



March 2026

Thabo Mboweni, Sihle Sotwili and Eddie Musasiwa

Financial Stability Department, South African Reserve Bank

Authorised for distribution by: Dr Nicola Brink

Nicola.Brink@resbank.co.za

Geopolitical risk, bank balance sheets and macroprudential policies in small open emerging market economies¹

Abstract

The paper calibrates a small open economy dynamic stochastic general equilibrium (DSGE) model for emerging economies with financial frictions and an exogenous geopolitical risk (GPR) shock that affects the country's risk premium and evaluates the stabilization ability of a combination of monetary policy, macroprudential and capital flows management policies. The pre-model empirical evaluation shows that overall, the relationship between GPR and country risk is evident, however, it is heterogeneous across emerging markets and depends on the nature of the geopolitical event. From the DSGE model, a positive GPR shock depreciates the domestic nominal and real exchange rates and is inflationary. It also reduces aggregate demand and raises the nominal interest rate as a response. The shock hampers the financial conditions by increasing both domestic and foreign borrowing rates, which leads to a decline in net worth of banks, causing a decline in the credit market. Policy experiments show that macroprudential policy can stabilise credit, investment and output conditions from the negative GPR shock, however, the policy causes an inflation-output trade-off. The results show that applying an optimal macroprudential policy rule in addition to the standard Taylor rule provides some additional benefit in terms of welfare in comparison to a combination of the standard Taylor rule and capital flows management policies.

¹ The paper benefitted from inputs and comments by external reviewers from the Bank of England (BoE).



1 Introduction

The interconnectedness of the global economy has increased awareness of the impact of geopolitical risk (GPR) on macroeconomic and financial stability, particularly in emerging markets. Geopolitical events such as trade wars, political unrest, and international conflicts can have far-reaching implications for economic stability, leading to fluctuations in exchange rates, interest rates, and capital flows (Feng, Han, Vigne and Xu, 2023, Iyke, Phan and Narayan, 2022). The increased incidents and intensity of geopolitical shocks have intensified concerns relating to geoeconomic fragmentation (GEF), particularly the associated disproportionate macro-financial impact on emerging markets (Campos, Estefanía-Flores, Furceri and Timini, 2023, IMF, 2023).

This study recognises the significant real-financial feedback effects of GPR and seeks to contribute to the existing literature by exploring their implications for emerging market economies. In line with previous research (e.g. Adolfson, Laséen, Lindé and Villani, 2007, Kitano and Takaku, 2020, Smets and Wouters, 2007); a small open economy dynamic stochastic general equilibrium (DSGE) model is employed for the analysis. The paper makes two contributions to the literature: 1) Incorporating GPR simply through the uncovered interest parity condition (UIP) of a small open economy DSGE model to uncover the impact of GPR on macro-financial variables. 2) The model enables an evaluation of monetary and macroprudential policy paths after GPR shocks, which is not always possible in the previous studies that mainly use VAR techniques.

The results indicate that a negative global GPR shock creates a negative wealth effect which lowers output, consumption and investment. This shock raises the country risk premium by design, which makes the foreign borrowing rate increase relative to the domestic borrowing rate. This effect results in capital outflows and a depreciation of the nominal exchange rate. The nominal exchange rate depreciation results in higher inflation as foreign goods become more expensive relative to domestic goods, which causes the nominal interest rate to increase. The exchange rate depreciation causes exports to increase, while imports decline, leading to a positive trade balance.

The net worth of the banking sector is reduced due to higher foreign borrowing costs. The decrease in the net worth tightens the banks' borrowing constraint, which reduces the banks' assets. With this tightening, the decrease in net worth also increases the spread between

the expected return on capital and the risk-free rate. The increase in the spread raises the cost of credit for non-financial borrowers. The rise in the cost of capital, in turn, causes a further decline in output and investment, which causes a decline in the price of capital. The decline in the price of capital exacerbates the deterioration of the capital value, which worsens the bank's balance sheet and further causes the spread to increase. Policy experiments show that macroprudential policy can stabilise credit, investment and output conditions from the negative GPR shock, however, the policy causes an inflation-output trade-off. The results show that applying an optimal macroprudential policy rule in addition to the standard Taylor rule provides some additional benefit in terms of welfare in comparison to a combination of the standard Taylor rule and capital flows management policies.

Recent work (e.g. Bolt, Den End, Grip, Mavromatis, Verhoeks and De Vette, 2023, Garcia-Saltos, Ilyina, Kangur, Kunaratskul, Rodriguez, Ruta, Schulze, Soderberg and Trevino, 2023, IMF, 2023) underscores the importance of financial institutions and regulatory frameworks in mitigating the effects of GPR on financial stability in emerging markets. Several studies have focused on the impact of GPR on the macroeconomy (Cheng and Chiu, 2018; Clance et al., 2019), trade (Gupta, Gozgor, Kaya and Demir, 2019), corporate decisions (Lee and Wang, 2021), banking stability (Demir and Danisman, 2021, Phan, Tran and Iyke, 2022), stock market dynamics (Caldara, Cavallo and Iacoviello, 2019), and commodity prices (Bouoiyour, Selmi, Hammoudeh and Wohar, 2019, Gkillas, Gupta and Pierdzioch, 2020). Heightened risk typically causes sovereign bond yields and credit default swap (CDS) spreads to rise as investors demand higher premiums to compensate for uncertainty (Afonso, Alves and Monteiro, 2024, Bolt et al., 2023, Demiralay, Kaawach, Kilincarslan and Semeyutin, 2024, Gamboa-Estrada and Romero, 2024, IMF, 2025, Naifar and Aljarba, 2023). Geopolitical events demonstrate the vulnerability of EMEs to external shocks. Due to contagion effects and heightened uncertainty, such events increase the borrowing cost for affected countries and raise the risk premiums across corresponding markets. According to the IMF (2025) sovereign risk premiums can increase notably in response to major GPR events, particularly in emerging market economies with weaker fiscal and external buffers. This justifies the choice of how the GPR shock enters the DSGE model through the sovereign risk channel.

Another strand of the literature which this study touches on is the way monetary policy and macroprudential policy affect macro-financial stability (e.g. Angelini, Neri and Panetta, 2014, Quint and Rabanal, 2017, Rubio and Carrasco-Gallego, 2016). The general result is that a monetary and macroprudential policy combination enhances macro-financial stability, especially when the economy faces housing market and financial market shocks.

In an open economy model with financial frictions, Bernanke (1999) and Unsal (2018) shows that under certain financial shocks, macroprudential regulation that reacts to total liabilities is more effective than that which reacts solely to foreign liabilities. Ghilardi and Peiris (2016) examine macroprudential regulation and monetary policy in an open economy model with financial frictions, as in Gertler and Karadi (2011). They show that macroprudential regulation can complement monetary policy and that countercyclical macroprudential policies can enhance welfare. Kitano and Takaku (2018) show that the welfare-improving effect of capital controls and macroprudential regulation depends on the degree of financial friction between domestic banks and foreign investors. Most of these models focus on foreign interest rate shocks, mainly from the US, which impact the global financial cycle. The focus of this study is on GPR shocks as a source of uncertainty that affects the country's risk premium (à la Araújo, Afonso, Neves and Sochirca, 2024).

The remainder of the paper is structured as follows. Section 2 describes the empirical evidence. Sections 3 describe the data and model employed in the study, respectively. The analysis of the results is presented in Section 4. Section 5 discusses the study's recommendations and conclusion.

2 Empirical facts: GPR index and sovereign risk spread

As argued above, there is generally a positive relationship between GPR and country risk spreads. To assess the link between the global GPR index and interest rate spreads, we regress the interest rate spread of each country on the global GPR index and some control variables. The regression, independently estimated for each country, is expressed as follows:

$$EMBI_t = \alpha + \gamma(\ln gpr_t - \ln gpr) + \beta X_t + \mu_t \quad (1)$$

where $EMBI_t$ is the country's interest rate spread, gpr_t is the global GPR index, and gpr is its mean. X_t is a vector of control variables: output growth, the trade-balance ratio to output,

and the debt-to-GDP ratio, while μ_t is the regression residual. The choice of variables is motivated by the studies of Drechsel and Tenreyro (2018), and Kitano (2022), who estimate the impact of commodity prices on country spreads. In this exercise, instead of commodity prices, we include the geopolitical risk index and keep the other control variables the same. These are variables that should matter for the sovereign creditworthiness of emerging market countries and thus determine the sovereign spreads. The country risk spreads, the Emerging Markets Bond Index Global (EMBIG) which are sourced from Bloomberg, and the GPR index is from Caldara, Conlisk, Iacoviello and Penn (2022), which is a text-based measure that measures the number of times the words related to geopolitical tensions appear in leading newspapers. This includes wars, terrorist events and political tensions which have negative consequences for international relations. Debt-to-GDP and trade-output ratios are from the IMF's World Economic Outlook (WEO) database. This is quarterly data that spans over the period 2000Q1 to 2023Q4 for all countries in the sample.

Table 1 shows the regression results on equation (1). The first row of the table indicates that the coefficients of GPR, γ , are significant and positive for Brazil, South Africa and India, not significant and positive for Chile and Mexico, and lastly, negative and not significant for Turkey. Overall, the results indicate country-specific heterogeneity in which GPR affects interest rate spreads and that the relationship is mostly positive, although not always significant, in line with other studies (e.g., Afonso et al., 2023; Aljarba and Naifar, 2023; Bolt et al., 2023).

Table 1: Regression results of EMBIG to GPR

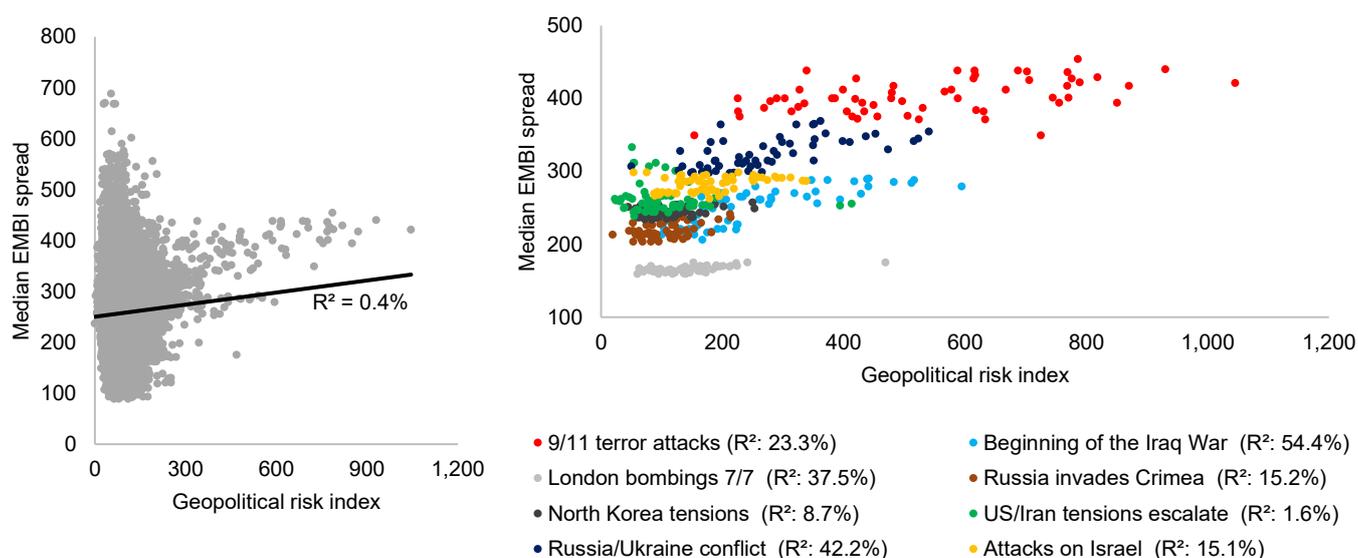
RHS variables	LHS variable: interest rate spread (EMBIG)					
	South Africa	Brazil	India	Chile	Mexico	Turkey
GPR	0.33**	0.64***	0.005*	0.09	0.07	-0.29
Output	-5.94***	-0.28	0.10***	-1.92***	-2.62**	-2.66
Trade balance	-0.70	2.10	-0.03	-1.11***	7.43***	7.91***
Debt-to-GDP	-1.06*	3.69**	-0.05**	0.20**	1.55**	-0.82
Constant	0.70***	0.03	-1.2e05	0.73***	0.87***	1.08***

*** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$. Note: 'Trade balance' denotes the trade balance to output ratio.

Source: Authors' calculations

Figure 1 highlights the complex relationship between GPR and EMBI spreads. Panel (a) shows a generally weak overall correlation, suggesting that while GPR is one factor influencing markets, many other factors play a dominant role in driving EMBI spreads when GPR is low. However, panel (b) isolates specific high-risk geopolitical events and their relationship with EMBI spreads over 60 days. This isolation reveals a much stronger relationship with EMBI spreads, and this can explain why significance levels differ across EMs in Table 1 when testing the entire sample. Nonetheless, the positive relationship between EMBI spreads and geopolitical tensions cannot be ignored entirely. Major conflicts such as the beginning of the Iraq war in 2003 and the Russia/Ukraine conflict of 2022 reflect heightened investor risk aversion. Other conflicts, such as the US/Iran tensions of early 2020, are less significant. This suggests that while heightened GPR events can impact EMBI spreads, these effects are conditional on the scale and perceived repercussions of each event.

Figure 1: Relationship between GPR and EMBI spreads



Source: Bloomberg, Caldara and Iacoviello (2022)

3 Model and quantitative analysis

The model is a small open economy DSGE incorporating real and nominal rigidities as in Smets and Wouters (2007), a banking sector following Kitano and Takaku (2017) and Kitano and Takaku (2020), which are open economy variations to the seminal work of Gertler and Karadi (2011) and Gertler, Kiyotaki and Queralto (2012). The model includes an oil sector,

as in Medina and Soto (2007, 2016), due to the inherent importance of GPR shocks through oil prices.

3.1 Risk premium and GPR

The domestic economy borrows from the foreign market by taking foreign deposits, b_t , which pays a nominal gross interest rate of, $r_{b,t}^*$. Foreign deposits are factored by the real exchange rate, rer_t , to convert them to domestic consumption, and the interest rate on foreign deposits is the combination of an exogenous constant foreign risk-free rate r_t^* and a foreign debt-elastic interest premium as in (Schmitt-Grohé and Uribe, 2003):

$$r_{b,t}^* = r_t^* e^{\left(\psi_{uip} \frac{rer_t \times b_t}{gdp_t}\right)} \times \left(\frac{gpr_t}{gpr}\right)^{\phi_{gpr}} \quad (2)$$

In this specification, we have a slight modification as the global interest rate is not only increasing in foreign debt $\psi_{uip} > 0$, but also increasing in GPR $\phi_{gpr} > 0$. The rise in the global interest rate causes the sovereign risk premium to also increase provided the foreign risk-free rate stays the same. Much literature points to the impact of global uncertainty on country spread premiums, especially in emerging markets. GPR is one form of uncertainty and generally has a positive effect on a country's risk premium.

3.2 Policy rules

The baseline policy rule is a standard Taylor (ST) rule with interest rate smoothing, which is a standard way to characterize monetary policy under an inflation-targeting framework. According to this rule, the central bank adjusts the nominal interest rate, $r_{n,t}$, in response to deviations in CPI inflation, π_t , from steady-state headline inflation, π , and output, gdp_t , from the steady-state output, gdp . The policy rule thus takes the form

$$\log r_{n,t} = \rho_r \log r_{n,t-1} + (1 - \rho_r) \left[\log r_n + \phi_\pi \left(\frac{\pi_t}{\pi}\right) + \phi_y \left(\frac{gdp_t}{gdp}\right) \right] \quad (3)$$

where, r_n, π and gdp are the steady state values of the nominal interest rate, CPI inflation and real output, respectively. The Fisher equation relates the nominal and real interest rates as follows:

$$r_t = E_t \left[\frac{r_{n,t}}{\pi_{t+1}} \right] \quad (4)$$

As in Villca (2022), by the capital requirement ratio, τ_t as follows:

$$\tau_t = \frac{n_t}{q_t s_t + \mathcal{R}_t^m}. \quad (5)$$

which affects the net worth in the following manner:

$$n_t = (\sigma + \xi)r_{k,t}q_{t-1}s_{t-1} - \sigma \frac{r_{b,t-1}^*}{\pi_t^*} r e r_{t-1} b_{t-1} - \sigma \frac{r_{n,t-1}}{\pi_t} d_{t-1} - \sigma \tau_t n_{t-1} \quad (6)$$

For simplicity, we assume that the denominator comprises two types of risks: credit risk and market risk. The first type of risk, which is symbolised by $q_t s_t$, refers to the possibility that the debtor cannot pay his debt, while the second type of risk, \mathcal{R}_t^m , refers to the possibility of incurring losses due to price fluctuations, fundamentally exchange rate fluctuations.

How to implement the countercyclical capital buffer remains an open question. The Basel Committee on Banking Supervision (BCBS) provides only a reference guide as a starting point and encourages national authorities to use their own judgement when implementing it. A study by Repullo and Saurina Salas (2011) criticize the design of the countercyclical capital buffer based on the credit-to-output gap and proposes the use of the output growth as a reference guide for taking buffer decisions. The argument is that the Basel III capital requirement, based on the credit-to-GDP ratio as a reference guide, has potential to exacerbate the pro-cyclicality of bank capital regulation, especially in countries where the credit-to-output ratio is negatively correlated with output. Therefore, in this model, the capital requirement rule is the one that reacts to changes in credit and output which was found to produce better results in terms of macroeconomic and financial stability (Liu and Molise, 2019). The macroprudential regulation is characterised as deviations of the capital requirements ratio from the minimum requirement as set by the regulator. This depends on the business cycle and the financial cycle, which determine the credit conditions of the economy, cc_t , given by:

$$\log \left(\frac{\tau_t}{\tau_b} \right) = \psi_1 \log \left(\frac{\tau_{t-1}}{\tau_b} \right) + (1 - \psi_1) \psi_2 cc_t \quad (7)$$

where ψ_1 is a parameter that captures the persistence of the capital requirement gap, while ψ_2 is the Basel III buffer and τ_b is the requirement set by regulation. The credit conditions index is composed of a weighted average of the business cycle and the financial cycle.

$$cc_t = \eta_b (gdp_t - gdp) + (1 - \eta_b) (q_t s_t - qs) \quad (8)$$

where η_b is the weight of the two types of cycles. If the economy is in its expansionary phase, $gdp_t > gdp$, ceteris paribus, then the requirement increases connection with the reference regulation, that is, $\log \tau_t > \log \tau_b$. Conversely, when the economy is in its recessionary phase, $gdp_t < gdp$, regulation decreases regarding the reference regulation $\log \tau_t < \log \tau_b$. When the economy is in equilibrium, then regulation remains constant. An analogous interpretation can be made with financial cycles. When the credit level is above its trend, $q_t s_t > q_s$, then $\log \log \tau_t > \log \tau_b$, and vice versa. Our analysis is more interesting in an open economy context. Remember that domestic credit is determined, among others, by external debt, $e_t b_t$, which is affected by global events such as GPR shocks. When the economy and the financial system are in their contractionary phases, due to a GPR shock, credit conditions slowdown, which induces a lower requirement for bank capital.

3.3 Calibration

The model is calibrated at a quarterly frequency. As in Lama and Medina (2020), the model is not calibrated for a specific economy but set the parameter values to match relevant ratios for an average of emerging and developing economies (EMDEs) and with open economies features and financial frictions. Parameters that capture some oil-importing nature of the countries considered are also set as in Medina and Soto (2007) and Hollander, Gupta and Wohar (2019).

The discount factor β is set to 0.9975, consistent with a steady-state real interest rate of 1%. We calibrate the elasticity of the labour supply parameter φ to 1.455, which is standard in the literature. Following Medina and Soto (2007) and Hollander et al. (2019), we set the elasticity of substitution between oil and non-oil consumption η_o to 0.2 and the share of oil consumption γ_o to 0.07. The elasticity of substitution between home and foreign intermediate goods, η_c is set to 0.60, and the share of imported goods γ_c in final aggregate demand is 0.27 as in Lama and Medina (2020). The share of imported goods broadly matches the average import-GDP ratio for 155 emerging and developing countries in the IMF WEO database for the period 2000-2018 (27%). The elasticity of substitution for export bundles, η^* is also set to 0.50.

Following (see for example, Gertler and Karadi, 2011, Gertler and Kiyotaki, 2010, Gertler et al., 2012) and the open economy versions, (e.g. Kitano and Takaku, 2017, Kitano and Takaku, 2020), we set the parameters for banks as follows: the fraction of divertible assets

θ and the transfer to entering banks ξ are set to hit the two targets of a steady-state interest rate spread of 100 basis points per year and a steady-state leverage ratio of 4. The survival rate of banks σ is chosen to generate an average horizon of banks of eight years.

The share of capital α is set at 0.35 and the share of oil ι to 0.05 in the production of final goods. To ensure an annual steady state return on capital of 10%, the rate of physical capital depreciation δ is set to 0.025. The steady-state ratio of foreign debt to GDP, b/gdp , is set to 0.4 as in (e.g. Kitano and Takaku, 2017, Kitano and Takaku, 2020). We set the parameter for the country-specific interest rate premium ψ_{uip} to 0.005, which fits between 0.001 in Aguiar and Gopinath (2007) and 0.0075 in Unsal (2018). We set the degree of financial friction ω to 0.43 as in Kitano and Takaku (2020).

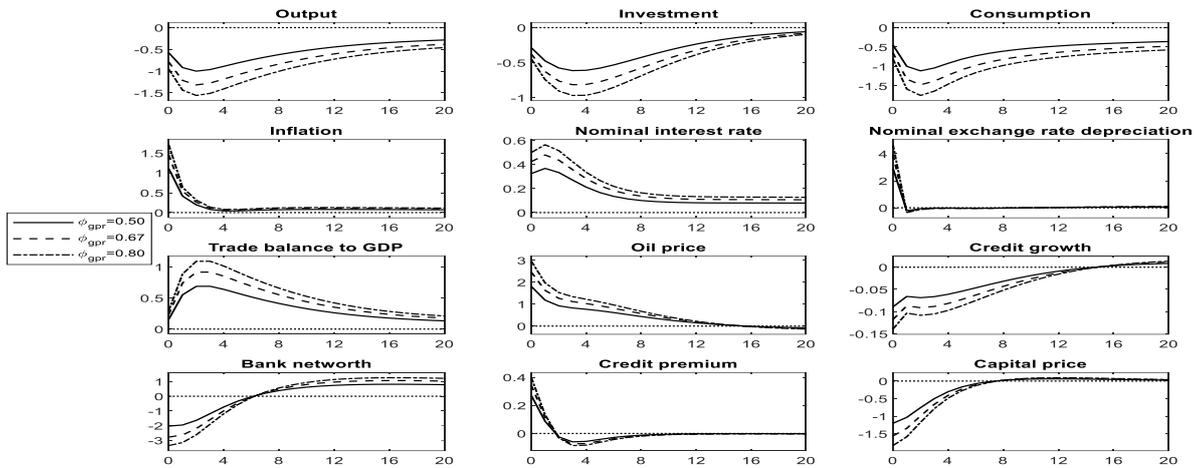
For nominal rigidities, we set Calvo (1983) parameters for domestic and import prices ϕ_h and ϕ_f to 0.75, meaning firms reset their prices every four quarters on average. To allow for indexation to previous period inflation, we set the indexation parameters ζ_p and ζ_f to 0.50. We set the Taylor rule coefficients ϕ_π and ϕ_y to 1.50 and 0.125 as in Lama and Medina (2020). We set the steady-state value of government spending to the GDP ratio to g/gdp to 0.2, which is standard in the literature. The elasticity of GPR on country risk premium is calibrated at 0.67, which is the average of the regression results in Table 1.

4 Results

4.1 Baseline Results

Figure 2 shows that the GPR shock acts as a risk premium shock, increasing the foreign interest rate spread and depreciating the nominal (and real) exchange rate of the domestic economy.

Figure 2: Baseline response for a GPR shock



Source: Authors' calculations

The exchange rate depreciation is inflationary as foreign goods become more expensive relative to domestic goods. In addition, exports rise in response to the favourable exchange rate, while the opposite holds for imports, resulting in an improvement in the trade balance. The domestic price of oil increases due to the depreciation of the exchange rate, which also contributes to rising inflation. The central bank responds to rising inflation by increasing the nominal interest rate which lowers the real interest rate which, in turn lowers consumption, investment and output. These results are in line with the quantitative VAR results obtained by Cheng and Chiu (2018).

In addition to the macro responses, an exogenous increase in GPR increases the banks' foreign borrowing costs, which reduces the banks' net worth. The decrease in the net worth tightens the banks' borrowing constraint, which reduces the banks' assets. With this tightening, the decrease in net worth also increases the spread between the expected return on capital and the risk-free rate. The increase in the spread raises the cost of credit for non-financial borrowers. The rise in the cost of capital, in turn, causes a further decline in output and investment, which causes a decline in the price of capital. The decline in the price of capital exacerbates the deterioration of the capital value, which worsens the bank's balance sheet and further causes the spread to increase. In this way, in the presence of financial frictions, the effects of an exogenous increase in GPR on output and the other main variables are amplified through banks' balance sheets.

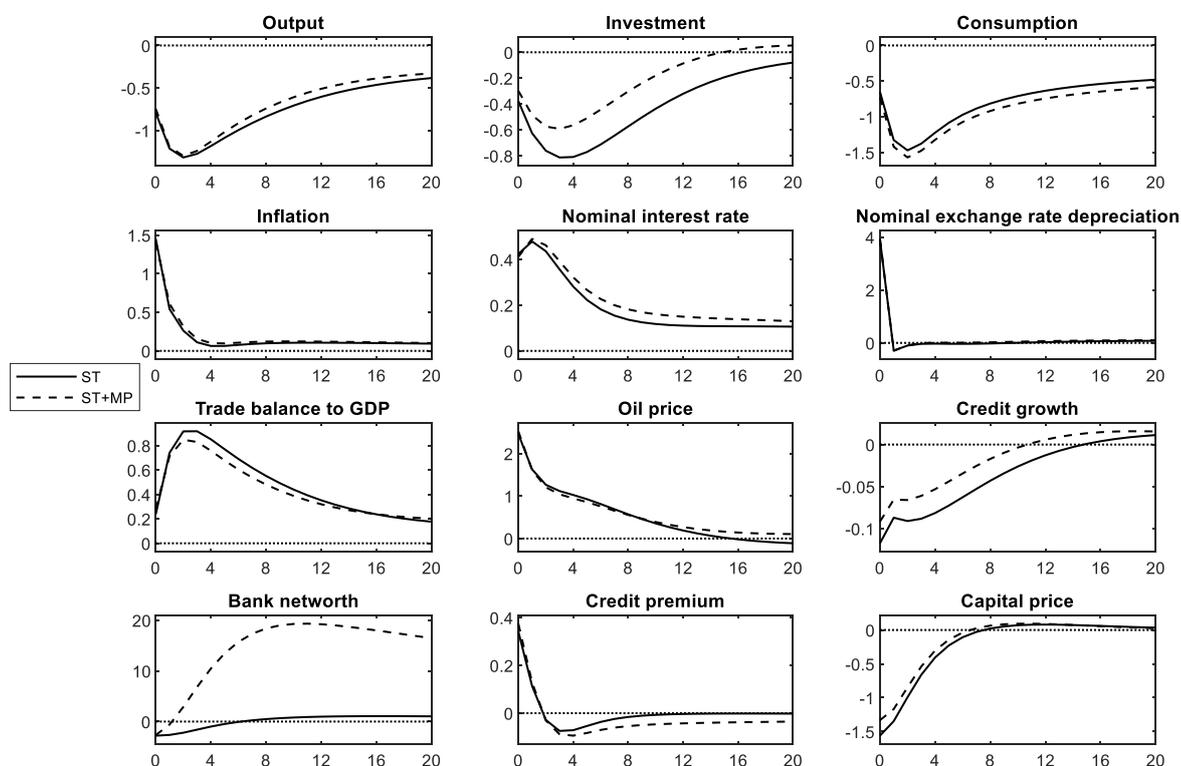
The figure also indicates that foreign interest rates increase as the GPR elasticity to the country's risk premium parameter increases. Hence, the domestic nominal interest rate also increases to keep parity with the foreign interest rate. Because of the sticky prices assumption in the model, the real interest rate increases, which consequently reduces aggregate demand (consumption, investment, and output are all lower). There is a further exchange rate depreciation that is more inflationary and increases the demand for factor input prices (wages and capital price). This lower aggregate demand also causes constrained financial conditions in the credit market, which lowers the net worth of banks; hence the credit risk premium is much higher.

5 Macprudential policy experiments

5.1 Impulse responses with and without macroprudential rules

Figure 3 compares a model with a standard Taylor (ST) rule to one augmented with a macroprudential (ST+MP) policy. The main aim of the ST+MP rule is to stabilize the economic downturn due to the GPR by relaxing the constraints on domestic borrowing which causes credit growth and investment to decrease by less compared to the ST rule case, as this policy expands the banks' balance sheet. This increased credit raises inflation through the demand effect. Hence the nominal interest rate is higher as the central bank reacts to the much-increasing inflation.

Figure 3: Impulse response for a GPR shock with and without macroprudential regulation



Note: The solid line is from the standard Taylor (ST) rule, and the dashed line corresponds to the standard Taylor rule plus the macroprudential policy (ST+MP) rule.

Source: Authors' calculations

The increasing interest rate environment further reduces consumption. Therefore, although the policy stabilises credit, investment, and output, it exacerbates the decline in consumption after a GPR shock.

5.2 Loss function and welfare

This section identifies optimal policy rules that would reduce the variance of key macroeconomic variables. To obtain this objective, we minimise a certain loss function after a GPR shock when the economy is under a monetary and/or a monetary plus macroprudential policy rule set by the central bank. The specification of the loss function considers the inflation-targeting monetary policy framework that many emerging economies' central banks follow, and the financial variable in the form of credit. We present a simple function in which the central bank aims to stabilise inflation, output and credit volatility.

$$L = \lambda_{\pi} \text{var}(\pi_t) + \lambda_y \text{var}(gdp_t) + \lambda_s \text{var}(s_t) \quad (9)$$

where $\text{var}(gdp_t)$, $\text{var}(\pi_t)$ and $\text{var}(s_t)$ are the unconditional variances of output, inflation and real credit, respectively. The parameters λ_y , λ_{π} and λ_s are the respective weights of output, inflation and credit in the loss function. For the choice of weight values, we follow (e.g., Alpanda, Kotzé and Woglom, 2010, Hove, Mama and Tchana, 2015, Omotosho, 2022), where we set the alternative values of the relative loss function from 0.5 to 2.0 with increments of 0.5. The relative weights attached to each variable in the loss function indicate the central bank's preference for stabilising the variables. We allow a search grid to search for the optimal policy parameter values, $\phi_{\pi} \in [1.1; 3.0]$, $\phi_y \in [0; 1.0]$, $\psi_1 \in [0; 1.0]$ and $\psi_2 \in [0; 10]$ which are plausible values in the literature.

Table 2: Optimised parameters

Rule/parameter	ϕ_{π}	ϕ_y	ψ_1	ψ_2
ST	3.00	0.00	-	-
ST+MP	3.00	0.00	0.83	10.00

Source: Authors' calculations

From Table 2, both policies require monetary policy to react aggressively to inflation (at maximum) with no reaction to output. There is also a complementary role of macroprudential policy to the strict inflation targeting, where there is a strong countercyclical reaction to the real credit gap and the business cycles.

The results from Table 3 indicate that macroprudential policy has a substantial extra loss-reducing effect compared to monetary policy in all weighting schemes of the loss function. Therefore, macroprudential tools can stabilise the business and financial cycles, with lower volatility in inflation, output and credit.

Table 3: Central bank loss

Weight on the loss function			Loss	
λ_π	λ_v	λ_s	ST	ST+MP
0.5	0.5	0.5	773.96	181.33
1.0	0.5	0.5	774.22	181.55
1.5	0.5	0.5	774.48	181.78
2.0	0.5	0.5	774.74	181.99
0.5	1.0	0.5	782.50	189.05
0.5	1.5	0.5	791.03	196.76
0.5	2.0	0.5	799.57	204.48
0.5	0.5	1.0	1539.14	354.72
0.5	0.5	1.5	2304.31	528.11
0.5	0.5	2.0	3069.49	701.50

Source: Authors' calculations

5.3 Loss function and welfare: alternative macroprudential policies

As a robustness test, this section provides an alternative way of thinking about macroprudential policy to deal with the GPR shock. This section allows the comparison of macroprudential policy to some degree of capital flow management policy. As a proxy to financial regulation, we assume the existence of a tax/subsidy scheme in the line of Paoli and Paustian (2017). Therefore, the aggregate net worth of the banking sector can be expressed as.

$$n_t = (\sigma + \xi)r_{k,t}q_{t-1}s_{t-1} - \sigma \frac{r_{b,t-1}^*}{n_t^*} r_{er,t-1}b_{t-1} - \sigma \frac{r_{n,t-1}}{n_t} d_{t-1} - \sigma \mathcal{J}_{i,t}n_{t-1} \quad i = b, k \quad (10)$$

Capital flow management and macroprudential policies are characterised by the following simple rules.

$$\mathcal{J}_{b,t} = \tau_b \left[\log \left(\frac{r_{er,t-1}b_{t-1}}{r_{er \times b}} \right) \right] \quad (11)$$

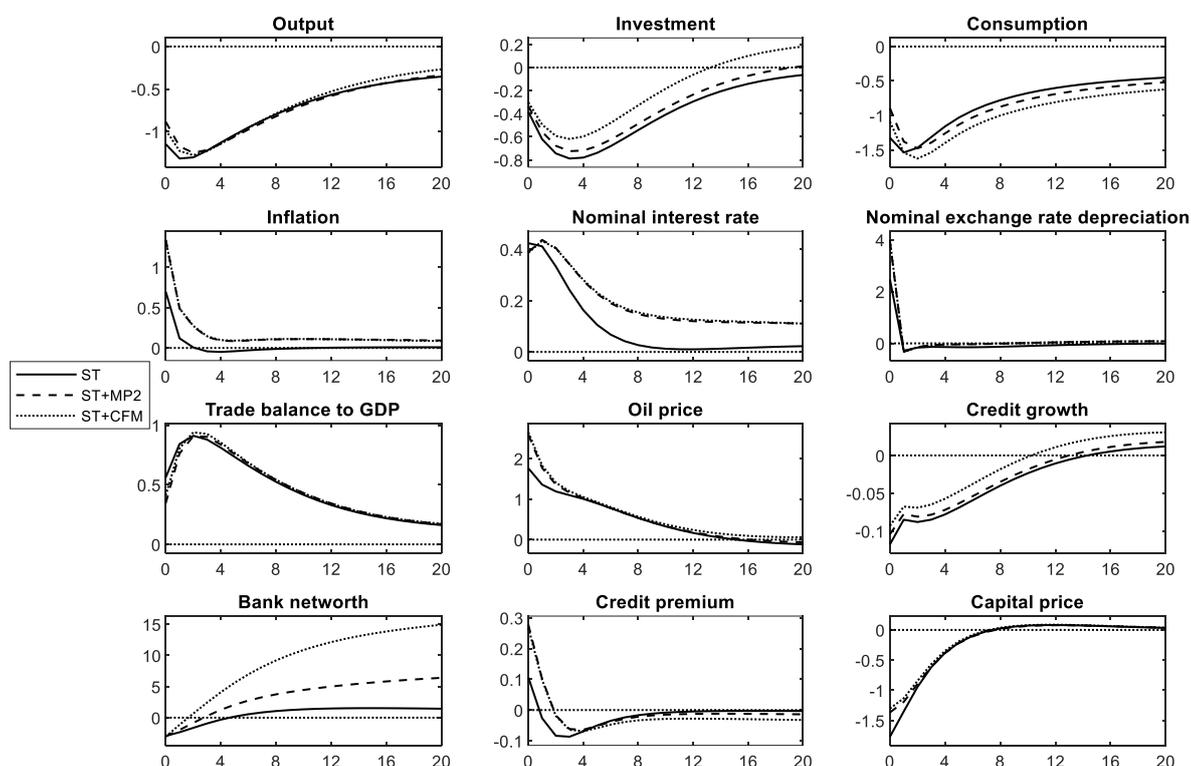
and

$$\mathcal{J}_{k,t} = \tau_k \left[\log \left(\frac{q_{t-1}s_{t-1}}{q \times s} \right) \right] \quad (12)$$

Figure 4 compares a model with a ST rule to one augmented with a macroprudential (ST+MP2) and capital flows management (ST+CFM) policies. Credit growth and investment decrease by less under these two alternative policies compared to the ST rule case, as these policies expand the banks' balance sheet. This increased credit raises inflation through the demand effect, causing a higher nominal interest rate. The capital flow management policy has a more stabilisation effect than the macroprudential policy, as under

this policy, GPR shock has a more direct impact on portfolio flows. Therefore, a policy that is aimed at portfolio flows will be more effective than one aimed at credit.

Figure 4 Impulse response for a GPR shock with standard monetary policy, macroprudential and capital flows management regulation



Note: The solid line is from the standard Taylor rule (ST), and the dashed line corresponds to the standard Taylor rule plus the macroprudential policy rule (ST+MP2), while the dotted line represents the standard Taylor rule and capital flows management policy (ST+CFM).

Source: Authors' calculations

In this section, we conduct the same exercise as in section 5.2, however, the search grid to search for policy parameters is given by, $\phi_\pi \in [1.1; 3.0]$, $\phi_y \in [0; 1.0]$, $\tau_k \in [0; 1.0]$ and $\tau_b \in [0; 1.0]$ which are plausible values of the policy parameters in the literature.

Table 4: Optimised parameters

Rule/parameter	ϕ_π	ϕ_y	τ_k	τ_b
ST	3.00	0.00	-	-
ST+MP2	3.00	0.00	1.00	-
ST+CC	3.00	0.00	-	0.22

Source: Authors' calculations

Comparing the two prudential policies, macroprudential policy acts as a complement to monetary policy, and the optimal rate must be exercised at the maximum possible value. The same result for capital flows management policy, however, this policy does not have to be exercised at full maximum. Therefore, capital flows management has the potential to be complementary to monetary policy in a less aggressive manner than the macroprudential policy.

Table 5: Central bank loss under alternative policy rules

Weight on the loss function			Loss		
λ_π	λ_y	λ_s	ST	ST+MP2	ST+CFM
0.5	0.5	0.5	773.96	218.85	360.58
1.0	0.5	0.5	774.22	219.05	360.78
1.5	0.5	0.5	774.48	219.26	360.99
2.0	0.5	0.5	774.74	219.46	361.19
0.5	1.0	0.5	782.50	226.08	368.08
0.5	1.5	0.5	791.03	233.31	375.58
0.5	2.0	0.5	799.57	240.54	383.07
0.5	0.5	1.0	1539.14	430.28	713.47
0.5	0.5	1.5	2304.31	641.71	1066.35
0.5	0.5	2.0	3069.49	853.14	1419.24

Source: Authors' calculations

The results from Table 5 indicate that macroprudential policy has a substantial extra loss-reducing effect compared to monetary policy and capital flows management policies in all weighting schemes of the loss function. Although capital flows management policies have a lower loss function than standard monetary policy and stronger effects on macro-financial variables, macroprudential policies have a better stabilisation effect, with lower volatility in inflation, output, and credit.

6 Conclusion

In this paper, we calibrate a small open economy DSGE model for emerging economies with financial frictions and an exogenous GPR shock that affects the country's risk premium. We evaluate the stabilisation ability of a combination of monetary policy, macroprudential, and capital flows management policies. The empirical estimates show that overall, the relationship between GPR and country risk is evident, however, it is heterogeneous across emerging markets and depends on the nature of the geopolitical event. A positive GPR shock depreciates the domestic nominal and real exchange rate, increases inflation, and reduces aggregate demand. The shock hampers the financial conditions by increasing both domestic and foreign borrowing rates, which leads to a decline in the net worth of banks, causing a decline in credit. Macroprudential policy can stabilise credit, investment and output conditions from the negative GPR shock. The results show that a macroprudential policy rule, in addition to the standard Taylor rule, provides some additional benefit in terms of welfare compared to a combination of the standard Taylor rule and capital flows management policies.

There are several caveats to take into consideration. First, our model is loosely calibrated and would be more beneficial for policymakers as policy guidance if it were estimated. Second, GPR is exogenous and enters the model in an ad hoc fashion through the country risk premium. An extension to elaborate and endogenize this risk would be desirable from a policy point of view. Lastly, the GPR shock affects other asset prices like stocks, therefore, a DSGE model with an implicit stock market would be appropriate to study such effects. All these aspects are left for future research.

References

- ADOLFSON, M., LASÉEN, S., LINDÉ, J. & VILLANI, M. 2007. Bayesian estimation of an open economy DSGE model with incomplete pass-through. *Journal of International Economics*, 72, 481-511.
- AFONSO, A., ALVES, J. & MONTEIRO, S. 2024. Beyond borders: Assessing the influence of Geopolitical tensions on sovereign risk dynamics. *European Journal of Political Economy*, 83, 102550.
- AGUIAR, M. & GOPINATH, G. 2007. Emerging market business cycles: The cycle is the trend. *Journal of political Economy*, 115, 69-102.
- ALPANDA, S., KOTZÉ, K. & WOGLOM, G. 2010. Should central banks of small open economies respond to exchange rate fluctuations? The case of South Africa. *Economic Research Southern Africa, Working Paper*, 174.
- ANGELINI, P., NERI, S. & PANETTA, F. 2014. The interaction between capital requirements and monetary policy. *Journal of money, credit and Banking*, 46, 1073-1112.
- ARAÚJO, T., AFONSO, Ó., NEVES, P. C. & SOCHIRCA, E. 2024. International spillovers of unconventional monetary policy: A meta-analysis. *Portuguese Economic Journal*, 1-20.
- BERNANKE, B. 1999. The Financial Accelerator in a Quantitative Business Cycle Framework. *Handbook of Macroeconomics/Elsevier*.
- BOLT, W., DEN END, J. W., GRIP, J., MAVROMATIS, K., VERHOEKS, R. & DE VETTE, N. 2023. Geo-economic fragmentation: economic and financial stability implications. *DeNederlandscheBank*.
- BOUOYOUR, J., SELMI, R., HAMMOUDEH, S. & WOHAR, M. E. 2019. What are the categories of geopolitical risks that could drive oil prices higher? Acts or threats? *Energy Economics*, 84, 104523.
- CALDARA, D., CAVALLO, M. & IACOVIELLO, M. 2019. Oil price elasticities and oil price fluctuations. *Journal of Monetary Economics*, 103, 1-20.
- CALDARA, D., CONLISK, S., IACOVIELLO, M. & PENN, M. 2022. Do geopolitical risks raise or lower inflation. *Federal Reserve Board of Governors*.
- CALVO, G. A. 1983. Staggered prices in a utility-maximizing framework. *Journal of monetary Economics*, 12, 383-398.
- CAMPOS, R. G., ESTEFANÍA-FLORES, J., FURCERI, D. & TIMINI, J. 2023. Geopolitical fragmentation and trade. *Journal of Comparative Economics*, 51, 1289-1315.
- CHENG, C. H. J. & CHIU, C.-W. J. 2018. How important are global geopolitical risks to emerging countries? *International economics*, 156, 305-325.
- DEMIR, E. & DANISMAN, G. O. 2021. The impact of economic uncertainty and geopolitical risks on bank credit. *The North American Journal of Economics and Finance*, 57, 101444.

- DEMIRALAY, S., KAAWACH, S., KILINCARSLAN, E. & SEMEYUTIN, A. 2024. Geopolitical tensions and sovereign credit risks. *Economics Letters*, 236, 111609.
- DRECHSEL, T. & TENREYRO, S. 2018. Commodity booms and busts in emerging economies. *Journal of International Economics*, 112, 200-218.
- FENG, C., HAN, L., VIGNE, S. & XU, Y. 2023. Geopolitical risk and the dynamics of international capital flows. *Journal of International Financial Markets, Institutions and Money*, 82, 101693.
- GAMBOA-ESTRADA, F. & ROMERO, J. V. 2024. *Geopolitical Risk and Emerging Markets Sovereign Risk Premia*, Banco de la Republica Colombia.
- GARCIA-SALTOS, T. G., ILYINA, A., KANGUR, A., KUNARATSKUL, T., RODRIGUEZ, S., RUTA, M., SCHULZE, T., SODERBERG, G. & TREVINO, J. P. 2023. Geoeconomic Fragmentation and the Future of Multilateralism.
- GERTLER, M. & KARADI, P. 2011. A model of unconventional monetary policy. *Journal of monetary Economics*, 58, 17-34.
- GERTLER, M. & KIYOTAKI, N. 2010. Financial intermediation and credit policy in business cycle analysis. *Handbook of monetary economics*. Elsevier.
- GERTLER, M., KIYOTAKI, N. & QUERALTO, A. 2012. Financial crises, bank risk exposure and government financial policy. *Journal of monetary economics*, 59, S17-S34.
- GHILARDI, M. F. & PEIRIS, S. J. 2016. Capital flows, financial intermediation and macroprudential policies. *Open Economies Review*, 27, 721-746.
- GKILLAS, K., GUPTA, R. & PIERDZIOCH, C. 2020. Forecasting realized gold volatility: Is there a role of geopolitical risks? *Finance Research Letters*, 35, 101280.
- GREENWOOD, J., HERCOWITZ, Z. & HUFFMAN, G. W. 1988. Investment, capacity utilization, and the real business cycle. *The American Economic Review*, 402-417.
- GUPTA, R., GOZGOR, G., KAYA, H. & DEMIR, E. 2019. Effects of geopolitical risks on trade flows: Evidence from the gravity model. *Eurasian Economic Review*, 9, 515-530.
- HOLLANDER, H., GUPTA, R. & WO HAR, M. E. 2019. The impact of oil shocks in a small open economy New-Keynesian dynamic stochastic general equilibrium model for an oil-importing country: The case of South Africa. *Emerging Markets Finance and Trade*, 55, 1593-1618.
- HOVE, S., MAMA, A. T. & TCHANA, F. T. 2015. Monetary policy and commodity terms of trade shocks in emerging market economies. *Economic Modelling*, 49, 53-71.
- IMF. 2023. April 2023 Global Financial Stability Report: Safeguarding Financial Stability amid High Inflation and Geopolitical Risks.
- IMF 2025. Global Financial Stability Report. *International Monetary Fund*.
- IYKE, B. N., PHAN, D. H. B. & NARAYAN, P. K. 2022. Exchange rate return predictability in times of geopolitical risk. *International Review of Financial Analysis*, 81, 102099.

- KITANO, S. 2022. How do world commodity prices affect Asian commodity exporting economies? The role of financial frictions. *Applied Economics Letters*, 29, 84-90.
- KITANO, S. & TAKAKU, K. 2017. Capital controls and financial frictions in a small open economy. *Open Economies Review*, 28, 761-793.
- KITANO, S. & TAKAKU, K. 2018. Capital controls as a credit policy tool in a small open economy. *The BE Journal of Macroeconomics*, 18, 20160231.
- KITANO, S. & TAKAKU, K. 2020. Capital controls, macroprudential regulation, and the bank balance sheet channel. *Journal of Macroeconomics*, 63, 103161.
- LAMA, R. & MEDINA, J. P. 2020. Mundell meets Poole: Managing capital flows with multiple instruments in emerging economies. *Journal of International Money and Finance*, 109, 102193.
- LEE, C.-C. & WANG, C.-W. 2021. Firms' cash reserve, financial constraint, and geopolitical risk. *Pacific-Basin Finance Journal*, 65, 101480.
- LIU, G. & MOLISE, T. 2019. Housing and credit market shocks: Exploring the role of rule-based Basel III counter-cyclical capital requirements. *Economic Modelling*, 82, 264-279.
- MEDINA, J. P. & SOTO, C. 2007. The Chilean business cycles through the lens of a stochastic general equilibrium model. *Central Bank of Chile Working Papers*, 457.
- NAIFAR, N. & ALJARBA, S. 2023. Does geopolitical risk matter for sovereign credit risk? Fresh evidence from nonlinear analysis. *Journal of Risk and Financial Management*, 16, 148.
- OMOTOSHO, B. S. 2022. Oil price shocks and monetary policy in resource-rich economies: Does capital matter? *Journal of Economic Dynamics and Control*, 143, 104479.
- PAOLI, B. D. & PAUSTIAN, M. 2017. Coordinating monetary and macroprudential policies. *Journal of Money, Credit and Banking*, 49, 319-349.
- PHAN, D. H. B., TRAN, V. T. & IYKE, B. N. 2022. Geopolitical risk and bank stability. *Finance Research Letters*, 46, 102453.
- QUINT, M. D. & RABANAL, M. P. 2017. *Should Unconventional Monetary Policies Become Conventional?*, International Monetary Fund.
- REPULLO, R. & SAURINA SALAS, J. 2011. The countercyclical capital buffer of Basel III: A critical assessment.
- RUBIO, M. & CARRASCO-GALLEGO, J. A. 2016. The new financial regulation in Basel III and monetary policy: A macroprudential approach. *Journal of Financial Stability*, 26, 294-305.
- SCHMITT-GROHÉ, S. & URIBE, M. 2003. Closing small open economy models. *Journal of international Economics*, 61, 163-185.
- SMETS, F. & WOUTERS, R. 2007. Shocks and frictions in US business cycles: A Bayesian DSGE approach. *American economic review*, 97, 586-606.

UNSAL, D. F. 2018. Capital flows and financial stability: monetary policy and macroprudential responses. *30th issue (March 2013) of the International Journal of Central Banking*.

VILLCA, A. 2022. Commodity prices, bank balance sheets and macroprudential policies in small open economies. *Latin American Journal of Central Banking*, 3, 100052.

Appendix

Households

There is a continuum of infinitely lived households in the domestic economy indexed $i \in [0, 1]$. Each household derives utility from consumption $c_t(i)$ and leisure $1 - l_t(i)$ where $l_t(i)$ represents labour hours supplied. We use the so-called GHH utility specification over hours worked proposed by Greenwood, Hercowitz and Huffman (1988) which eliminates wealth effects from labour supply. Each household maximises lifetime utility:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{\left(c_t(i) - \chi \frac{l_t(i)^\varphi}{\varphi} \right)^{1-\sigma_c} - 1}{1-\sigma_c} \right] \quad (A.1)$$

The parameter, β , is the subjective discount factor, and $\sigma_c > 0$ is the coefficient of relative risk aversion while, φ , determines the Frisch elasticity of labour supply, and χ , is the disutility of hours worked. The consumption bundle is a constant elasticity of substitution (CES) aggregator that consists of oil, $o_{c,t}(i)$, and non-oil, $c_{z,t}(i)$, consumption goods.

$$c_t = \left[(1 - \gamma_o)^{\frac{1}{\eta_o}} c_{z,t}^{\frac{\eta_o-1}{\eta_o}} + \gamma_o^{\frac{1}{\eta_o}} o_{c,t}^{\frac{\eta_o-1}{\eta_o}} \right]^{\frac{\eta_o}{\eta_o-1}} \quad (A.2)$$

The parameter, γ_o , defines the share of oil goods in the consumption basket and, η_o , represents the elasticity of substitution between oil and non-oil consumption goods. For any level of consumption, each household purchases a composite of oil and non-oil consumption goods in the period t and minimise the total cost of its consumption basket. Hence, each household minimises $p_{z,t}c_{z,t}(i) + p_{o,t}o_{c,t}(i)$, subject to equation (3), where $p_{z,t}$ and $p_{o,t}$ are the prices of oil and non-oil consumption goods, respectively. Therefore, the demand for core consumption and oil consumption goods is given by:

$$c_{z,t} = (1 - \gamma_o) \left(\frac{p_{z,t}}{p_t} \right)^{-\eta_o} c_t \quad (A.3)$$

and

$$o_{c,t} = \gamma_o \left(\frac{p_{o,t}}{p_t} \right)^{-\eta_o} c_t \quad (A.4)$$

The aggregate consumption price level is given by $p_t = \left[(1 - \gamma_o)p_{z,t}^{1-\eta_o} + \gamma_o p_{o,t}^{1-\eta_o} \right]^{\frac{1}{1-\eta_o}}$.

Households consume both domestic and foreign (imported) consumption goods, given by:

$$z_t = \left[(1 - \gamma_c)^{\frac{1}{\eta_c}} c_{h,t}^{\frac{\eta_c - 1}{\eta_c}} + \gamma_c^{\frac{1}{\eta_c}} c_{f,t}^{\frac{\eta_c - 1}{\eta_c}} \right]^{\frac{\eta_c}{\eta_c - 1}} \quad (\text{A.5})$$

where $c_{h,t}(i)$ and $c_{f,t}(i)$ are domestic and imported goods consumed by each household, respectively. The parameter, γ_c , defines the share of foreign goods in the non-oil consumption basket and, η_c , represents the elasticity of substitution between domestic and foreign goods. Minimizing the cost of this bundle determines the demands for home and foreign goods by each household which are given by:

$$c_{h,t} = (1 - \gamma_c) \left(\frac{p_{h,t}}{p_{z,t}} \right)^{-\eta_c} z_t \quad (\text{A.6})$$

and

$$c_{f,t} = \gamma_c \left(\frac{p_{f,t}}{p_{z,t}} \right)^{-\eta_c} z_t \quad (\text{A.7})$$

The price index for non-oil consumption is given by $p_{z,t} = [(1 - \gamma_c)p_{h,t}^{1-\eta_c} + \gamma_c p_{f,t}^{1-\eta_c}]^{\frac{1}{1-\eta_c}}$.

The budget constraint of the household in terms of the domestic consumption bundle is given by

$$c_t(i) + d_t(i) = w_t l_t(i) + \frac{r_{n,t-1}}{\pi_t} d_{t-1}(i) + \Pi_t(i) \quad (\text{A.8})$$

Households are recipients of real wage income, where w_t is the wage rate for the labour service they supply, and $\Pi_t(i)$ is the real net profit. They invest in domestic deposits $d_t(i)$ in a bank, and the deposit pays a nominal gross interest rate of $r_{n,t-1}$. The first-order equations of the utility maximisation problem with respect to the budget constraint variables, $l_t(i)$ and c_t ,

$$w_t = \chi l_t^{\varphi - 1} \quad (\text{A.9})$$

$$q_t = \beta r_{n,t} \left[E_t q_{t+1} \frac{1}{\pi_{t+1}} \right] \quad (\text{A.10})$$

where $u_{c,t} = \left(c_t - \frac{l_t(i)^\varphi}{\varphi} \right)^{-\sigma_c}$ is the marginal utility which equals q_t , the Lagrange multiplier for the dynamic optimization.

Banking

Banks raise funds from their net worth, deposits from households, borrow from foreign investors, and extend loans to goods producers. The balance sheet of a bank is given by

$$q_t s_t = n_t + r e r_t b_t + d_t \quad (\text{A.11})$$

where s_t is the quantity of financial claims on goods producers, q_t is the real price of claims relative to consumption goods, n_t is the net worth, b_t is foreign debt, $r e r_t$ is the real exchange rate, and d_t is deposits from domestic households.

The net worth of the bank is the difference between earnings on assets and interest payments on foreign debts and deposits. The evolution of the bank's net worth is then given as

$$n_t = r_{k,t} q_{t-1} s_{t-1} - \frac{r_{b,t-1}^*}{\pi_t^*} r e r_{t-1} b_{t-1} - \frac{r_{n,t-1}}{\pi_t} d_t \quad (\text{A.12})$$

where $r_{k,t}$ is the gross real return on assets, $r_{b,t}^*$ is the gross nominal interest rate on foreign debt in terms of domestic currency, $r_{n,t}$ is the gross nominal interest rate on deposits, which is the same as the policy rate.

The bank maximizes the present discounted value of future dividends given an exogenous probability of exiting the banking industry each period. The value of the bank at the end of the period t is given by

$$V_t = E_t \sum_{i=0}^{\infty} (1 - \sigma) \sigma^{i-1} \Lambda_{t,t+i} n_{t+i} \quad (\text{A.13})$$

The financial friction in this model is as follows. Bankers can divert a fraction of the assets they manage to their household, but this forces that bank into bankruptcy. The fraction of *divertible* assets financed by deposits (d_t) and net worth (n_t) is denoted θ , and the divertible fraction of assets financed by foreign borrowing $r e r_t b_t$ is denoted θ^* . We assume that the assets financed by foreign borrowing are easier to divert than those financed by deposits and net worth (*i. e.*, $\theta^* > \theta$). Thus, the following incentive constraint must hold for lenders to be willing to supply funds to the banker:

$$V_t(s_t, b_t, d_t) \geq \theta(d_t + n_t) + \theta^* r e r_t b_t \quad (\text{A.14})$$

The value of a bank, V_t must be not less than a bank's benefit from diverting funds, $\theta (d_t + n_t) + \theta^* r e r_t b_t$, so that households and foreign investors are willing to supply funds to a bank. For tractability, we set that.

$$\theta^* = (1 + \omega)\theta \quad (\text{A.15})$$

where $\omega > 0$ indexes the degree of financial friction between banks and foreign investors. If $\omega = 0$, foreign borrowing has the same degree of friction as domestic deposits. A higher value of $\omega > 0$ indicates a higher degree of financial frictions in foreign borrowing, because it implies that the asset financed by foreign lending is easier to divert than that financed by domestic deposits.

Since the “divertible” amount of assets financed by foreign borrowing must not be greater than the total amount of the funds financed by foreign borrowing, it must be that $r e r_t b_t \geq \theta (1 + \omega) r e r_t b_t$, and then the upper limit for ω exists (*i.e.*, $\frac{1}{\theta} - 1 \geq \omega$).

The value of the bank at the end of the period $t - 1$ satisfies the Bellman equation:

$$V_{t-1}(s_{t-1}, b_{t-1}, d_{t-1}) = E_{t-1} \Lambda_{t-1,t} \left\{ (1 - \sigma)n_t + \sigma \max_{s_t, b_t, d_t} V(s_t, b_t, d_t) \right\} \quad (\text{A.16})$$

We guess and verify that the value function is linear in s_t, b_t , and d_t :

$$V(s_t, b_t, d_t) = v_{s,t} s_t - v_{b,t} b_t - v_t d_t \quad (\text{A.17})$$

where $v_{s,t}$ is the marginal value of assets, $v_{b,t}$ is the marginal cost of international borrowing, and v_t is the marginal cost of deposits. Maximising the value function equation (A.17) subject to the incentive constraint equation (A.14) and equation (A.15), we obtain the following first-order conditions:

$$\left(v_{s,t} - \frac{v_{b,t}}{r e r_t} \right) (1 + \lambda_t) = \theta \omega \lambda_t \quad (\text{A.18})$$

$$\left(\frac{v_{s,t}}{q_t} - \frac{v_{b,t}}{r e r_t} \right) (1 + \lambda_t) = \theta (1 + \omega) \lambda_t \quad (\text{A.19})$$

$$\left[\theta - \left(\frac{v_{s,t}}{q_t} - v_t \right) \right] q_t s_t - \left[\theta \omega - \left(v_t - \frac{v_{b,t}}{r e r_t} \right) \right] r e r_t b_t = v_t n_t \quad (\text{A.20})$$

where λ_t is the Lagrange multiplier for the incentive constraint equation (A.15). From these conditions, and defining $\mu_{b,t} \equiv v_t - v_{b,t} e_t$ and $\mu_t \equiv v_{s,t} q_t - v_t$, we obtain

$$\mu_{b,t} = \omega\mu_t, \quad (\text{A.21})$$

and

$$q_t s_t = \phi_t n_t - \frac{\phi_t}{\phi_{b,t}} e_t b_t, \quad (\text{A.22})$$

where

$$\phi_t \equiv \frac{v_t}{\theta - \mu_t} \quad (\text{A.23})$$

and

$$\phi_{b,t} \equiv \frac{v_t}{\theta\omega - \mu_{b,t}} \quad (\text{A.24})$$

By combining the conjectured value function with the Bellman equation (A.16) and using equation (A.12), we can verify that the value function is linear in (s_t, b_t, d_t) if v_t, μ_t , and $\mu_{b,t}$ satisfy

$$v_t = E_t \Lambda_{t,t+1} \Omega_t r_t \quad (\text{A.25})$$

$$\mu_t = E_t \Lambda_{t,t+1} \Omega_t \left(r_{k,t+1} - \frac{r_{n,t}}{\pi_{t+1}} \right) \quad (\text{A.26})$$

and

$$\mu_{b,t} = E_t \Lambda_{t,t+1} \Omega_t \left(\frac{r_{n,t}}{\pi_{t+1}} - \frac{r_{b,t}^*}{\pi_{t+1}^*} \right) \quad (\text{A.27})$$

where

$$\Omega_t = (1 - \sigma) + \sigma(\phi_t \mu_t + v_t) \quad (\text{A.29})$$

Since ϕ_t and $\phi_{b,t}$ are independent of bank-specific factors, we can aggregate across banks. It follows from the equation that the net worth is given by:

$$n_t = \frac{1}{\phi_t} q_t s_t + \frac{1}{\phi_{b,t}} r e r_t b_t \quad (\text{A.30})$$

which can be rewritten as:

$$q_t s_t + \omega r e r_t b_t = \phi_t n_t \quad (\text{A.31})$$

Substituting equation (A.31) into the aggregate balance sheet ($q_t s_t = n_t + r e r_t b_t + d_t$), we obtain the aggregate deposit:

$$d_t = -(1 + \omega) r e r_t b_t + (\phi_t - 1) n_t \quad (\text{A.32})$$

In each period, the fraction σ of banks continue to operate in the next period. Therefore, it follows from equation (A.12) that the existing bank's net worth $n_{e,t}$ is given by

$$n_{e,t} = \sigma \left(r_{k,t} q_{t-1} s_{t-1} - \frac{r_{b,t-1}^*}{\pi_t^*} r e r_{t-1} b_{t-1} - \frac{r_{n,t-1}}{\pi_t} d_{t-1} \right) \quad (\text{A.33})$$

Following previous related studies, we assume that the household transfers the fraction $\xi/(1 - \sigma)$ of the total final period assets of exiting bankers to its entering bankers. Thus, the new bank's net worth is given by

$$n_{n,t} = \xi r_{k,t} q_{t-1} s_{t-1} \quad (\text{A.34})$$

The total net worth n_t is the sum of the net worth of existing banks $n_{e,t}$ and that of new banks $n_{n,t}$:

$$n_t = n_{e,t} + n_{n,t} \quad (\text{A.35})$$

Substituting equations (A.33) and (A.34) into equation (A.35), we obtain the evolution of n_t as follows:

$$n_t = (\sigma + \xi) r_{k,t} q_{t-1} s_{t-1} - \sigma \frac{r_{b,t-1}^*}{\pi_t^*} r e r_{t-1} b_{t-1} - \sigma \frac{r_{n,t-1}}{\pi_t} d_{t-1} \quad (\text{A.36})$$

Wholesale producers

Goods producers (entrepreneurs) are risk-neutral and produce homogeneous intermediate goods according to the following production function:

$$y_{h,t} = k_t(i)^\alpha o_{h,t}(i)^\iota l_t^{1-\alpha-\iota} \quad (\text{A.37})$$

where $y_{h,t}(i)$ is the intermediate output, $k_t(i)$ is the capital, $o_{h,t}(i)$ is the oil input and $l_t(i)$ represents labour hours. The parameter α represents the share of capital and ι the share of oil input in production. Final goods producers finance their capital acquisition by obtaining loans from banks:

$$q_t s_t = q_t k_{t+1} \quad (\text{A.38})$$

For tractability and simplicity, we assume that goods producers do not face financial friction when they obtain funds from banks; we focus only on financial frictions in banks. The goods producer chooses capital and labour to maximise its profit function subject to the production function yielding the demand for capital, labour and oil intermediate input respectively:

$$E_t r_{k,t} = E_t \left[\frac{p_{h,t+1} \alpha \frac{y_{h,t+1}}{k_t} + (1-\delta) q_{t+1}}{q_t} \right] \quad (\text{A.39})$$

$$w_t = p_{h,t} (1 - \alpha - \iota) \frac{y_{h,t}}{l_t} \quad (\text{A.40})$$

$$p_{o,t} = p_{h,t} \iota \frac{y_{h,t}}{o_{h,t}} \quad (\text{A.41})$$

where $p_{h,t}$ is the real domestic price of the wholesale goods produced by the intermediate goods producer.

Capital producers

We assume that capital producers operate in a competitive market, they buy investment goods and repair old, depreciated capital and transform these into new capital. The new capital is sold to the entrepreneur firms at a real unit price of, q_t . The capital producers also incur adjustment costs, so the capital evolution equation is given by:

$$k_t = (1 - \delta)k_{t-1} + \left[1 - f\left(\frac{i_t}{i_{t-1}}\right)\right] i_t \quad (\text{A.42})$$

where

$$f\left(\frac{i_t}{i_{t-1}}\right) = \frac{\eta_i}{2} \left[\frac{i_t}{i_{t-1}} - 1\right]^2 \quad (\text{A.43})$$

Capital producers require, i_t , units of investment goods and incur adjustment costs, to produce new investment goods and repair depreciated capital. Therefore, the capital producer maximises the discounted profits as follows:

$$\max_{i_t} E_0 \sum_{i=0}^{\infty} \Lambda_{t,t+i} \left\{ q_{t+i} i_{t+i} - \left[1 + f\left(\frac{i_{t+i}}{i_{t+i-1}}\right) i_{t+i}\right] \right\} \quad (\text{A.44})$$

subject to the capital evolution equation. The corresponding first-order condition is given by:

$$q_t \left[1 - f\left(\frac{i_t}{i_{t-1}}\right)\right] = q_t f'\left(\frac{i_t}{i_{t-1}}\right) \frac{i_t}{i_{t-1}} - \beta E_t \left[\frac{\lambda_{t+1}}{\lambda_t} q_{t+1} f'\left(\frac{i_{t+1}}{i_t}\right) \frac{i_{t+1}}{i_t} \right] \quad (\text{A.45})$$

which is the well-known Tobin-q equation. Investment goods consist of a CES aggregator of home $i_{h,t}$ and foreign goods $i_{f,t}$:

$$i_t = \left[(1 - \gamma)^{\frac{1}{\eta}} i_{h,t}^{\frac{\eta-1}{\eta}} + \gamma^{\frac{1}{\eta}} i_{f,t}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \quad (\text{A.46})$$

where η is the elasticity of substitution between home and foreign investment goods, and γ defines the share of domestic goods in investment. Maximising the expression above is subject to the budget constraint, $p_t i_t = p_{h,t} i_{h,t} + p_{f,t} i_{f,t}$, we obtain the investment demand functions for $i_{h,t}$ and $i_{f,t}$:

$$i_{h,t} = (1 - \gamma) \left(\frac{p_{h,t}}{p_t}\right)^{-\eta} i_t \quad (\text{A.47})$$

and

$$i_{f,t} = \gamma \left(\frac{p_{f,t}}{p_t}\right)^{-\eta} i_t \quad (\text{A.48})$$

Domestic retailers

There is a continuum of monopolistically competitive domestic retailers, $j \in [0; 1]$, that buy wholesale goods from entrepreneurs. The final domestic good, $y_{h,t}$, is a constant elasticity of substitution (CES) composite of a continuum of retail goods:

$$y_{h,t} = \left(\int_0^1 y_{h,t}(j)^{\frac{\theta_h-1}{\theta_h}} dj \right)^{\frac{\theta_h}{1-\theta_h}} \quad (\text{A.49})$$

where, $y_{h,t}(j)$, is the quantity sold by the retailer, j , at a price, $p_{h,t}(j)$, and θ_h , is the elasticity of substitution between domestic goods bundles. The domestic price index is given by:

$$p_{h,t} = \left(\int_0^1 p_{h,t}(j)^{1-\theta_h} dj \right)^{\frac{1}{1-\theta_h}} \quad (\text{A.50})$$

Each retailer sells its output at the price, $p_{h,t}(j)$, with a markup over the wholesale price, $p_{m,t}$. Therefore, the decision problem of the retailer is to maximise real discounted profits:

$$\frac{\Pi_{h,t}}{p_t} = \frac{p_{h,t}(j)}{p_t} y_{h,t}(j) - mc_t y_{h,t}(j) - \frac{\kappa_h}{2} \left(\frac{\pi_{h,t}(j)}{\zeta_p \pi_{h,t}} - 1 \right) \frac{p_{h,t}}{p_t} y_{h,t} \quad (\text{A.51})$$

here, ζ_p , represents the degree of price indexation to the previous period's domestic inflation, while κ_h , is a parameter that captures the level of price stickiness and it is linked to the stickiness parameter from the Calvo-price setting, ϕ_h , through $\kappa_h = (\theta_h - 1) \frac{\phi_h (1-\phi_h)}{(1-\beta\phi_h)}$, where θ_h is the steady state elasticity of substitution of domestic goods bundles. The real marginal cost is equal to the price of the wholesale good (*i.e.*, $mc_t = p_{m,t}$). The first-order condition with respect to price is respectively given by:

$$\left(\frac{\pi_{h,t}}{\zeta_p \pi_{h,t-1}} - 1 \right) \frac{\pi_{h,t}}{\zeta_p \pi_{h,t-1}} = E_t \left[\left(\beta \frac{\lambda_{t+1}}{\lambda_t} \right) \left(\frac{\pi_{h,t+1}}{\zeta_p \pi_{h,t}} - 1 \right) \frac{\pi_{h,t+1}}{\zeta_p \pi_{h,t}} \frac{y_{h,t+1}}{y_{h,t}} \right] + \frac{1}{\kappa_h} \left[(1 - \theta_h) + \theta_h \left(\frac{mc_t}{p_{h,t}} \right) \right] \quad (\text{A.52})$$

where, mc_t , represents the real marginal costs, $\pi_{h,t} = p_{h,t}/p_{h,t-1}$, is the domestic price inflation. The intermediate goods get exported or used in domestic production of the final good so that:

$$y_{h,t} = y_{h,t}^* + y_{h,t}^d \quad (\text{A.53})$$

where the aggregate foreign demand for domestically produced exports is given by:

$$y_{h,t}^* = \zeta^* \left(\frac{p_{h,t}}{e_t p_t} \right)^{-\eta^*} y_t^* \quad (\text{A.54})$$

where, ζ^* , corresponds to the share of domestic goods in the consumption basket of the foreign agents, and η^* , is the price elasticity of demand.

Import retailers

The imports sector consists of firms that buy homogeneous goods from the foreign market. There is a continuum of firms, $j \in [0, 1]$, that combine different varieties of imported goods using the production function:

$$y_{f,t} = \left(\int_0^1 y_{f,t}(j)^{\frac{\theta_f-1}{\theta_f}} dj \right)^{\frac{\theta_f}{1-\theta_f}} \quad (\text{A.55})$$

where, $y_{f,t}(j)$, is the quantity of variety, j , imported and, θ_f the parameter that governs the elasticity of substitutability between different imported goods varieties. The foreign price index is given by:

$$p_{f,t} = \left(\int_0^1 p_{f,t}(j)^{1-\theta_f} dj \right)^{\frac{1}{1-\theta_f}} \quad (\text{A.56})$$

Importers maximise the present value of profits (using the households' stochastic discount factor) subject to the demand function they are facing from the aggregators with respect to their output. The importer's profits during the period t are given by:

$$\frac{\Pi_{f,t}}{p_t} = \frac{p_{f,t}(j)}{p_t} y_{f,t}(j) - \frac{e_t p_{f,t}^*}{p_t} y_{h,t}(j) - \frac{\kappa_f}{2} \left(\frac{\pi_{f,t}(j)}{\pi_{f,t}^{\zeta_f}} - 1 \right) \frac{p_{f,t}}{p_t} y_{f,t} \quad (\text{A.577})$$

where, ζ_f , represents the degree of price indexation to the previous period of foreign inflation, κ_f , is a parameter that captures the level of price stickiness, and like in the domestic goods case, it is linked to the stickiness parameter from the Calvo-price setting,

$$\phi_f , \text{ through } \kappa_f (\theta_f - 1) \frac{\phi_f}{(1-\phi_f)(1-\beta\phi_f)}$$

where θ_f is the steady state elasticity of substitution of import goods bundles. The real marginal cost is equal to the relative price of foreign goods expressed in domestic currency,

$\frac{e_t p_{f,t}^*}{p_t}$. The first-order condition of importers with respect to price is given by:

$$\left(\frac{\pi_{f,t}}{\pi_{f,t-1}^{\zeta_f}} - 1 \right) \frac{\pi_{f,t}}{\pi_{f,t-1}^{\zeta_f}} = E_t \left[\left(\beta \frac{\lambda_{t+1}}{\lambda_t} \right) \left(\frac{\pi_{f,t+1}}{\pi_{f,t}^{\zeta_f}} - 1 \right) \frac{\pi_{f,t+1} y_{f,t+1}}{\pi_{f,t}^{\zeta_f} y_{f,t}} \right] + \frac{1}{\kappa_f} [(1 - \theta_f) + \theta_f \psi_{f,t}] \quad (\text{A.57})$$

where, $\psi_{f,t}$, is the law of one price gap. Following Gali & Monacelli (2005) and Justiniano & Preston (2010), to allow for imperfect exchange rate pass-through from import prices to domestic prices, the law of one price does not hold; instead, the following equation represents the deviation from the law of one price:

$$\psi_{f,t} = \frac{e_t p_{f,t}^*}{p_{f,t}} \quad (\text{A.58})$$

where, e_t , is the nominal exchange rate, $p_{f,t}^*$, and $p_{f,t}$, are import goods prices denominated in foreign and domestic currency, respectively.

Market clearing and aggregation

The real gross domestic product (GDP) is the value of domestic final goods production:

$$gdp_t = p_{h,t} y_{h,t} \quad (\text{A.59})$$

The balance of payments equation is given by

$$rer_t \frac{r_{b,t}^*}{\pi_t^*} b_{t-1} = rer_t b_t + tb_t \quad (\text{A.60})$$

where $tb_t = p_{h,t} y_{h,t}^* - rer_t y_{f,t}$ is the trade balance. The imports, $y_{f,t}$, are divided between consumption, $c_{f,t}$, investment, $i_{f,t}$, and oil imports $o_t = o_{c,t} + o_{h,t}$.