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The Impossible Trinity Revised: An Application to China

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THE IMPOSSIBLE TRINITY REVISED: AN APPLICATION TO CHINA

NON-TECHNICAL SUMMARY

A world of free-floating exchange rates, free capital mobility and inflation targeting is often promoted as bringing stability, allowing to accommodate shocks, and not requiring explicit coordination of monetary policies. However, the international monetary system has not yet reached this blessed area. Many *de jure* or *de facto* restrictions on capital mobility remain, many countries pursue a fixed or closely managed exchange rate. Furthermore, macro-prudential policies and capital controls in emerging markets are now considered as useful tools to limit the domestic impact of capital flows (Qureshi et al., 2011).

We propose a parsimonious DSGE model that compares the macroeconomic dynamics of fixed exchange-rate regimes cum sizable capital controls to the dynamics of flexible exchange-rate regimes. In line with Mundell (1960), the model aims to establish (i) under what conditions one regime is stable while the other system is unstable; (ii) how the path to equilibrium, in each system, is affected by the extent to which capital is internationally mobile; and (ii) to what extent should the central bank be concerned, in the fixed exchange system, about the absolute level of its reserves.

We show that in a fixed exchange-rate regime, in line with Mundell (1960), monetary policy is in charge of the viability of the regime in the long run, i.e. to avoid an excessive accumulation of foreign reserves, or their depletion. To ensure a stable dynamic, the monetary policy rule should then depend on the evolution of the net foreign asset position (or the level of official reserves). This task entrenches the ability of monetary policy to influence the internal equilibrium in the fixed exchange-rate regime, despite sizable restrictions on capital mobility.

More generally, in our two-country framework, the policy assignation offers a large variety of configurations. If a central bank takes in charge the full burden of long-run stability of the fixed exchange-rate regime, the other one is *de facto* in charge of global inflation stabilization. Among these configurations, the symmetric case (the same self-oriented monetary-policy rule in the two countries) induces instability unless some form of cooperation occurs or one country becomes pivotal.

We then apply this analysis to the exchange-rate regime of China both during the 1995-2005 period (strict peg) and the period since 2005 (crawling-peg with an endogenous nominal exchange-rate objective). Despite the formal differences between the two regimes, the conditions under which monetary policy in China supports the exchange-rate regime and avoid large official reserve accumulation are close, and the macroeconomic dynamics are similar. In particular, a large reactivity of monetary policy to domestic variables, like inflation, may generates long-lasting fluctuations of the trade balance and real exchange rate.

ABSTRACT

In a fixed exchange-rate regime, monetary policy is not devoted to internal equilibrium, such that the

Taylor principle is no more the condition to insure the determinacy of the dynamic. Monetary policy is in charge of stabilizing the fixed-exchange rate regime in the long run, i.e. to avoid an excessive accumulation of foreign reserves, or their depletion. For this purpose, the monetary policy rule has to include the evolution of the net foreign asset position. Stabilizing the fixed exchange-rate regime entrenches the ability of monetary policy to influence the internal equilibrium, despite sizable restrictions on capital mobility. This translates into a restriction on implementable monetary-policy rules. Ill-designed monetary-policy rules generates long-lasting fluctuations of the trade balance and the real exchange rate.

JEL Classification: F32, F33.

Keywords: Impossible Trinity, Monetary Policy, China.

Le triangle d'incompatibilité revisité: Le cas de la Chine

Résume non technique

Un système monétaire international caractérisé par des taux de change flexibles, une liberté de mouvement des capitaux et une politique monétaire qui stabilise l'inflation offre en principe des marges de manœuvre pour amortir les chocs et ne nécessite pas une coordination internationale des politiques monétaires. Le système monétaire international, tel qu'il fonctionne aujourd'hui, est encore éloigné de cet idéal : de nombreux régimes de change fixes ou intermédiaires demeurent accompagnés de contrôles de capitaux. Le Fonds monétaire international, sans les promouvoir explicitement, souligne l'intérêt de tels régimes pour la stabilité macroéconomique (Qureshi et al., 2011).

Nous proposons un cadre simple permettant de comparer les régimes de change fixe et les régimes de change flexible. Notre résultat principal modère l'apport des restrictions aux mouvements des capitaux à la stabilisation macroéconomique, en dehors des épisodes d'attaque spéculative ou d'entrées massives de capitaux. Des contrôles de capitaux peuvent certes permettre de mener une politique monétaire discrétionnaire tout en fixant le taux de change nominal. Mais pour assurer la stabilité du régime de change à long terme, la politique monétaire doit satisfaire à des contraintes qui limitent la possibilité d'amortir des chocs domestiques. Les contrôles de capitaux ne confèrent pas à la politique monétaire l'autonomie que l'on croit.

Cette analyse est mise à profit pour éclairer les conditions de stabilité du régime de change chinois. Dans une première phase, qui court du milieu des années 1990 à juillet 2005, le taux de change nominal vis-à-vis du dollar est fixe, les contrôles de capitaux sont stricts, et l'équilibre de la balance des paiements est assuré par l'accumulation de réserves de change. Celle-ci a été très importante durant cette première période : les réserves accumulées passant de 5% du PIB en 1995 à 30% en 2005. Cela peut être un effet secondaire du régime de change et du choix de la politique monétaire : des cycles longs d'accumulation de réserves de change sont une conséquence d'une politique monétaire qui cherche à amortir les chocs domestiques.

A partir de juillet 2005, le régime de change évolue vers plus de flexibilité. Les six premières années d'exercice de ce nouveau régime de change permettent d'inférer que le yuan est ré-aligné en fonction du niveau de l'inflation chinoise : une hausse de l'inflation accroît le rythme d'appréciation de la monnaie, la désinflation importée servant à limiter les tensions inflationnistes domestiques. Nous montrons que cette modification du régime de change a bien comme effet de limiter la volatilité de l'inflation, mais qu'elle ne modifie en rien la dynamique des réserves de change (avec des cycles longs d'accumulation). La dynamique de la position extérieure nette ne dépend donc pas simplement du régime de change, mais de l'interaction entre régime de change et règle de politique monétaire.

RÉSUMÉ COURT

Dans un régime de change fixe, la politique monétaire n'a pas pour tâche d'assurer l'équilibre interne et la stabilité des prix mais celle de pérenniser le régime de change, c'est-à-dire d'éviter une accumulation excessive de réserves de change, ou leur disparition. Une règle de politique monétaire doit donc lier les évolutions du taux d'intérêt à celles du niveau des réserves de change, même lorsqu'il existe de stricts contrôles de capitaux. Cette condition toutefois ne suffit pas. Il faut en outre que le taux d'intérêt réagisse faiblement au niveau de l'inflation domestique (contrairement au principe de Taylor) sous peine de créer des fluctuations très persistantes de l'activité, de l'inflation et de la balance commerciale.

Classification JEL : F32, F33.

Mots clés : Triangle d'incompatibilité, politique monétaire, Chine.

The Impossible Trinity Revised: An Application to China

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1. Introduction

A world of free-floating exchange rates, free capital mobility and inflation targeting is promoted as both bringing stability (i.e. no risk of exchange-rate crisis) and allowing to accommodate shocks through an appropriate monetary policy rule (see Ball & Sheridan (2005) and Rose (2007) for arguments in favor of inflation targeting). There is another argument in favor of such and exchange-rate regime: it does not requires explicit coordination of monetary policies. Gains from moving from self-oriented monetary policy to international coordination are at most moderate (Obstfeld & Rogoff, 2002; Clarida et al., 2002; Corsetti & Pesenti, 2005; Benigno & Benigno, 2006; Coenen et al., 2008).

However, the international monetary system has not yet reached this blessed area. Many *de jure* or *de facto* restrictions on capital mobility remain, many countries pursue a fixed or closely managed exchange rate, and despite formal inflation targeting policies in emerging countries, their implementation has been challenging at the end of 2008 during the economic crisis and in the face of large commodity price volatility. Furthermore, macro-prudential policies and capital controls in emerging markets are now considered as useful tools to limit the domestic impact of capital flows (Qureshi et al., 2011).

We propose a parsimonious DSGE model that compares the macroeconomic dynamics of fixed exchange-rate regimes with sizable capital controls or low international capital mobility with the dynamics in a flexible exchange-rate regime. Mundell (1960) introduced the first analysis of the dynamic properties of a small open economy with sticky prices (rigid in the short run, flexible in the long run) and imperfect capital mobility (capital flows adjust slowly to the interest rate differential) both in flexible and in fixed exchange-rate regimes. He emphasizes that "*the dynamical differences between the two systems are based on an inversion of the roles, in the dynamic adjustment process, of the terms of trade and the rate of interest*" (Mundell (1960), pp.228). In a flexible exchange-rate regime, the terms of trade are mainly driven by nominal exchange rate variations that correct external disequilibrium whereas monetary policy is devoted to internal stabilization. In a fixed exchange-rate regime, the terms of trade are driven by the level of inflation and so correct internal disequilibrium whereas monetary policy and the accumulation of foreign reserves are devoted to the achievement of external equilibrium. However, in his contribution on the dynamic adjustment in fixed and flexible exchange, Mundell

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assumes a "flow theory" of financial markets instead of a "portfolio theory" (Willett & Forte, 1969; Branson, 1970), considers the exchange rate as a backward-looking variable instead of a forward variable (Dornbusch, 1976) and inflation dynamic is not influenced by expectations (Calvo, 1983). Nevertheless, the main questions underlying his half-a-century old paper are still vivid in academic and policy debates (see Mundell (1960), p.228):

> (1) under what conditions will one system be stable while the other system is unstable; (2) how is the cyclicity or directness of the paths to equilibrium, in each system, affected by the extent to which capital is internationally mobile; (3) to what extent should the central bank be concerned, in the fixed exchange system, about the absolute level of its reserves, as opposed to the situation in the current balance of payments; and (4) to what extent can offsetting central bank action stabilize a system which is inherently unstable because of speculative capital movements?

In a nutshell, the present paper addresses the first three questions in the new open economy macroeconomics (NOEM) paradigm. The model assumes two countries producing imperfect substitute goods (the law of one price, LOOP, applies but deviations from purchasing power parity, PPP, are possible) and issuing imperfect substitute bonds (deviations from uncovered interest parity, UIP, are possible). Domestic and Foreign bonds are the only tradable assets such that there is no international risk sharing. Prices are sticky *à la* Calvo (1983).

Depending on the institutional context, different mechanisms may induce deviations from the UIP: a country without any restriction on capital mobility but where exchange-rate volatility induces a risk premium, a country with an under-developed financial market and large trade costs, or a country imposing capital controls. Deriving a convenient portfolio model relevant for each particular context is out the scope of our approach. We rather assume a simple *ad hoc* reduced form for the international portfolio choice (the share of wealth invested in foreign assets) that shares with Obstfeld (1980) the property that the private sector "*ignores the composition of the central bank's balance sheet in arriving at portfolio decisions*" (see Obstfeld (1980), p.180). This assumption is fundamental to induce an effect of official intervention. To illustrate this point, let us consider a representative agent model with an optimal portfolio (Devereux & Sutherland, 2008). The imperfect substitutability of domestic and foreign bonds is an equilibrium outcome resulting from the correlation between asset returns and the stochastic discount factor. Any modification of the balance sheet of the central bank (buying a foreign asset for example) results in a change of the correlation of future net transfers from the government (that now includes gains and losses on the price of the foreign asset) with the stochastic discount factor. Consequently, the representative agent will reduce his exposure to this risk and, without any change in relative prices, sell the asset. As a consequence, the private sector exactly offsets the central bank intervention. The representative agent perfectly internalizes the central bank decision, like in the Ricardian equivalence.[1] This idea is developed in Obstfeld (1982)

[1] Instead of transferring income between today and tomorrow through bond issued by the government, a (sterilized) official intervention transfers income from good shocks to bad shocks. In each case, the optimal response of the

in the fixed exchange rate case (i.e perfect foresight of future income streams generated by the holding of foreign bonds by the central bank). Therefore, relaxing (i) the optimal (no ignorance) portfolio or (ii) the representative agent hypothesis is necessary to resuscitate an effect of the central bank balance sheet on net capital flows and on the exchange rate (the portfolio channel of official interventions).

Obstfeld (1980) evaluates the ability of monetary policy to modify the market equilibrium outcome in a fixed exchange-rate regime with flexible prices and imperfect capital mobility. Henderson & Rogoff (1982) deny that a negative net foreign asset position (or a negative net position on foreign-currency denominated assets) is *per se* a cause of instability (absent destabilizing speculation). We show that, in a fixed exchange-rate regime, internal equilibrium is not achieved by monetary policy and the Taylor principle is no more the condition to insure the determinacy of the dynamic (both sides of the same coin). In line with Mundell (1960), monetary policy is in charge of stabilizing the fixed-exchange rate regime in the long run, i.e. to avoid an excessive accumulation of foreign reserves, or their depletion. The monetary policy rule should then react to the evolution of the net foreign asset position (or the level of official reserves) in order to stabilize the fixed exchange-rate regime. This task entrenches the ability of monetary policy to influence the internal equilibrium in the fixed exchange-rate regime, despite sizable restrictions on capital mobility. Thus translates into a restriction on implementable monetary-policy rules: the inflation weight in the simple rule has to be low enough, instead of high enough like the Taylor principle commands. Otherwise, the trade balance experiences long-lasting wavelength (several years) sustained oscillations.

More generally, in our two-country framework, the task-sharing between the two central banks offers a large variety of configurations. The objectives are the fixed exchange rate, worldwide inflation anchoring and the stabilization of the net foreign asset position between the two countries. The accumulation of official reserves (by one or the two central banks) and the two nominal interest rates are the instruments the players can use. If a central bank takes in charge the full burden of long-run stability of the fixed exchange-rate regime, the other one is *de facto* in charge of global inflation stabilization. Among these configurations, the symmetric case (the same self-oriented monetary-policy rule in the two countries) induces instability unless some form of cooperation occurs or one country turns leader.

2. THE MODEL

We consider a simple two-country NOEM model. Home and Foreign (variables of Foreign are denoted by a star) have identical structures except that the central bank of Foreign does not accumulate official reserve whereas Home pegs its currency on Foreign and adjusts the level of its official reserves accordingly. In addition to the traditional open economy DSGE models, we assume sizable restrictions on capital mobility between Home and Foreign, in a way similar to the Mundell-Fleming framework. The fixed exchange-rate regime can so be managed through

representative agent is to neutralize the policy through financial markets.

foreign reserves accumulation instead of loosing the independence of monetary policy (i.e. the level of interest rate). We ignore the positivity constraint on Foreign reserves.[2] We normalize the size of each country by the size of the world economy, such that, if s denotes the size of Home, the size of Foreign is equal to $s^* = 1-s$.

2.1. Households

Each country is populated by a representative infinitely-lived household who consumes C_t and works L_t. Its intertemporal utility is given by

$$\mathbb{E}_t \left\{ \sum_{k=0}^{\infty} \beta^s \left[(1-\kappa) \log(C_{t+k}) + \kappa \log(\bar{L} - L_{t+k}) \right] \right\}, \tag{1}$$

where β is the subjective discount factor, $0 \leq \kappa \leq 1$ a measure of preference for leisure and $\bar{L}$ the total amount of disposable time. The amount of assets (end of period) is denoted $\mathscr{A}_t$ and wealth inherited from the previous period (begin of period), Ω_t. $\mathscr{T}_t$ denotes the transfers from the government to households (negative in case of taxes). Let PC_t and W_t represent the price of the consumption basket and the nominal wage. The budget constraint is given by

$$PC_t C_t + \mathscr{A}_t = W_t L_t + \Omega_t + \mathscr{T}_t. \tag{2}$$

The portfolio of the representative household consists of equities (ownership of firms), foreign bonds B_t^F and domestic bonds B_t.[3] Let Q_t be the (end of period) price of equities and S_t the nominal exchange rate. Total assets holding writes

$$\mathscr{A}_t = Q_t + B_t + S_t B_t^F. \tag{3}$$

Given the asset purchase in period $t-1$ and the dividends D_t received at t, the level of wealth at the beginning of period t is equal to

$$\Omega_t = (Q_t + D_t) + R_t B_{t-1} + S_t R_{t-1}^* B_{t-1}^F. \tag{4}$$

The first-order conditions on equities, securities and hours supply write

[2]This simplifying assumption is justified as we restrict the interpretation of the model to episodes of large official reserves accumulation, above any reasonable value for a "buffer in case of crisis". One may also assume that Home central bank has unlimited access to funding from Foreign central bank.

[3]We also assume a complete set of contingent claims that are not traded internationally. Their net holding is zero but their price, $\mathscr{F}_t^{t+1}$, properly defines the program of firms.

$$\mathscr{F}_t^{t+1} = \beta \frac{C_t}{C_{t+1}} \frac{PC_t}{PC_{t+1}}, \qquad (5) \qquad Q_t = \mathbb{E}_t \left\{ \mathscr{F}_t^{t+1} (Q_{t+1} + D_{t+1}) \right\}, \qquad (6)$$

$$L_t = \bar{L} - \frac{\kappa}{1-\kappa} \frac{C_t}{W_t/PC_t}, \qquad (7) \qquad R_t \mathbb{E}_t \left\{ \mathscr{F}_t^{t+1} \right\} = 1. \qquad (8)$$

Imperfect capital mobility Imperfect capital mobility has been introduced in DSGE models in order to "close" open-economy models, i.e. to avoid an indetermination of the net foreign asset position at the steady-state, and a unit root in the dynamic in absence of perfect international risk-sharing (Schmitt-Grohé & Uribe, 2003). Following the two authors, most models assume very small frictions on international financial markets to minimize interferences with the short-term dynamic. Here, we assume that frictions are sizable and reproduce capital controls or imperfect international financial integration. More precisely, domestic and foreign bonds are the only traded assets, and the first order conditions on foreign bonds holding is modified such that the uncovered interest parity does not hold. Following Schmitt-Grohe and Uribe, we assume no asset cross-holding between Home and Foreign at the steady-state.[4] The share of foreign assets in the portfolio of the representative household is given by

$$\frac{S_t B_t^F}{\mathscr{A}} = (1-s)\varphi \mathbb{E}_t \left\{ \frac{S_{t+1}}{S_t} R_t^* \mathscr{F}_t^{t+1} - 1 \right\}, \qquad (9)$$

where $\mathscr{A}$ represents the steady-state level of total asset holding, $\varphi > 0$ is a measure of capital mobility i.e. the sensitivity of the portfolio allocation to excess return. If $\varphi \to 0$, the share of foreign assets in the domestic portfolio is exogenous. If $\varphi \to \infty$, there is no restrictions to capital mobility and the interest rate parity holds.[5]

2.2. Firms and price setting

The production function is common across firms $Y_t(i) = A_t L_t(i)$. Dividends (capital income) include the price mark-up over the marginal production cost ($D_t(i) = (P_t(i) - W_t/A_t)Y_t(i)$). Prices are sticky *à la* Calvo and firms that have the opportunity of setting freely their price at t will all choose the same optimal price $P_{t|t}$, due to their homogeneity. They maximize their profit expectancy until next free price setting

$$\max_{P_{t|t}} \mathbb{E}_t \sum_{s=0}^{\infty} \mathscr{F}_t^{t+s} \nu_p^s \left(P_{t|t} - MC_{t+s} \right) \left(\frac{P_{t|t}}{P_{t+s}} \right)^{-\frac{1+\mu}{\mu}} Y_{t+s}.$$

[4]Assuming assets cross-holding at the steady-state induces "valuation effects" in flexible exchange-rate regime. However, it does not modify the main results in fixed exchange-rate regimes.

[5]To derive this functional from a utility, see Schmitt-Grohé & Uribe (2003).

Let $\lambda = \frac{(1-\nu_p)(1-\beta\nu_p)}{\nu_p}$ and $\hat{mc}_t$ be the log-deviation of real marginal costs from the steady-state, the new-Keynesian Phillips curve writes

$$\pi_t = \lambda \hat{mc}_t + \beta \mathbb{E}_t\{\pi_{t+1}\}. \tag{10}$$

2.3. The central bank

In the flexible exchange-rate regime, each central bank set its own policy rate, according to a simple rule based on domestic inflation. In a fixed exchange-rate regime, the central bank of each country sets the level of the nominal interest rate according to a monetary policy rule described in Section 3. In addition, the central bank of Home buys and sells foreign assets *FR* to stabilize the exchange rate in the fixed exchange-rate regime. On one hand, the trade surplus depends on relative demand in Home and Foreign and the terms-of-trade (see below); On the other hand, the net financial flows depends on the interest rate gap between the two countries. In a flexible exchange-rate regime, expected appreciation or depreciation of the nominal exchange rate equilibrates the two flows. In a fixed exchange-rate regime, a variation of official reserves does. Assume that the current account and the (private) financial account do not balance each other at the current exchange rate (for example, a net private capital inflow and a current account surplus). Home central bank is forced to accumulate official reserves (a net public capital outflow) to maintain the fixed exchange rate.

How can the central bank finance foreign assets purchase? In the model, there is neither a banking sector nor fiat money. As a consequence, the central bank can neither impose reserves on private banks nor create money (the bulk of the liabilities of a normal central bank). However, this leaves the option of issuing sterilization bonds, an option that is *mutatis mutandis* equivalent to the so-called sterilized-interventions that consist in selling domestic assets (government bonds) to compensate for the buying of foreign assets, such that the size of the balance sheet stays constant (no money creation). Another option is available: levy funds on its shareholder, the government (i.e. ultimately the tax-payers). We exclude this option that differs greatly from what is commonly called non-sterilized interventions.[6]

The behavior of the Home central bank is described by three equations: (i) the exchange rate is maintained at the desired value S^{peg}, (ii) the central bank sterilizes official reserves purchases and (iii) the monetary policy rule (which is introduced in Section 3). The first two equations write

$$S_t = S^{\text{peg}}, \tag{11}$$

$$Bs_t = S_t FR_t. \tag{12}$$

In the balance sheet of the central bank, the asset-side contains official reserves FR_t whereas the liability-side consists of sterilization bonds Bs_t. In addition, any gain (or loss) due to valua-

[6] Instead of "money creation" the economy faces "tax creation". It is not comparable to an inflation tax because there is no inflation. It is more comparable to the opportunity cost of bank reserves at the central bank in order to avoid a credit expansion not compatible with the policy rate.

tion effects translates into a transfers to households when interests received on official reserves exceed those payed on domestic liabilities (sterilization bonds). The stock-flow equilibrium determines the level of net transfers from the central bank to the household sector

$$\mathscr{T}_t = Bs_t - R_{t-1}Bs_{t-1} - S_t(FR_t - R^*_{t-1}FR_{t-1}). \quad (13)$$

2.4. Trade, international accounts and market clearing

The consumption bundle of Home and Foreign households have the standard CES form with an elasticity of substitution ε. Let $\bar{\alpha}$ the world trade integration index, such that trade openness of Home and Foreign are given by $\alpha = (1-s)\bar{\alpha}$ and $\alpha^* = (1-s^*)\bar{\alpha}$ respectively.[7] We assume the law of one price (the difference between local currency pricing and producer currency pricing disappears in the fixed exchange rate regime). Domestic demand (D) and exports (X) of Home and Foreign, and the definition of consumption price are given by (we skip the t subscript for clarity)

$$D = (1-\alpha)\left(\frac{P}{PC}\right)^{-\varepsilon} C, \quad (14)$$

$$X = \alpha^* \left(\frac{P/S}{PC^*}\right)^{-\varepsilon} C^*, \quad (15)$$

$$PC = \left((1-\alpha)P^{1-\varepsilon} + \alpha\,(SP^*)^{1-\varepsilon}\right)^{\frac{1}{1-\varepsilon}}, \quad (16)$$

$$D^* = (1-\alpha^*)\left(\frac{P^*}{PC^*}\right)^{-\varepsilon} C^*, \quad (17)$$

$$X^* = \alpha \left(\frac{SP^*}{PC}\right)^{-\varepsilon} C, \quad (18)$$

$$PC^* = \left((1-\alpha^*){P^*}^{1-\varepsilon} + \alpha\,(P/S)^{1-\varepsilon}\right)^{\frac{1}{1-\varepsilon}}. \quad (19)$$

The trade account in Home currency and the accumulation of net foreign assets write

$$TB_t = P_tX_t - S_tP^*_tX^*_t, \quad (20)$$

$$NFA_t = S_t(FR_t + B^F_t) - B^{*H}_t = TB_t + S_tR^*_{t-1}(FR_{t-1} + B^F_{t-1}) - R_{t-1}B^{*H}_{t-1}. \quad (21)$$

The Home and Foreign bond market equilibria write

$$FR_t + B^F_t + B^*_t = 0, \quad (22) \qquad B^{*H}_t + B_t = Bs_t. \quad (23)$$

The Home and Foreign good market equilibria write

$$Y_t = D_t + X_t, \quad (24) \qquad Y^*_t = D^*_t + X^*_t. \quad (25)$$

[7] If $\bar{\alpha} = 0$, there is no trade at all; if $\bar{\alpha} = 1$, the share of domestic and foreign goods in the consumption bundle are equal to the size of each economy (no home bias).

Table 1 – Calibration

Name	Symbol	Value
Discount factor	β	0.99
Labor supply parameter	κ	0.2
Price mark-up	μ	0.15
Price rigidities	ν_p	0.8
Trade elasticity	ε	2
Trade integration	$\bar{\alpha}$	0.5
Relative size of Home	s	0.3 or 0
Financial integration	φ	5 or 50

2.5. Calibration

The period represents a quarter, the relative size of Home is set to 0 (the small open economy case) or 0.3, the latter matches the size of China comparing to the dollar area. Trade integration is set to 0.5 (trade openness of Home and Foreign are 0.35 and 0.15 respectively, fitting the China and US case). The value of the discount factor, the price mark-up and price rigidities are common in the literature and lead to a net wealth representing 3.75 years of GDP. Financial integration are calibrated for illustrative purpose. if $\varphi = 5$ (low capital mobility), a 1 per cent interest rate differential leads to a $2s(1-s)\varphi = 2.1\%$ reallocation of world assets. If $\varphi = 50$ (high capital mobility), reallocation reaches 21%.

3. The viability of the international monetary system

We now considers the conditions providing stability and determinacy of the dynamic system describing the economy in fixed and flexible exchange-rate regimes. The Blanchard-Kahn conditions (i.e. the number of explosive eigenvalues of the dynamic system relative to the number of non-predetermined variables) give the criterion for stability and determinacy of a dynamic system but the economic interpretation may raise some difficulties. The existence and uniqueness of a stable path of the dynamic system describing the economy is a holistic phenomenon, depending on the interaction of behavior of all agents. In a closed economy, the Taylor principle (monetary policy should responds more than one-to-one to inflation) does not raise much objections and is also compatible with learning (Bullard & Mitra, 2002): Blanchard-Kahn conditions and economic interpretation match in this case. The fiscal theory of price level, where the long-run solvency is not the result of the behavior of the government but an equilibrium outcome of the dynamic, is an example of a controversial case where Blanchard-Kahn conditions apply. On the contrary, sunspot equilibria that may appear with indeterminacy may also provide a pertinent analysis of the stagflation that occurs in the 70's (Farmer & Guo, 1994). Thus, the fulfilling of the Blanchard-Kahn conditions is not the touchstone of a relevant economic dynamic. We therefore pay attention to the economic interpretation of the conditions both in the flexible and the fixed exchange-rate regimes.

In a flexible exchange-rate regime, we assume no accumulation of official reserves whereas official reserve accumulation are mechanically triggered by the fixed exchange-rate policy in a fixed exchange-rate regime. The conditions providing determinacy in the each regimes are linked to the anchoring of inflation expectations (Home and Foreign inflation in the flexible exchange-rate regime, world inflation in the fixed exchange-rate regime). These conditions constrain monetary policy rules and give a natural generalization of the Taylor principle to international economics. The condition providing stability only constrains monetary policy in the fixed exchange-rate regime and is related to the dynamic of foreign assets and official reserve accumulation. The flexible exchange-rate regime allows a simple interpretation of the Blanchard-Kahn conditions (see Section 3.1 below). Yet, the fixed exchange-rate regime does not offer simple interpretations, except in some particular cases. The analysis of simple cases allows us to extend the interpretation of the Blanchard-Kahn conditions, that keeps a validity in the general case (see Section 3.2 and 3.3).

3.1. The flexible exchange-rate case

The Taylor principle in a closed economy has a simple generalization in a two-country context with a **flexible exchange rate**: it has to hold in each country. More precisely, we consider monetary policy rules based on current inflation

$$\ln(R_t) = \gamma_\pi \pi_t \qquad \text{and} \qquad \ln(R_t^*) = \gamma_\pi^* \pi_t^*.$$

Proposition 1 *In the flexible exchange-rate regime, the Taylor principle (a root of modulus larger than one related to the dynamic of inflation, which is a forward variable) requires* $\gamma_\pi - 1 > 0$ *and* $\gamma_\pi^* - 1 > 0$*. The stability of the dynamic system (a root of modulus smaller than one related to the net foreign asset position, which is a predetermined variable) requires* $\varphi > 0$ *and finite.*

The sketch of a formal proof is given in Appendix B. In a flexible exchange rate system, the determinacy of the dynamic system relies, in each country, on the Taylor principle, i.e. the response of the nominal interest rate to the inflation rate in the long run should be higher than one for one.[8]

If each central bank has its own inflation objective, the nominal exchange rate compensates for the gap. The low-inflation country isolates itself from the consequences of high inflation in the other one. However, the adoption of a monetary rule that respects the Taylor principle in one country does not isolate that country from the consequences of a monetary rule that breaks the Taylor principle in the other one. To illustrate this point, let us assume that $\gamma_\pi^* < 1$ (Foreign breaks the Taylor principle) while $\gamma_\pi > 1$ (Home respects it). Expectations-driven fluctuations may appear (there are multiple stable paths to the steady state), affecting both Foreign and Home.

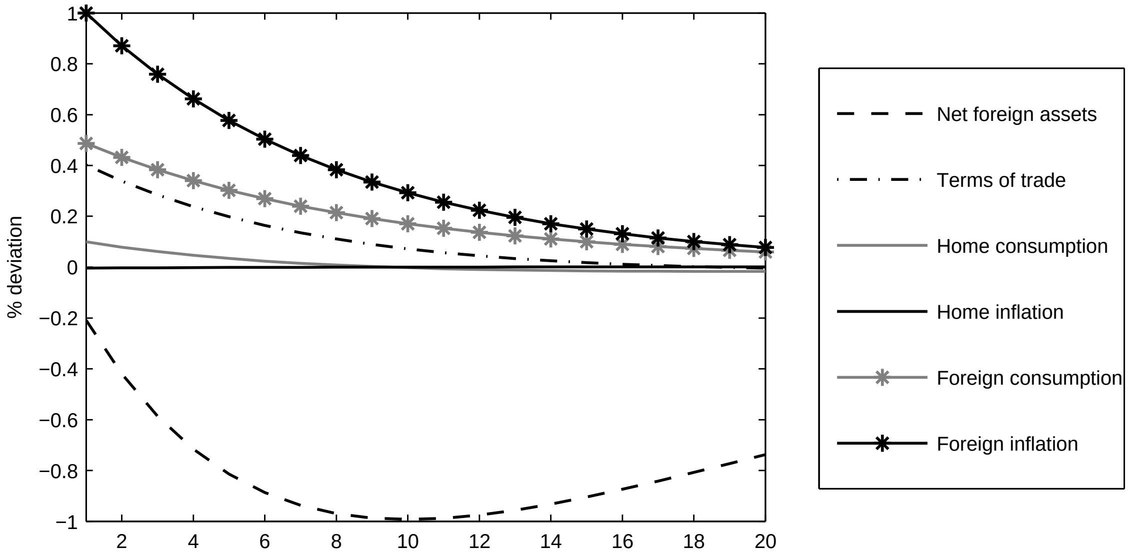
The impulse-response functions deriving from numerical simulations show that sunspot shocks affect mostly Foreign economy and, to a lesser extent, Home economy (see Figure 1).[9] Assume a positive sunspot shock (that drives inflation up in Foreign). The policy rate increases less than inflation (the Taylor principles does not hold in Foreign). The real interest rate drops, inducing a consumption hike in Foreign. The high nominal interest rate induces a nominal appreciation of the Foreign currency *vis-à-vis* its long-run value (dynamic appreciation). But, at the same time, the expected cumulated inflation differential between Home and Foreign triggers a large nominal depreciation in the long run (static depreciation). The reaction of the nominal exchange rate when the sunspot shock occurs is the combination of two opposite forces. As the interest rate increases less than inflation, the long-run (static) depreciation prevails over the short run (dynamic) appreciation. The nominal exchange rate of Foreign depreciates in the short run, inducing a trade deficit in Home and a deterioration of the net Foreign asset position. Later, the inflation differential allows Home to recover its competitiveness.

The stability of the dynamic system (the existence of at least one stable path to the steady-state) is independent from determinacy conditions. Given Ricardian properties (the infinite elasticity of saving to the level of interest rate in the long run) of the model, the imperfect capital mobility is a key ingredient to stability (Schmitt-Grohé & Uribe, 2003) whereas, despite perfect capital mobility, stability occurs in overlapping-generations models (Ghironi, 2006) or when some collateral constraints exists (Iliopulos, 2009).

[8] If the level of the output-gap is taken into account in the monetary policy rule, the condition is changed but not the principle by itself.

[9] See Appendix E for the computation of sunspot shocks IRF based on Lubik & Schorfheide (2003).

Figure 1 – An sunspot shock in the flexible exchange-rate regime when Foreign breaks the Taylor principle



3.2. The Taylor principle in fixed exchange-rate regimes

We now turn to the case in which Home maintains a **fixed nominal exchange-rate**. Monetary policy is no more able to isolate the domestic economy from monetary conditions abroad. It also contribute to macroeconomic evolutions in the Foreign through the policy-driven accumulation of foreign assets. In addition, the evolutions of Home and Foreign inflation are closely linked by purchasing power parity (PPP) in the long run. Thus, in a fixed exchange-rate regime, determinacy (the generalized Taylor principle) reduces to a single condition on monetary policy rules of both Home and Foreign. However, monetary policy rules that rely on inflation only in Home and Foreign are not able to insure the stability of the international monetary regime. More precisely

Proposition 2 *Absent the net foreign asset position in monetary policy, the dynamic system describing the fixed exchange-rate regime is unstable.*

See Appendix A.2 for a formal proof. The intuition is the following. Despite imperfect capital mobility, that prevents a unit root related to the net foreign asset position in a flexible exchange-rate regime, the accumulation of official reserves to maintain the fixed exchange rate may entails a dynamic of the net foreign asset position without mean-reverting forces. In order to generate such a mean-reverting mechanism, monetary policy should ease when the economy accumulates net foreign assets in order to stimulate consumption. We then consider monetary policy rules of the form

$$\ln(R_t) = \gamma_\pi \pi_t - \gamma_F \frac{NFA_t}{P_t Y_t} \qquad \text{and} \qquad \ln(R_t^*) = \gamma_\pi^* \pi_t^* + \gamma_F^* \frac{NFA_t}{S_t P_t^* Y_t^*},$$

where the coefficients γ_F and γ_F^* are assumed to be non negative ($\gamma_F \geq 0$ and $\gamma_F^* \geq 0$).

Proposition 3 *In the fixed exchange rate regime, the (generalized) Taylor principle writes*

$$\gamma_F^* s(\gamma_\pi - 1) + \gamma_F s^*(\gamma_\pi^* - 1) > 0. \quad (26)$$

For the sketch of a formal proof, see Appendix C.1. This condition can be elucidated in some particular cases.

Symmetric policies Assume $\gamma_F = \gamma_F^* > 0$ and $\gamma_\pi = \gamma_\pi^*$. Symmetric and anti-symmetric variables have separate dynamic and the Taylor principle, Equation (26), reduces to $\gamma_\pi = \gamma_\pi^* > 1$. A more general case requires only $\gamma_F = \gamma_F^* > 0$. In this case, the Taylor principle writes $s\gamma_\pi + s^*\gamma_\pi^* > 1$. This relation has an intuitive interpretation: the global nominal interest rate $(si + s^*i^*)$ has to react more than one-to-one to global inflation $s\pi + s^*\pi^*$. If a country is less reactive to inflation, it can be compensated for by a larger reaction of the other country. The symmetric policies regime share some aspects of the Exchange Rate Mechanism (ERM) adopted by European countries during the 1979-1999 period.[10]

Small open economy $s \to 0$. the generalized Taylor principle reduces to the Taylor principle in Foreign as a closed economy ($\gamma_\pi^* > 1$): Home monetary policy parameters are not relevant. This case is relevant for small countries unilaterally adopting a fixed exchange-rate *vis-à-vis* an international currency like the dollar or the euro.

Home in charge of the peg $\gamma_F^* = 0$ and $\gamma_F > 0$. Home is the only country to change its monetary policy when the net foreign asset position is modified, i.e. Home is in charge of the fixed exchange rate system whereas Foreign follows a kind of benign neglect policy regarding the exchange-rate regime. In this context, the sentence "being in charge of the fixed exchange-rate regimes" does not refers to the fact that Home is the only country to accumulate foreign reserves (Foreign may also accumulate reserves for instance when Home suffers large capital outflows). Being in charge of the fixed-exchange rate regime means that Home is the only country to adjust the level of its nominal interest rate when a drift of the net external position occurs. Then, the Taylor principle writes $\gamma_\pi^* - 1 > 0$, i.e. the Taylor principle for Foreign as a closed economy (Home monetary policy reaction to the level of inflation is irrelevant for determinacy). The two countries have specialized responsibilities: Foreign for price stability in the long run, Home for the fixed exchange-rate regime stability in the long run.[11] Given its economic size, China and its exchange-rate regime is the natural example (see Section 4).

Upside down $\gamma_F = 0$ and $\gamma_F^* > 0$. This case is less intuitive: *Foreign* increase its interest rate when *Home* accumulates excessive reserves. In this case, Home should have an active monetary policy ($\gamma_\pi > 1$) in order to manage world inflation whereas Foreign only needs to create

[10]However, the ERM organized rate bands instead of a strictly fixed exchange rate, allowed central parity adjustments if the official rate had deviated from the fundamental one and the system was not entirely symmetric given the particular role of Germany, that did not used to pursue infra-marginal interventions.

[11]The Taylor principle is a necessary but not a sufficient condition for Blanchard-Kahn conditions. see below for the stability constraint.

conditions such that the fixed exchange rate regime of Home is sustainable. The survival of the Gold Exchange Standard after 1969 would have required some form of coordination (Germany easing its monetary policy to help the United States rebuilding its golden reserves) that may have looked like the upside down regime.

3.3. A case for instability

The Taylor principle in fixed exchange-rate regimes does not rule out the occurrence of unstable dynamics. How can the fixed exchange-rate system be unstable? Let first consider a flexible exchange-rate system and the role of monetary policy. Assume that a country has an undervalued real exchange rate (i.e. the economy is out of equilibrium). Absent nominal appreciation, the country should experience an inflation surge that triggers an increase in the nominal interest rate and... an appreciation of the exchange rate. In equilibrium, the nominal exchange rate jumps and the undervaluation disappears. Thus, stabilizing inflation is the condition to avoid exchange rate misalignments. In a fixed exchange-rate regime, undervaluation is no longer an out-of-equilibrium concept, and inflation is the only way to close the gap and to return to the long-run equilibrium. But if inflation triggers monetary tightening, the economy returns to the steady-state at a slower pace. Furthermore, the combination of a depressed domestic demand and an undervalued real exchange-rate produces a large trade surplus and an accumulation of foreign reserves: an active monetary policy exacerbates imbalances in fixed exchange-rate regimes (while reducing them in a flexible regime). This mechanism is sufficient to produce an instability. The full description of the dynamics is given in Section 5. We first consider the eigenvalues underlying the dynamics which give conditions for stability. Having a simple and analytic condition in our context is difficult as it rests on the localization of the roots of a degree 6 polynomial. So, we develop analytically the result in some particular cases.

Small open economy case

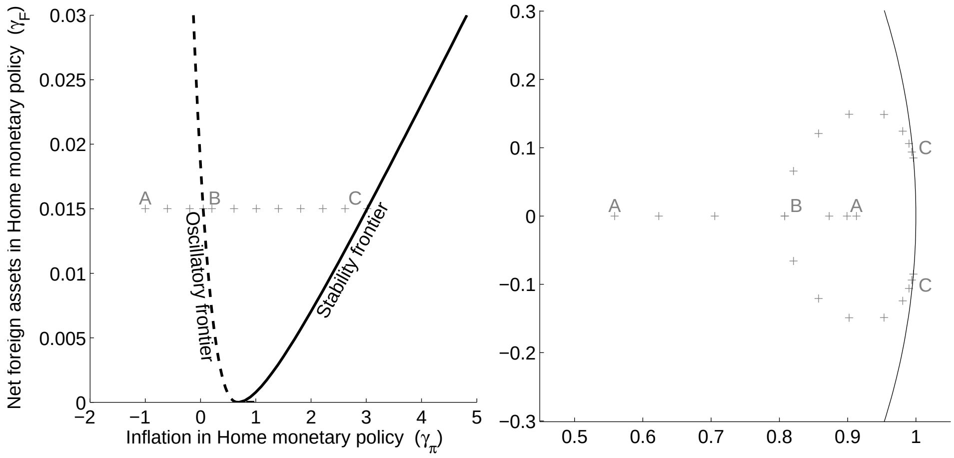
Proposition 4 *Assume that Home is a **small open economy**. The stability of the dynamic system requires* $\gamma_F > \overline{\gamma_F}(\gamma_\pi) \geq 0$*, where* $\overline{\gamma_F}$ *is a non-decreasing function.*

In the conditions of Proposition 4, the generalized Taylor principle depends on Foreign monetary policy rule only, as settled by Proposition 3, and stability conditions solely rely on Home monetary-policy parameters. Figure 2a, right panel, draws the domain in the plane (γ_π, γ_F) where Blanchard-Kahn conditions are satisfied. The persistence of fluctuations following a shock depends on the values of the eigenvalues strictly smaller that one. These eigenvalues are plotted in Figure 2a for policy rules depicted in the left panel. The larger the reaction of Home monetary policy to the net foreign asset, the lower the eigenvalues.

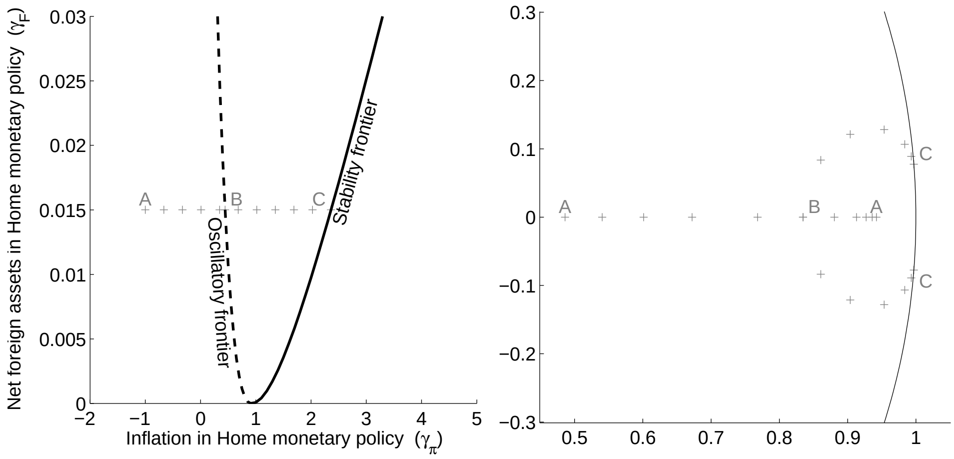
The roots of the dynamic system related to the evolution of the two predetermined variables in Figure 2a. Starting from a monetary policy rule given by the point A (negative response of Home nominal interest rate to Home inflation), we progressively increase the response to inflation. If

Figure 2 – Stability frontier and stable eigenvalues in the unit circle

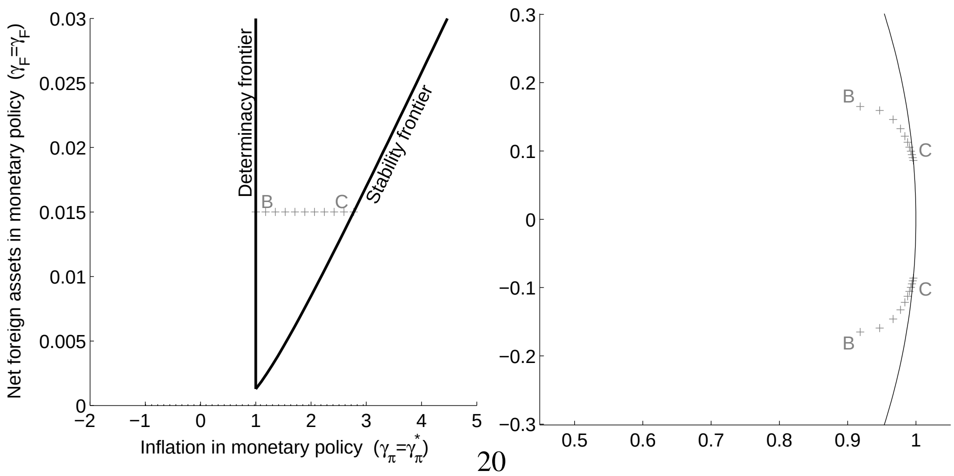
(a) Small open economy



(b) Home in charge of the peg



(c) Symmetric policies



the monetary-policy rule weakly weighs inflation (like any point on the $[A,B]$ line, see Figure 2a, left panel), the related stable eigenvalues are real (see Figure 2a, right panel). In this case, following a shock, the dynamic driving back to the steady-state is non-oscillatory. Increasing the weight of inflation in the policy rule modifies the picture. For intermediate weights (like any point on the $[B,C]$ line), the related stable eigenvalues are complex and conjugate, denoting an oscillatory dynamic (see Section 5 for the analysis of impulse-response functions). Increasing the weight of inflation further (beyond the point C) induces an unstable dynamic: the exchange-rate regime collapses. Figure 2a, left panel, plots the stability frontier (the locus of C points) and the oscillatory frontier (the locus of B points).

Home in charge of the peg case

Proposition 5 *Assume that Foreign monetary policy rule does not consider the net foreign asset position ($\gamma_{\mathrm{F}}^* = 0$). The stability of the dynamic system then requires $\gamma_{\mathrm{F}} > \overline{\gamma}(\gamma_\pi) \geq 0$, where $\overline{\gamma}$ is a non-decreasing function.*

The Home in charge of the peg case is qualitatively similar to the small open economy case: the monetary policy in Foreign is devoted to the management of world inflation whereas the monetary policy in Home stabilizes the dynamic of the net foreign asset position. However, the economic variables in Home now affects the dynamic in Foreign. Figure 2b plots the stability and the oscillatory frontiers when Home and Foreign have the same economic size ($s = s^* = 1/2$).

Symmetric case

Proposition 6 *Assume that Home and Foreign have* ***symmetric policies*** *($\gamma_{\mathrm{F}} = \gamma_{\mathrm{F}}^*$ and $\gamma_\pi = \gamma_\pi^*$). The stability of the dynamic system then requires $\gamma_{\mathrm{F}} = \gamma_{\mathrm{F}}^* > \overline{\gamma}(\gamma_\pi) \geq 0$, where $\overline{\gamma}$ is a non-decreasing function.*

In, the symmetric policies case, monetary policy is challenged by the anchoring of inflation expectations (the Taylor principle) on the one hand, and the stability of the exchange-rate regime on the other hand. The Taylor principle requires a high reactivity of monetary policy to the level of inflation whereas the stability is produced by a low reactivity. The two constraints narrow the area of possible policy rules (see Figure 2c, left panel) and, more importantly, are not compatible with a non-oscillatory dynamic. In order to avoid inefficient fluctuations, some form of explicit policy coordination (the domestic interest rate depends on foreign macroeconomic variables) should be considered.

3.4. The role of monetary-policy rule in fixed exchange-rate regimes

In a fixed exchange-rate regime, capital controls allow to avoid large fluctuations of official reserves. As far as the zero lower bound (for official reserves) is binding today or may be binding tomorrow, any reinforcement of capital controls helps reaching a larger set of macroeconomic outcomes. Yet, this set has a limited outreach. Monetary policy cannot be only devoted to internal equilibrium, the rule has also to backup the exchange-rate regime. Behind the "reserves depletion" frontier, related to the dynamic of official reserves in the short run, a "stability" frontier, related to the trade surplus and the net foreign assets position dynamic in the long run, limits the ability of monetary policy to accommodate inflationary shocks. And this second frontier is entirely independent from capital controls.

Fixed, symmetric exchange-rate regimes, like the ERM, challenge monetary policy. In order to avoid fluctuations occurring after a shock, either monetary policy should take into account the policy rate of the other countries belonging to the exchange-rate arrangement, or a pivotal country, in charge of anchoring inflation expectations, should emerge, the remainder countries being in charge of the dynamic of the net foreign asset position. Separated responsibilities appears more stable than shared responsibilities. German dominance in the eighties was not designed for stability, but was the result of its better credibility in fighting inflation. However, absent such asymmetry in credibility, the polarization of the exchange-rate regime around a pivotal country would have been a reasonable outcome.

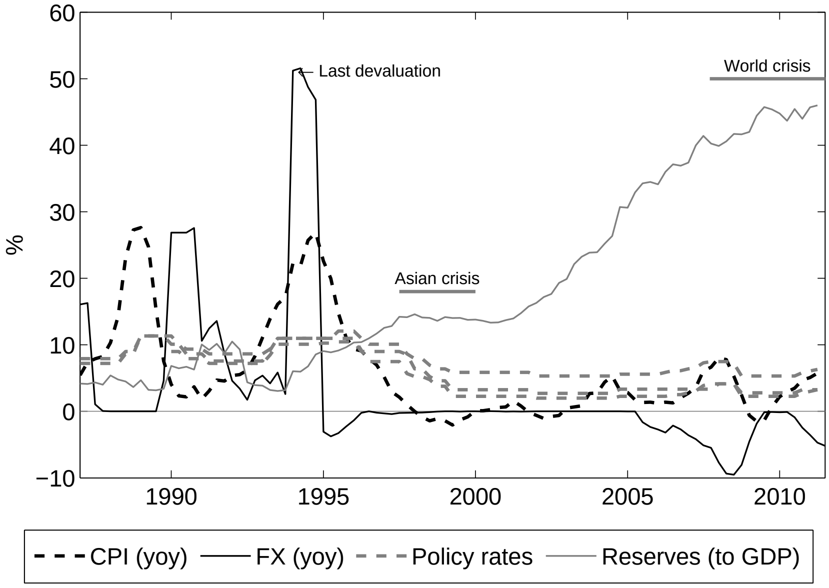
4. An application to China

4.1. China as a large pegger

Following a decade during which China had experienced two episodes of very high inflation, the country has decided to peg its currency to the dollar in the mid-1990 as part of a set of monetary reforms to reduce inflation (see Figure 3). The policy has been a large success for about 10 years. However, the level of international reserves has continuously increased since, except during the Asian crisis, from 5% of annual GDP in 1994 up to around 45% recently. The strategy to contain inflation has been undermined as inflation started surging in the mid 2000's, mainly due to food and commodity prices. The political context (the US urging for an appreciation of the renminbi), the higher inflation level and the growing international reserves have convinced China's authorities to add some flexibility to the exchange-rate regime even if the currency is still not convertible.

Since July 2005, the new exchange-rate regime in China has not differed significantly from a crawling peg. The daily exchange rate have been thoroughly managed, and the appreciation of the currency against the dollar has been regular, at a moderate pace. The Chinese authorities do not announce in advance the future path of the nominal exchange rate but it can be inferred from the first five years of the new regime that currency appreciations mirror the inflation rate in an inverse PPP-reversal fashion (a price hike triggers a currency appreciation): the sudden fall of inflation during the economic crisis in 2008 and 2009 coincides with the pause in the appreciation of the renminbi. The new regime and, probably to a large extent, the economic crisis, have limited the accumulation of foreign reserves.

Figure 3 – Monetary and exchange rate policy in China



Beside the exchange-rate regime, monetary policy implementation in China is also far from common practice in developed economies. The policy rate poorly reacts to inflation rate so that the Taylor principle (interest rate adjusts more than one-to-one to inflation) does not hold. However, credit to the private (and the public) sector is managed through credit rationing and credit easing as the banking sector is largely under the control of the government. Consequently, policy rates poorly reflect the monetary stance in China. As much as a developed banking system and a functional money market are absent, policy rates will only play a minor role. Recent reforms to relax capital controls may represent a first step to favor the role of the money market in monetary-policy transmission.

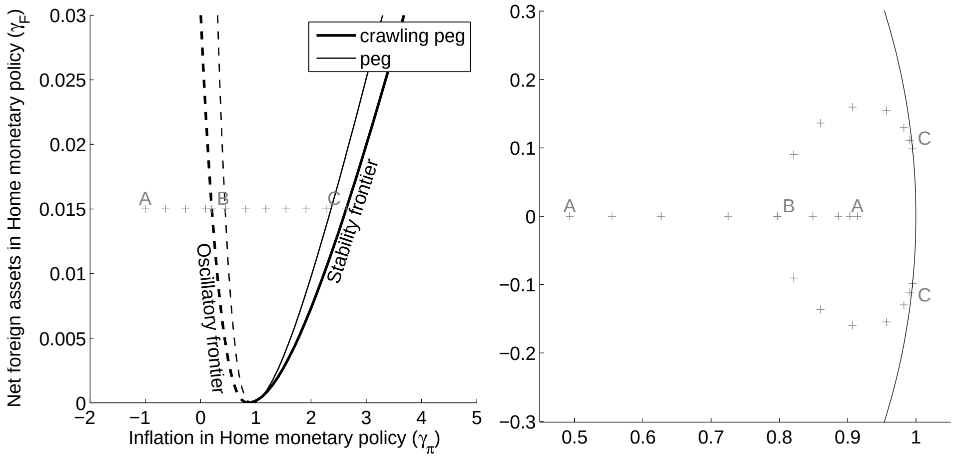
In the following, we calibrate the model in China by assuming the size of Home to be $s = 0.3$ and trade openness to be $\alpha = (1-s)\bar{\alpha} = 0.35$. We compare the peg regime (corresponding to the 1995-2005 period) and the crawling-peg regime (since 2005).

4.2. The crawling peg case

Since July 2005, The nominal exchange rate of China has been adjusted according to the level of inflation. Even though this exchange-rate rule is not officially announced, the last six years exhibit a very large correlation between nominal appreciation and inflation. This regime is a kind of endogenous crawling peg and can be expressed as

$$S_t = S_{t-1} \left(\frac{P_{t-1}}{P_t} \right)^{\gamma}. \tag{27}$$

Figure 4 – Stability frontier with a crawling peg (Home in charge of the peg)



During the European ERM, European countries had realigned parities several times, so that accumulated inflation differentials were compensated for ($\gamma = -1$). Nominal exchange rate realignments was driven in order to reestablish PPP. This flexibility of the exchange-rate regime comes at a cost: policies that aim to reduce inflation in France, Italy and Spain in the first half of the 80's were less credible as the private sector expectations took into account possible future realignments.

On the contrary, the exchange rate policy in China do not take the form of exceptional realignments (the peg is adjusted everyday) and the nominal exchange rate is adjusted in order to magnified PPP deviations created by domestic inflation rather than correcting them ($\gamma = 1$). Following a transitory inflation surge originated in the domestic sector (due to wage or mark-ups) or in commodity prices, the exchange-rate policy appreciates the currency in order to import disinflation. If one expects a permanent real appreciation of the Chinese currency, this appreciation will be realized half through nominal appreciation and half through domestic price increase. Indeed, since 2005, China has started facing inflationary pressures related to an undervalued real exchange rate (with growing pressures in the labor market) and commodity price hikes.

Compared to strict peg policy, the crawling peg regime does not change the condition for determinacy (the generalized Taylor principle), and, only to a small extent, it changes the condition for stability (See Figure 4). Furthermore, this amended regime does not avoid the endogenous fluctuations that result from a self-oriented monetary-policy rules (i.e. reactive to domestic inflation). However, the dynamic of the economy is modified as the nominal exchange-rate varies (see Section 5).

4.3. Reserves in monetary policy

Up to this section, we have ignored the dynamic of official reserves and the role of capital controls because these variables do not interact with the dynamic of other macroeconomic variables. Indeed, we assume that official interventions on the foreign exchange market are fully sterilized which reduces the impact of such interventions to a shift in a portfolio reallocation of the private sector and a modification of the nominal exchange rate. As a consequence, official interventions affect other macroeconomic variables only through the nominal exchange rate channel: foreign reserves enter neither in the Euler equation nor in the new-Keynesian Phillips curve. Furthermore, until now we have restricted the set of monetary-policy rules to rules that includes domestic inflation and the net foreign asset position. However, depending on the institutional framework, it may be relevant to assume that the policy rate is set according the the level of official reserves instead of the net foreign assets position.

As long as the central bank manages restrictions on capital mobility, it can both achieve the desired nominal exchange-rate and avoid immoderate reserve accumulation or the risk of their depletion. A policy rate that ignores the level of official reserves is implementable. If restrictions on capital mobility are relaxed, large shocks may drive official reserves in the red zone and the central bank will be forced to take into account their level in its policy rule (easing if over-accumulation happens, toughing in case of depletion). We now assume that monetary policy rule in Home relies on a domestic variable, inflation, and the ratio of official reserves to GDP, whereas Foreign monetary policy depends on inflation. The new assumption creates a link between capital controls, official reserves and the macroeconomic dynamic.

$$\ln(R_t) = \gamma_\pi \pi_t + \gamma_{\mathrm{F}} \frac{S_t F_t^*}{P_t Y_t} \qquad (28) \qquad\qquad \ln(R_t^*) = \gamma_\pi^* \pi_t^* \qquad (29)$$

Proposition 7 *Assume Foreign adopts an active monetary policy and Home has a monetary-policy rule given by Equation (28), the stability of the dynamic system requires* $\gamma_{\mathrm{F}} > \overline{\gamma_{\mathrm{F}}}(\gamma_\pi) \geq 0$*, where* $\overline{\gamma_{\mathrm{F}}}$ *is a non-decreasing function.*

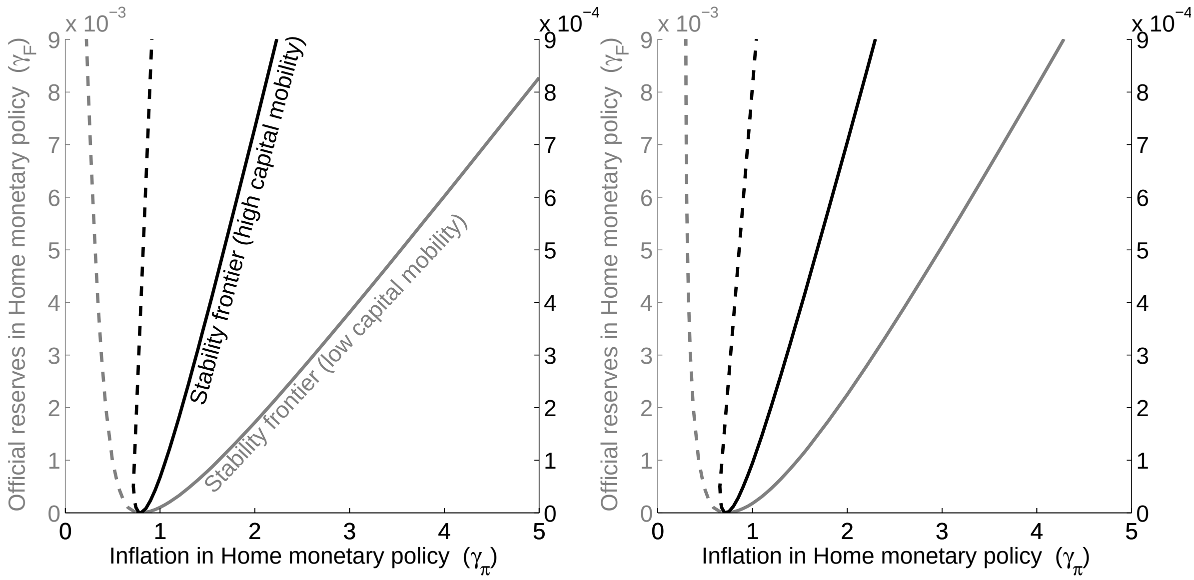
When capital mobility is perfect (i.e. no deviation from UIP) the only condition is a strictly positive sensitivity of the domestic interest rate to the level of international reserves ($\gamma_{\mathrm{F}} > 0$). In this case, any positive (negative) gap between the domestic and the foreign country nominal interest rate motivates large capital inflows (outflows) and reserve accumulation (loss) until the interest gap is filled. This *peg-driven* monetary policy rule is the only one to be available for monetary authorities with perfect capital mobility, in line with the Impossible Trinity.

For lower level of capital mobility, the stability of the policy rule comes at the condition that the sensitivity is high enough ($\gamma_{\mathrm{F}} > \overline{\gamma_{\mathrm{F}}}(\gamma_\pi) \geq 0$) with $\overline{\gamma_{\mathrm{F}}}$ a non-decreasing function. Figure 5 plots the function $\overline{\gamma_{\mathrm{F}}}$ (i.e. the stability-frontier) for different degrees of capital mobility and in the different versions of the model (peg regime and crawling-peg regime). The dotted lines materializes the oscillatory-frontier.

The stability condition is more restrictive when capital mobility is low: the lower capital mobil-

Figure 5 – Stability frontier when policy depends on official reserves (HCP case)

(a) Peg regime **(b)** Crawling peg regime



Black curves represent high capital mobility ($\varphi = 50$) and correspond to right axis, whereas grey curves represents low capital mobility ($\varphi = 5$) and correspond to left axis. The scale of the two axis are adjusted to compensate for capital mobility.

ity, the larger the sensibility of the interest rate to the level of official reserves has to be. Nothing unnatural behind this result. If capital mobility is low, capital inflows do not surge when an interest-rate gap appears. To avoid the accumulation of trade surplus, the policy rule should be more reactive to the level of official reserves (that play the role of a proxy for the net foreign assets position). But, at the same time, this condition deprives Home monetary policy of margin of a domestic-oriented monetary policy. Despite large capital controls, the monetary policy rule cannot (systematically) pursue a domestic goal (internal equilibrium): monetary policy rule is not autonomous. In order to compare the ability of monetary policy to react to domestic inflation, Figure 5 plots the stability and the oscillatory frontiers of a low capital mobility case ($\varphi = 5$, grey lines, left axis) and a high capital mobility case ($\varphi = 50$, black lines, right axis) with a different scale on the y-axis in order to compensate for capital mobility: capital flows are ten times more reactive in the second case, the coefficient γ_F should be ten times lower to be comparable. The low capital mobility allow to reach a larger set of policy rules. Yet, the extended area encompasses rules generating oscillations (complex eigenvalues). Furthermore, the set of rules that avoid oscillations is reduces.

5. IMPULSE-RESPONSE FUNCTIONS

5.1. Net foreign assets position in monetary policy

The fixed exchange-rate regime crudely modifies the international propagation of macroeconomic shocks, resulting in high and long lasting spillovers between the two countries. To illustrate this point, Proposition 4 states that, in a closed economy, the stability of the fixed exchange-rate system relies on the monetary-policy rule of Home. This proposition is also true in the 'Home in charge of the peg' case, i.e. if $\gamma_{\mathrm{F}}^* = 0$ and $\gamma_\pi^* > 1$. To illustrate how the choice of a monetary-policy-rule modifies the Impulse-Response Functions (IRF) of the economy following a technology shock, a mark-up shock and a monetary shock at Home, we assume that Home represents 30% of the world economy (China represents around 30% of the economic entity containing the U.S. and China). We will consider three kind of monetary-policy in Home:

(a) Large inflation reaction, low NFA reaction: $\ln(R_t) = 2\pi_t + 0.01\frac{NFA_t}{P_tY_t}$;
(b) Large inflation reaction, large NFA reaction: $\ln(R_t) = 2\pi_t + 0.1\frac{NFA_t}{P_tY_t}$;
(c) No inflation reaction, low NFA reaction: $\ln(R_t) = 0.01\frac{NFA_t}{P_tY_t}$.

The first monetary rule is chosen close to the stability frontier. The second rule weighs the net foreign assets position ten times more than the first rule, in order to avoid large fluctuations but keeping a role of the domestic variable (inflation) in monetary policy. The third rule cancels the weight of inflation of the first rule.

First consider a monetary-policy rule which is close to the stability frontier. According to Figure 2a, the presence of two conjugate, stable, complex eigenvalues implies that the dynamic is oscillatory (see Figure F.1, first line, first column). A Home productivity shock decreases inflation (-0.3%), Home monetary-policy accommodates this shock through a large decrease in the nominal interest rate and consumption increases (+0.4%). At this point, assuming the productivity shock vanishes, Home has an undervalued real exchange rate. The inflation rate is positive and, due to the monetary-policy rule, the real interest rate increases and consumption drops (-0.2% at period 2). Through, the mean-reverting PPP dynamic is slow and, during 10 periods, Home accumulates foreign assets (due to the depressed consumption and the undervalued exchange rate). Then, this accumulation triggers a monetary easing in Home that will boost consumption. Following the stimulus, the real exchange rate appreciates and the net foreign asset starts declining.

In a fixed exchange-rate system, the PPP in the long run is achieved through inflation differential between Home and Foreign. Assume Home is undervalued, inflation must appear in the future to fill the gap. However, if monetary-policy is too reactive to inflation, this mean-reverting mechanism comes with low domestic demand. As a result, the trade balance turns positive, triggering the net foreign asset position accumulation. Though the inclusion of net foreign asset in monetary-policy rule, the regime is stable but at the cost of large endogenous fluctuations.

In order to reduce the fluctuations induced by the exchange-rate and monetary regime, one may consider to increase the weight of the net foreign assets in monetary-policy (see Figure F.1, second line). Fluctuations are reduced (both the magnitude and the duration) but do not disappear. In order to avoid endogenous fluctuations, Figure 2a suggests to decrease the weight of inflation, up to a point where monetary-policy rule turns "passive" (see Figure F.1, last line). In this case, monetary policy does not convert expected inflation into depressed domestic demand and avoid the accumulation of net foreign assets.

A monetary shock in Home reduces consumption and inflation. After the shock, Home is undervalued. Given the monetary policy in Home and Foreign, consumption drops in Home and increases in Foreign. larger inflation in Home drives the terms-of-trade back to equilibrium, but with an oscillatory dynamic. The second monetary-policy rule gives more weight on the net foreign asset position (see Figure F.1, second line). Inflation decreases less at impact and variables turn back to equilibrium faster. Last, a monetary policy rule that fully ignore internal equilibrium make a monetary shock more effective on inflation and the economy turns back to equilibrium very fast (see Figure F.1, last line).

A mark-up shock increases by large inflation and reduces consumption. However, the consumption drop is lower when monetary policy does not include inflation. The speed at which variables return to the steady-state is similar than for the two other shocks.

Turning to a crawling-peg regime does not change qualitatively the results of the peg regime. Fluctuations remains but the frequency is higher. This comes from the fact that nominal rigidities are reduced through the indexation of the nominal exchange rate to the price level: for a given real appreciation, the output-gap has to be twice smaller.

5.2. Reserves in monetary-policy

We now assume that monetary policy in Home depends on domestic inflation and the level of official reserves. To compare the analysis with the previous section, we also assume three different rules

(a) Large inflation reaction, low official reserves reaction: $\ln(R_t) = 2\pi_t + 0.005\frac{S_t F_t^*}{P_t Y_t}$;

(b) Large inflation reaction, large official reserves reaction: $\ln(R_t) = 2\pi_t + 0.05\frac{S_t F_t^*}{P_t Y_t}$;

(c) No inflation reaction, low official reserves reaction: $\ln(R_t) = 0.005\frac{NFA_t}{P_t Y_t}$.

For low capital mobility the net foreign asset position and the level of official reserves are of the same magnitude. The dynamic of macroeconomic variables are similar: (a) long-lasting fluctuations when the monetary rule is close to the stability frontier, and (b) and (c) a more stable dynamic if the monetary policy takes into account the exchange-rate regime through a higher weight on the official reserves or the removal of the domestic variable (inflation). Whatever the monetary-policy rule, a monetary shock is able to affect consumption, inflation and the trade balance (see Figure F.3). For high capital mobility, the ability of monetary policy to modify the economic outcome is entrenched but at the price of a very high volatility of official reserves (see Figure F.4). Reasonable dynamics following a productivity or a mark-up shock are similar to the low capital mobility case but discretionary monetary policy is now nonoperative.

6. CONCLUSION

We analyze the dynamic properties of flexible and fixed exchange-rate regimes in the standard NOEM framework with imperfect capital mobility and find many results that have not been yet studied in the literature.

A flexible exchange-rate regime is stable and determinate if each country implements a monetary policy that respects the Taylor principle. Furthermore, the indeterminacy generated by a break of the Taylor principle in one country weakly spills over into the other country.

In a fixed exchange-rate system, the Taylor principle reduces to a single condition. By induction, in an N-country monetary system with $T < N$ independent (and compatible) fixed exchange rates, the generalized Taylor principle imposes exactly $N-T$ conditions.

A fixed exchange rate system challenges monetary policy in the anchor-currency country (which is *de facto* in charge of global inflation-expectations stability) and in the peg-currency country (which is in charge the stability of the net foreign asset position). In the former, a monetary-policy rule that is too self-oriented (too reactive to domestic inflation) damages stability or creates long lasting fluctuations. The ability of monetary policy to stabilize the economy is entrenched by its role in the long run stability. The larger the activism of monetary policy, the more it has to react to the level of official reserves or the net foreign assets position.

A symmetric, fixed exchange-rate regime is difficult to implement as it naturally conduces to fluctuations except if monetary policies are coordinated (are set according to global inflation instead of national inflation) or if a pivotal country emerges (in charge of global inflation expectations).

Considering the case of China, the fixed exchange-rate regime of the 1995-2005 period requires a monetary-policy rule that is not only domestic-oriented. Contrary to a flexible exchange-rate regime, the strong reaction of monetary policy to domestic inflation (Taylor principle) is not a condition for inflation anchoring in a fixed exchange-rate regime. On the contrary, a too strong reaction of monetary policy to domestic inflation is detrimental to the stability of the exchange-rate regime: long-lasting fluctuations of the terms-of-trade and the net foreign asset position is a natural outcome of an ill-designed monetary policy (i.e. weighting too much domestic inflation and not enough the level of official reserves). As a result, the large official reserve accumulation since the end of the nineteens may have been a side-effect of the ill-designed monetary-policy rule instead of a desired outcome. To test this hypothesis, one has to estimates the coefficients of the monetary-policy rule. However, the role of the policy rate in the conduct of monetary policy is weak in China; monetary policy is based on the quantity (credit easing or credit restriction) rather than on the price (the policy rate). The new exchange-rate regime launched in 2005 (endogenous crawling-peg) has the same stability constraint, so the vary same conclusions apply.

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APPENDIX

A. Log-linearization of the model

A.1. The steady-state

Except the size, parameters are equal in Home and Foreign. At the steady-state, the terms of trade are 1 and the trade balance is zero. Let $\eta = \frac{1-\kappa}{\kappa}\frac{1}{1+\mu}$, $mc = \frac{MC}{P} = \frac{1}{1+\mu}$, $L = \frac{\bar{L}}{1+\eta}$, $C = \frac{A\bar{L}}{1+\eta}$.

A.2. Log-linearization

The consumption price, imports and demand addressed to domestic firms respectively write in Home (left column) and Foreign (right column)

$$\hat{pc}_t = -\alpha\hat{\tau}_t \qquad \hat{pc}^*_t = \alpha^*\hat{\tau}_t$$

$$\hat{m}_t = \hat{c}_t + \varepsilon(1-\alpha)\hat{\tau}_t \qquad \hat{m}^*_t = \hat{c}^*_t - \varepsilon(1-\alpha^*)\hat{\tau}_t$$

$$\hat{d}_t = \hat{c}_t - \varepsilon\alpha\hat{\tau}_t \qquad \hat{d}^*_t = \hat{c}^*_t + \varepsilon\alpha^*\hat{\tau}_t$$

Labor supply, good demand and labor demand write

$$\hat{mc}_t = \hat{c}_t - \hat{a}_t + \eta\hat{l}_t - \alpha\hat{\tau}_t \qquad \hat{mc}^*_t = \hat{c}^*_t - \hat{a}^*_t + \eta\hat{l}^*_t + \alpha^*\hat{\tau}_t$$

$$\hat{y}_t = (1-\alpha)\hat{c}_t + \alpha\hat{c}^*_t - \varepsilon(2-\bar{\alpha})\alpha\hat{\tau}_t \qquad \hat{y}^*_t = (1-\alpha^*)\hat{c}^*_t + \alpha^*\hat{c}_t + \varepsilon(2-\bar{\alpha})\alpha^*\hat{\tau}_t$$

$$\hat{l}_t = \hat{y}_t - \hat{a}_t \qquad \hat{l}^*_t = \hat{y}^*_t - \hat{a}^*_t$$

Let $\zeta = 1+\eta(1-\alpha)$, $\zeta^* = 1+\eta(1-\alpha^*)$ and $\varpi = 1+\eta\varepsilon(2-\bar{\alpha})$. The **new Keynesian Philipps curve** in each country writes

$$\pi_t = \beta\mathbb{E}_t\{\pi_{t+1}\} + \lambda\zeta\hat{c}_t + \lambda\eta\alpha\hat{c}^*_t - \lambda(1+\eta)\hat{a}_t - \lambda\alpha\varpi\hat{\tau}_t \qquad \pi^*_t = \beta\mathbb{E}_t\{\pi^*_{t+1}\} + \lambda\zeta^*\hat{c}^*_t + \lambda\eta\alpha^*\hat{c}_t - \lambda(1+\eta)\hat{a}^*_t + \lambda\alpha^*\varpi\hat{\tau}_t$$

The **Euler equation** in each country in the **fixed exchange-rate** regime

$$\hat{c}_t = \mathbb{E}_t\{\hat{c}_{t+1}\} - i_t + (1-\alpha)\mathbb{E}_t\{\pi_{t+1}\} + \alpha\mathbb{E}_t\{\pi^*_{t+1}\} \qquad \hat{c}^*_t = \mathbb{E}_t\{\hat{c}^*_{t+1}\} - i^*_t + (1-\alpha^*)\mathbb{E}_t\{\pi^*_{t+1}\} + \alpha^*\mathbb{E}_t\{\pi_{t+1}\}$$

or alternatively in the **flexible exchange-rate** regime[12]

$$\hat{c}_t = \mathbb{E}_t\{\hat{c}_{t+1}\} - i_t + \mathbb{E}_t\{\pi_{t+1}\} - \alpha(\mathbb{E}_t\{\hat{\tau}_{t+1}\} - \hat{\tau}_t) \qquad \hat{c}^*_t = \mathbb{E}_t\{\hat{c}^*_{t+1}\} - i^*_t + \mathbb{E}_t\{\pi^*_{t+1}\} + \alpha^*(\mathbb{E}_t\{\hat{\tau}_{t+1}\} - \hat{\tau}_t)$$

Let $\omega = \bar{\alpha}[\varepsilon(2-\bar{\alpha})-1]$ The evolution of the **net foreign asset position** (a convenient renormalization given by $\hat{f}_t = \frac{1}{ss^*}\frac{NFA_t}{S_tP^*_tY^*_t+P_tY_t}$) writes

$$\hat{f}_t = \frac{1}{\beta}\hat{f}_{t-1} + \bar{\alpha}(\hat{c}^*_t - \hat{c}_t) - \omega\hat{\tau}_t$$

[12] This formulation is also true for the fixed exchange-rate system but less convenient as it does not respect the predetermined / non-predetermined variables convention.

In the **flexible exchange-rate** regime, the evolution of the terms of trade is given by the **modified interest rate parity** (including imperfect capital mobility) given by

$$\hat{\tau}_t = \mathbb{E}_t\{\hat{\tau}_{t+1}\} + (i_t - \mathbb{E}_t\{\pi_{t+1}\}) - (i^*_t - \mathbb{E}_t\{\pi^*_{t+1}\}) + \frac{1}{2\mathscr{A}\varphi}\hat{f}_t$$

The **fixed exchange-rate** regime modifies the status of the term of trades as it becomes a state-variable instead of a forward-looking variable

$$\hat{\tau}_t = \hat{\tau}_{t-1} + (\pi_t - \pi^*_t)$$

The last six equations (two NKPC, two Euler equations, the evolution of the net foreign position and the fixed exchange rate regime) have to be closed with two additional equations describing monetary policy rules in Home and Foreign.

The law of motion of the terms of trade is completely different in the two regimes. First, terms of trade appear as a predetermined variable in the fixed exchange-rate regime whereas they appear as a jump variable in the flexible exchange-rate regime. Second, imperfect substitutability between Home and Foreign assets makes, in the flexible regime, the exchange-rate responsive to the net foreign asset position in a stabilizing way: a net debt depreciates the currency, improves the trade balance and reduces the net debt. On the contrary, this link is broken in the fixed regime and the predetermined variable $\hat{f}$ only appears in one equation with an explosive root. Thus, despite imperfect capital mobility, the dynamic system describing the fixed exchange-rate regime is unstable, except if the monetary policy rule of at least one country includes the net foreign asset position $\hat{f}_t$.

B. Flexible exchange rate regime

The dynamic system in the flexible exchange-rate regime (DS1) write $A\mathbb{E}_t\{X_{t+1}\} = BX_t$ with $X_t = (\hat{f}_{t-1}, \hat{\tau}_t, \hat{c}_t, \pi_t, \hat{c}^*_t, \pi^*_t)'$ and

$$A = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ \frac{1}{2\mathscr{A}\varphi} & 1 & 0 & -1 & 0 & 1 \\ 0 & -\alpha & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & \beta & 0 & 0 \\ 0 & \alpha^* & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & \beta \end{pmatrix} \quad \text{and} \quad B = \begin{pmatrix} \frac{1}{\beta} & -\omega & -\bar{\alpha} & 0 & \bar{\alpha} & 0 \\ 0 & 1 & 0 & -\gamma_\pi & 0 & \gamma^*_\pi \\ 0 & -\alpha & 1 & \gamma_\pi & 0 & 0 \\ 0 & \lambda\alpha\varpi & -\lambda\zeta & 1 & -\lambda\eta\alpha & 0 \\ 0 & \alpha^* & 0 & 0 & 1 & \gamma^*_\pi \\ 0 & -\lambda\alpha^*\varpi & -\lambda\eta\alpha^* & 0 & -\lambda\zeta^* & 1 \end{pmatrix}$$

The condition for having a unit root is $\det(A - B) = 0$.

$$\det(B-A) = \begin{vmatrix} \gamma_\pi - 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & \gamma^*_\pi - 1 & 0 & 0 & 0 & 0 \\ -(\gamma_\pi + 1) & \gamma^*_\pi + 1 & -\frac{1}{2\mathscr{A}\varphi} & 0 & 0 & 0 \\ 0 & 0 & \frac{1}{\beta} - 1 & -\omega & -\bar{\alpha} & \bar{\alpha} \\ 1-\beta & 0 & 0 & \lambda\alpha\varpi & -\lambda\zeta & -\lambda\eta\alpha \\ 0 & 1-\beta & 0 & -\lambda\alpha^*\varpi & -\lambda\eta\alpha^* & -\lambda\zeta^* \end{vmatrix}$$

C. Policy rule with the net foreign asset position

We assume that Home and Foreign take into account the net foreign asset position as a ratio to domestic GDP in their monetary-policy rule.

$$i_t = \gamma_\pi \pi_t - \gamma_F s^* \hat{f}_t \qquad | \qquad i_t^* = \gamma_\pi^* \pi_t^* + \gamma_F^* s \hat{f}_t$$

The dynamical system (DS2) is therefore given by

$$\begin{aligned}
\hat{f}_t &= \frac{1}{\beta}\hat{f}_{t-1} - \omega\hat{\tau}_{t-1} - \bar{\alpha}(\hat{c}_t - \hat{c}_t^*) - \omega(\pi_t - \pi_t^*) \\
\hat{\tau}_t &= \hat{\tau}_{t-1} + (\pi_t - \pi_t^*) \\
\mathbb{E}_t\{\hat{c}_{t+1}\} + (1-\alpha)\mathbb{E}_t\{\pi_{t+1}\} + \alpha\mathbb{E}_t\{\pi_{t+1}^*\} &= -\gamma_F s^* \hat{f}_t + \hat{c}_t + \gamma_\pi \pi_t \\
\beta\mathbb{E}_t\{\pi_{t+1}\} &= \lambda\alpha\varpi\hat{\tau}_t + \pi_t - \lambda\zeta\hat{c}_t - \lambda\eta\alpha\hat{c}_t^* \\
\mathbb{E}_t\{\hat{c}_{t+1}^*\} + (1-\alpha^*)\mathbb{E}_t\{\pi_{t+1}^*\} + \alpha^*\mathbb{E}_t\{\pi_{t+1}\} &= \gamma_F^* s \hat{f}_t + \hat{c}_t^* + \gamma_\pi^* \pi_t^* \\
\beta\mathbb{E}_t\{\pi_{t+1}^*\} &= -\lambda\alpha^*\varpi\hat{\tau}_t + \pi_t^* - \lambda\zeta^*\hat{c}_t^* - \lambda\eta\alpha^*\hat{c}_t
\end{aligned}$$

Matrix formulation Let $X_t = (\hat{c}_t, \pi_t)'$ and $X_t^* = (\hat{c}_t^*, \pi_t^*)'$ denote non-predetermined variables of Home and Foreign, and $Y_t = (\hat{f}_t, \hat{\tau}_t)'$ international predetermined variables. As they are not relevant to the dynamic stability, we ignore at the first stage the vector of shocks $\varepsilon_t = (\hat{a}_t, \hat{a}_t^*)'$. The dynamic system is given by

$$Y_t = \begin{pmatrix} \frac{1}{\beta} & -\omega \\ 0 & 1 \end{pmatrix} Y_{t-1} + \begin{pmatrix} -\bar{\alpha} & -\omega & \bar{\alpha} & \omega \\ 0 & 1 & 0 & -1 \end{pmatrix} \begin{pmatrix} X_t \\ X_t^* \end{pmatrix}$$

$$\begin{pmatrix} 1 & 1-\alpha & 0 & \alpha \\ 0 & \beta & 0 & 0 \\ 0 & \alpha^* & 1 & 1-\alpha^* \\ 0 & 0 & 0 & \beta \end{pmatrix} \begin{pmatrix} \mathbb{E}_t\{X_{t+1}\} \\ \mathbb{E}_t\{X_{t+1}^*\} \end{pmatrix} = \begin{pmatrix} -s^*\gamma_F & 0 \\ 0 & \lambda\varpi\alpha \\ s\gamma_F^* & 0 \\ 0 & -\lambda\varpi\alpha^* \end{pmatrix} Y_t + \begin{pmatrix} 1 & \gamma_\pi & 0 & 0 \\ -\lambda\zeta & 1 & -\lambda\eta\alpha & 0 \\ 0 & 0 & 1 & \gamma_\pi^* \\ -\lambda\eta\alpha^* & 0 & -\lambda\zeta^* & 1 \end{pmatrix} \begin{pmatrix} X_t \\ X_t^* \end{pmatrix}$$

C.1. The Taylor principle

We look at unit-root of the dynamic system, i.e. a non-zero vector Z that verifies $AZ = BZ$ where

$$A = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1-\alpha & 0 & \alpha \\ 0 & 0 & 0 & \beta & 0 & 0 \\ 0 & 0 & 0 & \alpha^* & 1 & 1-\alpha^* \\ 0 & 0 & 0 & 0 & 0 & \beta \end{pmatrix} \quad \text{and} \quad B = \begin{pmatrix} \frac{1}{\beta} & -\omega & -\bar{\alpha} & -\omega & \bar{\alpha} & \omega \\ 0 & 1 & 0 & 1 & 0 & -1 \\ -s^*\gamma_F & 0 & 1 & \gamma_\pi & 0 & 0 \\ 0 & \lambda\alpha\varpi & -\lambda\zeta & 1 & -\lambda\eta\alpha & 0 \\ s\gamma_F^* & 0 & 0 & 0 & 1 & \gamma_\pi^* \\ 0 & -\lambda\alpha^*\varpi & -\lambda\eta\alpha^* & 0 & -\lambda\zeta^* & 1 \end{pmatrix}$$

A necessary and sufficient condition is $\det(B-A)=0$. We then reorder rows and columns of $B-A$

$$
\begin{aligned}
\det(B-A) &= \begin{vmatrix} 0 & 1 & -1 & 0 & 0 & 0 \\ -s^*\gamma_{\mathrm{F}} & \gamma_\pi-(1-\alpha) & -\alpha & 0 & 0 & 0 \\ s\gamma^*_{\mathrm{F}} & -\alpha^* & \gamma^*_\pi-(1-\alpha^*) & 0 & 0 & 0 \\ \frac{1}{\beta}-1 & -\omega & \omega & -\omega & -\bar{\alpha} & \bar{\alpha} \\ 0 & 1-\beta & 0 & \lambda\alpha\varpi & -\lambda\zeta & -\lambda\eta\alpha \\ 0 & 0 & 1-\beta & -\lambda\alpha^*\varpi & -\lambda\eta\alpha^* & -\lambda\zeta^* \end{vmatrix} \\
&= \begin{vmatrix} 0 & 0 & -1 \\ -s^*\gamma_{\mathrm{F}} & \gamma_\pi-1 & -\alpha \\ s\gamma^*_{\mathrm{F}} & \gamma^*_\pi-1 & \gamma^*_\pi-(1-\alpha^*) \end{vmatrix} \begin{vmatrix} -\omega & -\bar{\alpha} & \bar{\alpha} \\ \lambda\alpha\varpi & -\lambda\zeta & -\lambda\eta\alpha \\ -\lambda\alpha^*\varpi & -\lambda\eta\alpha^* & -\lambda\zeta^* \end{vmatrix} \\
&= -\lambda^2(1+\eta)[\bar{\alpha}^2\varpi+(1+\eta\bar{\alpha})\omega][\gamma^*_{\mathrm{F}}s(\gamma_\pi-1)+\gamma_{\mathrm{F}}s^*(\gamma^*_\pi-1)]
\end{aligned}
$$

A necessary and sufficient condition for $\det(B-A)=0$ is $\gamma^*_{\mathrm{F}}s(\gamma_\pi-1)+\gamma_{\mathrm{F}}s^*(\gamma^*_\pi-1)=0$

C.2. The crawling peg regime

The general case The dynamical system in the crawling peg regime (DS3) is derived from DS2 with differences in Equation 2 (the evolution of the term of trade takes into account the nominal exchange-rate adjustment) and Equation 3 and 5 (the expected inflation takes into account the nominal exchange-rate adjustment)

$$
\begin{aligned}
\hat{\tau}_t &= \hat{\tau}_{t-1}+2\pi_t-\pi^*_t \\
\mathbb{E}_t\{\hat{c}_{t+1}\}+(1-2\alpha)\mathbb{E}_t\{\pi_{t+1}\}+\alpha\mathbb{E}_t\{\pi^*_{t+1}\} &= -\gamma_{\mathrm{F}}s^*\hat{f}_t+\hat{c}_t+\gamma_\pi\pi_t \\
\mathbb{E}_t\{\hat{c}^*_{t+1}\}+(1-\alpha^*)\mathbb{E}_t\{\pi^*_{t+1}\}+2\alpha^*\mathbb{E}_t\{\pi_{t+1}\} &= \gamma^*_{\mathrm{F}}s\hat{f}_t+\hat{c}^*_t+\gamma^*_\pi\pi^*_t
\end{aligned}
$$

D. Policy rule with official reserves

D.1. The peg case

The interest rate depends on inflation and official reserves. As Foreign does not accumulate reserves, the log-linearization of policy rules writes

$$
i_t=\gamma_\pi\pi_t-\gamma_{\mathrm{F}}s^*\left[\hat{f}_t-2\varphi\mathscr{A}^w(i^*_t-i_t)\right] \qquad | \qquad i^*_t=\gamma^*_\pi\pi^*_t
$$

Let $x=\frac{2s^*\gamma_{\mathrm{F}}\varphi\mathscr{A}^w}{1+2s^*\gamma_{\mathrm{F}}\varphi\mathscr{A}^w}$ The policy rule in Home writes

$$
i_t=(1-x)\gamma_\pi\pi_t+x\gamma^*_\pi\pi^*_t-(1-x)\gamma_{\mathrm{F}}s^*\hat{f}_t
$$

The dynamical system (DS4) is the same as DS2 except for Equation 3

$$
\mathbb{E}_t\{\hat{c}_{t+1}\}+(1-\alpha)\mathbb{E}_t\{\pi_{t+1}\}+\alpha\mathbb{E}_t\{\pi^*_{t+1}\}=-(1-x)\gamma_{\mathrm{F}}s^*\hat{f}_t+\hat{c}_t+(1-x)\gamma_\pi\pi_t+x\gamma^*_\pi\pi^*_t
$$

D.2. The crawling-peg case

The nominal realignment rule modifies expected returns, portfolio allocation and the reduced form of monetary policy rule in Home

$$i_t = \gamma_\pi \pi_t - \gamma_{\mathrm{F}} s^* \left[\hat{f}_t - 2\varphi \mathscr{A}^w (i_t^* - i_t - \mathbb{E}_t\{\pi_{t+1}\})\right]$$

The dynamical system (DS5) is the same as DS3 except for Equation 3

$$\mathbb{E}_t\{\hat{c}_{t+1}\} + (1+x-2\alpha)\mathbb{E}_t\{\pi_{t+1}\} + \alpha\mathbb{E}_t\{\pi^*_{t+1}\} = -(1-x)\gamma_{\mathrm{F}} s^* \hat{f}_t + \hat{c}_t + (1-x)\gamma_\pi \pi_t + x\gamma^*_\pi \pi^*_t$$

E. Expectation shocks in the flexible exchange-rate regime

We assume $\gamma^*_\pi < 1$ and $\gamma_\pi > 1$. There are 5 jump variables (and one predetermined variable) for only 4 instable eigenvalues. The dynamical system writes $A\mathbb{E}_t\{X_{t+1}\} = BX_t$ with $X_t = (\hat{f}_{t-1}, \hat{\tau}_t, \hat{c}_t, \pi_t, \hat{c}^*_t, \pi^*_t)'$ and matrix A and B given in Appendix B, page 33. A is invertible so the (dimension 5) no-jump sub-space F is given by the condition

$$\hat{f}_t + \omega\hat{\tau}_t + \bar{\alpha}\hat{c}_t - \bar{\alpha}\hat{c}^*_t = 0.$$

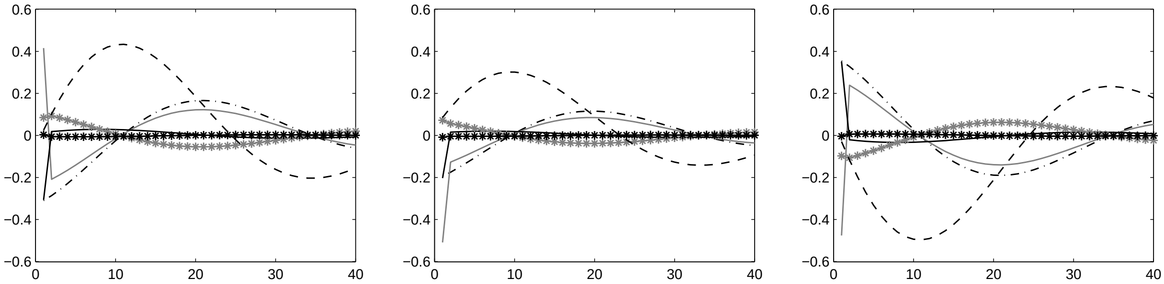
The (dimension 2) stable sub-space H^- is generated by the eigenvectors corresponding to stable eigenvalues of the dynamic system. Expectation shocks appear in the sub-space $H^- \bigcap F$ which is of dimension 1 (assuming the rank condition, i.e. $\dim(H^- \bigcap F) = \dim(H^-) + \dim(F) - 6$).

F. Impulse-response functions

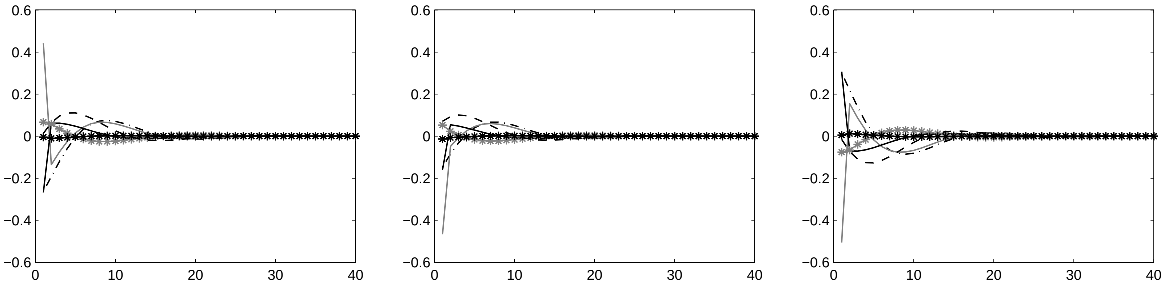
Figure F.1 – Peg regime, NFA in monetary policy

Home productivity shock Home monetary shock Home mark-up shock

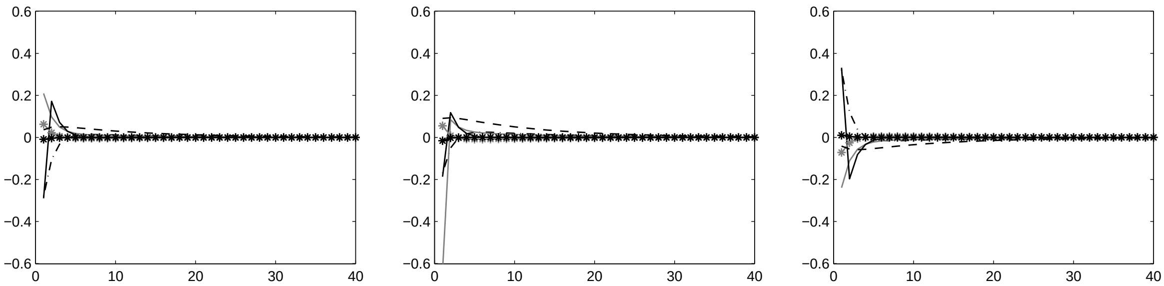
(a) Large inflation reaction, low NFA reaction $\ln(R_t) = 2\pi_t + 0.01\frac{NFA_t}{P_tY_t}$



(b) Large inflation reaction, large NFA reaction $\ln(R_t) = 2\pi_t + 0.1\frac{NFA_t}{P_tY_t}$



(c) No inflation reaction, low NFA reaction $\ln(R_t) = 0.01\frac{NFA_t}{P_tY_t}$



Foreign monetary policy rule is given by $\ln(R_t) = 2\pi_t$.
Three regimes are considered for monetary policy in Home

(a) Large inflation reaction, low NFA reaction

(b) Large inflation reaction, large NFA reaction

(c) No inflation reaction, low NFA reaction

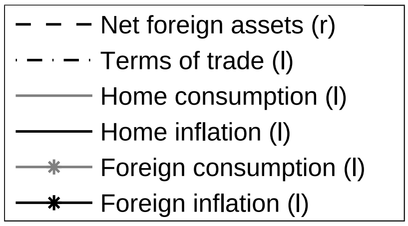
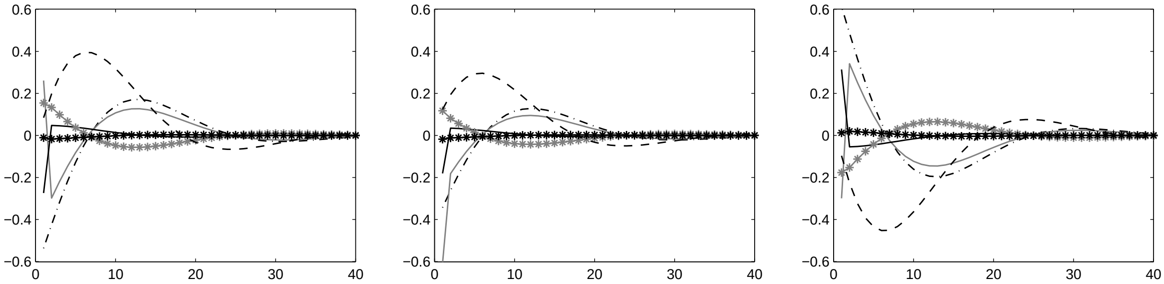


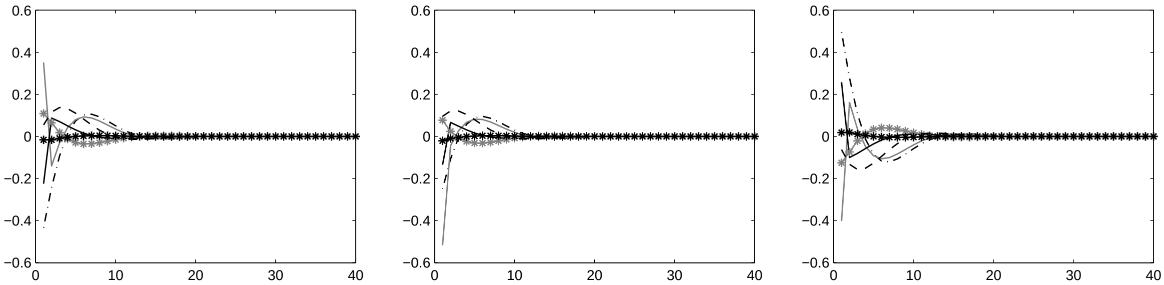
Figure F.2 – Crawling peg regime, NFA in monetary policy

Home productivity shock Home monetary shock Home mark-up shock

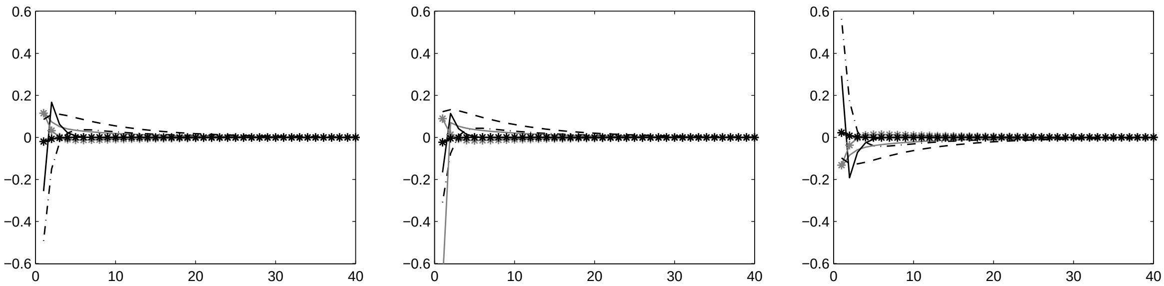
(a) Large inflation reaction, low NFA reaction $\ln(R_t) = 2\pi_t + 0.01\frac{NFA_t}{P_tY_t}$



(b) Large inflation reaction, large NFA reaction $\ln(R_t) = 2\pi_t + 0.1\frac{NFA_t}{P_tY_t}$



(c) No inflation reaction, low NFA reaction $\ln(R_t) = 0.01\frac{NFA_t}{P_tY_t}$



Foreign monetary policy rule is given by $\ln(R_t) = 2\pi_t$.
Three regimes are considered for monetary policy in Home

(a) Large inflation reaction, low NFA reaction

(b) Large inflation reaction, large NFA reaction

(c) No inflation reaction, low NFA reaction

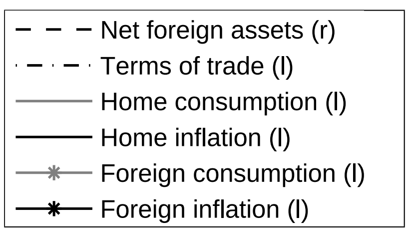
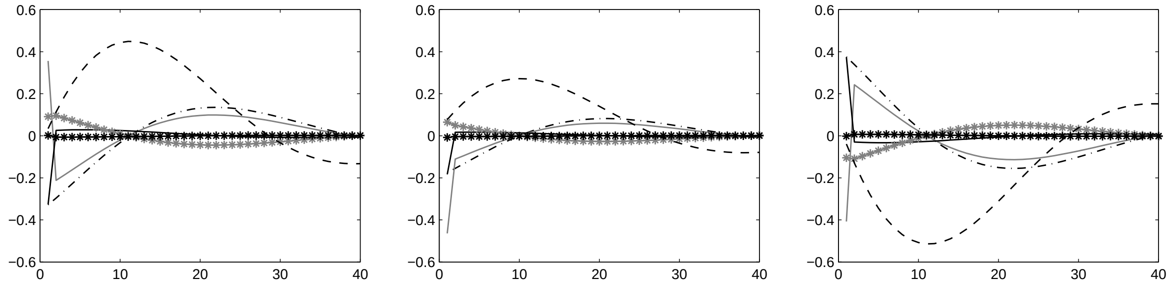


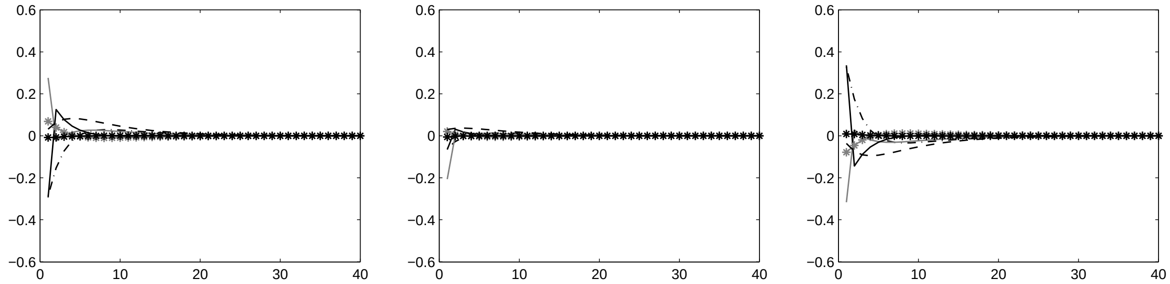
Figure F.3 – Peg regime, Reserves in monetary policy, low capital mobility

Home productivity shock   Home monetary shock   Home mark-up shock

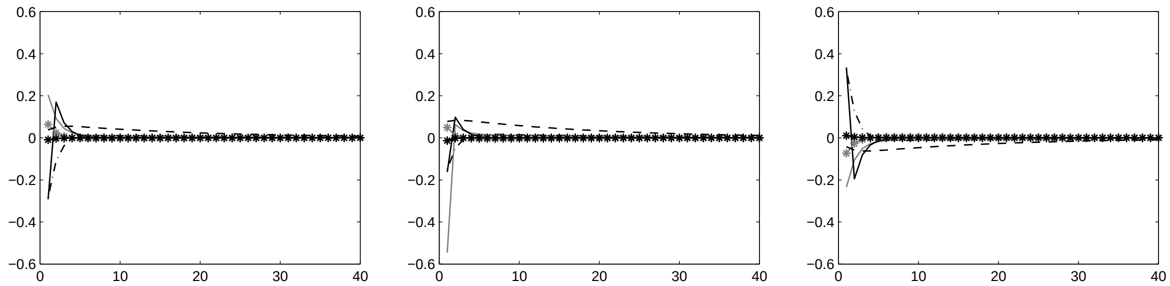
(a) Large inflation reaction, low RES reaction $\ln(R_t) = 2\pi_t + 0.005\frac{S_t F_t^*}{P_t Y_t}$



(b) Large inflation reaction, large RES reaction $\ln(R_t) = 2\pi_t + 0.05\frac{S_t F_t^*}{P_t Y_t}$



(c) No inflation reaction, low RES reaction $\ln(R_t) = 0.005\frac{S_t F_t^*}{P_t Y_t}$



Foreign monetary policy rule is given by $\ln(R_t) = 2\pi_t$.
Three regimes are considered for monetary policy in Home

(a) Large inflation reaction, low reserves reaction

(b) Large inflation reaction, large reserves reaction

(c) No inflation reaction, low reserves reaction

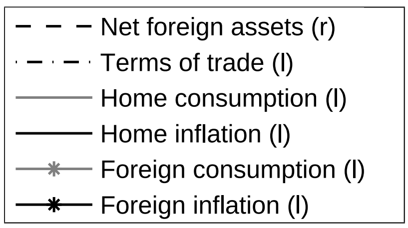
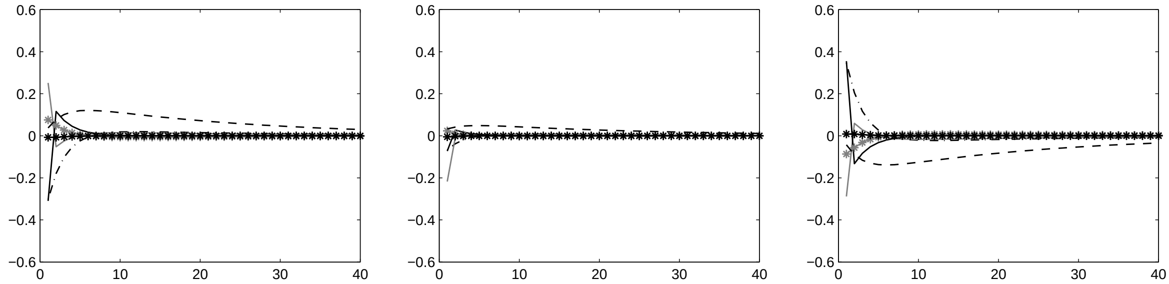


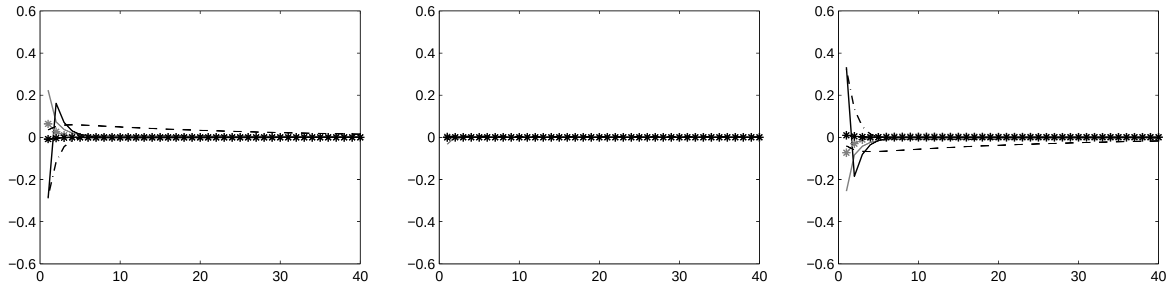
Figure F.4 – Peg regime, Reserves in monetary policy, high capital mobility

Home productivity shock Home monetary shock Home mark-up shock

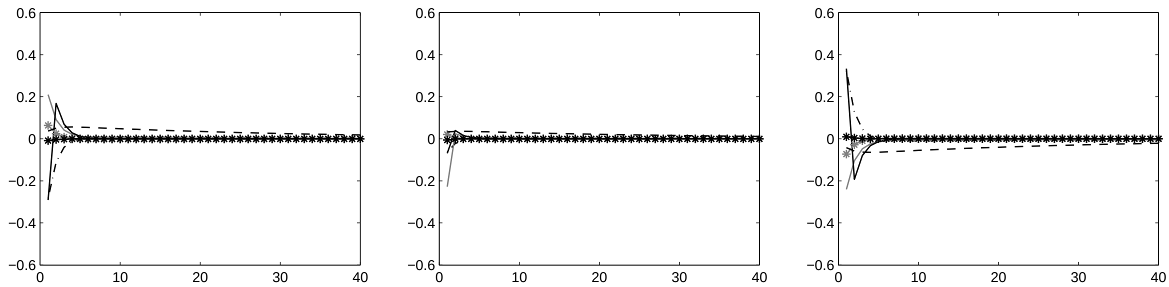
(a) Large inflation reaction, low RES reaction $\ln(R_t) = 2\pi_t + 0.005\frac{S_t F_t^*}{P_t Y_t}$

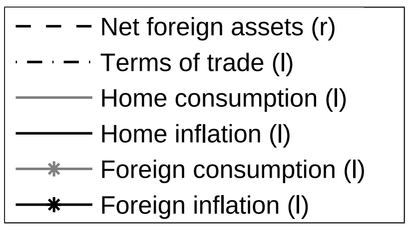


(b) Large inflation reaction, largeRES reaction $\ln(R_t) = 2\pi_t + 0.05\frac{S_t F_t^*}{P_t Y_t}$



(c) No inflation reaction, low RES reaction $\ln(R_t) = 0.0025\frac{S_t F_t^*}{P_t Y_t}$





Foreign monetary policy rule is given by $\ln(R_t) = 2\pi_t$.
Three regimes are considered for monetary policy in Home

(a) Large inflation reaction, low reserves reaction

(b) Large inflation reaction, large reserves reaction

(c) No inflation reaction, low reserves reaction

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