Fiscal Deficits, Current Account Dynamics and Monetary Policy*

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Abstract

This paper develops a *stochastic* two-country "perpetual youth" Dynamic New Keynesian model of the international business cycle with incomplete international financial markets and stationary net foreign assets. The model allows for a thorough analysis of the interaction of endogenous monetary policy with endogenous, non-balanced budget fiscal policy.

We derive the dynamic and cyclical properties of fiscal deficit feedback rules under alternative monetary regimes, discuss the international transmission of productivity shocks, and the implications for net foreign assets and exchange rate dynamics. Our results imply that the degree of "fiscal discipline", i.e. the extent to which the fiscal rule responds to debt dynamics, is crucial for the dynamics of net foreign assets. We show that under low fiscal discipline (characterizing most industrialized countries, first and foremost the U.S.) temporary positive productivity shocks may result in highly persistent deteriorations of the external position in the medium run. Our results also suggest that any attempt by monetary policy alone to stabilize the dynamics of net foreign assets would induce excessive and costly fluctuations of the exchange rate.

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1 Introduction

A renewed interest in the dynamics of the current account spurred by productivity and fiscal shocks has recently emerged as a consequence of the record deterioration of the current account balance in the US, which has been accompanied first by the faster productivity growth of the 90's, and then by the new large fiscal deficits run in the aftermath of September 11.

Standard economic theory has a simple textbook argument to explain the negative effect of large fiscal deficits on the current account: an increase in public spending or a reduction in taxes lowers national savings; if investments do not react too much (as supported by most empirical evidence), it is necessary for the trade balance to match the reduction in national savings and for the country to become a net debtor. The effect on the current account will depend upon capital mobility (and substitutability) among foreign and domestic assets, the planning horizon of agents and the degree of financial markets participation.

A powerful tool to integrate such long-run view with fully specified short-run dynamics, may be provided by open economy Dynamic Stochastic General Equilibrium (DSGE) models. These models are also the natural environment to investigate the dynamic effects and the international transmission of idiosyncratic productivity shocks.

In the New Open Economy Macroeconomics (NOEM) literature, several contributions have been devoted to analyze monetary policy. However, in the same literature the analysis of fiscal behavior has been given less attention, and it has been mainly limited to the analysis of balanced budget (BB) policies.[1] The benchmark open economy model in the NOEM tradition (the *Redux* model of Obstfeld and Rogoff, JPE 1995) builds on the joint assumption of infinitely lived household and frictionless financial markets. Hence, this model results in non-stationary net foreign asset dynamics; moreover ricardian equivalence in this setting severely limits the range of fiscal policies that can be studied. On the contrary, the Stability and Growth Pact in the European Union stimulated an increasing number of empirical studies focusing on discretionary fiscal policy as a stabilization tool. Such studies emphasized the empirical performance of different endogenous fiscal deficit feedback rules.[2]

This paper offers a methodological contribution to the NOEM literature based on DSGE models. As mentioned above, in the *Redux* model, the joint assumption of Ricardian Agents and frictionless financial markets implies indeterminacy of the steady-state holdings of net foreign assets. Up to now, the literature has taken two different routes to overcome this limit. Benigno (CEPR, 2001), Erceg–Guerrieri–Gust (IF, 2005) and Hunt–Rebucci (IF, 2005) among others, chose to retain the fully stochastic Representative Agent (RA) structure of the

[1] A non-exhaustive list of some recent contributions includes Beetsma–Jensen (JIE, 2005), Benigno–De Paoli (2006), Ferrero (2006), Galì–Monacelli (2006), Ganelli (JIE, 2005) and Gnocchi–Rovelli (2007).

[2] See, among the others, Favero–Monacelli (2005), Galì–Perotti (EP, 2003) and Manasse (2006).

demand side. However, they introduced additional frictions (in the form of intermediation costs) in the international financial markets, in order to introduce a link between consumption and NFA dynamics and thus achieve stationarity. The second approach, adopted by Cavallo–Ghironi (JME, 2002), Smets–Wouters (JME, 2002) and Ganelli (JIE, 2005) among the others, maintained a frictionless financial structure while introducing non-Ricardian agents, so that the evolution of financial wealth affects consumption and stationarity is again achieved. In order to solve the model, however, these contributions take a step back to the *Redux* model by restoring a perfect foresight environment. This approach provides a natural environment for the analysis of non-BB fiscal policies. However it does not allow to say much about the cyclical properties of different rules, because of the perfect foresight assumption.

The main methodological contribution of this paper is to provide a *fully stochastic* NOEM DGE framework in which consumers are non-ricardian and financial markets are frictionless (though incomplete). We develop a stochastic two-country perpetual youth model with imperfect competition and nominal rigidities that draws on Di Giorgio–Nisticò (JMCB, 2007), extended to allow for endogenous determination of current account dynamics and fiscal deficits. Such framework can be used for the joint analysis of endogenous monetary and non-BB fiscal policies and to derive dynamic and cyclical implications for exchange rate determination and net foreign assets.[3]

The demand-side of our economy is a discrete-time stochastic version of the perpetual youth model introduced by Blanchard (JPE, 1985) and Yaari (RES, 1965). Consumers, in each country, supply labor services in a domestic competitive labor market and demand consumption goods and financial assets issued in the two currencies. In addition, each consumer in each country is endowed with an equal amount of non-tradeable shares of the domestic firms. We assume the following financial structure: markets are complete within each country and incomplete internationally. The only assets tradable across borders are one-period zero-coupon bonds issued in the two currencies by the governments to finance their budget deficits. The joint assumption of non-ricardian consumers and incomplete international financial markets is key to generate determinacy of the steady state stock of net foreign assets, and allows for a thorough analysis of current account dynamics in a DSGE framework. Moreover, the assumption of non-ricardian agents also allows to study a wider range of fiscal shocks compared to the Representative Agent (RA) setup.

The supply-side is standard and consists of a continuum of imperfectly competitive firms operating in each country. These firms hire labor from domestic households to produce differentiated consumption goods. Firms set their prices according to a Calvo rule that allows only a fraction of them to optimally revise prices in a given period in order to maximize

[3]For a closed-economy analysis of non-BB fiscal policy in a stochastic non-ricardian framework, see Annicchiarico–Marini–Piergallini (2004).

profits.

The government in each country purchases a fraction of domestically produced consumption goods, raises lump sum taxes and issues riskless nominal bonds to finance its budget deficit. We assume governments to make fiscal policy by controlling the level of real taxes, given an exogenous process for government expenditures, and compare alternative fiscal regimes defined in terms of specific targets for the primary budget deficit. In particular, we focus on the specification used in some recent empirical studies, that assume the primary fiscal deficit to be set according to a counter-cyclical feedback rule reacting to the output gap and the existing stock of outstanding debt. In particular, Galì–Perotti (EP, 2003) estimate deficit feedback rules for a wide set of industrialized countries with the aim of establishing whether or not the SGP has limited the ability of EMU countries to implement counter-cyclical fiscal policy relative to other non-EMU countries. Their estimates for the U.S. provide strong evidence of a counter-cyclical conduct during the 90's but not in the 80's. They did not find any evidence of a significant response to debt dynamics.[4] We show below that this evidence points to fiscal policy as one of the important drivers of the observed dynamics of the U.S. external balance in the past 20 years.

Monetary policy is modeled by means of usual instrument rules à la Taylor. We consider different policy regimes and compare them with a Wicksellian Policy that implements the flexible-price allocation. Our feedback rules have interest rates responding to either domestic inflation or CPI inflation. We also consider the effect of an exchange rate peg and the case in which the Central Bank aims at stabilizing NFA dynamics by means of an aggressive managed floating.

We study the impact of relative productivity shocks on external and fiscal imbalances and the dynamics of the exchange rate by simulating the model under a set of different combinations of monetary and fiscal rules.

Our main results can be summarized as follows. 1) Under endogenous counter-cyclical fiscal policy, the degree of fiscal discipline plays a crucial role for the NFA and exchange rate dynamics. We define the degree of fiscal discipline as the degree of responsiveness of the deficit rule to the stock of outstanding debt. 2) Since consumption smoothing is the only motive for foreign asset accumulation, a positive productivity shock under BB fiscal policy results into a current account surplus (as long as home and foreign goods are substitute in the utility). However, if the government follows a counter-cyclical deficit rule with scarce fiscal discipline (as the empirical evidence for the U.S. suggests), then *positive* productivity shocks may result in persistent *deteriorations* of the external balance in the medium run. Regardless of the fiscal stance, the nominal exchange rate depreciates on impact and appreciates in the

[4]Favero–Monacelli (2005) estimate an analogous feedback rule for the U.S. only, adopting Markov-switching regression methods, and find evidence of a switch to a passive (in the terminology of Leeper, JME 1991) and more counter-cyclical regime during the 90's.

transition. 3) Under scarce fiscal discipline, persistent negative imbalances may result also from purely temporary monetary restrictions. 4) Any attempt by monetary policy alone to stabilize the dynamics of NFA would imply excessive volatility of the exchange rate, inflation and output. 5) On the contrary, endogenous fiscal policy characterized by high fiscal discipline can prevent persistent external imbalances from arising, *regardless of the monetary policy rule adopted by the Central Bank*.

These results can be compared with those of several related contributions.

Cavallo–Ghironi (JME, 2002) study the dynamic effects of unexpected productivity shocks for exchange rate determination and NFA dynamics, in a perfect foresight framework. They show that, because of a monetary policy rule responding to the level of output (rather than the output gap), an unexpected positive productivity shock deteriorates the external balance only as long as it is permanent, while it always appreciates the exchange rate.

Ganelli (JIE, 2005) introduces a perpetual youth structure in the *Redux* model, to show the implications for exchange rate dynamics of alternative fiscal shocks. In his framework, a tax cut unambiguously drives the exchange rate to appreciate on impact and depreciate in the long run, while the effects of debt-financed government expenditures are ambiguous.[5]

The analysis of the international transmission of idiosyncratic productivity shocks and their effects on the external balance dates back to Backus, Kehoe and Kydland (JPE, 1992), who extend the standard Real Business Cycle model to a two-country world, and evaluate the implications for the international business cycle. They show that a positive temporary productivity shock on the home economy deteriorates the external balance through an inflow of physical capital for about four quarters, while it implies a persistent positive balance afterwards.

The same international RBC model is used by Kollmann (1998) to study the role of international asset market structure in the transmission of productivity shocks to the external balance in the U.S. in the 1980's. He shows that a positive productivity shock to the domestic economy can induce a persistent external deficit only as long as international asset markets are incomplete *and* the idiosyncratic shock is permanent. A temporary productivity shock (even as persistent as implied by an autoregressive coefficient of .95) can only imply an external surplus, no matter what the degree of asset market completeness is.

To explain the sustained deterioration of the U.S. external position in the 90's, in the face of a stronger productivity growth, Fogli–Perri (2006) use an analogous two-country RBC model with borrowing limits, and argue that the higher relative reduction in the volatility of structural shocks in the U.S. produced a fall in precautionary savings, able to account

[5] Although the main focus of this paper is on productivity shocks, our framework can also be used to show that such ambiguous response of the exchange rate stems from the assumption that public consumption is uniformly distributed over domestic and foreign goods. We explicitly address this topic in a companion paper.

for about 20% of the observed deterioration in the U.S. external balance. To the same aim, Hunt–Rebucci (IF, 2005) simulate the quantitative GEM model of the IMF and show that a number of additional features are still needed to match the observed dynamics, in particular uncertainty and learning about the persistence of productivity shocks and a consumers portfolio preference shift in favor of U.S. assets.

The paper is organized as follows. In section 2 we lay out the model. In section 3 we describe the linearized version of the model and the behavior of monetary and fiscal authorities. Section 4 presents the implications of different policy scenarios for the dynamics of the current account and the other main endogenous variables. Section 5, finally, summarizes and concludes.

2 A DSGE Two-Country Model with Incomplete Markets

In this section we present a two-country OLG model which draws on the analysis developed in Di Giorgio and Nisticò (JMCB, 2007). This specification, coupled with the assumption of incomplete international bond markets, generates determinacy of the stock of net foreign assets in the steady state and allows for a thorough analysis of current account dynamics in a DSGE framework.

Following Obstfeld and Rogoff (JPE, 1995) and Benigno and Benigno (REStud, 2003), we model the world economy as consisting of a continuum of households and firms in the interval [0, 1], divided in two countries H and F, of dimension n and $(1-n)$ respectively.

The two countries are structurally symmetric. Each household, in each country, supplies labor inputs to firms and demands a bundle of consumption goods consisting of both home and foreign goods.

The productive sector produces a continuum of perishable goods, which are differentiated across countries and with respect to one another. To assign a relevant role to monetary policy[6] we introduce nominal rigidities by assuming that both domestic and foreign firms, each period, face an exogenous probability of optimally changing the price of their good (see Calvo, JME 1983).

2.1 The Demand-Side.

The demand-side of our economy is a discrete-time stochastic version of the perpetual youth model introduced by Blanchard (1985) and Yaari (1965). Each period a constant-sized cohort

[6]One should notice that, although we do not model money holdings for simplicity, we assign to the Central Bank the role of setting the interest rate according to some optimal "rule". This is the sense by which we talk about monetary policy.

of households enters each country, facing a constant probability γ of dying before the next period begins.[7] To abstract from population growth the cohort size is set equal to γ.

2.1.1 Intertemporal Allocation.

Consumers have log-utility preferences over consumption and leisure, supply labor services in a domestic competitive labor market and demand consumption goods. Moreover, they allocate savings among a full set of domestic state contingent private securities and two internationally traded riskless financial assets issued in the two currencies by the governments to finance their budget deficits. Each consumer in each country is endowed with an equal amount of non-tradable shares of the domestic firms.

Let $\mathcal{E}_t$ be the nominal exchange rate defined as the domestic price of foreign currency, $T_t^i(j)$ denote real lump-sum taxes levied by the fiscal authority of country i on household j, and variables with a superscript * denote nominal values. In particular, $B_{k,t}^{*i}(j)$ denotes holdings of risk-free assets held by generation j living in country i, in nominal terms and denominated in the currency of country k, for $i, k = H, F$: such financial assets are one-period zero-coupon bonds issued by the governments. $Q_{i,t}^*(j)$ denotes cohort j's holdings of the portfolio of state-contingent assets, denominated in domestic currency, for which the relevant discount factor pricing one-period claims is $\mathcal{F}_{t,t+1}^i$.[8] Moreover, given the law of one price and the absence of any home bias in consumption (see the section on intratemporal allocation), it follows that $P_t^H = \mathcal{E}_t P_t^F$. Each household enters each period with a stock of bond holdings which also pays off the return on the insurance contract *à la* Blanchard (1985).

Then, the optimization problem faced at time 0 by the representative consumer of cohort $j < 0$ living in country i is to choose $\{C_t^i(j),\, N_t^i(j),\, Q_{i,t}^{*i}(j),\, B_{H,t}^{*i}(j),\, B_{F,t}^{*i}(j)\}_{t=0}^{\infty}$ to maximize

$$E_0 \sum_{t=0}^{\infty} \beta^t (1-\gamma)^t \Big[\log C_t^i(j) + \delta \log(1 - N_t^i(j)) \Big]$$

subject to a sequence of budget constraints of the form

$$\begin{aligned} P_t^H C_t^H(j) + E_t\{\mathcal{F}_{t,t+1}^H Q_{H,t}^*(j)\} + B_{H,t}^{*H}(j) + \mathcal{E}_t B_{F,t}^{*H}(j) \leq \\ \leq \frac{1}{1-\gamma} \left[(1 + r_{t-1}^H) B_{H,t-1}^{*H}(j) + \mathcal{E}_t (1 + r_{t-1}^F) B_{F,t-1}^{*H}(j) + Q_{H,t-1}^*(j) \right] + \\ + W_t^H N_t^H(j) + P_t^H D_t^H(j) - P_t^H T_t^H(j) \quad (1) \end{aligned}$$

[7] We interpret the concepts of "living" and "dying" in the sense of being or not being operative in the markets and thereby affecting or not economic activity through decision-making processes. In this perspective, the expected life-time $1/\gamma$ is interpreted as the effective decision horizon. See also Leith and Wren-Lewis (2000), Leith and vonThadden (2004), Nisticò (2005) and Piergallini (2004).

[8] The stochastic discount factor is unique, within each country, given the assumption of complete domestic markets.

for households living in country H, in which $D_t^H(j) \equiv \frac{1}{nP_t^H}\int_0^n D_{H,t}^*(h,j)\,\mathrm{d}h$ denotes j's claims on real profits from domestic firms, and

$$P_t^F C_t^F(j) + E_t\{\mathcal{F}_{t,t+1}^F Q_{F,t}^*(j)\} + \frac{B_{H,t}^{*F}(j)}{\mathcal{E}_t} + B_{F,t}^{*F}(j) \leq$$
$$\leq \frac{1}{1-\gamma}\left[(1+r_{t-1}^H)\frac{B_{H,t-1}^{*F}(j)}{\mathcal{E}_t} + (1+r_{t-1}^F)B_{F,t-1}^{*F}(j) + Q_{F,t-1}^*(j)\right] +$$
$$+ W_t^F N_t^F(j) + P_t^F D_t^F(j) - P_t^F T_t^F(j) \quad (2)$$

for those living in country F, in which $D_t^F(j) \equiv \frac{1}{(1-n)P_t^F}\int_n^1 D_{F,t}^*(f,j)\,\mathrm{d}f$.

Standard FOCS imply the following UIP conditions:

$$E_t\left\{\mathcal{F}_{t+1}^H\left[\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t}(1+r_t^F) - (1+r_t^H)\right]\right\} = 0 \quad (3)$$

$$E_t\left\{\mathcal{F}_{t+1}^F\left[\frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}(1+r_t^H) - (1+r_t^F)\right]\right\} = 0, \quad (4)$$

where $\mathcal{F}_{t,t+1}^i = \beta\frac{\Lambda_{t+1}^i(j)}{\Lambda_t^i(j)}$, defines the equilibrium stochastic discount factor for country i and $\Lambda_t^i(j)$ denotes the lagrange multiplier on the constraint for household j living in country i.

We can also define nominal financial wealth carried over from period $t-1$ as:

$$\Omega_{t-1}^{*H}(j) \equiv \frac{1}{1-\gamma}\left[(1+r_{t-1}^H)B_{H,t-1}^{*H}(j) + \mathcal{E}_t(1+r_{t-1}^F)B_{F,t-1}^{*H}(j) + Q_{H,t-1}^*(j)\right] \quad (5)$$

$$\Omega_{t-1}^{*F}(j) \equiv \frac{1}{1-\gamma}\left[(1+r_{t-1}^H)\frac{B_{H,t-1}^{*F}(j)}{\mathcal{E}_t} + (1+r_{t-1}^F)B_{F,t-1}^{*F}(j) + Q_{F,t-1}^*(j)\right]. \quad (6)$$

As a consequence, equilibrium conditions in the asset markets imply

$$E_t\mathcal{F}_{t,t+1}^H(1-\gamma)\Omega_t^{*H}(j) = B_{H,t}^{*H}(j) + \mathcal{E}_t B_{F,t}^{*H}(j) + E_t\{\mathcal{F}_{t,t+1}^H Q_{H,t}^*(j)\} \quad (7)$$

$$E_t\mathcal{F}_{t,t+1}^F(1-\gamma)\Omega_t^{*F}(j) = \frac{B_{H,t}^{*F}(j)}{\mathcal{E}_t} + B_{F,t}^{*F}(j) + E_t\{\mathcal{F}_{t,t+1}^F Q_{F,t}^*(j)\}. \quad (8)$$

Accordingly, we can re-write the budget constraint for generic cohort j living in country i in period t as a stochastic difference equation in the nominal financial wealth:

$$P_t^i C_t^i(j) + E_t\mathcal{F}_{t,t+1}^i(1-\gamma)\Omega_t^{*i}(j) = \Omega_{t-1}^{*i}(j) + P_t^i\varpi_t^i(j), \quad (9)$$

in which $\varpi_t^i(j) \equiv \frac{W_t^i}{P_t^i}N_t^i(j) + D_t^i(j) - T_t^i(j)$ denotes real non-tradable human and financial wealth. The above equation can be solved forward to express personal nominal consumption as a linear function of total tradable and non-tradable wealth:

$$P_t^i C_t^i(j) = \varsigma(\Omega_{t-1}^{*i}(j) + \mathcal{H}_t^{*i}(j)), \quad (10)$$

where $\varsigma \equiv 1-\beta(1-\gamma)$ is the propensity to consume out of total wealth, which is common across cohorts and over time, and $\mathcal{H}_t^{*i}(j)$ is the expected discounted stream of future nominal non-tradable wealth:

$$\mathcal{H}_t^{*i}(j) \equiv E_t\left\{\sum_{k=0}^{\infty}\mathcal{F}_{t,t+k}^{i}(1-\gamma)^k P_{t+k}^{i}\varpi_{t+k}^{i}(j)\right\}. \tag{11}$$

Aggregating across cohorts,[9] it is possible to write the relevant equilibrium conditions as:

$$\delta P_t^i C_t^i = W_t^i(1-N_t^i) \tag{12}$$

$$P_t^i C_t^i + E_t\mathcal{F}_{t,t+1}^{i}\Omega_t^{*i} = P_t^i\varpi_t^i + \Omega_{t-1}^{*i} \tag{13}$$

$$P_t^i C_t^i = \varsigma(\Omega_{t-1}^{*i} + \mathcal{H}_t^{*i}). \tag{14}$$

Solving the system (13)–(14) we derive the dynamic path of aggregate consumption:

$$P_t^i C_t^i = \sigma E_t\mathcal{F}_{t,t+1}^{i}\Omega_t^{*i} + \frac{1}{\beta}E_t\mathcal{F}_{t,t+1}^{i}P_{t+1}^{i}C_{t+1}^{i} \tag{15}$$

where the first term (in which $\sigma \equiv \gamma[1-\beta(1-\gamma)]/[\beta(1-\gamma)]$) captures the financial wealth effect. Notice that the wealth effect fades out as the probability of exiting the market (γ) goes to zero.

2.1.2 Intratemporal Allocation.

At time t, for each household living in country i and belonging to cohort j, personal consumption is given by the following composite bundle:[10]

$$C_t^i(j) = \left[n^{\frac{1}{\theta}}C_{H,t}^{i}(j)^{\frac{\theta-1}{\theta}} + (1-n)^{\frac{1}{\theta}}C_{F,t}^{i}(j)^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}, \tag{16}$$

in which $\theta > 0$ is the elasticity of substitution between Home and Foreign goods, and $C_{H,t}^i(j)$ and $C_{F,t}^i(j)$ result from Dixit-Stiglitz-aggregation of the consumption goods produced in the two countries:

$$C_{H,t}^{i}(j) = \left[\left(\frac{1}{n}\right)^{\frac{1}{\epsilon}}\int_0^n C_t^i(h,j)^{\frac{\epsilon-1}{\epsilon}}dh\right]^{\frac{\epsilon}{\epsilon-1}} \quad C_{F,t}^{i}(j) = \left[\left(\frac{1}{1-n}\right)^{\frac{1}{\epsilon}}\int_n^1 C_t^i(f,j)^{\frac{\epsilon-1}{\epsilon}}df\right]^{\frac{\epsilon}{\epsilon-1}} \tag{17}$$

where $\epsilon > 1$ is the elasticity of substitution between the differentiated goods in the intervals $[0,n]$ and $(n,1]$. We assume such elasticity, reflecting the degree of market power, to be the same across countries.

[9] The aggregate *per-capita* levels across cohorts for each generation-specific variable $X(j)$ are computed as the weighted average $X_t \equiv \sum_{j=-\infty}^{t}\gamma(1-\gamma)^{t-j}X_t(j)$, for both countries.

[10] We assume that there is no home bias in consumption. Equation (16) is therefore the sam for both countries; as a consequence, the Law of One Price in this setting implies PPP at each point in time, as discussed below.

Total expenditure minimization yields the price indexes for goods produced in countries H and F and sold in country $i = H, F$

$$P^i_{H,t} = \Big[\frac{1}{n}\int_0^n P^i_t(h)^{1-\epsilon}dh\Big]^{\frac{1}{1-\epsilon}} \qquad P^i_{F,t} = \Big[\frac{1}{1-n}\int_n^1 P^i_t(f)^{1-\epsilon}df\Big]^{\frac{1}{1-\epsilon}}, \tag{18}$$

the consumer-price index (CPI) for country i

$$P^i_t = \Big[n(P^i_{H,t})^{1-\theta} + (1-n)(P^i_{F,t})^{1-\theta}\Big]^{\frac{1}{1-\theta}} \tag{19}$$

and the total demand $C^d_t(i',j) \equiv nC^H_t(i',j) + (1-n)C^F_t(i',j)$ for goods produced at home and abroad for generation j

$$C^d_t(h,j) = \left(\frac{P^i_t(h)}{P^i_{H,t}}\right)^{-\epsilon}\left(\frac{P^i_{H,t}}{P^i_t}\right)^{-\theta} C^W_t(j) \qquad C^d_t(f,j) = \left(\frac{P^i_t(f)}{P^i_{F,t}}\right)^{-\epsilon}\left(\frac{P^i_{F,t}}{P^i_t}\right)^{-\theta} C^W_t(j), \tag{20}$$

in which $C^W_t(j) \equiv nC^H_t(j) + (1-n)C^F_t(j)$ denotes the total world demand for consumption of generation j.

We define the Terms of Trade (ToT) as the relative price of foreign goods in terms of home goods ($\mathcal{S}_t \equiv P^i_{F,t}/P^i_{H,t}$),[11] and assume that the Law of One Price (LOP) holds at the brand level: $P^H_t(i') = \mathcal{E}_t P^F_t(i')$, for all i'=h, f. Moreover, since preferences are identical and there is no home-bias in consumption, the LOP at the brand level implies Purchasing Power Parity (PPP) at each point in time:

$$P^H_{i,t} = \mathcal{E}_t P^F_{i,t} \qquad\qquad P^H_t = \mathcal{E}_t P^F_t. \tag{21}$$

Aggregating across cohorts conditions (20) yields:

$$C^d_t(h) = \left(\frac{P_t(h)}{P_{H,t}}\right)^{-\epsilon}\left(\frac{P_{H,t}}{P_t}\right)^{-\theta} C^W_t \qquad C^d_t(f) = \left(\frac{P_t(f)}{P_{F,t}}\right)^{-\epsilon}\left(\frac{P_{F,t}}{P_t}\right)^{-\theta} C^W_t, \tag{22}$$

where C^W_t denotes world per-capita consumption, and we dropped the country superscript in the relative prices, given PPP.

[11] Notice that, given the definition of terms of trade, the CPI can be also expressed as

$$P^i_t = P^i_{H,t}\Big[n + (1-n)\mathcal{S}_t^{1-\theta}\Big]^{\frac{1}{1-\theta}} = P^i_{F,t}\Big[n\mathcal{S}_t^{\theta-1} + (1-n)\Big]^{\frac{1}{1-\theta}},$$

for $i = H, F$.

2.1.3 The Government

We assume that the government of each country consumes an exogenously given amount of domestic goods:

$$G_t(h) = \left(\frac{P_t(h)}{P_{H,t}}\right)^{-\epsilon} G_t^H \qquad G_t(f) = \left(\frac{P_t(f)}{P_{F,t}}\right)^{-\epsilon} G_t^F. \tag{23}$$

Using the above, and the familiar Dixit-Stiglitz aggregators

$$Y_t^H \equiv \left[n^{-1}\int_0^n Y_t(h)^{\frac{\epsilon-1}{\epsilon}}\,dh\right]^{\frac{\epsilon}{\epsilon-1}} \qquad Y_t^F \equiv \left[(1-n)^{-1}\int_n^1 Y_t(f)^{\frac{\epsilon-1}{\epsilon}}\,df\right]^{\frac{\epsilon}{\epsilon-1}},$$

we can obtain, for each country i, the following brand-specific and aggregate demands:

$$Y_t^d(i') = C_t^d(i') + G_t(i') = \left(\frac{P_t(i')}{P_{i,t}}\right)^{-\epsilon} Y_t^i \qquad Y_t^i = \left(\frac{P_{i,t}}{P_t}\right)^{-\theta} C_t^W + G_t^i. \tag{24}$$

The government of country i can finance its own consumption G_t^i by levying lump-sum taxes T_t^i to domestic households and by issuing nominal debt denominated in local currency $B_{i,t}^*$. This implies the following budget constraint for the fiscal authority, in nominal per-capita terms:

$$B_{i,t}^* = (1 + r_{t-1}^i)B_{i,t-1}^* + Z_t^{*i}, \tag{25}$$

where Z_t^{*i} denotes the nominal primary deficit for country i, defined as

$$Z_t^{*i} \equiv P_{i,t}^i G_t^i - P_t^i T_t^i. \tag{26}$$

Since all variables in equation (25) are in per-capita terms, and the public debt of each government can be bought by residents in either one of the two countries, the following must hold:

$$B_{H,t}^* \equiv \frac{nB_{H,t}^{*H} + (1-n)B_{H,t}^{*F}}{n} \tag{27}$$

$$B_{F,t}^* \equiv \frac{nB_{F,t}^{*H} + (1-n)B_{F,t}^{*F}}{1-n}. \tag{28}$$

2.2 The Supply-Side.

Each firm, in each country, has access to a stochastic linear technology $Y_t(i') = A_t^i N_t(i')$, with $i' = h, f$ and $i = H, F$, whose country-specific productivity shock is A_t^i. Firms choose labor demand in a competitive labor market by minimizing their total real costs subject to the technological constraint. In equilibrium, for each firm in country i, the real marginal cost will hence be

$$MC_{i,t} = \frac{W_t^i}{P_{i,t}^i A_t^i}. \tag{29}$$

Using the brand-specific demand functions (24) and aggregating across domestic brands, we get the aggregate production function for country H:

$$Y_t^H \Xi_t^H = A_t^H N_t^H,$$

in which $\Xi_t^H \equiv n^{-1} \int_0^n \left(P_t^H(h)/P_{H,t}^H \right)^{-\epsilon} \mathrm{d}h$ captures (second-order) relative price dispersion among domestic firms and $N_t^H \equiv n^{-1} \int_0^n N(h)\, \mathrm{d}h$ is the aggregate per-capita amount of hours worked in country H.[1]

Equilibrium in the labor market and the definition of the terms of trade imply that real marginal costs equal

$$MC_{H,t} = \frac{\delta C_t^H}{A_t^H - Y_t^H \Xi_t^H} \left[n + (1-n) \mathcal{S}_t^{1-\theta} \right]^{\frac{1}{1-\theta}} \tag{30}$$

$$MC_{F,t} = \frac{\delta C_t^F}{A_t^F - Y_t^F \Xi_t^F} \left[n \mathcal{S}_t^{\theta-1} + (1-n) \right]^{\frac{1}{1-\theta}}. \tag{31}$$

We follow most of the literature in the field and assume that firms set prices according to Calvo's (1983) staggering mechanism, with $1 - \vartheta^i$ being the probability for each firm in country i to optimally adjust its price. In equilibrium, this assumption implies a set of familiar New Keynesian Phillips Curves.

3 The Linear Model and Macroeconomic Policies.

In Appendix A we present the complete model and the zero-inflation/zero-deficit long-run equilibrium.

Let $x_t \equiv \log X_t - \log X$ denote the log-deviation of variable X from its steady state, except $g_t^i \equiv \frac{G}{Y} \log(G_t^i/G)$, $\tau_t^i \equiv \frac{T}{Y} \log(T_t^i/T)$, and z_t^i, ω_t^i and $b_{i,t}$, which, given the assumption of zero-primary deficit in steady state, we define as $z_t^i \equiv Z_t^i/C$, $\omega_t^i \equiv \Omega_t^i/C$ and $b_{i,t} \equiv B_{i,t}/C$. Moreover, let $x^W \equiv n x^H + (1-n) x^F$ denote world aggregates and $x^R \equiv x^H - x^F$ denote H relative aggregates. We also set $s_c \equiv Y/C$.

Log-linearization of equation (12) yields

$$c_t^i + \varphi n_t^i = w_t^i - p_t^i \tag{32}$$

The linearized version of the UIP is

$$E_t \Delta e_{t+1} = r_t^H - r_t^F, \tag{33}$$

which, coupled with the LOP and the symmetric preferences over consumption indexes, implies

$$r_t^H - E_t \pi_{t+1}^H = r_t^F - E_t \pi_{t+1}^F, \tag{34}$$

in which $\pi_t^i \equiv \log(P_t^i/P_{t-1}^i)$ is the CPI-based inflation rate for country i.

From equations (13), (25), (26) and the definition of aggregate dividends we derive the linear state equation for aggregate financial wealth in country i:

$$\beta\omega_t^i = \omega_{t-1}^i + s_c(y^i - g_t^i) - c_t^i + (p_{i,t}^i - p_t^i) + b_{i,t} - \frac{1}{\beta}b_{i,t-1}. \tag{35}$$

Let $b_{k,t}^i \equiv (B_{k,t}^i - B_k^i)/C$, for $i,k = H,F$. Linearizing the definition (5) implies:

$$\omega_t^H = \frac{1}{\beta}b_{H,t}^H + \frac{B_H^H}{\beta C}(r_t^H - \varrho) + \frac{1}{\beta}b_{F,t}^H + \frac{B_F^H}{\beta C}(r_t^F - \varrho + E_t\Delta e_{t+1}), \tag{36}$$

in which $\varrho \equiv -\log\beta$ denotes the steady state real interest rate. Using the UIP in the last term finally implies:

$$\omega_t^H = \frac{1}{\beta}(b_{H,t}^H + b_{F,t}^H) + \frac{B_H^H + B_F^H}{\beta C}(r_t^H - \varrho) = \frac{1}{\beta}(b_{H,t}^H + b_{F,t}^H), \tag{37}$$

where the last equality is implied by equation (A.36): zero-holdings of financial assets in steady state makes the interest rate irrelevant for the dynamics of financial wealth and net foreign assets. For country F, analogously we have:

$$\omega_t^F = \frac{1}{\beta}(b_{H,t}^F + b_{F,t}^F). \tag{38}$$

Therefore equation (35) can be written as:

$$\alpha_t^i = \frac{1}{\beta}\alpha_{t-1}^i + s_c(y^i - g_t^i) - c_t^i + (p_{i,t}^i - p_t^i), \tag{39}$$

where $\alpha_t^i \equiv \beta\omega_t^i - b_{i,t} = b_{H,t}^i + b_{F,t}^i - b_{i,t}$ denote the holdings of net foreign assets of residents in country i.[12]

A second implication is that it must be $n\alpha_t^H + (1-n)\alpha_t^F = 0$, for all t. Given the previous implication, and since $p_{H,t}^H - p_t^H = -(1-n)s_t$ and $p_{F,t}^F - p_t^F = ns_t$, the law of motion for net foreign assets can be expressed in terms of country H's position as:

$$\alpha_t^H = \frac{1}{\beta}\alpha_{t-1}^H + (1-n)s_c(y^R - g_t^R) - (1-n)c_t^R - (1-n)s_t. \tag{40}$$

[12]To see this, consider the linear version of equations (27) and (28):

$$b_{H,t} = b_{H,t}^H + \frac{1-n}{n}b_{H,t}^F \qquad b_{F,t} = \frac{n}{1-n}b_{H,t}^F + b_{F,t}^F,$$

and notice that they imply

$$b_{H,t}^H + b_{F,t}^H - b_{H,t} = b_{F,t}^H - \frac{1-n}{n}b_{H,t}^F \qquad b_{H,t}^F + b_{F,t}^F - b_{F,t} = b_{F,t}^F - \frac{n}{1-n}b_{F,t}^H.$$

Therefore, being the difference between domestic (per-capita) claims on foreign debt ($b_{F,t}^H$ for the case of country H) and foreign (per-capita) claims on domestic debt ($\frac{1-n}{n}b_{H,t}^F$), the above define the holdings of net foreign assets in the two countries.

Linearization of the aggregate demands (24) yields:

$$y_t^H = \frac{\theta(1-n)}{s_c} s_t + \frac{1}{s_c} c_t^W + g_t^H \tag{41}$$

$$y_t^F = -\frac{\theta n}{s_c} s_t + \frac{1}{s_c} c_t^W + g_t^F, \tag{42}$$

from which it follows:

$$y_t^W = \frac{1}{s_c} c_t^W + g_t^W \tag{43}$$

$$y_t^R = \frac{\theta}{s_c} s_t + g_t^R. \tag{44}$$

Using the last relation, we can reduce the law of motion of net foreign assets to a function of consumption differential and the terms of trade:

$$\alpha_t^H = \frac{1}{\beta} \alpha_{t-1}^H + (\theta - 1)(1-n) s_t - (1-n) c_t^R. \tag{45}$$

The dynamics of net foreign assets with respect to the terms of trade are the result of two competing effects. On the one side, a depreciation of s_t deteriorates the current account because it reduces the real value of domestic production, relative to absorption (negative absorption effect: $-(1-n)s_t$). On the other side, a deterioration of the terms of trade makes domestic goods more competitive in the international markets, and imply a switch towards home goods and a consequent improvement in net foreign asset holdings (positive switching effect: $\theta(1-n)s_t$). As long as Home and Foreign goods are substitute in the utility of consumers ($\theta > 1$) the positive switching effect dominates and a deterioration of the terms of trade implies a current account surplus.

Let $\pi_{i,t} \equiv \log(P_{i,t}/P_{i,t-1})$ denote the PPI-based inflation rate for country i. The following relations hold:

$$\pi_t^H = \Delta e_t + \pi_t^F \tag{46}$$

$$\pi_t^H = \pi_{H,t} + (1-n)\Delta s_t \tag{47}$$

$$\pi_t^F = \pi_{F,t} - n\Delta s_t. \tag{48}$$

The above equations, moreover, imply the following law of motion for the terms of trade:

$$s_t = s_{t-1} + \Delta e_t + \pi_{F,t} - \pi_{H,t}. \tag{49}$$

Public debt in country i evolves according to the following linearized law of motion:

$$b_{i,t} = \frac{1}{\beta} b_{i,t-1} + z_t^i, \tag{50}$$

where $z_t^i \equiv Z_t^i/C$ denote the real primary deficits:

$$z_{H,t} = s_c(g_t^H - \tau_t^H) - (s_c - 1)(1-n)s_t \tag{51}$$

$$z_{F,t} = s_c(g_t^F - \tau_t^F) + (s_c - 1)ns_t. \tag{52}$$

The state equations for domestic, world and relative consumption read:

$$c_t^i = E_t c_{t+1}^i - (r_t^i - E_t\pi_{t+1}^i - \varrho) + \sigma\beta\omega_t^i \tag{53}$$

$$c_t^W = E_t c_{t+1}^W - (r_t^W - E_t\pi_{t+1}^W - \varrho) + \sigma b_t^W \tag{54}$$

$$c_t^R = E_t c_{t+1}^R + \sigma b_t^R + \frac{\sigma}{1-n}\alpha_t^H \tag{55}$$

in which relative public debt evolves according to $b_t^R = \frac{1}{\beta}b_{t-1}^R + z_t^R$.

On the supply side, finally, Calvo price-setting implies two NKPC of the usual kind:

$$\pi_{i,t} = \beta E_t\pi_{i,t+1} + \lambda^i mc_{i,t}, \tag{56}$$

in which the real marginal costs, expressed in terms of aggregate and relative variables, follow:

$$mc_{H,t} = \frac{s_c + \varphi}{s_c}c_t^W + (1-n)c_t^R + (1-n)\frac{s_c + \varphi\theta}{s_c}s_t + \varphi g_t^H - (1+\varphi)a_t^H \tag{57}$$

$$mc_{F,t} = \frac{s_c + \varphi}{s_c}c_t^W - nc_t^R - n\frac{s_c + \varphi\theta}{s_c}s_t + \varphi g_t^F - (1+\varphi)a_t^F. \tag{58}$$

3.1 The Policy Makers

In this paper we do not explicitly address issues related to welfare and do not derive optimal monetary and fiscal policies. We take a positive approach and limit our analysis to compare the outcome of different simple fiscal and monetary rules.[13]

In each country two policy makers act: a Central Bank and a fiscal authority.

The monetary policy regime that we use as benchmark in both countries is the "Wicksellian" Monetary Policy, targeting the Natural Rate, $\overline{rr}_t^i$, and leading to price stability. A credible threat to deviate from $\overline{rr}_t^i$ rules out indeterminacy and implements the flexible-price allocation:[14]

$$r_t^i = \overline{rr}_t^i + \phi_\pi^i \pi_{i,t}. \tag{59}$$

Governments are in charge of fiscal policy. We assume they use real taxes as an instrument to meet their policy targets, given an exogenous stationary process for public spending:

[13] Fully articulated normative and welfare analysis, and the solution of the associated issues implied by the population structure, is an ambitious target left for further research.

[14] We restrict our attention to active monetary policy, satisfying the Taylor principle ($\phi_\pi^i > 1$, for all $i = H, F$). The Flexible-Price equilibrium is described in the Appendix.

$g_t^i = \rho_g^i g_{t-1}^i + u_{g,t}^i$. Our benchmark specification for fiscal policy follows some recent empirical literature (e.g. Galì and Perotti, 2003) and has the target primary deficit vary countercyclically, according to a feedback rule of the following kind:

$$z_t^i = \rho_z^i z_{t-1}^i - (1-\rho_z^i)[\mu_b^i b_{t-1}^i + \mu_x^i x_t^i] + u_{z,t}^i, \tag{60}$$

where x_t^i denotes country i's domestic output gap, all response coefficients are positive and $\rho_z^i \in [0,1)$.[15]

As argued in the introduction, the reason for choosing this kind of specification for fiscal policy lies in its flexibility to nest several fiscal regimes which may characterize modern industrialized economies and in its widespread use in the recent empirical literature. In this perspective, an additional goal of our analysis is to evaluate the theoretical properties of such a deficit rule in a fully fledged DSGE model with endogenous interaction between fiscal and external balances.

4 Simple Policy Rules and Current Account Dynamics

In this section we simulate our model and study the macroeconomic implications of different combinations of monetary and fiscal policies.

We study six alternative monetary policy specifications. The benchmark regime is the "Wicksellian" Monetary Policy:

$$r_t^i = \overline{rr}_t^i + \phi_\pi^i \pi_{i,t}, \tag{61}$$

in which $\phi_\pi^i > 1$, for all $i = H, F$. We then compare the dynamic and cyclical properties of several simple rules to the ones featured by this benchmark.

The first two simple rules considered are standard interest rate rules of the kind introduced by Taylor (1993). One has the nominal interest rate respond to deviations of the GDP deflator $\pi_{H,t}$ and the domestic output gap from the zero targets (DITR):

$$r_t^H = \varrho + \phi_\pi^H \pi_{H,t} + \phi_x^H x_t^H + u_{m,t}^H, \tag{62}$$

in which $u_{m,t}^H$ are white noises capturing pure monetary policy shocks. The second (CITR) modifies equation (62) by allowing for a reaction to variations in the CPI inflation rate π_t^H:

$$r_t^H = \varrho + \phi_\pi^H \pi_t^H + \phi_x^H x_t^H + u_{m,t}^H. \tag{63}$$

[15] Also with respect to this policy rule, restrictions on the response coefficients must be satisfied in order for the equilibrium to be determinate. In particular, given the assumption of active monetary policy, to rule out the unstable root implicit in the law of motion of public debt (50) the response coefficient to the stock of outstanding debt must be larger than the steady state net interest rate, in each country: $\mu_b^i > \varrho$, for all $i = H, F$.

In the quantitative analysis below, we parameterize both rules with a reaction coefficients equal to $\phi_\pi^H = 2$ and $\phi_x^H = .5$.

An alternative monetary regime may ask for the control of the nominal exchange rate, possibly in the attempt of correcting external imbalances. In this regime, the exchange rate is devaluated when the stock of outstanding net foreign assets falls below its potential level:

$$e_t = -\chi_\alpha(\alpha_{t-1}^H - \overline{\alpha}_{t-1}^H) + u_{m,t}^H. \tag{64}$$

Depending on the value assigned to the response coefficient, we can define three different stances: $\chi_\alpha = 0$ denotes a pure exchange rate peg (PEG), while $\chi_\alpha = 1$ (FLOPAS) and $\chi_\alpha = 6$ (FLOACT) account for different degrees of aggressiveness in the attempt of the Central Bank to correct external imbalances.

As to fiscal policy, we consider four alternative specifications, focusing only on "passive" (in the sense of Leeper, JME 1991) or implementable (in the sense of Schmitt-Grohe and Uribe, 2006) fiscal rules.

First, we consider a fiscal regime (TX) in which real taxes follow an exogenous, stationary autoregressive process:

$$\tau_t^H = \rho_\tau^H \tau_{t-1}^H + (1 - \rho_\tau^H)\xi_b^H b_{t-1}^H + u_{z,t}^H, \tag{65}$$

where a drift adjusting to the stock of outstanding debt insures equilibrium determinacy ($\xi_b^H = (\varrho/s_c)$) and fiscal solvency.[16]

The second specification (BB) considers the case in which the government targets a balanced budget in every period:

$$z_t^i = 0, \tag{66}$$

while in the third (DS) implies full stabilization of the debt-to-GDP ratio:

$$b_t^i = y_t^i. \tag{67}$$

Our benchmark specification considers the case in which governments set their primary deficit following a counter-cyclical feedback rule (60) of the kind:

$$z_t^i = \rho_z^i z_{t-1}^i - (1 - \rho_z^i)[\mu_b^i b_{t-1}^i + \mu_x^i x_t^i] + u_{z,t}^i. \tag{68}$$

We calibrate the parameters above using the estimates provided by Galì and Perotti (EP, 2003) for the period 1992-2001.[17] We identify the U.S. as the H country and the group of

[16] This specification may proxy the way the U.S. administration conducted fiscal policy in the '80s, as the empirical evidence in Galì and Perotti (2003) suggests. Note, in fact, that the regime TX is equivalent to our benchmark deficit feedback rule (60), when the response coefficient to the output gap is zero.

[17] The empirical analysis in Galì and Perotti (2003) also provides estimates for the 1980-1991 period, which show that in the '80s the response coefficients (μ_x^H, μ_b^H) for the U.S. where both insignificant. This case broadly corresponds to the fiscal regime that we labeled TX.

EMU10 as the F country: $\rho_z^H = 0.25$, $\rho_z^F = 0.42$, $\mu_x^H = 1.43$, $\mu_x^F = 0.47$, $\mu_b^F = 0.07$. As to the Home response to the existing stock of debt, μ_b^H, we consider two alternative degree of fiscal discipline: a "low" and a "high" degree. "Low" fiscal discipline implies a policy rule in which the response coefficient to the stock of outstanding debt is set at a level slightly higher than the one necessary to grant solvency and determinacy: $\mu_b^H = 1.5\varrho$. This calibration implies a response coefficient to existing debt of about .015, and is consistent with the estimates of Galì and Perotti (EP, 2003) for many OECD countries[18] and with the estimate provided by Favero and Monacelli (2005) for the U.S. for the 90's. As "High" degree of fiscal discipline we consider $\mu_b^H = 15\varrho$, which implies a response of about .15, and is consistent with the evidence of countries with a virtuous debt dynamics like Australia.

In the next subsections, we compare the dynamic and cyclical properties of alternative combinations of monetary and fiscal policies for the Home economy. We will constantly assume that the foreign authorities follow our defined benchmark regimes (i.e. the "Wicksellian" Monetary Policy and the counter-cyclical deficit feedback rule (68), calibrated as discussed above).

4.1 Calibration

We parameterize the model on a quarterly frequency, following previous studies and convention. Specifically, the steady-state net quarterly interest rate ϱ was set at 0.01, implying a long-run real annualized interest rate of 4%.[19] The probability of exiting the markets γ was set at 0.05, implying a moderate elasticity of world consumption to financial wealth ($\sigma = 0.0032$). In order to meet the steady-state restrictions, the intertemporal discount factor β was set at 0.99. The elasticity of substitution among intermediate goods ϵ was set at 11, implying a steady-state net mark-up rate of 10%, while the probability for firms of having to keep their price fixed for the current quarter was set at 0.75 for both countries, implying that prices are revised on average once a year.

The elasticity of substitution between Home and Foreign goods was set equal to 1.5, which implies that home and foreign goods are substitute in the utility function of consumers. With respect to this parameter there has been considerable debate over its true value, with the empirical literature providing a vast range of estimates, often dependent on the level of aggregation used. Until recently, most of the literature provided values in the range of unity (using aggregate data[20]) or much above (between 3 and 6, using disaggregated

[18]The estimate that Galì and Perotti (EP, 2003) report for the U.S. is actually not significantly different from zero, over the whole 1980-2001 sample.

[19]Since we concentrate on a symmetric steady state the values reported in the text are meant to refer to both countries as well as to the world economy.

[20]See e.g. Hooper–Marquez (2003).

data).[21] Recently, the role of a θ lower than unity has been given more attention from both a theoretical and empirical perspective, and was shown to be crucial in determining the international transmission of productivity shocks through the response of the terms of trade.[22] Although we consider in our main simulation a conservative value for θ, we explore the implications of allowing for lower-than-one trade elasticity in our set up, and show that low fiscal discipline still induce a sizable and persistent worsening of the external balance relative to the benchmark equilibrium.

As to the steady-state Frisch elasticity of labor supply, $1/\varphi$, there is wide controversy about the value that should be assigned to this parameter. The empirical microeconomic literature suggests values for φ ranging from .1 to .5 (see Card, 1994, for a survey), while business cycle literature mostly uses values greater than 1 (see e.g. Cooley and Prescott, 1995). We choose a baseline value of $\varphi \equiv \frac{N}{1-N} = 1$; given the steady state restrictions derived in the appendix and the implied value of μ, this requires a value of δ equal to 1.125. Finally, we parameterize the dimension of the Home country n to 0.6, roughly consistent with the ratio of U.S. to Euro-10 GDP.

As to the stochastic shocks, we allow for international propagation of productivity shocks and therefore assume that they evolve as a stationary VAR(1) process: $\mathbf{a}_t = \mathbf{P}_a \mathbf{a}_{t-1} + \mathbf{u}_{at}$, where $\mathbf{a} \equiv [a^H \quad a^F]'$. To calibrate persistence and volatilities, we estimate the VAR using quarterly HP-filtered data on labor productivity in the U.S. and the Euro Area for the period spanning from 1970:1 to 2005:4.[23] The values obtained are reported in Table 1 (t-statistics in parenthesis).

Table 1: Stochastic properties of the productivity shocks.

Shock	P_a		σ_a^i	$corr(u_a^H, u_a^F)$
a^H	**0.740**	**-0.188**	**0.0069**	**0.0802**
	(12.573)	(-2.066)		
a^F	**0.118**	**0.684**	**0.0043**	
	(3.208)	(12.099)		

As the table shows, we find significant evidence of an international stochastic relation

[21] See Obstfeld–Rogoff (2001) and McDaniel–Balistreri (2003) for reviews and discussions of the main empirical contributions.

[22] See Corsetti–Dedola–Leduc (2004) for a theoretical analysis and empirical assessment of low trade elasticity in open economy models, and Lubik–Schorfheide (2006) for empirical support to low trade elasticity in NOEM models.

[23] Data for the Euro Area are taken from the Area-Wide Model Database, available to EABCN members at http://www.eabcn.org/data/awm/index.htm. For a description of this database, see Fagan–Henry–Mestre (2001).

Table 2: Stochastic properties of the fiscal shocks.

Shock	ρ^i	σ^i	$Adj.R^2$
g^H	**0.696**	**0.0079**	**0.5038**
	(12.012)		
g^F	**0.638**	**0.0041**	**0.4159**
	(10.056)		
τ^H	**0.768**	**0.0192**	**0.5802**
	(14.008)		
τ^F	**0.905**	**0.0105**	**0.8181**
	(25.269)		

between productivity in the U.S. and the Euro Area, and a small positive correlation between the innovations.

Analogously, to calibrate persistence and volatility of the fiscal shocks (g^i and τ^i), we estimate an independent AR(1) process for each shock, using quarterly HP-filtered data on government consumption and real personal taxes in the U.S. and the Euro Area for the available sample (1970:1 to 2005:4).[24] The values obtained are reported in Table 2. Given the structural symmetry of our framework, we follow Backus, Kehoe and Kydland (1992), among the others, and use for the benchmark simulation a symmetrized version of our estimates[25] We therefore calibrate matrix P_a to

$$P_a = \begin{bmatrix} 0.712 & -0.035 \\ -0.035 & 0.712 \end{bmatrix}, \tag{69}$$

the standard deviations of productivity shocks at $\sigma_a^i = 0.0056$ for $i = H, F$ and the correlation at the estimated value (0.0802). As to the fiscal shocks, we calibrate $\rho_g^i = 0.666$, $\sigma_g^i = 0.0060$, $\rho_\tau^i = 0.836$ and $\sigma_z^i = 0.0148$.

4.2 The Dynamic Response to Productivity Shocks

We start by studying the macroeconomic effects of a positive domestic productivity shock, under alternative fiscal and monetary regimes (figures 1–4). More precisely, figures 1–3

[24]Since the dynamics of τ^i represent discretionary fiscal policy in a particular regime, we interpret the standard deviation of the innovations to τ^i more broadly as the volatility of innovations to discretionary fiscal policy and therefore use the estimates in the latter two rows of table 2 also for the other fiscal regimes considered.

[25]We performed the simulations also under the asymmetric calibration implied by the estimates, without substantial effects on the results.

focus on the three *exogenous* fiscal regimes (TX, BB, and DS) and compare the Wicksellian Monetary Policy with the Domestic Inflation-based Taylor rule. In Figure 4, which considers alternative *endogenous* deficit feedback rules, we add a third monetary regime, based on aggressive managed floating. We do not report in these figures the other three monetary regimes explored (CITR, PEG, FLOPAS) because they prove inferior in replicating the Wicksellian Policy, with respect to the DITR. We explore this issue further in the next session, when investigating the cyclical properties of the alternative regimes.

The effect of idiosyncratic productivity shocks on the international business cycle was first studied by Backus, Kehoe and Kydland (JPE, 1992), who showed that a positive temporary productivity shock at home deteriorates the current account through an inflow of physical capital. However, this negative effect is only temporary, while it implies a persistent positive external balance in the medium run. Kollmann (1998) later shows that an international RBC model can imply a persistent external deficit following a positive productivity shock, but only as long as international markets are incomplete *and* the shock is permanent.

The presence of nominal rigidities and endogenous economic policies makes the dynamics in our framework quite different.

The effect of a local, positive, productivity shock on domestic inflation, the output gap and the exchange rate is qualitatively similar across all fiscal regimes. Under flexible prices, such effect is a deterioration in the terms of trade (raise in s_t), and the relative reduction in domestic interest rates induces a depreciation of the exchange rate. On impact, then, the economy experiences a current account surplus, through higher competitiveness, because residents in the Home country accumulate foreign assets to smooth the effects of the shock on consumption. Under sticky prices, these dynamic effects are closely mirrored if the Central Bank adopts a simple interest rate rule. However, in the case of aggressive managed floating domestic interest rates rise on impact to prevent the depreciation of the exchange rate, thus causing a deeper fall in the output gap (see figure 4). When a surplus in the natural current account starts accumulating, the Central Bank accommodates such dynamics by lowering interest rates so as to depreciate the exchange rate and support higher levels of output and inflation.

When it comes to the reaction of the other variables of interest, the actual fiscal regime adopted becomes relevant.

Figure 1 shows that, when the government has no target in terms of primary deficit (TX), the depreciation of the terms of trade stimulates a primary fiscal surplus, through the reduction of home relative prices (at which public purchases are made). Taxes move slightly, to ensure a non-explosive path to public debt. On impact, net foreign assets are accumulated given higher relative productivity. In the medium run, the dynamics of public debt becomes the dominant factor for the evolution of national savings, and governs the

speed of convergence of NFA.

Figure 2 shows the case of a balanced budget target for the government (BB). In this case, the effect due to competitiveness is the only one at play, given that no debt is issued, and the dynamics of NFA are mean reverting, like the one of the terms of trade (not showed). Analogously, when the government seeks to stabilize the debt-to-GDP ratio (figure 3), the net foreign assets revert to their steady state level, driven by the terms of trade, while primary deficit and public debt jump on impact to match the increase in real output induced by the productivity shock.

Turning to the endogenous fiscal regimes, figure 4 compares the dynamic outcomes of following "low" versus "high" fiscal discipline. Under the "Wicksellian" regime, a positive productivity shock produces a surplus in the current account, which is gradually absorbed over time. Given that the output gap is unaffected, both the primary deficit and the stock of public debt do not move (only real taxes slightly fall, in order to sterilize the initial depreciation of the terms of trade).

If monetary policy is conducted according to simple policy rules the productivity shock is only partially accommodated, inflation and the output gap decrease on impact, to revert to their equilibrium values over time, and the deterioration of the terms of trade is weaker. The fiscal rule requires real taxes to fall to offset the fall of the output gap: thereby the stock of public debt increases.

Under DITR, "Low" fiscal discipline results in public debt accumulation (DITR-Low). Both public and private savings fall, the latter through expansionary wealth effects on consumption. Eventually, the fall in national savings overrules the initial depreciation of the terms of trade, and the country moves to a persistent external deficit. Notice that, in presence of "Low" fiscal discipline, monetary policy could prevent the current account deficit from developing, by aggressively managing the exchange rate (FLOACT-Low). However such a policy would require a strong and persistent depreciation of the exchange rate, with high costs in terms of both inflation and output volatility.

On the other hand, a "High" degree of fiscal discipline allows the government to drive both NFA and the stock of outstanding debt back to their equilibrium values. This result holds *regardless of the monetary policy rule adopted*.[26] This is due to the fact that under "High" fiscal discipline real taxes would adjust to produce a moderate primary surplus before the growth of public debt starts overruling the terms-of-trade effect. The degree of fiscal discipline therefore plays a crucial role in the dynamics of net foreign assets, especially in the medium run.

All these simulations have been undertaken by assuming a larger-than-one elasticity of substitution between Home and Foreign goods. As mentioned above, this assumption

[26]Not showed in the figure. An appendix with all the impulse response functions is available upon request.

has been recently challenged in the literature. Corsetti–Dedola–Leduc (2004) estimate a coefficient of 0.85, and show that, in an economy with pervasive home bias in consumption and distribution services, technology shocks tend to *appreciate* the real exchange rate and the terms of trade, substantially altering the international propagation of the shock. In an independent study, Lubik–Schorfheide (2006) estimate with bayesian methods a NOEM model and find an estimated elasticity of 0.43.

We believe that it is important to stress, however, that these empirical analyses, while finding support to $\theta < 1$, both still imply also that domestic and foreign goods are substitute in the utility of consumers, as they also find a low enough elasticity of intertemporal substitution (0.5 in Corsetti–Dedola–Leduc, 2004 and not higher than 0.36 in Lubik–Schorfheide, 2006). Also on the basis of this evidence, therefore, we view the assumption of a lower-than-one trade elasticity as not particularly appealing in our framework, because it would imply that home and foreign goods are complement in the utility of consumers (given log-utility). Nonetheless, figure 5 reports the dynamic effects of a positive productivity shock in the case θ equals 0.85.

The absence of home bias in consumption, coupled with endogenous monetary policy, drives the result that, even in a low-elasticity environment, a positive productivity shock *depreciates* the nominal exchange rate and the terms of trade. However, equation (45) shows that, when home and foreign goods are complement, the negative absorption effect becomes dominant over the positive switching effect. Thereby, a depreciation of the terms of trade following the productivity shock implies a fall in net foreign asset holdings. The implications of the lack of fiscal discipline, however, are not substantially affected. In fact, while a disciplined government would succeed in keeping NFA dynamics close to the Wicksellian path, figure 5 shows that under low fiscal discipline, the result would be a highly persistent and deep deterioration of the external balance, relative to our benchmark equilibrium.

4.3 Extension: Fiscal and Monetary Policy Shocks

The model can be used to evaluate the dynamic effects of a wide range of fiscal and monetary policy shocks. Here we summarize the main results (all impulse responses are available upon request).

First, a tax cut induces a fiscal deficit and the issuance of new debt to finance it.[27] On impact, the world and relative stocks of outstanding debt increase, as well as world and relative consumption, through wealth effects. The increase in relative consumption then induces upward pressures on relative marginal costs, which require an increase in relative

[27]We take this scenario to approximate, in the context of our stylized model, the situation in the U.S. at the beginning of the 1980s, when the Reagan administration approved the largest tax cut in American history while apparently not following any deficit feedback rule and the twin deficits first appeared

nominal interest rates (and the following appreciation in the nominal exchange rate and the terms of trade).

These events trigger the gradual accumulation of a current account deficit. Overtime, when the government does not tightly control debt dynamics, a persistent accumulation in the stock of public debt emerges, which then translates persistently into: negative external imbalances, depreciation of the exchange rate and eventually a negative relative consumption (when the negative effect of the current account deficit overrules the positive effect of accumulating public debt, according to equation (55)).

Although working through a different mechanism, and in a richer environment, therefore, we obtain the same qualitative results in terms of dynamics as Ganelli (JIE, 2005).

Second, a balanced-budget expansion in relative public consumption tends to raise relative marginal costs (equations (57)–(58)), thereby triggering an increase in relative interest rates to offset the inflationary pressures. This results in a short-run appreciation of the nominal exchange rate, which worsens the external position. As a consequence, relative consumption falls (equation (55)).

In our setting, therefore, due to the joint presence of home biased public consumption[28] and endogenous monetary policy, the final short-run effect on relative consumption and net foreign assets are the same as in Ganelli (JIE, 2005) and Obstfeld–Rogoff (JPE, 1995), while the effects on the exchange rate are reversed.

Third, it follows that a debt-financed expansion in public consumption (resulting from the combination of the two previously described policy actions) unambiguously induces an appreciation of the nominal exchange rate on impact (unlike in Ganelli, JIE 2005) and a depreciation in the transition.

Finally, persistent external imbalances can also arise following purely temporary monetary policy shocks. In the case of endogenous, counter-cyclical fiscal policy, a monetary policy shock affects inflation and the output gap, thereby triggering a reaction by the fiscal authority. Once the fiscal deficit is moved, fiscal discipline rules the medium-run dynamics of net foreign asset and public debt, which are going to revert back to mean, the faster the more disciplined the government. Hence, a fiscal authority with a low degree of fiscal discipline might leave room for growing and persistent external imbalances spurred also by temporary monetary policy shocks.

[28]This assumption follows most of the recent literature and seems roughly consistent with empirical evidence. Di Giorgio–Nisticò (2008) study analytically the role of home bias in public consumption for the exchange rate dynamics, in an extension of the *Redux* model.

4.4 Implied Volatilities.

Table 1 reports the standard deviations, in percentage points, of selected variables implied by all combinations of monetary and fiscal policy rules. For each entry (except for the Wicksellian policy) a bold figure indicates the relative performance with respect to a benchmark regime: with respect to domestic inflation and the output gap (driven to zero under Wicksellian policy), the comparison is made with the Domestic Inflation-based Taylor Rule, while for all other variables the bold figure reports the ratio with respect to the corresponding standard deviations implied by the Wicksellian regime. For the entries corresponding to low fiscal discipline (Low), we also report the relative volatility loss implied by a higher response to debt dynamics (ratio Low-to-High). Table 1 suggests the following.

First. Regarding the volatility of inflation and the output gap, the monetary policy interest rate rule reacting to *domestic* inflation (DITR) proves superior to all the other ones in approximating the Wicksellian regime, *regardless of the fiscal regime in place*. The third and fourth panels show the – familiar – result that reacting to CPI inflation or pegging the nominal exchange rate generates excessive smoothness in the exchange rate and the terms of trade relative to the benchmark case, and yields amplified fluctuations for both inflation and the output gap.[29] This is why we mainly discussed impulse responses for the DITR and FLOACT cases.

Second. Moving from controlling an interest rate to managing the exchange rate allows to better approximate the volatility of net foreign assets to the one obtained under the Wicksellian policy, *regardless of the fiscal regime in place*.

Third. Under the TX fiscal regime, both the stocks of net foreign assets and public debt experience huge volatilities, due to the near-unit root in the dynamics of the latter.

Fourth. Fiscal discipline pays off in terms of stability gain for both debt and net foreign assets, without any cost for the volatility of inflation and the output gap. Whatever the monetary regime, switching from Low to High fiscal discipline allows to better approximate the volatility under the Wicksellian benchmark, for both the stocks of net foreign assets and public debt.

Fifth. Comparing the cyclical properties of the policy mix consisting of aggressive managed float and poorly disciplined deficit rule (FLOACT-Low) with the ones of the alternative mix "DITR-High" shows that all endogenous variables are more stable if monetary policy deals with inflation and output gap and the fiscal authorities behave rigorously. As a matter of fact, the policy mix "FLOACT-Low" shows some ability in controlling the dynamics of the external balance, but it implies much higher volatility of inflation, the exchange rate and

[29] In terms of the volatility of net foreign assets, the excess smoothness of the exchange rate passes through to the external balance under "High" fiscal discipline. Under "Low" fiscal discipline, such volatility is strongly affected by the dynamics of public debt.

the output gap.

5 Concluding Remarks.

This paper lays out a tractable stochastic two-country "perpetual youth" DNK model, which achieves determinacy of steady state net foreign asset holdings, and allows for endogenous interaction of the external balance with fiscal and monetary policies. Within this framework we analyze the theoretical properties of deficit feedback rules (in line with most of the recent empirical literature) and investigate the dynamic and cyclical properties of several alternative combinations of monetary and fiscal policy following productivity (and fiscal) shocks.

We find that "fiscal discipline", defined as the degree of concern about public debt dynamics on the part of the fiscal authority, plays an important role for net foreign asset dynamics and exchange rate determination. Moving from a fiscal regime in which the budget deficit is set "exogenously" to one in which it "endogenously" responds to the business cycle (as the empirical evidence suggests for the 1990's) may induce a transmission mechanism that amplifies the distortions in the system, following a structural shock. In such circumstances, persistent deteriorations of the external balance may spur from fiscal expansions as well as from positive productivity shocks, and even after temporary monetary restrictions, unless an appropriate systematic response is granted to public debt dynamics ("High" fiscal discipline). Interestingly, however, the available empirical evidence does not support the view that such an appropriate response has characterized recent fiscal behavior of most industrialized countries, first and foremost the U.S. Any attempt by monetary policy alone to stabilize the external balance could prove somehow effective but would require excessive fluctuations in the exchange rate and imply high costs in terms of inflation and output gap volatility.

Consistently with existing literature on monetary policy, we also find that, with respect to inflation and output gap volatility, interest rate rules reacting to domestic inflation perform better than the alternatives considered, regardless of the fiscal regime in place.

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A Appendix

A.1 The Complete Model.

At time t, the aggregate *per-capita* equilibrium conditions read

$$\delta P_t^i C_t^i = W_t^i(1 - N_t^i) \tag{A.1}$$

$$P_t^i C_t^i + E_t \mathcal{F}_{t,t+1}^i \Omega_t^{*i} = P_t^i \varpi_t^i + \Omega_{t-1}^{*i} \tag{A.2}$$

$$\varpi_t^i = \frac{W_t^i}{P_t^i} N_t^i + D_t^i - T_t^i \tag{A.3}$$

$$P_t^i C_t^i = \sigma E_t \mathcal{F}_{t,t+1}^i \Omega_t^{*i} + \frac{1}{\beta} E_t \mathcal{F}_{t,t+1}^i P_{t+1}^i C_{t+1}^i \tag{A.4}$$

$$Y_t^i = \left(\frac{P_{i,t}^i}{P_t^i} \right)^{-\theta} C_t^W + G_t^i \tag{A.5}$$

$$B_{i,t}^* = (1 + r_{t-1}^i) B_{i,t-1}^* + Z_t^{*i} \tag{A.6}$$

$$nB_{H,t}^* = nB_{H,t}^{*H} + (1-n) B_{H,t}^{*F} \tag{A.7}$$

$$(1-n) B_{F,t}^* = nB_{F,t}^{*H} + (1-n) B_{F,t}^{*F} \tag{A.8}$$

$$P_t^i Z_t^i = P_{i,t}^i G_t^i - P_t^i T_t^i \tag{A.9}$$

$$MC_{i,t} = \frac{W_t^i}{P_{i,t}^i A_t^i} \tag{A.10}$$

$$\Xi_t^i Y_t^i = A_t^i N_t^i \tag{A.11}$$

$$P_t^i D_t^i = P_{i,t}^i Y_t^i - W_t^i N_t^i \tag{A.12}$$

$$\frac{P_{H,t}^H}{P_t^H} = \left[n + (1-n) \mathcal{S}_t^{1-\theta} \right]^{\frac{1}{\theta - 1}} = h(\mathcal{S}_t) \tag{A.13}$$

$$\frac{P_{F,t}^F}{P_t^F} = \left[n \mathcal{S}_t^{\theta - 1} + (1-n) \right]^{\frac{1}{\theta - 1}} = \mathcal{S}_t h(\mathcal{S}_t) \tag{A.14}$$

$$E_t \mathcal{F}_{t,t+1}^H \left[\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} (1 + r_t^F) - (1 + r_t^H) \right] = 0 \tag{A.15}$$

$$\mathcal{S}_t = \frac{P_{F,t}^i}{P_{H,t}^i} \tag{A.16}$$

$$Y_t^H - G_t^H = \mathcal{S}_t^{\theta} (Y_t^F - G_t^F) \tag{A.17}$$

$$C_t^W = nC_t^H + (1-n) C_t^F \tag{A.18}$$

$$Y_t^W = nh(\mathcal{S}_t) Y_t^H + (1-n) \mathcal{S}_t h(\mathcal{S}_t) Y_t^F \tag{A.19}$$

$$G_t^W = nh(\mathcal{S}_t) G_t^H + (1-n) \mathcal{S}_t h(\mathcal{S}_t) G_t^F \tag{A.20}$$

$$Y_t^W = C_t^W + G_t^W. \tag{A.21}$$

A.2 Steady-State.

In this Appendix we derive the relations characterizing a zero-inflation steady state.

First of all, the Uncovered Interest Parity implies $r^H = r^F = r$.

From equations (12), (29) and the aggregate production function we get

$$C^H = \frac{h(\mathcal{S})(A^H - Y^H)}{\delta(1+\mu)} \tag{A.22}$$

$$C^F = \frac{\mathcal{S}h(\mathcal{S})(A^F - Y^F)}{\delta(1+\mu)} \tag{A.23}$$

$$\frac{\mathcal{S}C^H}{A^H - Y^H} = \frac{C^F}{A^F - Y^F}, \tag{A.24}$$

and the world level of output:

$$Y^W = \frac{A^W + \delta(1+\mu)G^W}{1+\delta(1+\mu)}. \tag{A.25}$$

Define aggregate nominal dividends in each country as $P_t^i D_t^i = P_{i,t}^i Y_t^i - W_t^i N_t^i$. Using the definition of non-tradable wealth ϖ_t^i and equations (25), (13), and (15) we obtain:

$$\varpi^i = \frac{P_i^i}{P^i}(Y^i - G^i) - rB_i \tag{A.26}$$

$$\Omega^i = C^i + \frac{\Omega^i}{1+r} - \frac{P_i^i}{P^i}(Y^i - G^i) + rB_i \tag{A.27}$$

$$C^i\beta(1+r) = \beta\sigma\Omega^i + C^i \tag{A.28}$$

$$rB_i = -Z^i = T^i - \frac{P_i^i}{P^i}G^i \tag{A.29}$$

The definition of tradable financial wealth implies $\Omega^i = (1+r)[B_H^i + B_F^i]$, while the world amount of outstanding debt is denoted by $B \equiv nB_H + (1-n)B_F$. Hence, using equation (A.29), aggregation across countries yields:

$$\Omega^W = (1+r)B \tag{A.30}$$

$$rB = T^W - G^W = -Z^W. \tag{A.31}$$

Finally, we can aggregate (A.28) across countries, and use (A.30) to get:

$$\beta(1+r) = \frac{1}{1-\sigma B/C^W}, \tag{A.32}$$

which determines, together with equation (A.31), the world interest rate r and the world amount of outstanding debt B, given the world primary deficit Z^W.

Therefore, we can write

$$\beta(1+r) = 1+\psi, \tag{A.33}$$

in which

$$\psi \equiv \frac{\sigma B/C^W}{1-\sigma B/C^W}. \tag{A.34}$$

Considering for analytical simplicity a symmetric steady state with zero-primary deficit in both countries ($Z^i = 0$ and therefore $B_i = B = 0$), we obtain that $\psi = 0$ and the world interest rate is simply:

$$(1+r)\beta = 1. \tag{A.35}$$

Moreover, using (A.35) into (A.28) allows to pin down also the steady state aggregate financial wealth for each country i, which under the considered assumptions is zero:

$$\Omega^i = (1+r)(B_H^i + B_F^i) = 0. \tag{A.36}$$

The above also implies zero-holdings of net foreign assets, defined as the domestic claims on foreign assets net of the foreign claims on domestic assets (in per capita terms):

$$NF^H = B_F^H - \frac{1-n}{n}B_H^F = 0 \qquad\qquad NF^F = B_H^F - \frac{n}{1-n}B_F^H = 0. \tag{A.37}$$

Equation (A.36), combined with equations (A.27), allows to derive the steady state level of consumption for the two countries:

$$C^H = h(\mathcal{S})(Y^H - G^H) \tag{A.38}$$

$$C^F = \mathcal{S}h(\mathcal{S})(Y^F - G^F). \tag{A.39}$$

Using equations (A.22) and (A.38), ((A.23) and (A.39) for country F), we can pin down the steady state level of output:

$$Y^i = \frac{A^i + \delta(1+\mu)G^i}{1+\delta(1+\mu)}. \tag{A.40}$$

Given equations (A.24), (A.38), (A.39), the aggregate demands (24) and the above equation (A.40), we can also determine the steady state level for the terms of trade:

$$\mathcal{S} = \left(\frac{A^H - G^H}{A^F - G^F}\right)^{1/\theta}. \tag{A.41}$$

Notice that in a symmetric steady state ($A^H = A^F = A$ and $G^H = G^F = G$) the terms of trade is driven to $\mathcal{S}$=1, and symmetry applies also to all other real variables.[30]

[30] Hence:

$$Y = Y^W = Y^H = Y^F = \frac{A+\delta(1+\mu)G}{1+\delta(1+\mu)} \qquad D = D^H = D^F = Y\frac{\mu}{1+\mu}$$

$$N = N^W = N^H = N^F = \frac{1+\delta(1+\mu)\frac{G}{A}}{1+\delta(1+\mu)} \qquad \Omega = \Omega^W = \Omega^H = \Omega^F = 0$$

$$C = C^W = C^H = C^F = \frac{A-G}{1+\delta(1+\mu)} \qquad \mathcal{S} = h(\mathcal{S}) = f(\mathcal{S}) = 1$$

$$r = r^W = r^H = r^F = \frac{1-\beta}{\beta} \simeq -\log\beta \equiv \varrho \qquad T = T^H = T^F = G.$$

As a consequence, we also have

$$\varphi \equiv \frac{N}{1-N} = \frac{1+\delta(1+\mu)\frac{G}{A}}{\delta(1+\mu)(1-\frac{G}{A})}. \tag{A.42}$$

A.3 The Linear System.

After linearization around a zero-inflation, zero-deficit, symmetric steady state, therefore, the equations nedeed to study the equilibrium (given stochastic processes for g_t^i and a_t^i) are the following:

$$s_t = s_{t-1} + \Delta e_t + \pi_{F,t} - \pi_{H,t} \tag{A.43}$$

$$\alpha_t^H = \frac{1}{\beta}\alpha_{t-1}^H + (\theta-1)(1-n)s_t - (1-n)c_t^R \tag{A.44}$$

$$c_t^W = E_t c_{t+1}^W - (r_t^W - E_t\pi_{W,t+1} - \varrho) + \sigma b_t^W \tag{A.45}$$

$$c_t^R = E_t c_{t+1}^R + \sigma b_t^R + \frac{\sigma}{1-n}\alpha_t^H \tag{A.46}$$

$$b_t^H = \frac{1}{\beta}b_{t-1}^H + z_t^H \tag{A.47}$$

$$b_t^F = \frac{1}{\beta}b_{t-1}^F + z_t^F \tag{A.48}$$

$$r_t^R \equiv r_t^H - r_t^F = E_t\Delta e_{t+1} \tag{A.49}$$

$$\pi_{H,t} = \beta E_t\pi_{H,t+1} + \lambda^H mc_{H,t} \tag{A.50}$$

$$\pi_{F,t} = \beta E_t\pi_{F,t+1} + \lambda^F mc_{F,t} \tag{A.51}$$

$$mc_{H,t} = \frac{s_c+\varphi}{s_c}c_t^W + (1-n)c_t^R + (1-n)\frac{s_c+\varphi\theta}{s_c}s_t + \varphi g_t^H - (1+\varphi)a_t^H \tag{A.52}$$

$$mc_{F,t} = \frac{s_c+\varphi}{s_c}c_t^W - nc_t^R - n\frac{s_c+\varphi\theta}{s_c}s_t + \varphi g_t^F - (1+\varphi)a_t^F \tag{A.53}$$

$$z_{H,t} = s_c(g_t^H - \tau_t^H) - (s_c-1)(1-n)s_t \tag{A.54}$$

$$z_{F,t} = s_c(g_t^F - \tau_t^F) + (s_c-1)ns_t. \tag{A.55}$$

Closing the model with two monetary policy rules, determining either the nominal interest rate or the exchange rate, and two fiscal rules determining either the path of primary deficits or real taxes, and specifying some initial conditions for the position in net foreign asset, public debts and the terms of trade (α_{-1}^H, $b_{i,-1}$ and s_{-1}), we get a system of 17 stochastic difference equations, which yields as a solution the equilibrium values of the 17 endogenous variables:

$$\{s_t, \alpha_t^H, b_{H,t}, b_{F,t}, c_t^W, c_t^R, \Delta e_t, \pi_{H,t}, \pi_{F,t}, mc_{H,t}, mc_{F,t}, z_t^H, z_t^F, \tau_t^H, \tau_t^F, r_t^H, r_t^F\}_{t=0}^{\infty}$$

Considering then $c_t^W = c_t^H - (1-n)c_t^R = c_t^F + nc_t^R$ and the domestic demand schedules (41)–(42), we can finally recover also c_t^H, c_t^F, y_t^H, y_t^F, y_t^W.

A.4 The Flexible-Price Equilibrium

Let $\overline{m}_t$ denote the level of generic variable m_t in the flexible-price equilibrium at time t. Given stochastic processes for a_t^i and g_t^i, the complete linear model under flexible prices and counter-cyclical deficit rules becomes:

$$\Delta\overline{s}_t = \Delta\overline{e}_t \tag{A.56}$$

$$\overline{\alpha}_t^H = \frac{1}{\beta}\overline{\alpha}_{t-1}^H + (\theta-1)(1-n)\overline{s}_t - (1-n)\overline{c}_t^R \tag{A.57}$$

$$\overline{c}_t^W = E_t\overline{c}_{t+1}^W - \overline{rr}_t^W + \sigma\overline{b}_t^W \tag{A.58}$$

$$\overline{rr}_t^R = E_t\Delta\overline{s}_{t+1} \tag{A.59}$$

$$\overline{c}_t^R = E_t\overline{c}_{t+1}^R + \sigma\overline{b}_t^R + \frac{\sigma}{1-n}\overline{\alpha}_t^H \tag{A.60}$$

$$\beta\overline{b}_t^H - \beta\overline{z}_t^H = \overline{b}_{t-1}^H \tag{A.61}$$

$$\beta\overline{b}_t^F - \beta\overline{z}_t^F = \overline{b}_{t-1}^F \tag{A.62}$$

$$0 = \frac{s_c+\varphi}{s_c}\overline{c}_t^W + (1-n)\overline{c}_t^R + (1-n)\frac{s_c+\varphi\theta}{s_c}\overline{s}_t + \varphi g_t^H - (1+\varphi)a_t^H \tag{A.63}$$

$$0 = \frac{s_c+\varphi}{s_c}\overline{c}_t^W - n\overline{c}_t^R - n\frac{s_c+\varphi\theta}{s_c}\overline{s}_t + \varphi g_t^F - (1+\varphi)a_t^F \tag{A.64}$$

$$\overline{z}_t^H = \rho_z^H\overline{z}_{t-1}^H - (1-\rho_z^H)\mu_b^H\overline{b}_{t-1}^H + u_{z,t}^H \tag{A.65}$$

$$\overline{z}_t^F = \rho_z^F\overline{z}_{t-1}^F - (1-\rho_z^F)\mu_b^F\overline{b}_{t-1}^F + u_{z,t}^F. \tag{A.66}$$

In the flexible price equilibrium, marginal costs are zero in both countries, and so are domestic inflation rates. The condition $mc_{H,t} = mc_{F,t} = 0$ implies (aggregating across countries):

$$\overline{c}_t^W = \frac{s_c}{s_c+\varphi}\left((1+\varphi)a_t^W - \varphi g_t^W\right). \tag{A.67}$$

Moreover, the same condition also implies:

$$\overline{s}_t = \frac{s_c}{s_c+\varphi\theta}[(1+\varphi)a_t^R - \varphi g_t^R - \overline{c}_t^R]. \tag{A.68}$$

As to the remaining conditions, the relevant system to be studied is the following 6-by-6:

$$E_t\overline{c}^R_{t+1} + \sigma(\overline{b}^H_t - \overline{b}^F_t) + \frac{\sigma}{1-n}\overline{\alpha}^H_t = \overline{c}^R_t \tag{A.69}$$

$$\beta\overline{\alpha}^H_t = \overline{\alpha}^H_{t-1} - (1-n)\beta\theta\frac{s_c+\varphi}{s_c+\varphi\theta}\overline{c}^R_t + \beta(\theta-1)(1-n)\frac{s_c}{s_c+\varphi\theta}[(1+\varphi)a^R_t - \varphi g^R_t] \tag{A.70}$$

$$\beta\overline{b}^H_t - \beta\overline{z}^H_t = \overline{b}^H_{t-1} \tag{A.71}$$

$$\beta\overline{b}^F_t - \beta\overline{z}^F_t = \overline{b}^F_{t-1} \tag{A.72}$$

$$\overline{z}^H_t = \rho^H_z\overline{z}^H_{t-1} - (1-\rho^H_z)\phi^H_b\overline{b}^H_{t-1} + u^H_{z,t} \tag{A.73}$$

$$\overline{z}^F_t = \rho^F_z\overline{z}^F_{t-1} - (1-\rho^F_z)\phi^F_b\overline{b}^F_{t-1} + u^F_{z,t}. \tag{A.74}$$

Provided that the conditions on the response coefficients to the stock of outstanding debt in the fiscal rules are satisfied, the system above delivers the Wicksellian (or natural) values for the relative consumption $\overline{c}^R_t$, the net foreign asset holdings $\overline{\alpha}^H_t$, the two deficits $\overline{z}^i_t$ and the stocks of debt $\overline{b}^i_t$, for $i = H, F$.

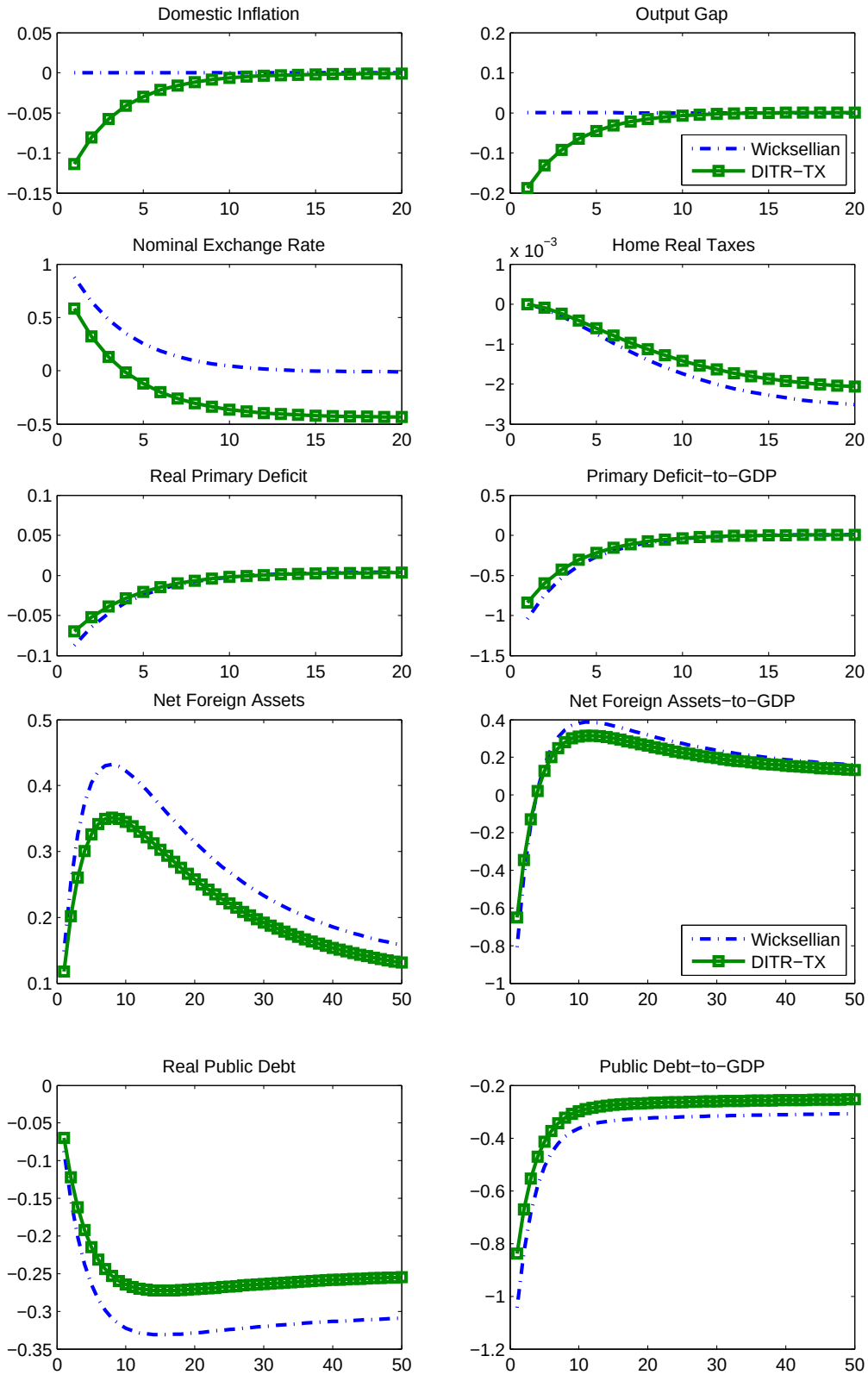

Figure 1: Dynamic responses in the H-country to a Home productivity shock when the Home Government has no target for the primary deficit.

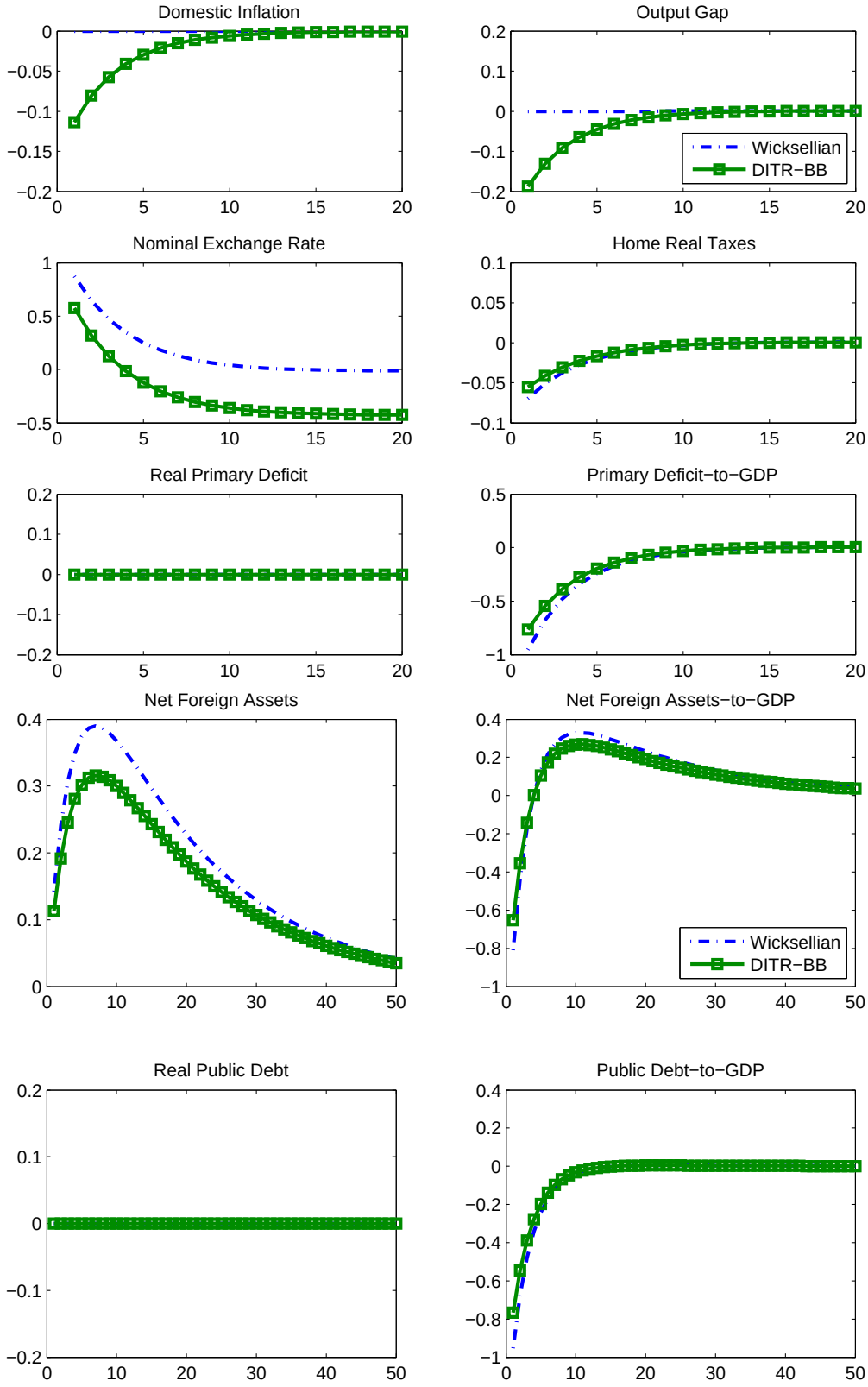

Figure 2: Dynamic responses in the H-country to a Home productivity shock when the Home Government runs balance budgets in every period.

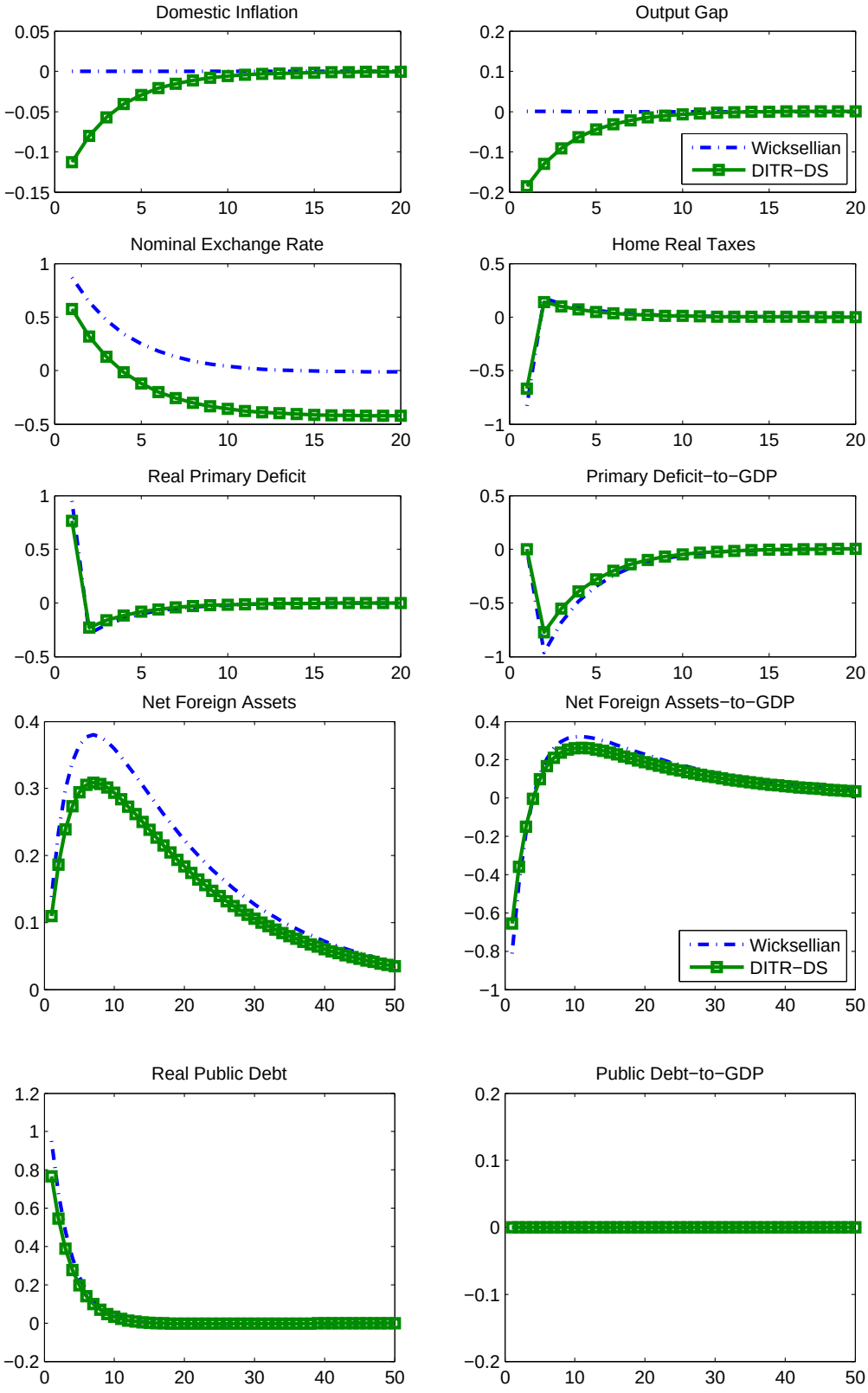

Figure 3: Dynamic responses in the H-country to a Home productivity shock when the Home Government stabilizes the debt-to-GDP ratios.

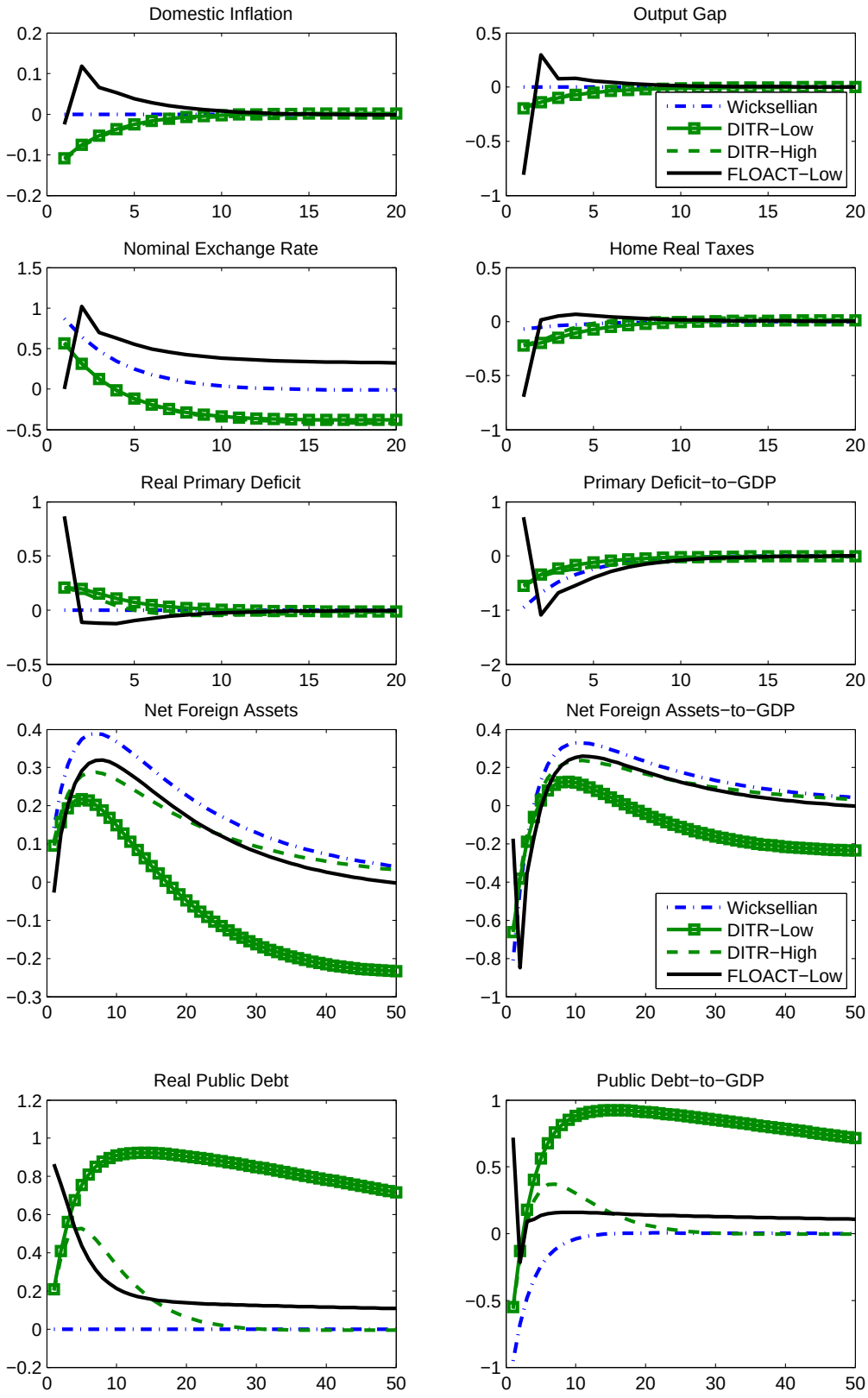

Figure 4: Dynamic responses in the H-country to a Home productivity shock when the Home Government follows a counter-cyclical deficit feedback rule (Low and High).

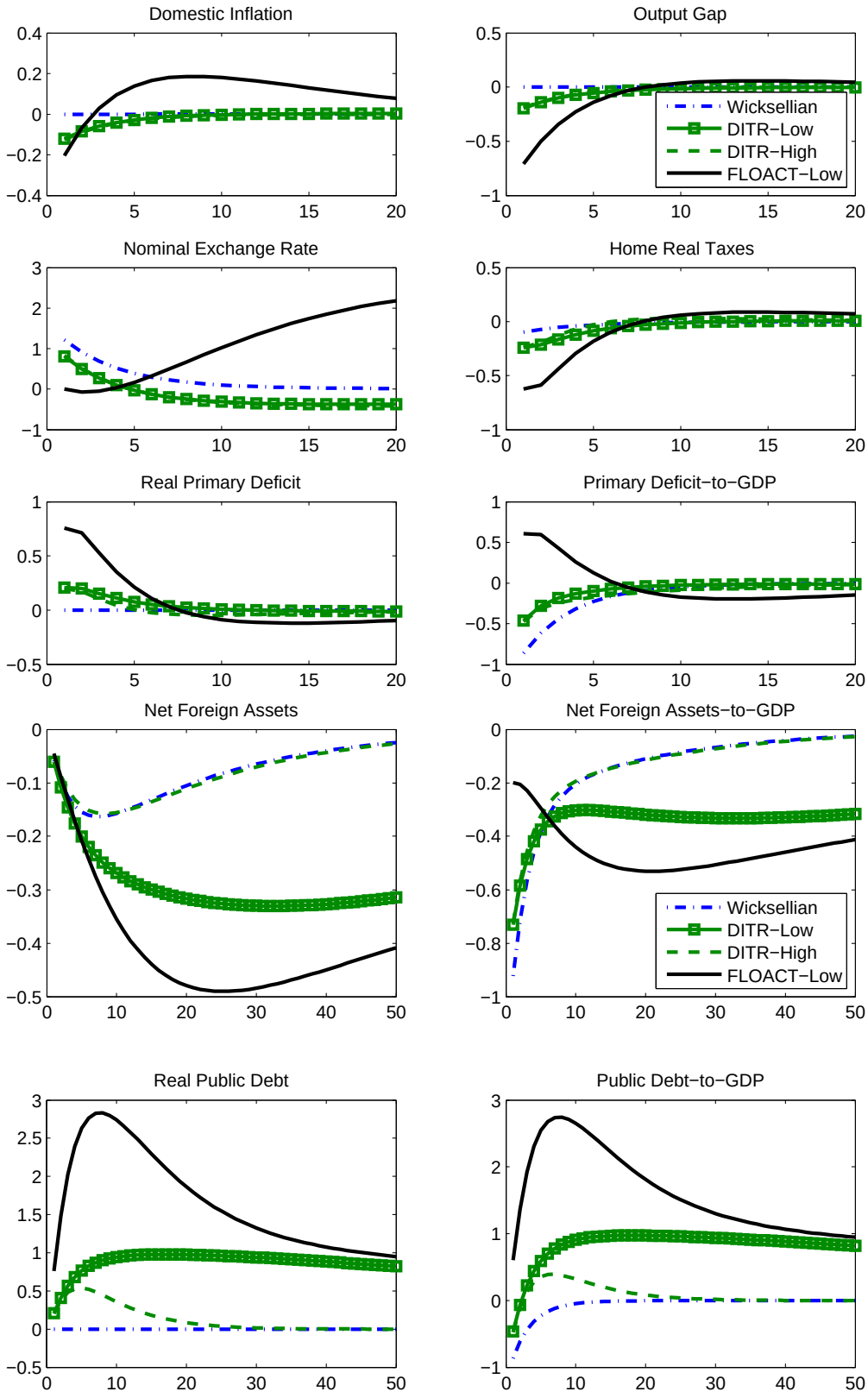

Figure 5: Dynamic responses in the H-country to a Home productivity shock when the Home Government follows a counter-cyclical deficit feedback rule (Low and High). Low Trade elasticity: $\theta = .85$.

Table 1. Cyclical properties of alternative policy regimes, Country *H*

Monetary Regime / ***Fiscal Regime***	**Wicksellian**					**DITR**					**CITR**				
	BB	***FR-Low***	***FR-High***	***DS***	***TX***	***BB***	***FR-Low***	***FR-High***	***DS***	***TX***	***BB***	***FR-Low***	***FR-High***	***DS***	***TX***
Output Gap	0.00	0.00	0.00	0.00	0.00	0.32	0.32	0.32	0.32	0.32	0.39	0.40	0.39	0.39	0.40
Ratio to DITR						**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.25**	**1.23**	**1.24**	**1.24**	**1.27**
Ratio to "FR-High"							***1.02***					***1.01***			
Domestic Infl.	0.00	0.00	0.00	0.00	0.00	0.11	0.11	0.11	0.11	0.63	0.12	0.12	0.12	0.12	0.62
Ratio to DITR						**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.06**	**1.06**	**1.06**	**1.06**	**0.99**
Ratio to "FR-High"							***1.02***					***1.02***			
CPI Inflation	0.33	0.33	0.33	0.33	0.35	0.36	0.36	0.36	0.36	0.72	0.23	0.23	0.23	0.23	0.65
Ratio to Wicksellian						**1.08**	**1.08**	**1.08**	**1.08**	**2.08**	**0.71**	**0.71**	**0.70**	**0.71**	**1.90**
Ratio to "FR-High"		***1.00***					***1.00***					***1.01***			
Nom. Int. Rates	0.28	0.28	0.28	0.28	0.69	0.40	0.41	0.40	0.40	1.31	0.34	0.35	0.34	0.34	1.28
Ratio to Wicksellian						**1.44**	**1.44**	**1.43**	**1.44**	**1.89**	**1.21**	**1.22**	**1.21**	**1.22**	**1.86**
Ratio to "FR-High"		***1.01***					***1.01***					***1.02***			
Depreciat. Rate	0.82	0.82	0.82	0.82	0.86	0.86	0.86	0.86	0.85	1.09	0.55	0.55	0.55	0.55	0.84
Ratio to Wicksellian						**1.04**	**1.04**	**1.04**	**1.04**	**1.26**	**0.67**	**0.67**	**0.67**	**0.67**	**0.97**
Ratio to "FR-High"		***1.00***					***1.00***					***1.00***			
Terms of Trade	1.09	1.10	1.09	1.09	1.79	1.04	1.04	1.04	1.04	1.77	0.94	0.94	0.94	0.94	1.70
Ratio to Wicksellian						**0.95**	**0.95**	**0.95**	**0.96**	**0.99**	**0.86**	**0.85**	**0.86**	**0.86**	**0.95**
Ratio to "FR-High"		***1.01***					***1.00***					***1.00***			
Govt Deficit	0.00	1.55	1.57	0.67	4.90	0.00	1.60	1.61	0.73	4.89	0.00	1.61	1.64	0.69	4.88
Ratio to Wicksellian						**--**	**1.03**	**1.03**	**1.08**	**1.00**	**--**	**1.04**	**1.04**	**1.02**	**1.00**
Ratio to "FR-High"		***0.99***					***0.99***					***0.98***			
Public Debt	0.00	19.68	3.80	0.87	330.58	0.00	20.16	3.96	0.84	329.29	0.00	20.11	4.01	0.83	329.14
Ratio to Wicksellian						**--**	**1.02**	**1.04**	**0.97**	**1.00**	**--**	**1.02**	**1.06**	**0.96**	**1.00**
Ratio to "FR-High"		***5.18***					***5.09***					***5.02***			
Net Foreign Assets	1.69	7.25	1.71	1.68	130.55	1.62	7.29	1.62	1.62	130.04	1.59	7.27	1.61	1.58	129.98
Ratio to Wicksellian						**0.96**	**1.00**	**0.94**	**0.96**	**1.00**	**0.94**	**1.00**	**0.94**	**0.94**	**1.00**
Ratio to "FR-High"		***4.24***					***4.51***					***4.53***			
Deficit-to-GDP	0.87	1.80	1.80	0.87	5.48	0.84	1.84	1.84	0.85	5.49	0.83	1.84	1.87	0.84	5.44
Ratio to Wicksellian						**0.97**	**1.02**	**1.02**	**0.97**	**1.00**	**0.95**	**1.02**	**1.04**	**0.96**	**0.99**
Ratio to "FR-High"		***1.00***					***1.00***					***0.99***			
Debt-to-GDP	0.87	19.69	3.90	0.00	330.15	0.84	20.15	4.03	0.00	328.82	0.83	20.10	4.05	0.00	328.68
Ratio to Wicksellian						**0.97**	**1.02**	**1.03**	**--**	**1.00**	**0.95**	**1.02**	**1.04**	**--**	**1.00**
Ratio to "FR-High"		***5.04***					***5.00***					***4.96***			
NFA-to-GDP	1.79	7.31	1.81	1.79	131.16	1.74	7.35	1.74	1.75	130.68	1.69	7.33	1.71	1.69	130.61
Ratio to Wicksellian						**0.98**	**1.01**	**0.97**	**0.98**	**1.00**	**0.95**	**1.00**	**0.95**	**0.95**	**1.00**
Ratio to "FR-High"		***4.04***					***4.22***					***4.28***			

Note: **Entries are standard deviations in %.**
Country F follows Wicksellian Monetary Rule and Deficit Feedback Rule

(... Table 1.)

Monetary Regime / ***Fiscal Regime***	**PEG**					**FLOPAS**					**FLOACT**				
	BB	***FR-Low***	***FR-High***	***DS***	***TX***	***BB***	***FR-Low***	***FR-High***	***DS***	***TX***	***BB***	***FR-Low***	***FR-High***	***DS***	***TX***
Output Gap	0.69	0.69	0.69	0.69	0.73	0.82	0.83	0.82	0.83	0.86	1.02	1.04	1.02	1.02	1.04
Ratio to DITR	**2.20**	**2.13**	**2.18**	**2.20**	**2.31**	**2.62**	**2.57**	**2.60**	**2.62**	**2.70**	**3.23**	**3.20**	**3.23**	**3.23**	**3.29**
Ratio to "FR-High"		***1.00***					***1.01***					***1.01***			
Domestic Infl.	0.19	0.19	0.19	0.19	0.22	0.17	0.19	0.17	0.17	0.19	0.13	0.16	0.13	0.13	0.14
Ratio to DITR	**1.70**	**1.64**	**1.70**	**1.70**	**0.34**	**1.50**	**1.65**	**1.51**	**1.51**	**0.30**	**1.18**	**1.41**	**1.21**	**1.19**	**0.22**
Ratio to "FR-High"		***0.98***					***1.11***					***1.19***			
CPI Inflation	0.11	0.11	0.11	0.11	0.12	0.35	0.37	0.36	0.35	0.36	0.70	0.72	0.71	0.70	0.71
Ratio to Wicksellian	**0.33**	**0.32**	**0.33**	**0.33**	**0.36**	**1.08**	**1.11**	**1.08**	**1.08**	**1.03**	**2.13**	**2.19**	**2.15**	**2.13**	**2.06**
Ratio to "FR-High"		***1.00***					***1.03***					***1.02***			
Nom. Int. Rates	0.29	0.30	0.29	0.29	0.68	0.71	0.73	0.71	0.71	0.94	1.62	1.66	1.63	1.62	1.76
Ratio to Wicksellian	**1.04**	**1.06**	**1.05**	**1.04**	**0.99**	**2.52**	**2.60**	**2.55**	**2.53**	**1.36**	**5.78**	**5.89**	**5.84**	**5.79**	**2.55**
Ratio to "FR-High"		***1.02***					***1.03***					***1.02***			
Depreciat. Rate	0.00	0.00	0.00	0.00	0.00	0.78	0.79	0.79	0.78	0.78	1.62	1.65	1.63	1.62	1.65
Ratio to Wicksellian	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.95**	**0.96**	**0.96**	**0.95**	**0.91**	**1.97**	**2.01**	**1.98**	**1.96**	**1.91**
Ratio to "FR-High"		***--***					***1.01***					***1.01***			
Terms of Trade	0.56	0.53	0.56	0.56	1.47	0.80	0.78	0.80	0.80	1.58	1.26	1.29	1.27	1.26	1.88
Ratio to Wicksellian	**0.52**	**0.48**	**0.51**	**0.52**	**0.82**	**0.73**	**0.71**	**0.73**	**0.73**	**0.89**	**1.15**	**1.17**	**1.16**	**1.15**	**1.05**
Ratio to "FR-High"		***0.96***					***0.98***					***1.01***			
Govt Deficit	0.00	1.75	1.78	0.78	4.88	0.00	1.81	1.85	1.08	4.88	0.00	1.83	1.89	1.73	4.89
Ratio to Wicksellian	**--**	**1.13**	**1.14**	**1.16**	**1.00**	**--**	**1.17**	**1.18**	**1.60**	**1.00**	**--**	**1.18**	**1.20**	**2.58**	**1.00**
Ratio to "FR-High"		***0.98***					***0.98***					***0.97***			
Public Debt	0.00	21.83	4.63	0.89	329.65	0.00	20.80	4.47	1.01	329.79	0.00	19.64	3.96	1.26	330.23
Ratio to Wicksellian	**--**	**1.11**	**1.22**	**1.02**	**1.00**	**--**	**1.06**	**1.18**	**1.17**	**1.00**	**--**	**1.00**	**1.04**	**1.45**	**1.00**
Ratio to "FR-High"		***4.71***					***4.65***					***4.96***			
Net Foreign Assets	1.30	7.56	1.25	1.30	130.16	1.37	7.29	1.35	1.36	130.22	1.57	7.17	1.59	1.56	130.40
Ratio to Wicksellian	**0.77**	**1.04**	**0.73**	**0.77**	**1.00**	**0.81**	**1.01**	**0.79**	**0.81**	**1.00**	**0.93**	**0.99**	**0.93**	**0.93**	**1.00**
Ratio to "FR-High"		***6.05***					***5.41***					***4.50***			
Deficit-to-GDP	0.89	2.10	2.15	0.90	5.31	1.01	2.31	2.37	1.02	5.35	1.26	2.61	2.66	1.27	5.49
Ratio to Wicksellian	**1.02**	**1.17**	**1.20**	**1.02**	**0.97**	**1.17**	**1.29**	**1.32**	**1.17**	**0.98**	**1.45**	**1.45**	**1.48**	**1.45**	**1.00**
Ratio to "FR-High"		***0.98***					***0.98***					***0.98***			
Debt-to-GDP	0.89	21.81	4.72	0.00	329.22	1.01	20.79	4.59	0.00	329.35	1.26	19.66	4.20	0.00	329.80
Ratio to Wicksellian	**1.02**	**1.11**	**1.21**	**--**	**1.00**	**1.17**	**1.06**	**1.18**	**--**	**1.00**	**1.45**	**1.00**	**1.08**	**--**	**1.00**
Ratio to "FR-High"		***4.62***					***4.53***					***4.68***			
NFA-to-GDP	1.53	7.64	1.49	1.53	130.77	1.62	7.38	1.61	1.63	130.83	1.87	7.27	1.89	1.87	131.01
Ratio to Wicksellian	**0.86**	**1.05**	**0.83**	**0.86**	**1.00**	**0.91**	**1.01**	**0.89**	**0.91**	**1.00**	**1.04**	**1.00**	**1.05**	**1.04**	**1.00**
Ratio to "FR-High"		***5.12***					***4.58***					***3.85***			

Note: **Entries are standard deviations in %.**
Country F follows Wicksellian Monetary Rule and Deficit Feedback Rule