the parameters $\kappa_{bE}$ and $\kappa_{bh}$. The utility function of the loan unit is as follows:

$$\max_{[v_t^{bh}(j), v_t^{be}(j)]} E_0 \sum_{s=0}^{\infty} (\beta_P)^s \frac{\beta^{t+s}}{\lambda_t^s} \left[ \frac{b_t^{bh}(j)}{\tau_t^{bh}(j)} b_t^{bh}(j) + \frac{r_t^{be}(j)}{\tau_t^{be}(j)} b_t^{be}(j) - R_t^{b} B_{t+s}(j) \right]$$

$$\quad - \frac{\kappa_{bh}}{2} \left( \frac{b_t^{bh}(j)}{\tau_t^{bh}(j)} - 1 \right)^2 r_t^{bh} b_t^{bh}$$

$$\quad - \frac{\kappa_{be}}{2} \left( \frac{b_t^{be}(j)}{\tau_t^{be}(j)} - 1 \right)^2 r_t^{be} b_t^{be}$$

subject to

$$b_t^{bh}(j) = \left( \frac{r_t^{bh}(j)}{\tau_t^{bh}} \right)^{-\epsilon_t^{bh}} b_t^{bh}$$

$$b_t^{be}(j) = \left( \frac{r_t^{be}(j)}{\tau_t^{be}} \right)^{-\epsilon_t^{be}} b_t^{be}$$

$$B_t(j) = b_t(j) = b_t^{bh}(j) + b_t^{be}(j).$$

In linear form, the lending rate for households is as follows:

$$\dot{r}_t^{bh} = \frac{1}{(1 + R_t^{b})} \left( \frac{1 + R_t^{b}}{(1 + r_t^{bh})(\epsilon_t^{bh} - 1 + \beta_P\kappa_{bh} + \kappa_{bh})} \right) \frac{R_t^{b}}{R_t^{b}}$$

$$\quad + \frac{\beta_P\kappa_{bh}}{(\epsilon_t^{bh} - 1 + \beta_P\kappa_{bh} + \kappa_{bh})} \dot{r}_{t+1}^{bh}$$

$$\quad + \frac{\kappa_{bh}}{(\epsilon_t^{bh} - 1 + \beta_P\kappa_{bh} + \kappa_{bh})} \dot{r}_{t-1}^{bh}.$$
The wholesale deposit rate is inversely proportional to the deposit rate set by the deposit unit. The response of the deposit rate to the wholesale rate is faster if the wholesale unit lowers its interest rates. In contrast, the response of the deposit rate is not as high if the wholesale deposit rate is increased.

4.5 The Government and Central Bank

The government collects taxes and lends on the domestic market (through banks) and on the international market to offset spending. Government budget constraints in the economy are as follows:

\[ P_t g_t + (1 + r^*_{G,t-1}) e_t b^*_G,t-1 + (1 + r_{t-1}) b_{G,t-1} = (T^P_t + T^I_t) + e_t b^*_G,t + b_{G,t} \]  

(60)

where \( g_t \) is government spending modelled with the dynamics, AR(1), \( b^*_G,t \) is external government loans that are also modelled as AR(1), and \( T^P_t \) as well as \( T^I_t \) are taxes collected from patient and impatient households.

Determining the policy rate (\( r_t \)) set by the central bank is modelled using the Taylor Rule as follows:

\[ (1 + r_t) = \left( \frac{1 + r_{t-1}}{1 + \bar{r}} \right) \left( \frac{\pi_t}{R_t} \frac{\phi_y}{\phi_v} \right)^{1-\phi_R} \]  

(61)

where \( \phi_y \) and \( \phi_v \) are the respective weights of inflation and output stabilisation, \( \bar{r} \) is the steady state nominal interest rate and \( \varepsilon_{r,t} \) is the i.i.d shock on monetary policy with a normal distribution and standard deviation \( \sigma_r \).

4.6 Market Clearing Conditions

To finalise the model, market clearing condition equations are required for goods produced by final goods producers, goods produced by intermediate goods producers (intermediate homogeneous goods), the housing market, the balance of payments and the definition of GDP in the model. Furthermore, as the economy being modelled is a small open economy, the risk premium must be specified, which is a
function of the ratio of total external debt to GDP (pursuant to Schmitt-Grohe and Uribe, 2003).

**Final Goods Producers Output**

\[ \tilde{\pi}_t = \eta(p_H) \left( \frac{1}{\rho} \tilde{\pi}_{H,t} + \tilde{\pi}_{H,t-1} \right) + (1 - \eta)(p_F) \left( \frac{1}{\rho} \tilde{\pi}_{F,t} + \tilde{\pi}_{F,t-1} \right) \]  

\[ \frac{c}{y} \tilde{e}_t = y^l c^l \tilde{e}_t + \frac{y^p c^p}{y} \tilde{e}_t + RnY \ast N \]  

**Intermediate Homogenous Goods Market**

\[ \int_0^1 y_{H,t}(j) dj + \int_0^1 y_{H,t}(j) dj = y_{W,t} \]  

**Housing Market**

\[ y^p x^p_t + y^l x^l_t = x_t \]  

**Balance of Payment**

\[ P_{F,t} y_{F,t} + e_t(1 + r_{t-1}) p_{t-1} b_{tot,t-1} = e_t p_H^* y_{H,t} + e_t b_{tot,t} \]  

**GDP**

\[ P_t \tilde{y}_t = P_t y_t + e_t p_H^* y_{H,t} - P_{F,t} y_{F,t} \]  

**Risk Premium**

\[ (1 + \rho_t) = \exp \left( -q \frac{e_t b_{tot,t}^*}{P_t \tilde{y}_t} \right) \epsilon_{\beta t} \]  

5 **ESTIMATION**

Quarterly data from quarter I 2001 until quarter IV 2012 is used for the purposes of estimation. In addition, the following real sector data is also used: private consumption, government spending, exports, imports, headline inflation, import deflator, export deflator and the exchange rate. GDP data published by Statistics Bureau of Indonesia is used for disaggregated GDP data, the export deflator and import deflator. Exchange rate data along with headline inflation are acquired from the ARIMBI/SOFIE database models. Concerning external sector variables, data is again taken from the ARIMBI and SOFIE models, namely global inflation, US inflation and LIBOR.

In terms of the banking sector, the following data is used: the policy rate (BI rate); the deposit rate and total deposits accumulated; bank capital; the interest rate and total outstanding household credit (consumer loans); the interest rate and total outstanding household credit (consumer loans).

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7 ARIMBI is Bank Indonesia core model, based on semi DSGE model. SOFIE is satellite model of ARIMBI that disaggregate the projection result from ARIMBI into its component.
outstanding corporate loans (investment credit and working capital); total Bank Indonesia Certificates (SBI) (and other monetary operations) held by banks; total bank debt owed to the central government (SBN), total bank reserves (including cash in vault); and non-performing loans (NPL).

Actual data for the estimation period (quarter 1 2001 – quarter 4 2011) is used as the primary reference when determining the steady state values of real sector variables. Nonetheless, steady state values are also calculated using the DSGE models of advanced countries and developing countries alike for comparison. Disaggregated GDP data is based on that processed using the HP Filter as illustrated in Figure 5.

Departing from the disaggregation conducted by BPS-Statistics Indonesia for the variable, investment (business investment and construction investment), is split into two in this model, namely: housing investment and investment in capital goods. To calculate the steady state value of housing investment to total GDP, we multiply the ratio of completed construction for that category of building (0.4) with the average ratio of construction investment to total investment (0.83), and then multiply that with the ratio of investment to GDP (0.22). Using that approach (and rounding off), we determine that the steady state value of housing investment to total GDP is 0.08.

Using a similar approach, we also calculate the steady state values for components of the balance sheet. As can be seen in Figure 7, however, the results of the HP filter for the ratio of the balance sheet to total assets is not stable around a specific value. In addition to using the results of the HP filter presented in Figure 7, the research of Gunadi and Budiman (2011) concerning the optimisation of bank portfolio...
composition in Indonesia is used to determine the steady state values of bank balance sheets, which are presented in full in Table 4.

Table 4. Steady State Value of Bank Balance Sheet Variables

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Loan</td>
<td>0.7</td>
<td>Deposit</td>
<td>0.9</td>
</tr>
<tr>
<td>SBI</td>
<td>0.12</td>
<td>Capital</td>
<td>0.1</td>
</tr>
<tr>
<td>Loan to Government (SBN)</td>
<td>0.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reserve</td>
<td>0.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Referring to Figure 8 that presents the results of the HP filter of different interest rate variables in the model, we can observe that the spread between the BI rate and deposits rate is not stable. When the BI rate is high, for example, the spread with the deposit rate is also high. When the BI rate is low, however, the spread with the deposit rate is also low. As we use a steady state value of the BI rate that is categorised as low for data consistency, a low value of spread is also used to calculate the steady state value of the deposit rate. Utilising this method, we determine the steady state value of the deposit rate to be 4.5 percent. Additionally, to calculate the steady state value of interest rates on consumer loans and investment credit, we include the average difference between both aforementioned rates and the BI rate during the sample period, which produces a steady state value for the interest rate on consumer loans of 13.65 percent and a steady state value for the interest rate on corporate loans (working capital and investment) of 11.4 percent. For the LIBOR rate, which is a proxy of international interest rates, we use the same value as that found in the ARIMBI model, namely 3 percent.
In full, the steady state values of all variables used in the model are presented in Table 5 as follows:

Table 5. Steady State Value of All Variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumption to GDP ratio</td>
<td>0.59</td>
</tr>
<tr>
<td>Capital investment to GDP ratio</td>
<td>0.19</td>
</tr>
<tr>
<td>Housing investment to GDP ratio</td>
<td>0.08</td>
</tr>
<tr>
<td>Government expenditure to GDP ratio</td>
<td>0.09</td>
</tr>
<tr>
<td>Import to absorption ratio</td>
<td>0.38</td>
</tr>
<tr>
<td>Export to output ratio</td>
<td>0.44</td>
</tr>
<tr>
<td>Loan to HH to GDP ratio</td>
<td>0.31</td>
</tr>
<tr>
<td>Loan to entrepreneur to GDP ratio</td>
<td>0.71</td>
</tr>
<tr>
<td>Deposit to GDP ratio</td>
<td>1.28</td>
</tr>
<tr>
<td>Importer’s profit margin</td>
<td>0.03</td>
</tr>
<tr>
<td>Exporter’s profit margin</td>
<td>0.026</td>
</tr>
<tr>
<td>Domestic retailer’s profit margin</td>
<td>0.18</td>
</tr>
<tr>
<td>Rate on loan to HH*</td>
<td>14.98 percent</td>
</tr>
<tr>
<td>Rate on loan to entrepreneur*</td>
<td>12.9 percent</td>
</tr>
<tr>
<td>Rate on deposit*</td>
<td>4.5 percent</td>
</tr>
<tr>
<td>Foreign interest rate*</td>
<td>3 percent</td>
</tr>
<tr>
<td>CAR</td>
<td>0.14</td>
</tr>
<tr>
<td>Bank’s profit to total asset ratio</td>
<td>0.025</td>
</tr>
<tr>
<td>Deposit to bank’s total asset ratio</td>
<td>0.9</td>
</tr>
<tr>
<td>Bank’s capital to total asset ratio</td>
<td>0.1</td>
</tr>
<tr>
<td>Loan to bank’s total asset ratio</td>
<td>0.7</td>
</tr>
<tr>
<td>Risk free asset to bank’s total asset ratio**</td>
<td>0.2</td>
</tr>
<tr>
<td>Reserve to total asset ratio</td>
<td>0.1</td>
</tr>
</tbody>
</table>

A number of parameters used in the model are calibrated using the values found in other models developed by Bank Indonesia and related empirical research. Capital share in the production function is set at 0.54 in line with the 2012 MODBI model. The value of home bias of the parameters is calculated based on the HP filter value of the import to absorption ratio of Indonesia during the estimation period. The parameters that determine the elasticity of substitution between domestic and foreign goods as well as the elasticity of substitution for export goods are based on the research

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8 MODBI is Bank Indonesia long-term projection model, based on simultaneous econometric method.
of Zhang and Verikios (2006). The values of the risk premium and that which controls the cost of managing bank capital are calculated through the steady state correlation between several variables included in the model. The Calvo parameter for labour follows the estimation results of the BISMA model (2009). The parameters of the ad hoc equations, which determine the dynamics of risk-weighted assets (Equation 44) and bank reserves (Equations 45 - 47) utilise the results of the partial equation based on data for the estimation period.

### Table 6. Parameter Values from Calibration

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mark-up parameter in labor market</td>
<td>$\varepsilon_w$</td>
</tr>
<tr>
<td>Depreciation rate of capital</td>
<td>$\delta_k$</td>
</tr>
<tr>
<td>Depreciation rate of housing asset</td>
<td>$\delta_x$</td>
</tr>
<tr>
<td>Cost to managing bank’s capital</td>
<td>$\delta_b$</td>
</tr>
<tr>
<td>Risk premium parameter</td>
<td>$\rho^b$</td>
</tr>
<tr>
<td>Capital share in production function</td>
<td>$\alpha$</td>
</tr>
<tr>
<td>Home bias parameter</td>
<td>$\eta$</td>
</tr>
<tr>
<td>Elasticity of substitution between domestic and foreign goods</td>
<td>$\mu$</td>
</tr>
<tr>
<td>Elasticity of substitution for export goods</td>
<td>$\mu_{H^*}$</td>
</tr>
<tr>
<td>Labour income share of unconstrained household</td>
<td>$\mu_L$</td>
</tr>
<tr>
<td>The probability of given labor (from patient and impatient HH) is selected not to reoptimize its wage</td>
<td>$\theta_{wp}, \theta_{wi}$</td>
</tr>
<tr>
<td>Reserve equation’s parameter</td>
<td>$\rho_r$</td>
</tr>
<tr>
<td>Excess reserve equation’s parameter</td>
<td>$\rho_{e}$</td>
</tr>
</tbody>
</table>

The prior distributions of parameters are determined through the same approach as that used to calculate the calibrated parameters, namely by utilising the values of models previously developed and related empirical research. For the parameters $\kappa_d, \kappa_{be}$ and $\kappa_{bi}$, the prior distributions are determined by setting the bank retail interest rate response to policy rate shocks in accordance with the estimations of immediate pass-through conducted by Harmanta and Purwanto (2012). For the Taylor rule parameters ($\rho_r, \rho_y$ and $\rho_y$), the values of priors are set according to the value contained in the ARIMBI core model. The prior distribution of the parameter that measures habit persistence in household consumer activity is the same as that in the BISMA model (2009). The prior distributions, types of distribution and posterior distributions of the parameters are presented in full in Table 7.

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9 Utilising a CES-based estimation congruent with the assumptions used when developing the model used in this research.

10 BISMA is structural DSGE model that give a focus on complete households balance sheet, with no discussion about complete banking sector.
### Table 7. Parameter Values from Estimation

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Distributions</th>
<th>Prior Distribution</th>
<th>Posterior Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inverse of intertemporal elasticity of substitution for housing</td>
<td>$\sigma_x$</td>
<td>normal</td>
<td></td>
</tr>
<tr>
<td>Inverse of intertemporal elasticity of consumption</td>
<td>$\sigma_c$</td>
<td>normal</td>
<td></td>
</tr>
<tr>
<td>Inverse of Frisch elasticity of labour supply</td>
<td>$\sigma_n$</td>
<td>normal</td>
<td></td>
</tr>
<tr>
<td>Adjustment cost parameter for deposit rate</td>
<td>$\kappa_d$</td>
<td>gamma</td>
<td></td>
</tr>
<tr>
<td>Adjustment cost parameter for entrepreneur loan rate</td>
<td>$\kappa_{be}$</td>
<td>normal</td>
<td></td>
</tr>
<tr>
<td>Adjustment cost parameter for household loan rate</td>
<td>$\kappa_{bi}$</td>
<td>normal</td>
<td></td>
</tr>
<tr>
<td>Adjustment cost parameter for capital investment</td>
<td>$\kappa_k$</td>
<td>gamma</td>
<td></td>
</tr>
<tr>
<td>Adjustment cost parameter for housing investment</td>
<td>$\kappa_{\delta}$</td>
<td>normal</td>
<td></td>
</tr>
<tr>
<td>Adjustment cost parameter for bank’s CAR</td>
<td>$\kappa_{bb}$</td>
<td>beta</td>
<td></td>
</tr>
<tr>
<td>Calvo parameter for import goods</td>
<td>$\theta_f$</td>
<td>beta</td>
<td></td>
</tr>
<tr>
<td>Calvo parameter for domestic goods</td>
<td>$\theta_h$</td>
<td>beta</td>
<td></td>
</tr>
<tr>
<td>Calvo parameter for export goods</td>
<td>$\theta_{h^*}$</td>
<td>beta</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0.2</td>
<td>4.1670</td>
<td>0.2</td>
</tr>
<tr>
<td>2</td>
<td>0.2</td>
<td>2.1274</td>
<td>0.2</td>
</tr>
<tr>
<td>2</td>
<td>0.2</td>
<td>4.1417</td>
<td>0.2</td>
</tr>
<tr>
<td>3.25</td>
<td>0.2</td>
<td>3.2675</td>
<td>0.2</td>
</tr>
<tr>
<td>3.5</td>
<td>0.2</td>
<td>3.7420</td>
<td>0.2</td>
</tr>
<tr>
<td>8</td>
<td>0.2</td>
<td>8.1676</td>
<td>0.2</td>
</tr>
<tr>
<td>5</td>
<td>0.5</td>
<td>5.1631</td>
<td>0.5</td>
</tr>
<tr>
<td>50</td>
<td>0.5</td>
<td>49.3372</td>
<td>0.5</td>
</tr>
<tr>
<td>1</td>
<td>0.05</td>
<td>0.9684</td>
<td>0.05</td>
</tr>
<tr>
<td>0.7</td>
<td>0.05</td>
<td>0.6254</td>
<td>0.05</td>
</tr>
<tr>
<td>0.4</td>
<td>0.05</td>
<td>0.3948</td>
<td>0.05</td>
</tr>
<tr>
<td>0.6</td>
<td>0.05</td>
<td>0.7898</td>
<td>0.05</td>
</tr>
</tbody>
</table>

# 6 SIMULATIONS

We will study the dynamics of the impulse function produced by the model in this section. Discussion focuses on the simulation of monetary policy in the form of shocks in the BI rate, total factor productivity and the exchange rate as well as simulations of macroprudential policy. In accordance with model design, macroprudential policy includes the capital adequacy requirement, the LTV ratio and reserve requirement (RR). Furthermore, the dynamics of the impulse function relating to shocks stemming from the banking sector, namely a decrease in bank capital, will also be investigated. This is done in order to understand the transmission of such shocks to the real sector and comprehend the role played by monetary policy in terms of mitigating such shocks. The model developed in this research assumes a small open economy; therefore a shock in the form of increased world GDP will also be studied.
6.1 BI Rate Shock

A 1 percent hike in the BI rate (blue line in the figure) would be transmitted to the various interest rates in the banking sector. The magnitude of those interest rates is determined by the mark-up applied at the respective bank as well as the level of stickiness of each corresponding interest rate. The fastest response to an increase in the BI rate is transmitted to the deposit rate, which is raised directly in the same period as the BI rate hike. This is because the deposit rate has a lower level of stickiness than the lending rate. Furthermore, raising the lending rate would also exacerbate the risk of default, which is demonstrated by an increase in non-performing loans and ultimately erodes a bank’s capital adequacy ratio due to the high risk-weighted assets. A decline in the extension of total credit would lower bank LDR and eventually also dissuade investment and undermine capital.

The effect of the financial accelerator mechanism can be observed in the variable, idiosyncratic shock, which is higher ex-post than ex-ante, which forces banks to bear risk and reduce their capital. The higher idiosyncratic shock ex-post compared to ex-ante is the result of banks overvaluing their assessment of the return on capital from the entrepreneur due to an ongoing economic contraction that means the actual return on capital is not as large as that predicted by the bank.

The increase that occurs in the lending rates offered to households would impinge upon the households’ ability to consume. Moderating domestic demand compels producers to reduce production, which is evidenced by a decline in final goods output. A lower level of production of final goods would also manifest due to rupiah appreciation stemming from a hike in the BI rate, which compromises product competitiveness and ultimately suppresses exports. Imports would also slump as a consequence of weaker demand for consumption and investment. Against this backdrop, the rate of inflation would decrease.

It is assumed that the policy implemented does not merely rely on the BI rate but also a combination of countercyclical macroprudential policy to suppress credit
growth that involves lowering the LTV ratio (red line). The simulations prove that a shock in the form of a policy mix would stifle credit growth more deeply than conditions without an LTV shock. GDP and the rate of inflation decline but only moderately compared to conditions when only BI rate policy is used. Instituting a policy mix enables the slump in consumption to be offset by the slowdown in imports, hence GDP tends to remain more stable. The simulations also show that in addition to a policy mix helping to stabilise GDP and inflation, it also controls consumption thus alleviating the demand for imported goods. Coupled with stable exports, the decline in imports would favourably impact the current account.

### 6.2 Households’ LTV Ratio Requirement Shock

**Figure 10. Impulse Response Household LTV Ratio Shock**

Raising the LTV ratio requirement on household credit (consumer loans) triggers an increase in the volume of household credit due to an incentive stemming from the larger volume of loan that can be allocated by the banks and backed by the collateral of the household. By raising the LTV ratio, but with the same asset value, households could borrow more from a bank. The increase in loan volume encourages banks to manage their asset portfolio by lowering the volume of credit extended to entrepreneurs. Increasing total bank loans would raise bank LDR and reduce bank CAR due to credit expansion implemented by the bank. A high level of credit allocation also increases bank profit and would ultimately bolster bank capital in subsequent periods. The increase in total loans extended to households would cause impatient households to increase their level of consumption, which would prompt producers to ramp up production of final goods output. Such conditions would eventually stimulate GDP growth.

Economic expansion due to greater GDP growth would increasingly expedite credit allocation due to the financial accelerator mechanism. The effect of the financial accelerator mechanism can be observed in the variable, idiosyncratic shock, which is
lower ex-post than ex-ante, which shows that the actual return on capital from entrepreneurs is higher than the banks’ expectations. This helps to lower the level of non-performing loans (NPL).

6.3 CAR Requirement Shock

When the CAR requirement experiences an increase, banks tend to transfer their assets by reducing credit extension, both to households and entrepreneurs, and increasing risk-free assets. Such conditions would lower the LDR ratio as the disbursement of credit slows. On the other hand, however, banks would enjoy an increase of capital as a result of the reduction in credit allocation, thus raising the level of CAR. Figure 11 illustrates that an increase in bank CAR would not be as pronounced as the increase in the CAR requirement, which is possible due to the small adjustment cost of the difference in the CAR requirement estimated in the model because of how far apart the steady state value of CAR is compared to the CAR requirement.

This kind of shock in the banking sector also impacts the real sector, which is represented by a reduction in the disbursement of credit that erodes investment and the production of final goods by producers. Accordingly, the GDP of Indonesia would decline.
6.4 Bank Capital Shock

Figure 12. Impulse Response Bank Capital Shock

When a shock appears in the form of less bank capital, banks react by reducing their disbursement of loans, both to households and to entrepreneurs, thus the amount of total loans would decrease. Less capital at a bank would also precipitate a decline in risk-free assets and, thus, a lower LDR ratio. Less bank capital also forces the bank to increase profit, hence the accumulation of profit can boost capital in the subsequent period.

Greater bank profit would increase the income of patient households as the owners of the bank, which subsequently results in more consumption. Greater consumption would drive up production of final goods as well as investment. Consequently, total GDP will follow an upward trend and the rupiah appreciation that occurs will lower the price of imported goods and suppress the rate of inflation, which will elicit a central bank response in the form of lowering its policy rate.
6.5 World GDP Shock

An increase in world GDP would trigger a surge in exports followed by growth in final goods output. The increase in final goods output would lead to an increase in investment and imports of raw materials required for production. Such circumstances would raise GDP as well as income and ultimately boost public purchasing power. Greater public purchasing power would bolster consumption and spark inflationary pressures in the economy. Consumer loans would also expand in line with solid public consumption. Greater public purchasing power would also occasion an increase in deposits held at banks, which are subsequently allocated by the banks in the form of loans to the household sector. An increase in loan disbursements would also improve bank profits and subsequently buoy bank capital, thereby eventually raising bank CAR.

Under expansive economic conditions, when the production of goods increases due to the positive shock of stronger international demand, the financial accelerator also encourages the banking sector to expand credit allocation. Such behaviour is observed in the variable, idiosyncratic shock, for which the ex-post value is smaller than the ex-ante value; therefore, non-preforming loans are lower and the external finance premium becomes increasingly small. Such conditions make it easier to access credit from the banking sector.
6.6 Exchange Rate Shock

Figure 14. Impulse Response Exchange Rate Shock

Depreciation in the rupiah exchange rate would boost the competitiveness of export products, hence creating a surge in exports accompanied by an increase in final goods output. The increase in production of final goods would be followed by a greater requirement for investment, thereby raising GDP and income. Greater income would strengthen public purchasing power and drive consumption. The gains in consumption, however, would exacerbate inflationary pressures in the economy.

The requirement for greater production of goods by producers would cause entrepreneurs to borrow more from the banks. During an expansive economic phase, when the production of goods increases to meet the surge in exports, the financial accelerator compels banks to lend more. The effect of the financial accelerator mechanism can be observed in the idiosyncratic shock variable, which is lower ex-post than ex-ante; thus, non-performing loans are low and the external finance premium also becomes increasingly small. Such conditions make it easier to access credit from the banking sector.

7 CONCLUSION

A DSGE model was developed in this research for the small open economy of Indonesia, complemented with financial frictions in the form of collateral constraints and the financial accelerator mechanism as well as a banking sector designed according to the conditions found in Indonesia. Analysis of the impulse response function of the model showed that the transmission of monetary and macroprudential policy is as follows:

a) Raising the BI rate would compel banks to hike their retail rate and reduce loan disbursements, which would ultimately erode final goods output. Such conditions would subsequently lower GDP and the rate of inflation. The proceeding economic contraction would trigger a larger idiosyncratic shock ex-post than ex-ante, where the expected return on capital of the entrepreneur would exceed the actual realisation and, therefore, non-performing loans (NPL) would increase. This situation
forces the banks to bear the risks that emerge and erode bank capital. Such conditions would also raise the external finance premium, thereby making it increasingly difficult for entrepreneurs to borrow from banks.

b) Raising the LTV ratio requirement for household credit (consumer loans) triggers a surge in consumption and purchases of housing assets by households. Strong demand from households would force producers to increase final goods output, thus causing an increase in output and eventually pushing up the rate of inflation. Consequently, in order to expand credit allocation to the household sector, banks would reduce their risk-free assets.

c) A shock in the banking sector in the form of a more stringent CAR requirement would force the banks to reduce credit allocation to the household sector and entrepreneurs, precipitating a decline in bank LDR. Such a shock would also impact the real sector through a decline in loan disbursements that would undermine investment and reduce the production of final goods by producers. Consequently, GDP and the rate of inflation would both decelerate.

d) Simulations show that a policy mix combining monetary policy and macroprudential policy would not only spur stable GDP growth and inflation but also control consumption and alleviate demand for imports. Coupled with stable exports, weaker imports would favourably impact the current account.

By including the banking sector in the model, analysis was possible of the policies required to overcome shocks originating from the banking sector. When bank capital suddenly plummeted (due to large-scale write-offs of their assets), the central bank would be required to provide a stimulus in the form of lowering its policy rate (BI rate) in the same period as the shock. Postponing the reduction in the policy rate by the central bank would lead to a more pronounced decline in output and require a much larger monetary stimulus. The simulations conducted in this research highlight the importance of timely monetary policy when confronting a shock stemming from the banking sector. The origins of shock need to be identified before central bank decides the policy response needed. For example, if there is an increase in technological shock that increases the GDP as well as credit volume, it is not necessary to increase the policy rate since there will be no hike price due to high supply of goods.

The model developed in this research met all of its development objectives, namely, to simulate monetary policy (BI rate) and macroprudential policy (CAR and LTV requirement). There remains one caveat, however, which should be remembered when interpreting the simulation of an LTV shock produced by the model. The definition and assumption of the LTV ratio requirement in the model is not fully aligned with the concept of the LTV ratio requirement applied in Indonesia since 2012. Consequently, the results of the simulations performed using this model must be more carefully interpreted.

Further Model Development

Based on the impulse response function and the potential for this model to be used under the Bank Indonesia FPAS (forecasting and policy analysis) framework, there are several refinements that could be made as follows:

a) Develop a model that supports a broader application relating to interaction between a range of monetary and macroprudential policies. This could be achieved, among
others, by endogenously modelling macroprudential policy, for instance with a CAR requirement rule, LTV requirement rule and their interaction with the Taylor rule.

b) Develop a model that could not only be used as a simulation model but also to project macro variables as well as variables linked to balance sheets and conditions in the banking sector.
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Discussion\textsuperscript{11}

Dr. Shanaka Jayanath Peris noted that the paper used the Gerali et al. (2010) model with additional features such as a housing finance channel, inflation and households. An interesting conclusion was that the use of macroprudential policy (loan-to-value (LTV) in the paper) combined with monetary policy would be more effective in bringing down inflation and credit growth. Said result suggests coordination between monetary policy and macroprudential policy, which may depend on the type of shock. Likewise notable was the inclusion of reserve requirement in the model. There was uncertainty whether the degree of excess reserves has a direct impact on the lending rate.

One participant requested clarifications on the necessity of distinguishing the policy rate from the short-term Treasury bill rates, and on whether adjustment cost should be applied on all asset types for symmetry.

Another participant noted that implicit in the model was financial friction, which is about the inability to hedge and automatically swap bonds. It may be worthwhile to investigate whether economic agents who do not hedge due to prohibitive costs will have an impact on the paper’s result. Furthermore, the LTV and the policy rate seemed to reinforce each other in minimizing shocks to output when they move in the same direction (towards tightening in the paper). However, in some countries, LTV was being tightened at a time when monetary policy was being eased. Thus, the possibility of both moving in opposite directions should be considered.

One participant mentioned that the discussion on the comparative advantage of different instruments in different situations is useful. However, there was not enough information to confirm the effect of macroprudential tools on output.

Dr. Harmanta mentioned that moving forward, suggestions will be considered to fine tune their model. In particular, adjustment costs on all asset types and opposing directions of macroprudential policy will be considered.

\textsuperscript{11} Dr. Shanaka Jayanath Peris of the International Monetary Fund was the discussant of the paper.
Session 4
Policy Discussion on the Evolving Role and Limits of Monetary Policy: New Perspectives for Emerging Market Economies
1 Current developments complicate monetary policy

The monetary world today has become more complicated than the world a decade ago. A decade ago, it was fine to operate in line with the Taylor rule. The transmission mechanism was well understood. Likewise, the exchange rate channel, cash flows with intertemporal substitution, and equilibrium real interest rate were well understood. However, at present, there is no certainty whether the Taylor rule is right particularly from the financial stability perspective, why the transmission mechanism is not working, and how to measure the concept of monetary policy particularly at the zero lower bound.

The very low interest rates and the monetary creation have been compounded with three developments: (i) capital accounts have been more open with money being transferred around the world more quickly; (ii) financial systems are more liberalized; and (iii) fiscal policy is not boosting aggregate demand, but is causing contraction in aggregate demand. This had made the task of monetary policy more complicated. Overburdening monetary policy has caused problems in the global economy.

The balance sheet problems in the household and financial sectors in the US, and in the government and the financial sector in the Euro area, and the big shock to aggregate demand left deep scars in the business and household psychology. Given the low levels of confidence, this has led to excess capacity. Global appetite for real investment is very low relative to appetite for savings, which have kept equilibrium rates very low.

The non-crisis countries have imported the low interest rates of the large developed economies through their currency appreciation, and the low interest rates have, in turn, pushed up asset prices. Thus, in a number of countries, including Australia, growth is unbalanced.

2 Limits of monetary policy

The central issue in the G-20 meeting in 2014, which was chaired by Australia, was the apparent inability of monetary policy to stimulate real investment in many countries. People have been shifting from bank deposits to existing assets and, in the process, have pushed up the price of existing assets. The housing markets in many countries, including Australia, are good examples of this.

However, demand for new assets and new investments have not increased because people do not want to do intertemporal substitution. Low interest rates are not working because it is making people more nervous about the future. The household sector in many countries have large balance sheet problems and the corporate sector is scarred because of the depth of the shock to aggregate demand. Thus, if the transmission mechanism is temporarily or perhaps persistently broken, monetary policy will just push up the price of existing assets without encouraging intertemporal

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1 Deputy Governor, Reserve Bank of Australia
substitution that is required to stimulate real investment. Ultimately, this will lead to more risks in the financial system.

3 Measures apart from monetary policy

What can be done? The G-20 gave two possibilities, neither of them involves central banks, but they involve governments. The first is structural policy. Competition in trade, entrepreneurship and innovation need to be encouraged. The basic problem is that businesses do not want to invest because they consider the economic climate as not conducive to greater capital expenditure. The investment environment has to be changed to encourage investors to invest rather than placing their money in the bank earning zero interest.

The second is spending on infrastructure. Many countries have huge shortfalls in infrastructure. Expanding supply in the economy will increase the potential for future growth. However, proper project selection, contract design, and financing structure must be exercised. Infrastructure spending is a sensible approach that will take the pressure off monetary policy.

4 Tensions with macroprudential policy

In general, financial risk is increasing. In response, macroprudential tools need to be tightened to reflect the greater risk. However, there is a tension because the reason for having low interest rates is to stimulate intertemporal substitution. People are being encouraged to borrow against future income – to spend today that would help stimulate the economy. However, with low interest rates pushing up existing asset prices, macroprudential policy is being used to reduce borrowing. Thus, there is a tension between monetary policy and macroprudential policy.

In Australia, macroprudential policy has been used even in the 1970s. All forms of restrictions have been used and frequently adjusted – controls on the rate of growth of the bank balance sheet, controls on the housing loan portfolio, and debt servicing restrictions. The restrictions worked for a while, but ultimately failed because the financial sector was able to innovate around the restrictions, which created distortions in the system.

5 Challenges in Australia remain

Currently, monetary policy rate in Australia is at its lowest level on record and will likely stay low for years to come. Capital flows are high, but have recently gone down. In addition, Australia had very strong aggregate investment, all narrowly focused in the resource sector, particularly in the mining sector. Investments in non-mining sectors have been weak, which is lowest in many decades. Even though Australia did not have a financial crisis, it is not in a comfortable position because business psychology has been scarred and the prices of existing assets, particularly in the housing market, are increasing quickly.

At this juncture, the best macroprudential tool is government spending on infrastructure because that would take the pressure off on low global interest rates and reduce the risks in the financial system.
Flexible Inflation Targeting: Past, Present, and Future

John Murray

1 Canada’s experience with flexible inflation targeting before and after the crisis

Canada is an early adopter of inflation targeting. It started to use the framework in February 1991. It is the second country, after New Zealand, to adopt inflation targeting. There was an initial apprehension whether growth and low inflation were good partners, but with the framework, inflation was kept close to target and growth was stronger.

The performance of the economy over the 1991-2007 period was better than what was expected. In addition, the performance of the economy during and after the crisis was better than most other countries. Inflation targeting was an important contributor to this good performance. Nevertheless, not everything can be credited to inflation targeting. Canada had sound fiscal policy and oil, which helped the economy.

2 Renewal of Canada’s inflation target

Is flexible inflation targeting the best that can be done for Canada?

Prior to the 2011 renewal of inflation targeting framework, the Bank of Canada had an extensive research program that focused on three questions.

First, is 2 percent still the right inflation target? The concern was whether the target should be lower, since the 2 percent target was set prior to the crisis. Second, would a price level target be better than inflation targeting? Studies conducted as far back as 1991 have shown that there could be some benefits from price level targeting. Third, should financial stability concern get more explicit recognition in the monetary policy objective function or should it just be inflation? Monetary policy has a role to play in financial stability, but it has a longer term view. Monetary policy is only the fourth line of defense. The first line of defense for financial stability is not monetary policy, but responsibility at the individual borrower and lender level. The second line of defense is microprudential regulation and supervision. The third line of defense is macroprudential regulation and supervision, and adjustment of these tools as appropriate. These tools were already used in the past – moral suasion, window guidance, selective lending, and reserve requirement. The fourth line of defense, when all else fail, is monetary policy.

Prior to the renewal in 2011, the Bank of Canada hosted a number of conferences and invited many academics and central bankers to do extensive research. The outcome was a number of theoretical and empirical work supporting the case for a lower inflation target and the case for price level targeting instead of inflation targeting. But evidence for lower inflation target and price targeting was not very strong. The Bank of Canada was not willing to risk something that is already working for the promise of a little something better. Thus, there was no change to the existing framework, but the central bank had a renewed appreciation for what is already being done.

1 Former Deputy Governor, Bank of Canada
3  Outstanding issues related to the framework

Many issues remain unresolved and are being re-examined in the run-up to Bank of Canada’s 2016 inflation targeting renewal:

- Are encounters with the zero-lower-bound going to be more frequent?
- Does this suggest the need for a higher inflation target?
- Does it increase the attractiveness of price level or GDP level targeting versus inflation targeting?
- Can unconventional tools play a useful role in “peace time”?
- Is forward guidance only helpful in emergency situations?
- How long should emergency liquidity measures be kept in place?
- Do financial stability concerns need to be given more explicit recognition in the monetary policy objective function? If yes, how?

4  Monetary policy as a culprit, captive and savior

There are some exaggerated and unhelpful characterizations of monetary policy. Is monetary policy a culprit, captive or savior? First, it is a culprit – a major contributor to the crisis. Some view that the easy monetary policy facilitated some of the behavior in the run up to the crisis. But it is not the primary culprit in the search for yield, but financial liberalization and the lack of oversight. The failure to supervise markets and institutions adequately were the main reason for the crisis. It is misdirected to blame low interest rates because there are countries like Canada and Australia that had low interest rates but did not suffer. Second, it is captive – at risk of losing its independence. Monetary policy may be captive to governments (i.e., fiscal dominance). While this is a legitimate concern, countries are not at this point yet. Third, monetary policy is a savior. It is too popular for its own good and is being asked to do too much. Stable inflation does not guarantee financial instability. However, monetary policy is being overburdened with financial stability responsibilities. Some use it as a fallback for some policymakers’ failures.

5  Monetary policy in conjunction with other policies

It is helpful to mention the objective of the G-20 Framework: to promote strong and sustainable balance growth. It has four legs: (i) monetary policy easing; (ii) fiscal tightening, especially in advanced economies; (iii) structural reforms to promote longer-term growth; and (iv) financial regulation to ensure stability in the future.

Without the other three, monetary policy cannot deliver the solution to the recovery. Monetary policy can only do so much. Even if we see monetary policy in action, but inaction in the other three, then it should not be a surprise why recovery has been slow.

From the foregoing, two main messages can be obtained. First, monetary policy has not been a disappointment. Flexible inflation targeting is still the best thing that the Bank of Canada has ever tried. Second, flexible inflation targeting is very good, although it does not mean that it is the best. Caution must be made in pushing the financial stability front into monetary policy.
A New Era for Monetary Policy: Challenges for the European Central Bank

Ad van Riet

1 Crisis challenges for the ECB

The global crisis revealed the imbalances and shortcomings in the architectural design of the eurozone. One big consequence of the crisis was the fragmentation that appeared inside the eurozone along the national lines of credit worthiness. Debt has hampered the even transmission of monetary policy across the Eurozone. And this has been a great challenge for the ECB.

Before the crisis, standard measures were used. To deal with the challenges of the crisis, ECB needed to dig deep in its monetary policy toolkit. The crisis demanded the use of non-standard measures.

Standard measures included (i) reducing the three ECB key interest rates to effective zero bound; (ii) narrowing of interest rate corridor around the main refinancing rate; and (iii) steering bank reserves and excess liquidity.

Non-standard measures included (i) expanding liquidity by easing bank funding conditions in the money market in line with high demand for longer-term liquidity; (ii) enhancing credit support by easing bank credit supply conditions and/or creating market incentives to provide credit; (iii) widening the range of eligible collateral by lowering the minimum sovereign credit rating and accepting additional performing private sector credit claims; and (iv) improving monetary transmission by repairing malfunctioning financial market segments in context of high risk premia, to enforce the monetary stance.

2 Evolution of the eurozone crisis (2007-2014)

The eurozone crisis has evolved from 2007-2014. The financial turmoil that commenced in Summer 2007 was marked by high demand for liquidity as money markets froze. In response, ECB lent EUR 90 billion overnight to banks (9 August 2007).

After the Lehman Brothers collapse, the stability of the global financial system was threatened, as well as the euro area economy and the outlook for price stability. Beyond lowering its key interest rates, the ECB provided liquidity and enhanced credit support by easing bank funding conditions and supporting bank lending to households and firms. The following were provided: (i) unlimited liquidity provision at fixed interest rate, against adequate collateral; (ii) longer-term refinancing operations (LTROs) at longer maturities than usual (up to 1 year vs. 3 months normally); (iii) supplementary refinancing operations at maturities of 3 and 6 months; (iv) expansion of list of eligible collateral for ECB refinancing operations; (v) liquidity provision in foreign currencies against euro-denominated collateral, notably US dollars through the ECB swap facility with US Federal Reserve; and (vi)

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1 Senior Adviser in the Directorate Monetary Policy of the European Central Bank
implementation of the first Covered Bonds Purchase Program (CBPP 1) amounting to EUR 60 billion to ease conditions in bank financing.

During the great recession, enhanced credit support prevented a credit crunch. As recovery began, phasing out of non-standard measures was initiated, but was subsequently aborted due to the sovereign debt crisis. During this period, ECB conducted interventions on exceptional and temporary basis in the euro area debt securities markets (Securities Markets Program, SMP) to address malfunctioning sovereign bond markets, prevent contagion and restore monetary transmission. These included (i) purchases of sovereign bonds in volatile secondary markets from May 2010 until March 2012, for about EUR 220 billion; and (ii) sterilization of extra liquidity until June 2014.

To prevent a sovereign-bank feedback loop, several measures were undertaken, namely, (i) implementation of the second Covered Bonds Purchase Program (CBPP 2) amounting to EUR 40 billion; (ii) offering of two LTROs with exceptional 3-year maturity; (iii) lowering of required reserve ratio from 2 percent to 1 percent to free up collateral; and (iv) further expansion of list of eligible collateral (e.g. including performing bank credit claims).

The eurozone also experienced a confidence crisis. In response, ECB president, Mr. Draghi, made a pronouncement that “Within our mandate, the ECB is ready to do whatever it takes to preserve the euro. And believe me, it will be enough” (26 July 2012).

Financial stress and fragmentation started to decline from mid-2012. Steps towards European Banking Union was decided in June 2012. To break the doom-loop between vulnerable sovereigns and fragile banks, the following were undertaken: (i) ECB was assigned as the single bank supervisor from November 2014 to ensure quality of bank balance sheets; (ii) a new single bank resolution mechanism was adopted with rapid build-up of single bank resolution fund; and (iii) harmonization of retail bank deposit insurance across Europe.

Market confidence in eurozone and in distressed countries returned but remains fragile. Banks in Spain were stabilized and its government required no further official support. Ireland completed its EU/IMF program and regained full access to the capital market. Portugal is also back in the capital market and completed its EU/IMF program. Greece managed to borrow longer-term funds through syndicated loans. Cyprus followed step-by-step plan to relax restrictions on bank deposits and capital outflows.

Financial fragmentation in sovereign debt markets has receded, but an even monetary transmission across euro area is still impaired. Currency redenomination risk has essentially vanished. Likewise, money markets are more integrated, notably in the secured segment. Meanwhile, bond markets are more aligned at very low interest rates and equity markets are more integrated. Nevertheless, bank borrowing costs are still dispersed, especially in crisis-affected countries and for small- and medium-scale enterprises.

3 Introduction of forward guidance

The ECB enhanced its communication program by introducing forward guidance on its monetary stance and reaction function. In 4 July 2013, the ECB
proclaimed that “The Governing Council expects the key ECB interest rates to remain at present or lower levels for an extended period of time” (4 July 2013; since then reiterated). This had helped counter excessive volatility in the euro area. Forward guidance has likewise clarified ECB’s reaction function and has defined the scope of further rate cuts. This has anchored market expectations of ECB key interest rates, thereby enhancing the effectiveness of the desired monetary policy stance.

Forward guidance has helped reduce market uncertainty about the path of future short-term rates. It has likewise contained renewed dispersion across national sovereign bill and bond markets. There is also evidence of less sensitive market reaction to macroeconomic news.

4 Current challenges for the ECB

Inspite of the ECB’s efforts, important challenges remain. The September 2014 ECB staff projections pointed to a weak economic recovery. Contributing factors included high unemployment rate, sizeable unutilized capacity, need for further private and public sector deleveraging, and ongoing geopolitical tensions.

Moreover, the projections pointed to subdued inflation. Due to the risks associated with a too prolonged period of low inflation, the ECB decided to provide additional monetary policy accommodation and support lending to the real economy (Governing Council decisions of 5 June and 4 September 2014).

Targeted credit easing were implemented through several measures: (i) ECB key interest rates were effectively reduced to zero bound, resulting in negative deposit rate; (ii) suspension of weekly operations to sterilize liquidity injected via SMPs; (iii) targeted longer-term refinancing operations (TLTROs) at a fixed rate with built-in incentives for banks to lend to private sector (all maturing in September 2018); (iv) targeted purchase programme of high-quality asset-backed securities (ABS); and (v) implemented the third Covered Bonds Purchase Program (CBPP 3).

The rationale of this package is to maintain high degree of excess liquidity and contain volatility in the money market. Likewise, the measures were intended to enhance bank-based transmission, restore impaired non-bank credit markets, compress funding costs in targeted markets, and ease general financing conditions.

The monetary stance of the ECB is to achieve a sizeable, more controlled increase of the Euro system balance sheet. The forward guidance on key interest rates is expected to signal expansionary monetary stance over an extended horizon with key interest rates at zero bound. This will help anchor medium- to long-run inflation expectations.

5 New era for ECB monetary policy

Looking ahead, there is a new era for ECB monetary policy. Europe has revamped financial governance since the global financial crisis. New macroprudential institutions are in place, as follows:

First, the New European Systemic Risk Board is in place since 2011. It takes charge of macroprudential oversight of the financial system. Second, new European
Supervisory Authorities are in place since 2011 for banking (European Banking Authority), pensions (European Insurance and Occupational Pensions Authority) and securities markets (European Securities and Markets Authority) to more effectively coordinate national microprudential policies. Third, the Single Supervisory Mechanism (SSM) will be in place in November 2014 to supervise – independently from monetary policy – the 120 most significant banks (about 85 percent of total banking assets in the euro area) and to assume final responsibility for national bank supervision of the 6000 smaller banks. SSM may impose tighter (but not looser) macroprudential rules than set at national level. Fourth, a Single Resolution Mechanism will be established for effective management of a banking crisis if, after a private sector bail-in, the national bank resolution fund is exhausted and the government has no fiscal capacity to step in. Finally, a tightening of EU financial sector legislation in many areas, also following G20 agreements.

These fundamental reforms are expected to facilitate the conduct of the single monetary policy for a financially integrated, but heterogeneous monetary union. These are expected to make microprudential supervision more effective. The reforms are intended to make (cross-border) banks more stable and break the nexus between (cross-border) banks and their governments. Likewise, these reforms should make macroprudential supervision more effective. Improvements in identification, response and implementation of targeted instruments to deal with local systemic risks should prevent spillovers to other countries (e.g. using countercyclical tools to dampen national credit cycles and structural measures to reduce regional financial vulnerabilities). Moreover, tighter EU financial sector legislation is expected to reduce the chances of turmoil in financial markets, intermediaries and infrastructures.

The new architecture supports financial stability and reduces likelihood of financial fragmentation that hinders an even monetary transmission across the eurozone. It also helps to control risks from a prolonged very accommodative monetary stance.

6 Conclusion

To conclude, ECB faced a complex and evolving crisis-environment and had to dig deep in its monetary policy toolkit, combining standard and non-standard instruments. ECB focused on medium-term price stability, while contributing to financial stability as lender-of-last-resort for banks and as market-maker-of-last resort. It is committed to using additional unconventional tools within its mandate to address the risk of inflation staying low for too long. Nevertheless, the eighteen national policy makers must also join forces to underpin the euro area recovery with structural reforms and growth-friendly fiscal policies.

Major reforms in European finance should support a sound banking system, deepen financial integration and secure financial stability. This should ease the task of the ECB’s single monetary policy for the eurozone, assuming proper coordination among the relevant authorities.
Panel Discussion¹

Deputy Governor Philip Lowe agreed with Deputy Governor John Murray on the usefulness of flexible inflation targeting. It has helped Australia keep inflation within the target range.

One participant commented that it is easy to agree that flexible inflation targeting has worked very well, but it might have worked well in Canada and Australia in part because these countries have such good supervisors. It is possible that good supervision is a precondition for effective flexible inflation targeting. Furthermore, bank supervision is relatively easier in Australia and Canada due to the very small number of banks in these countries.

Another participant noted that for Canada, inflation came down right before the start of the flexible inflation targeting regime. Meanwhile, there are countries like the US and China which did not have inflation targeting but have stable inflation. Moreover, it should be noted that Australia and Canada are very open economies so the impact from the global supply chains may be a factor in affecting consumer prices.

Deputy Governor Murray noted that inflation targeting may be getting too much credit, in the sense that, it can be observed that other countries seem to do well without it, and there are some which did very badly with it. Stable and low inflation has helped anchor expectations for businesses and workers in Canada. It has made monetary policy more efficient in the sense that smaller interest rate movements are needed than before to control inflation. It has also allowed the Bank of Canada to do more dramatic things during the crisis. It does not guarantee, however, that the policy maker will do a good job at monetary policy and that it will be effective. In addition, caution must be made in using monetary policy in addressing financial stability concerns. The use of macroprudential tools must be considered instead.

One participant asked Senior Adviser Ad van Riet: How does ECB envision coordination with monetary policy and its supervisors? Is the use of medium-term price stability targets ECB’s way of incorporating financial stability into its reaction function?

In response, Senior Adviser van Riet stated that the ECB does not have the full responsibility for financial stability, but at the national level, ECB contributes to financial stability. The new institutional framework is an advantage since the ECB will have one pillar dealing with monetary policy and another pillar dealing with bank supervision. In addition, the macroprudential side will be the responsibility of the European Systemic Risk Board, which is also within the ECB. The new role of ECB as a bank supervisor means that it could tighten macroprudential measures at the national level. All of these are much more Europeanized than in the past and, therefore, also better coordinated than previously. Nevertheless, whether this is the proper architecture or not has yet to be seen.

Deputy Governor Lowe emphasized the importance of supervision. The global economy is paying a very heavy cost because of the failure of authorities in some large economies to effectively supervise banks.

One participant pointed out that financial stability is very important for monetary policy because it guarantees a smooth transmission mechanism. In addition,

¹ Policy discussion for the presentations of Deputy Governor Philip Lowe, Former Deputy Governor John Murray and Senior Adviser Ad van Riet
financial stability is a necessary condition for achieving other macroeconomic goals, including inflation goals. There is no inherent inconsistency between the pursuit of financial stability and price stability.

One participant raised the question of how to ensure inflation expectations are well anchored within the flexible range. Deputy Governor Lowe relayed that maintaining the credibility of the central bank is a very effective way of anchoring inflation expectations. For 20 years, Australians know that inflation would be 2½ percent and that has conditioned wage expectations. Thus, wages have been fairly constant, which may be attributed to the credibility of the inflation targeting regime. Deputy Governor Murray stated that for Canada, inflation targeting is achieved through interest rates adjustment and maintenance of a flexible exchange rate regime. Exchange rate is a monitored variable due to its impact on the real economy and inflation. Bank of Canada does not target exports or the exchange rate.

Another participant also asked whether intertemporal substitution is still working. Deputy Governor Lowe believes that the fundamental problem lies on the fact that it takes a long time for the balance sheet repair to occur. Thus, businesses do not want to invest and households are not willing to borrow. Both lead to weak aggregate demand, which is a bad equilibrium. A well-targeted infrastructure spending can potentially be the circuit breaker.
Closing Remarks

Diwa C. Guinigundo
Deputy Governor
Monetary Stability Sector
Bangko Sentral ng Pilipinas

Monetary policy has evolved in more ways than one and perspectives have multiplied in the aftermath of the great financial crisis. This international research conference has been timely and relevant as the global financial crisis has indeed set a watershed for monetary policy. The low policy rates of advanced economies and the consequent surges of capital flows have created challenges for monetary policy-making. Subsequently, there were major shifts in the structure and regulation of the financial sector and these changes may have affected the transmission mechanism of monetary policy.

Many economic practitioners would say that monetary policy is now in the new normal and there is now an even larger scope for monetary policy research. This is what we focused on in this conference, but as Frederic Mishkin concluded in his survey of literature before and after the global financial crisis, “the bad news is that we have just been in a once every hundred year credit tsunami with far reaching impact on the economy for many years to come, many more tail risk events could be forthcoming that could require us to do constant rethinking.” Nevertheless, economists and central bankers do not have to go back to the fundamentals and shred all that they have learned over the last 40 years.

Much of the science of monetary policy remains intact; the case for the basic monetary policy strategy that for many has become flexible, inflation targeting remains entrenched. The recent financial crisis, however, does require some major rethinking about the details of this basic framework for monetary policy strategy. The financial sector is now widely recognized, as it was recognized in this conference, to play a non-trivial role in the macroeconomy. We may also have to abandon the linear quadratic framework thinking on how to conduct monetary policy when there is financial disruption.

To me, therefore, the other piece of good news that has come out recently is that in the face of many new challenges both theoretical and practical, the field of macro and monetary economics has become a lot more exciting while perhaps the work of central bankers even more challenging. They now have to think about a much wider range of policy issues than they had to previously. This will surely be exhausting but central banking will be a far more stimulating profession.

Two years from now in 2016, the BSP will hold its next conference and there will probably be new economic issues unfolding by then. Would we have learned much by then to guide us in policy making? Would we have answered the questions that have been raised in the past two days or will new twists and turns in global developments take us to uncharted monetary policy realms again? I am sure all of us will continue to exploit information from observable data, and to infer from the unobservable so that we could all address the more difficult issues, providing
suitable and consistent institutional practical setting for conducting and implementing monetary policy.

Thank you very much and good afternoon!
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