Online Appendix for Box II.B

We develop a simple model for the main channels through which capital flows affect emerging market economies (EMEs), as discussed in the chapter. The model is a stylised pedagogical device designed to illustrate the main channels for policy analysis and as a reference point for future research.

The model examines the trade-offs faced by EME central banks in responding to capital flow fluctuations. In the model, a surge in capital inflows exerts appreciation pressure on the exchange rate, which, in turn, reduces import prices (pass-through channel) and export competitiveness (trade channel). The impact of the exchange rate on exports depends on trade invoicing and trade financing. Foreign currency invoicing and higher integration in global value chains (GVCs) weaken the trade channel, so that a currency appreciation might not drag economic activity down, at least in the short run. Furthermore, the exchange rate affects domestic expenditure through its impact on domestic financial conditions (financial channel). An exchange rate appreciation improves domestic credit conditions and thus boosts domestic demand. Monetary policy affects the economy through the standard effects of the interest rate on domestic demand and on the exchange rate.

The core of the model consists of three equations:

$$y = \alpha_D \left(-i + \psi e\right) + \alpha_E \left(-i^* - \tau e\right) \tag{1}$$

$$\pi = \kappa y + \eta \left(\pi^* - \rho_I e\right) \tag{2}$$

$$e = i - i^* + f - \gamma x \tag{3}$$

where y is output, π domestic consumer price inflation and e the exchange rate defined as the foreign price of the domestic currency, such that an increase in e is an appreciation of the domestic currency. All variables are expressed in percentage deviations from their steady state levels.

The first equation is a standard IS curve. Domestic output is determined by domestic demand, with elasticity α_D, and export demand, with elasticity α_E. Domestic demand is affected by the domestic policy rate i and the exchange rate. The parameter $\psi > 0$ measures the strength of the financial channel of the exchange rate.[1] Export demand depends on the foreign interest rate i^* and the exchange rate. The parameter $\tau \equiv \rho_E - \nu$ indexes the trade channel of the exchange rate, where $\nu > 0$ captures the exchange rate impact on GVCs and $\rho_E \in [0,1]$ measures the exchange rate pass-through to export prices. Pass-through is zero when all exports are priced in foreign currency, and is one when they are all priced in domestic currency.

The second equation, a standard Phillips curve, relates consumer price inflation to domestic output and import prices. The parameter κ measures the elasticity of domestic prices to economic activity, ie the slope of the Phillips curve. The parameter η captures the impact, both direct and indirect through domestic marginal costs, of import prices on inflation, where π^* is foreign price inflation and $\rho_I \in [0,1]$ measures the degree of exchange rate pass-through to imported goods prices.

[1] Capital flows can also impact domestic financial conditions directly, not only through the exchange rate. The analysis developed below would not change in the presence of such a direct link. That is, we could replace ψe with ψf without altering the conclusions of the analysis.

The last equation is a modified uncovered interest parity condition where f is a risk premium term that captures foreign investors' risk appetite. An increase in f is akin to a surge in capital inflows that increases the demand for domestic currency and leads to an exchange rate appreciation. Finally, x represents changes in foreign reserves, and the parameter γ measures the effectiveness of FX intervention. With respect to FX intervention, we assume that the central bank operates a managed floating exchange rate regime described by the policy rule:

$$x = \delta e \tag{4}$$

with $\delta \geq 0$. According to this rule, the central bank responds to changes in total exchange market pressure by absorbing a fraction $\gamma\delta/(1+\gamma\delta)$ as change in foreign exchange reserves and allowing the remainder to show through as a change in the exchange rate. When $\delta = 0$, the central bank does not intervene and the exchange rate follows a fully floating regime.

The short-term inflation/output trade-off

The equilibrium of the model yields the equation:

$$\pi = \left(\kappa + \Lambda\right) y + \Sigma \tag{5}$$

where $\Lambda \equiv \eta\rho_I/[(1-\psi+\gamma\delta)\alpha_D + \tau\alpha_E]$ denotes the impact of monetary policy on inflation relative to its impact on output and $\Sigma \equiv \Lambda(\alpha_D + \alpha_E)i^* - \Lambda\alpha_D f + \eta\pi^*$ denotes the combination of external disturbances. This equation describes the set of allocations implementable by the central bank through interest rate policy, for any given combination of external disturbances.[2]

We use the model to study the problem faced by the central bank in the wake of shifts in capital flows. Assume, for simplicity and without loss of generality, that $i^* = \pi^* = 0$, so that $\Sigma = -\Lambda\alpha_D f$. The objective of the central bank is to choose the combination of π and y that minimises:

$$L = \phi\pi^2 + y^2 \tag{6}$$

where L is the welfare loss induced by fluctuations in output and inflation, and ϕ measures the weight that the central bank attaches to inflation stabilisation relative to output stabilisation. The central bank would never choose an allocation where both output and inflation are above, or below, their steady state levels since it could reduce, or increase, them simultaneously and improve welfare. Therefore, we can restrict attention to the set of feasible allocations in which output and inflation deviations have opposite signs. This set is described by the equation:

$$\left|\pi\right| = -\left(\kappa + \Lambda\right)\left|y\right| + \Lambda\alpha_D\left|f\right| \tag{7}$$

where $|\cdot|$ denotes the gap of a variable – that is, its absolute distance from its steady state level. This equation describes the combinations of output and inflation gaps achievable by the central bank through interest rate policy, and is represented by the straight line in Graph II.B.1. The equation of the indifference curves (the dotted curves in Graph II.B.1) – that is, the combinations of output and inflation gaps that yield the same welfare loss – is:

[2] We restrict our attention to the region of the parameter space where a reduction in the policy rate is expansionary – that is, $\Lambda > 0$. Formally, this requires $(1-\psi)\alpha_D + \tau\alpha_E > 0$.

$$|\pi| = \sqrt{\frac{\bar{L} - |y|^2}{\phi}} \tag{8}$$

where each curve is associated with a different level of welfare loss $\bar{L}$, and higher curves are associated with higher welfare losses.

The optimal allocation is:

$$|y| = \frac{\phi(\kappa + \Lambda)\alpha_D \Lambda}{1 + \phi(\kappa + \Lambda)^2} |f| \tag{9}$$

$$|\pi| = \frac{\alpha_D \Lambda}{1 + \phi(\kappa + \Lambda)^2} |f| \tag{10}$$

while the minimised welfare loss is $L = \phi(\alpha_D \Lambda f)^2 / [1 + \phi(\kappa + \Lambda)^2]$.

The welfare loss caused by a change in f is increasing in Λ.[3] Therefore, the effect of the financial, trade and pass-through channels of the exchange rate on the welfare of the economy depends on their impact on Λ. A strong financial channel (high ψ), a weak trade channel (low τ) and a strong pass-through channel (high ρ_I) all raise Λ and thus increase the welfare loss caused by capital flow swings. The intuition for this result lies in the degree of synchronisation between output and inflation. For example, a stronger financial channel reduces the impact of capital flow swings on output. Therefore, when the financial channel of the exchange rate is strong, output and inflation respond to capital flows in a less synchronised way. However, monetary policy can only move them in tandem. This implies that, in order to achieve the same level of inflation, the central bank is forced to raise output further above its desired level. The larger the gap between their responses, the worse the output/inflation stabilisation trade-off faced by the central bank. A similar logic applies in the case of a weak trade channel and a strong pass-through channel.

Foreign exchange intervention can absorb part of the capital flows and thus mitigate their impact on the economy. In fact, a more stable exchange rate (high δ) reduces Λ and thus improves welfare (Graph II.B.1, right-hand panel). Other things equal, economies with a strong financial channel, a weak trade channel or a strong pass-through channel benefit more from stabilising their exchange rate, as these channels worsen the trade-off faced by the central bank as a consequence of capital flow swings.

The intertemporal trade-off

In addition to the short-term trade-off, there is an intertemporal one. To capture the role of financial vulnerabilities in the conduct of monetary policy, we extend the model dynamically by assuming that the strength of the financial channel is proportional to the country's net foreign asset position and thus evolves with the country's current account position. To capture this formally, we assume that the law of motion of the strength of the financial channel of the exchange rate ψ is given by:

$$\psi' = (\varrho - \mu)\psi - \omega\left[\xi\left(-i^* + \nu e - e\right) - \iota\left(-i + \psi e\right)\right] \tag{11}$$

[3] Notice that a higher Λ increases the equilibrium output gap while its impact on the inflation gap is ambiguous. This is because a higher Λ decreases the cost of stabilising inflation in terms of output. Hence, the central bank might choose to stabilise inflation more because its cost, given by a larger output gap, falls.

where ψ' represents the strength of the financial channel in the future and ϱ measures its persistence. The term in square brackets is the country's current account balance, with ξ and ι being the elasticity of export and import expenditures, respectively, and ω the contribution of the current account to the build-up of financial vulnerabilities. The parameter $\mu \geq 0$ captures the effect of macroprudential policies. Macroprudential policies, such as reserve requirements or countercyclical capital buffers, increase the resilience of the financial sector and reduce future financial vulnerabilities. In other words, a higher μ reduces ψ'.

The dynamic evolution of ψ links current outcomes with future macroeconomic volatility and gives rise to an intertemporal dimension of monetary policy. In setting its policy rate, the central bank takes into account its intertemporal effect and minimises not only current but also future expected welfare losses. Formally, the objective of the central bank is to minimise:

$$\mathcal{L} = L + \beta E\left[L'\right] \tag{12}$$

where L is the loss today from equation (6) and $E[L']$ is the expected future loss, while $\beta \in (0,1)$ represents the rate at which the central bank discounts the future.

We use the model to study the intertemporal problem faced by the central bank in response to an increase in f. The appreciation induced by the surge in capital inflows reduces both output and inflation, and induces the central bank to cut its policy rate. If the expansionary stance of monetary policy boosts import expenditures relatively more than export expenditure, then it reduces the current account and raises financial vulnerabilities. This, in turn, increases the economy's exposure to future capital flow swings, raises macroeconomic volatility and thus reduces expected future welfare.[4] We capture this intertemporal trade-off by looking at the relationship between the current inflation gap and its future standard deviation. Formally, this link is described by the following equations:

$$\sigma_{\pi'} = \frac{\alpha_D \Lambda'}{1 + \phi\left(\kappa + \Lambda'\right)^2} \sigma_{f'} \tag{13}$$

$$\Lambda' = \frac{\eta \rho_I}{\left(1 - \psi' + \gamma\delta\right)\alpha_D + \tau\alpha_E} \tag{14}$$

$$\psi' = \left(\varrho - \mu\right)\psi - \omega\Delta\left|\pi\right| + \omega\left(\iota - \alpha_D \Delta\right) f \tag{15}$$

where $\sigma_{f'}$ is the standard deviation of f' and $\Delta \equiv \Lambda\,[(1-\psi+\gamma\delta)\iota - (1-\nu)\xi]/[\eta\rho_I(\kappa+\Lambda)]$ measures the impact of monetary policy on the current account relative to its impact on inflation. If the elasticity of import expenditure is large compared with the elasticity of export expenditure, such that $\Delta > 0$, then a reduction in the domestic policy rate reduces the current account and raises ψ'. This implies that stabilising inflation comes at the cost of future macroeconomic volatility. This relationship is represented by the downward sloping line in Graph II.B.2.[5]

4 While in the current setup the vulnerabilities arise through the current account, in more general settings they could arise more broadly through the interaction of capital flows with the domestic financial cycle. Capturing this would entail extending the IS curve in equation (1) to include a state variable, such as leverage, that interacts with capital flows and exerts potentially non-linear effect on output – for example, boosting it at low levels and reducing it at high levels. Such an extension is beyond the scope of this Appendix.

5 In plotting this relationship, we assume that a higher Λ' raises $\sigma_{\pi'}$. From the static analysis developed above, we know that a higher Λ' reduces welfare but could lead to a more stable inflation (see

By using the solution to the short-term problem, we can express the expected future welfare loss as $E[L'] = \phi[1 + \phi(\kappa + \Lambda')^2]\sigma_{\pi'}^2$. Therefore, the intertemporal welfare loss can be rewritten as a function of the current inflation gap and future inflation volatility, as follows:

$$\mathcal{L} = \phi|\pi|^2 + \left(\frac{\alpha_D \Lambda f - |\pi|}{\kappa + \Lambda}\right)^2 + \beta\phi\left[1 + \phi(\kappa + \Lambda')^2\right]\sigma_{\pi'}^2 \tag{16}$$

The equation of the indifference curves represented by the dotted curves in Graph II.B.2 is:

$$\sigma_{\pi'} = \sqrt{\frac{1}{\beta\phi}\frac{\bar{\mathcal{L}} - \phi|\pi|^2 - \left(\frac{-|\pi| + \alpha_D \Lambda f}{\kappa + \Lambda}\right)^2}{1 + \phi(\kappa + \Lambda')}} \tag{17}$$

where each curve is associated with a different level of welfare loss $\bar{\mathcal{L}}$.

The equilibrium inflation gap is given by:

$$|\pi| = \frac{\alpha_D \Lambda f}{1 + \phi(\kappa + \Lambda)^2} + \Delta\frac{\beta\Lambda'\alpha_D\omega}{\eta\rho_I}\frac{(\kappa + \Lambda)^2}{1 + \phi(\kappa + \Lambda)^2}\frac{1 + \kappa\phi(\kappa + \Lambda')}{1 + \phi(\kappa + \Lambda')^2}E[L'] \tag{18}$$

The first term in equation (18) is the solution to the short-term problem, while the second term captures the effect of the intertemporal dimension of monetary policy. If $\Delta > 0$, in response to a surge in capital inflows the central bank stabilises inflation less to prevent the excessive build-up of financial vulnerabilities.[6]

The activation of macroprudential policies reduces ψ' and improves the intertemporal trade-off (Graph II.B.2, right-hand panel). Similarly, by stabilising the exchange rate, foreign exchange intervention can reduce the impact of capital inflows on the current account and lower ψ'.

footnote 2). In this case, the line would slope upwards, but the conclusions of the analysis developed below would not change.

6 Vice versa, in response to an increase in capital outflows the central bank would like to stabilise inflation more since the increase in the policy rate required to fight the exchange rate depreciation also reduces financial vulnerabilities.