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Abstract

In this paper the interaction between FX markets driven by trading based on behavioral forecasting rules and the macroeconomy of a small open economy is investigated. A special focus of the paper is set on the consequences of chartism or technical analysis for the stability at the macroeconomic level. Furthermore, the performance of alternative monetary policy rules concerning the overall stabilization of the economy is investigated through numerical analysis.

Keywords: Behavioral Expectations, Exchange Rate Dynamics, Monetary Policy
JEL CLASSIFICATION SYSTEM: F3, E44, E52

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1 Introduction

One of the most defining characteristics of small open economies, and specially of emerging market countries, is their greater reliance on nominal and real exchange rate developments than larger and relatively more closed economies (for example, as emphasized by Calvo and Reinhart (2002), exchange rate shocks in emerging market economies tend to feed into aggregate inflation at a much faster rate than in industrial economies). As it is widely acknowledged, this macroeconomic characteristic conveys both advantages and disadvantages: On the one hand, small open economies can match external and internal shocks in an easier and faster manner than larger and more closed economies through accordant adjustments of their nominal and real exchange rates. On the other hand, however, the greater reliance on the nominal exchange rate of such economies complicates the conduction of an independent monetary policy, and makes them much more dependent on developments in the international financial markets.

So far, in a great amount of the literature on international finance and small open economies – including the NOEM (New Open Economy Macroeconomics) DSGE strain put forward by Obstfeld and Rogoff (1995) – the dynamics of the nominal exchange rate are determined by the forward-looking behavior of economic agents with rational expectations. However, even though theoretically appealing, the empirical implications of the rational expectations assumption seem to be at odds with empirical data of the dynamics of nominal exchange rates (see Engel and West (2005) for an alternative view on this respect). Indeed, as pointed out e.g. by De Grauwe and Grimaldi (2006), Efficient Markets Rational Expectations (EMRE) models seem incompatible with important stylized facts on foreign exchange (hereafter FX) rate fluctuations as well as the occurrence of speculative bubbles, herding behavior and currency runs. On the contrary, behavioral "non-rational" models, that is, models which feature economic agents with heterogenous beliefs, attitudes or trading schemes, seem much more successful in this task, see e.g. Frankel and Froot (1987), Allen and Taylor (1992), Cheung and Chinn (2001) and Manzan and Westerhoff (2007). Indeed, the inclusion of such a heterogeneity, and therefore of a somewhat "non-rational" behavior by the economic agents has proven quite valuable in providing insights and explanations concerning some of the "puzzles" which arise when "rationality" is assumed (see De Grauwe and Grimaldi (2006, ch.1) for an extensive discussion of the advantages of the heterogenous agents-approach with respect to the rational-expectations approach in the explanation of empirical financial market data).

The analysis undertaken in the majority of such non-rational, heterogenous expectations models has been, however, often constrained to the FX markets by assuming an exogenous stochastic process for the fundamental nominal exchange rate; The effects of a non-rational behavior by the FX market participants for the dynamic macroeconomic stability of small open economies, as well as for the conduction and effectiveness of monetary policy, have still not been widely investigated.

In this paper an attempt is made to fill in this gap by analyzing the performance of different monetary policy rules in a stylized macroeconomic model with a FX market where traders choose between two behavioral forecasting rules concerning the future development of the nominal exchange rate: fundamentalism and chartism. The main contribution of this paper to the literature is thus its focus on the one hand on the role of behavioral FX trading not only for the dynamics and stability of that single market but for those of the economy as a whole, and on the other hand, the analysis of the effectiveness of monetary policy concerning macroeconomic stabilization in such an environment.[1]

The remainder of the paper is organized as following: In section 2 the theoretical framework is described. The basic dynamics of the model is also discussed in section 2. Section 3 describes a variety of stochastic simulations of the model under different monetary policy rule specifications. Finally, section 4 draws some concluding remarks from this study.

2 The Model

In the following a small open economy is assumed which is linked with the rest of the world through international trade of goods and services, as well as through an international FX market with perfect capital mobility.

[1]Recent research within the DSGE framework has also focused on the interplay of macroeconomic fundamentals, nominal and real exchange rate dynamics and monetary policy rules: see e.g. Benigno and Benigno (2008).

2.1 The International FX Market

As in Proaño (2011) an international FX market is assumed, where traders – no matter their nationality – can freely trade domestic in foreign currency (and vice versa) and then invest in both domestic and foreign bonds given the perfect capital mobility between the domestic economy and the rest of the world. This international FX market is characterized by "boundedly rational" traders which, due to informational, time and/or cognitive constraints, do not/cannot calculate "mathematically rational" expectations with respect to the future dynamics of the nominal exchange rate (as it is assumed in the NOEM/DSGE framework), but use behavioral forecasting rules for this task instead.

For the following formulation of the sequence of events underlying the theoretical model of this paper, it is useful to differentiate between the beginning and the end of a period t, and to consider the timing under which data becomes observable related with such a differentiation: Since contemporaneous variables which are determined within a period t only become observable at the end of that period, they can still not be contained in the information set available to the economic agents at the beginning of a period t, entering the information set available to agents not until the beginning of period $t+1$. In a world of "non-rational" financial market agents, thus, they make their economic decisions at the beginning of a period t for period t on the basis of the macroeconomic data generated up to $t-1$.

Accordingly, let us now assume that the following sequence of events holds: At the beginning of a period t, the FX market participants form their forecasts of the nominal exchange rate at $t+1$ on the basis of the information set containing macroeconomic data generated up to $t-1$. Independently, the domestic monetary authorities set the nominal interest rate on the basis of the same information. Then, given the perfect capital mobility between the domestic economy and the rest of the world and the trading of the FX market participants on the basis of (possibly) different forecasts, the nominal exchange rate level of period t adjusts so that the Uncovered Interest Rate Parity (UIP) holds at the market level. Finally, the real variables output and inflation in the domestic economy are determined.

As it is done in the majority of heterogeneous expectations models in order to make the theoretical dynamics of the nominal exchange rate more accordant with the empirical evidence, see e.g. De Grauwe and Grimaldi (2006) and Manzan and Westerhoff (2007), the FX traders are assumed to choose between two types of behavioral forecasting rules: one which only takes into account certain macroeconomic fundamentals (the "fundamentalist" rule), and one which is based only on the past developments of the nominal exchange rate (the "chartist" or "technical analysis" rule).

Accordingly, let now s_t represent the logarithm of nominal exchange S_t and E_t^j denote the expectations operator of a particular behavioral forecasting rule j based on the information set available at the beginning of period t. Then, according to the "fundamentalist" forecasting rule, the expected log nominal exchange rate at $t+1$ is given by

$$E_t^f s_{t+1} = s_{t-1} + \beta_s^f (f_{t-1} - s_{t-1}), \tag{1}$$

where f_{t-1} represents the (log) fundamental nominal exchange rate at time $t-1$ and $\beta_s^f > 0$ a scaling factor linked with the speed of adjustment of the log nominal exchange rate towards its long-run equilibrium level f assumed by the fundamentalists.[2] As it is usually done in the literature (see e.g. Froot and Rogoff (1995), Taylor and Peel (2000) and Taylor, Peel and Sarno (2001)), the PPP postulate (in its absolute form) is assumed to represent the long-run point of reference for the nominal (and real) exchange rate, that is

$$f_t = p_t - p_t^* \tag{2}$$

with $p_t = \ln(P_t)$ and $p_t^* = \ln(P_t^*)$ denoting the log price levels in the domestic and foreign economies, respectively (in the following foreign economy variables will be denoted by *).[3] Inserting this expression in eq.(1) delivers

$$\begin{aligned} E_t^f s_{t+1} &= s_{t-1} + \beta_s^f (p_{t-1} - p_{t-1}^* - s_{t-1}) \\ &= s_{t-1} - \beta_s^f \eta_{t-1} \end{aligned} \tag{3}$$

where η_t is the log of the real exchange rate $\mathcal{N} = SP^*/P$ at time t and $\eta_o = 0$ its PPP-consistent level.

[2] Note that this scaling factor could depend on the past absolute deviations of the expected nominal exchange rate values from their actual level, as assumed for example in De Grauwe and Grimaldi (2005), see also Proaño (2011).

[3] Note that this is not the only possible specification for the fundamentalist rule: The "fundamentalist" expected nominal exchange rate depreciation could also be determined by the PPP in its relative form, that is $E_t^f(\Delta s_{t+1}) = \pi_t - \pi_t^*$ (π_t and π_t^* being the domestic and foreign price inflation rates).

By contrast, according to the "chartist" forecasting rule, the respecting expected log nominal exchange rate at $t+1$ is assumed to be given by

$$E_t^c s_{t+1} = s_{t-1} + \beta_s^c \Delta s_{t-1}, \tag{4}$$

where $\Delta s_{t-1} = s_{t-1} - s_{t-2}$ and $\beta_s^c > 0$ is a scaling factor representing the degree of "persistence" or trend-chasing by the nominal exchange rate expected by the "chartist" forecasting rule.

With (eventually) different expectations concerning the future development of the nominal exchange rate resulting from the two behavioral forecasting rules just described, the last-period earnings of investing one unit of domestic currency in the foreign currency depend of course on the accuracy of the respective forecasting rules in the previous period (see De Grauwe and Grimaldi (2006)), that is

$$\psi_{t-1}^j = [S_{t-1}(1+i_{t-1}^*) - (1+i_{t-1})S_{t-2}] \text{ sgn } [E_{t-2}^j \Delta s_{t-1}] \quad j = c, f \tag{5}$$

with

$$\text{sgn}[\, E_{t-2}^j \Delta s_{t-1} \,] = \begin{cases} 1 & \text{for } E_{t-2}^j \Delta s_{t-1} > 0 \\ 0 & \text{for } E_{t-2}^j \Delta s_{t-1} = 0 \\ -1 & \text{for } E_{t-2}^j \Delta s_{t-1} < 0 \end{cases}$$

According to eq.(5), if for example a domestic currency depreciation from $t-2$ to $t-1$ was implied by the chartism rule ($E_{t-2}^c \Delta s_{t-1} > 0$) and the nominal exchange rate indeed depreciated ($\Delta s_{t-1} > 0$), the profit associated with the use of the technical analysis rule is equal to $S_{t-1}(1+i_{t-1}^*) - (1+i_{t-2})S_{t-2}$. If in contrast the FX market traders use the fundamentalist rule according to which $E_{t-2}^f \Delta s_{t-1} < 0$, but $\Delta s_{t-1} > 0$ actually occurs, they make an analogous associated loss of the same amount. Accordingly, the FX market traders choose between the two forecasting rules on the basis to their respective relative profitability in the previous period.

At every t, the share of FX traders using the fundamentalist forecasting rule (the so-called "market mood" in Dieci, Foroni, Gardini and He (2005)) is given by the variable ω_t, which, in the spirit of Brock and Hommes (1997, 1998) – see also De Grauwe and Grimaldi (2006), is determined by

$$\omega_t = \frac{\exp[\gamma(\psi_{t-1}^f - \sigma_{f,t-1}^2)]}{\exp[\gamma(\psi_{t-1}^f - \sigma_{f,t-1}^2)] + \exp[\gamma(\psi_{t-1}^c - \sigma_{c,t-1}^2)]} \tag{6}$$

with

$$\lim_{\psi^f_{t-1}\to\infty} \omega_t = 1 \quad \text{and} \quad \lim_{\psi^f_{t-1}\to 0} \omega_t = 0,$$

and

$$\sigma^2_{j,t-1} = (E^j_{t-2}S_{t-1} - S_{t-1})^2 \quad j = c, f,$$

being the last period's squared forecast error of the behavioral forecasting rule j and γ measuring the sensitivity with which traders revise their choice of the forecasting rules. The evolution of the market mood variable ω_t is thus assumed to be determined by the relative profitability resulting from the fundamentalist and the chartist forecast rules, by their actual accuracy as well as by the sensitivity of the market with respect to investment return differentials.[4]

Figure 1 illustrates the ω function for different values of ψ^f and ψ^c (assuming σ_f and σ_c to be zero for simplicity).

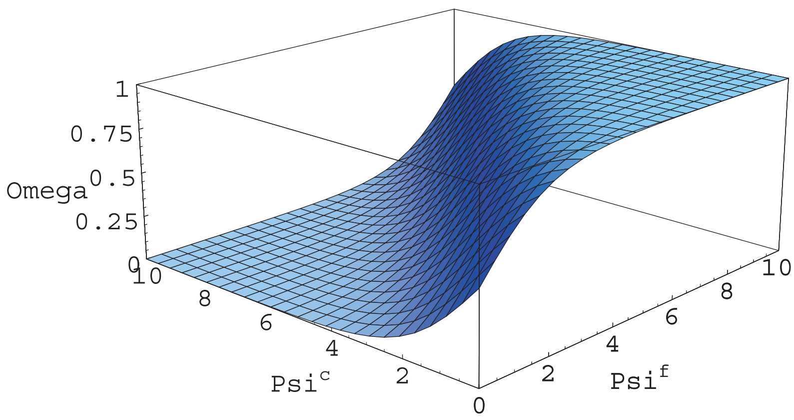

Figure 1: The ω_t function

As it can be clearly observed, for similar values of ψ^f and ψ^c (i.e. for similar returns associated with the use of the fundamentalist and chartist rules), ω is approximately 0.5. But as the differential between ψ^f and ψ^c grows, the share of traders using the fundamentalist rule ω either increases (for $\psi^f > \psi^c$) or decreases (for $\psi^c > \psi^f$), moving towards 1 in the first case and towards 0 in the second case.

[4]It is worth noting that a higher γ implies a stronger reaction to the profitabilities differentials between the two rules, and could be related with periods of higher FX market volatility.

On the basis of the expressions for $E_t^f s_{t+1}$ and $E_t^c s_{t+1}$ given by eqs. (1) and (3), respectively, and eq.(6), the market expectation of the log nominal exchange rate at $t+1$ is simply the weighted average of the two expected nominal exchange rates, that is

$$\begin{aligned} E_t^m s_{t+1} &= \omega_t E_t^f s_{t+1} + (1-\omega_t) E_t^c s_{t+1} \\ &= s_{t-1} - \omega_t \beta_s^f \eta_{t-1} + (1-\omega_t)\beta_s^c \Delta s_{t-1}. \end{aligned} \tag{7}$$

with ω_t given by eq.(6).

Given the perfect capital mobility assumed in the model, the expected rates of return of domestic and foreign bonds are equated by the adjustment of the log nominal exchange rate s_t to the interest rate differentials and the market expectations on the future nominal exchange rate, that is

$$s_t = i_t^* - i_t + E_t^m s_{t+1}. \tag{8}$$

It is important to notice that the UIP condition – which implies the equality of expected returns of the domestic and foreign interest bearing assets at the market level – is thus assumed to hold in this framework – though under a behaviorally determined $E_t^m s_{t+1}$ instead of the "mathematically rational" $E_t s_{t+1}$ assumed in the standard international finance literature. This turns clear after the insertion of $E_t^m s_{t+1}$ in eq.(8), namely

$$s_t = i_t^* - i_t + s_{t-1} - \omega_t \beta_s^f \eta_{t-1} + (1-\omega_t)\beta_s^c \Delta s_{t-1}. \tag{9}$$

It should be pointed out, however, that the UIP condition holds only *ex-ante* in this model through the immediate adjustment of the nominal exchange rate to eventual differential in the expected return rates of the two financial assets. Such a return equality does not, of course, hold *ex-post*, especially if the agents' expectations formation is based on subjective behavioral rules.

By subtracting s_{t-1} from both sides, we obtain the following behaviorally founded law of motion for the log nominal exchange rate

$$\Delta s_t = i_t^* - i_t - \omega_t \beta_s^f \eta_{t-1} + (1-\omega_t)\beta_s^c \Delta s_{t-1}. \tag{10}$$

It should be noted that since the relative weight of the two forecasting rules ω_t is still determined by eq.(6), the dynamics of the log nominal exchange rate described by eq.(9) or rather eq.(10) are determined not only by the nominal interest rate differentials as it is standard in the literature, but – innovatively – also by the relative importance of the "fundamentalist" and "chartist" forecasting rules in the FX market (the "market mood"), which depends in turn in a nonlinear manner (see Figure 1) on the relative profitability of both rules and therefore, indirectly, also on the nominal interest rate differentials.

It is important to highlight that the resulting equation eq.(9) or rather eq.(10) indeed are able, at least theoretically, to account for important stylized facts of the dynamics of the nominal exchange rate such a regime switching behavior (determined by the relative profitability and interplay of the two forecasting rules), periods of large persistence in the nominal exchange rate (and of deviations of the real exchange rate from the PPP level) as well as nonlinear nominal exchange rate adjustments towards PPP, as assumed theoretically e.g. by De Grauwe and Grimaldi (2005) and documented empirically by Taylor and Peel (2000) Taylor et al. (2001), among others. We will address some of these issues below.

2.2 The Macroeconomy

In order to keep this exposition as transparent as possible, the real side of the economy is modeled in a quite parsimonious manner. Accordingly, the output dynamics are represented by the following standard open-economy IS-relationship

$$y_t = \alpha_y y_{t-1} - \alpha_{yr}(i_{t-1} - \pi_t - (i_o - \pi_o)) + \alpha_{y\eta}\eta_{t-1}, \qquad \alpha_y \leq 1, \tag{11}$$

where y_t denotes the output gap (defined as log deviations of actual output from its potential level), i_{t-1} the short-term nominal interest rate (i_o being the steady state nominal interest rate), π_t the price inflation rate (π_o being the steady state inflation rate) and η_t the log real exchange rate, with $\eta_t = \eta_o = 0$.

With respect to the domestic price inflation dynamics, a standard backward-looking Phillips Curve equation of the form

$$\pi_t = \alpha_{\pi y} y_{t-1} + \alpha_\pi \pi_{t-1}, \tag{12}$$

is assumed, where $\alpha_{\pi y}$ represents the slope of the Phillips curve and α_π the degree of inflation persistence present in the economy.[5]

[5]The use of a forward-looking Phillips Curve as usually done in the literature would imply additional

Together with the law of motion for the log nominal exchange rate given by eq.(10), the price inflation adjustment equation for the domestic economy (assuming $\pi_t^* = \bar{\pi}^*$ =const.) delivers the following equation for the evolution of the log real exchange rate:

$$\begin{aligned} \Delta\eta_t &= \Delta s_t + \bar{\pi}^* - \pi_t \\ &= i_t^* - i_t - \omega_t \beta_s^f \eta_{t-1} + (1-\omega_t)\beta_s^c \Delta s_{t-1} + \bar{\pi}^* - \pi_t. \end{aligned} \tag{13}$$

with ω_t given by eq.(6).

2.3 Monetary Policy

Concerning monetary policy, the following general specification for the domestic nominal interest rate

$$i_t = \phi_i i_{t-1} + (1-\phi_i)\left[i_o + \phi_\pi(\pi_{t-1}^c - \pi_o) + \phi_y\, y_{t-1} + \phi_s \Delta s_{t-1} \right] \tag{14}$$

is formulated, with

$$\pi_t^c = (1-\xi)\pi_t + \xi\pi_t^m = (1-\xi)\pi_t + \xi(\pi_t^* + \Delta s_t),$$

defining CPI inflation, $\pi_t^m = \pi^* + \Delta s_t$ being the domestic-currency inflation of foreign goods and ξ being the share of imported goods in the CPI basket – set equal to $\xi = 0.15$ following Rabanal and Tuesta (2006). In this general specification, the nominal interest rate set by the central bank is thus assumed to depend on the steady state nominal rate of interest i_o, on the inflation gap $\pi^c - \pi_o$ (with a reaction strength ϕ_π), on the output gap (with a reaction strength ϕ_y), and on the nominal exchange rate growth Δs (with a reaction strength ϕ_s).

As it can be clearly observed, eq.(14) is a general formulation of the response of the domestic monetary authorities to a variety of macroeconomic variables which can be easily adjusted to represent different monetary policy rules. For instance, a monetary policy rule

assumptions concerning the expectations of future inflation which would detract from the focus of this paper on the FX markets. In this sense, the use of a New Keynesian Phillips curve of the form $\pi_t = E_t(\pi_{t+1}) + \kappa y_t$, with E_t as the mathematical expectations operator, would imply a rational inflation expectations formation concerning price inflation which would stand at odds with the behavioral expectations formation in the FX market assumed in this paper.

with a PPI inflation target, an output gap target and an interest rate smoothing term can be obtained by setting $\xi = 0$ and $\phi_s = 0$, so that

$$i_t = \phi_i i_{t-1} + (1 - \phi_i)\left[i_o + \phi_\pi(\pi_{t-1} - \pi_o) + \phi_y\, y_{t-1}\right].$$

In contrast, a flexible CPI inflation targeting without interest rate smoothing results when $\phi_i = 0$ and $\phi_s = 0$, namely

$$i_t = i_o + \phi_\pi(\pi^c_{t-1} - \pi_o) + \phi_y\, y_{t-1},$$

and a strict nominal exchange rate targeting without interest rate smoothing can be expressed by $\phi_\pi = 0$, $\phi_i = 0$ and $\phi_y = 0$ as

$$i_t = i_o + \phi_s \Delta s_{t-1}.$$

Before analyzing in detail the performance of alternative monetary policy rules in this behavioral macroeconomic framework, in the next section the model's dynamic adjustment to one-time shocks are discussed.[6]

2.4 Dynamic Adjustments

The parameter values underlying the following simulations are summarized in Table 1. Since a monthly frequency is assumed in the following, $\beta^f_s = 1/6$ implies that according to the fundamentalist rule deviations of the nominal exchange rate from PPP are expected to be corrected ceteris paribus within six months. The value $\beta^c_s = 1.25$, in contrast, implies that a certain overshooting – of a small dimension though – expected by the chartism rule. Concerning the market sensitivity parameter, an intermediate value of $\gamma = 10$ was chosen as the baseline. All other parameters are standard in the literature, see e.g. Gerlach and Smets (1999) and reflect the significant autocorrelation of output gap and price inflation, the negative influence of the output gap on the real interest rate, as well as the positive dependence of the former on the real exchange rate.

As it can be observed in Figure 2, a one-time increase in the domestic nominal interest rate leads to a differentiated performance of the chartist and fundamentalist forecasting

[6]Due to the fact that we do not assume rational expectations formation, the differentiation between anticipated and unanticipated shocks is not applicable here.

Table 1: Parameter Values

Output Gap	Phillips Curve	Monetary Policy	FX Markets
$\alpha_y = 0.9$	$\alpha_{\pi y} = 0.24$	$\phi_i = 0.7$	$\beta_s^f = 1/6$
$\alpha_{yr} = 0.1$	$\alpha_\pi = 0.8$	$\phi_\pi = 1.5$	$\beta_s^c = 1.25$
$\alpha_{y\eta} = 0.01$		$\phi_y = 0.5$	$\gamma = 10$

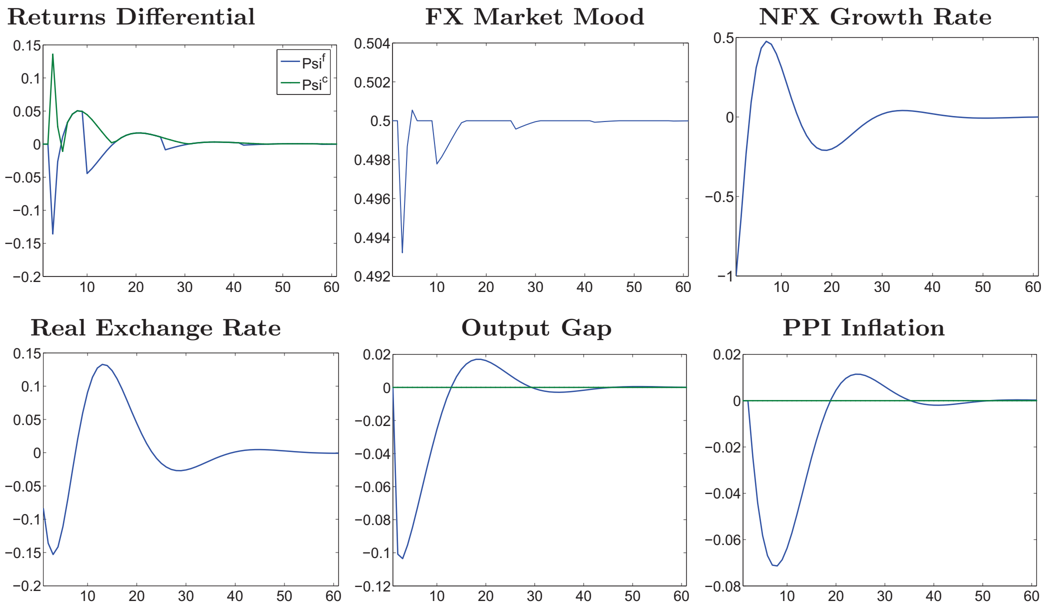

Figure 2: Dynamic responses of FX markets and real economy to a one-time domestic monetary policy shock

strategies, which in turn leads in the first instance to a shift in the FX market mood towards chartism (or, in other words, to a reduction of the share of fundamentalists in the market). Further, the initial appreciation of the nominal and real exchange rate – together with the nominal interest rate increase – lead to a downturn of economic activity and to a reduction of domestic price inflation below its baseline level, which in turn lead to a decrease in the nominal interest rate beyond its initial value due to its endogenization via the monetary policy rule given by eq.(14) (not shown in Figure 2). The domestic interest rate reaction, in turn, feeds back again in the performance of the chartists and fundamentalists in the FX markets, influencing again the FX market mood and the path of the nominal exchange rate, which experiences a depreciation beyond its initial level.

It should be however noted that due to the non-linear specification of FX market mood variable ω, see eq.(6), its reaction is not monotonic but rather abrupt and not easily unforecastable, as illustrated in the second panel of the first row in Figure 2. The non-linear reaction of ω should not, however, be interpreted as a potential source of instability for the FX market, but instead as a catalyzer of the (stabilizing and destabilizing) impulses stemming from the real economy, monetary policy and the FX traders.[7] Indeed, in first instance the dynamic reaction to shocks, and especially the amplitude and persistence (as well as the potential divergent behavior) of the nominal exchange rate is determined by the relative predominance of the two forecasting strategies in the FX market, determined in turn by their relative profitability, and thus by the actual values of β_s^f and β_s^c.[8]

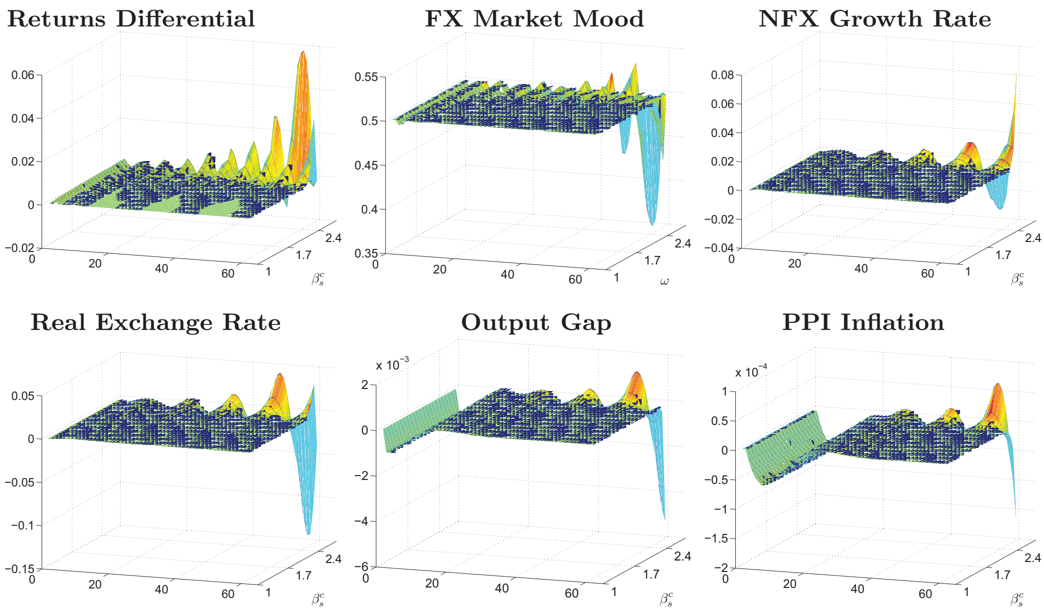

Figure 3: Dynamic responses of FX markets and real economy to a one-time domestic monetary policy shock for varying values of $\beta_s^c \in (0, 2.4)$ (with $\beta_s^f = 0.5$)

[7]Ehrmann and Fratzscher (2005, p.16) state in this respect: "[...] the reaction of exchange rates to monetary policy decisions also depends on the markets's interpretation of the underlying reason for the decisions and the expected effect on the economy."

[8]The apparent nonlinear adjustment of nominal exchange rates with respect to macroeconomic fundamentals, one of the main stylized facts in the behavioral international finance literature, lead to the presumption that these parameter (assuming its actual existence) are quite likely to be state-dependent and time-varying in the real world, as discussed in Taylor et al. (2001).

Figure 3 illustrates the importance of the degree of chartism, and thus of the specific forecasting rules used by the FX traders not only for the stability of the FX market, but of the economy as a whole: There the reaction of all macroeconomic variables to a one-time domestic nominal interest rate shock for different values of the trend-chasing parameter $\beta_s^c \in (0, 2)$ and $\beta_s^f = 0.5$ (for the sake of a better graphical exposition) is illustrated. As it can be observed, for increasing values of β_s^c, the response of the macroeconomic variables to the initial monetary policy shock becomes more persistent and of a larger amplitude due to the increased persistence of the nominal exchange rate induced by such large values.[9] As it can be clearly observed, larger values of β_s^c act in a clearly destabilizing manner not only for the dynamics in the FX markets, but also for the dynamics of the real economy, due to the feedback of the nominal exchange rate on the real side of the economy and the subsequent reaction of the interest rate.[10]

It should be clear, however, that the extent by which the destabilizing chartism rule may affect the actual dynamics of the nominal exchange rate and also the real economy depends to a great extent on the sensitivity of the FX market with respect to the period return differentials of the two forecasting strategies. In the present model, as previously discussed, this degree of sensitivity (which, however, should not be mistaken with "rationality") is represented by the parameter γ. Figure 4 illustrates the influence of this parameter on the dynamics of the model using the (stable) parameter values given by Table 1.

Indeed, as it can be clearly observed in this last figure for the case of a domestic aggregate demand shock, larger values of γ unambiguously lead to a significant increase in the amplitude of the dynamic adjustment of the FX market mood variable. However, given the fact that all other parameter values are chosen such that no divergent behavior takes place, an increase in the sensitivity of the FX market with respect to the returns differentials of the alternative forecasting rules (represented here by larger values of γ) does not seem to translate (at least for the considered parameter values) into macroeconomic instability. Indeed, since the dynamic behavior of the real economy variables – output and inflation – seems to be rather invariant to changes in γ (the sensitivity parameter in the FX

[9]In contrast, in the opposite case – for $\beta_s^c = 0$ – the dynamics of the nominal exchange rate are driven solely by the deviation of the log real exchange rate from PPP, see eq.(10).

[10]See Proaño (2011) for a more elaborated two-country model which focuses on the potentially destabilizing effects of behavioral FX trading at the macroeconomic level.

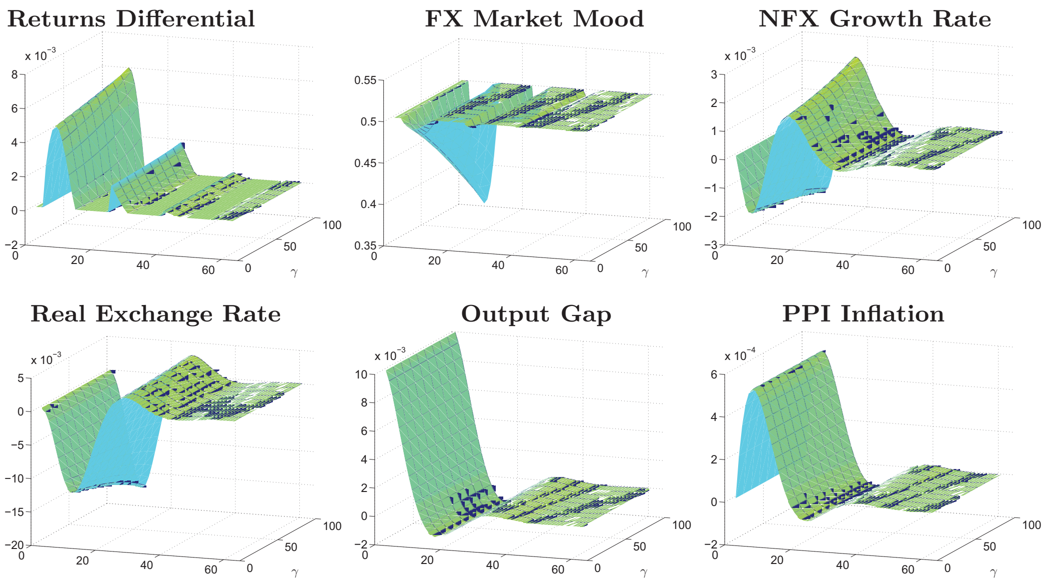

Figure 4: Dynamic responses of FX markets and real economy to a domestic one-time aggregate demand shock for varying values of $\gamma \in (0, 100)$ (with parameter values given by Table 1)

market mood variable ω), the large fluctuation in ω also does not affect significantly the behavior of the nominal interest rate. The endogeneity of ω, the share of fundamentalists in the market (or the FX market mood) does thus not imply per se instability for the model dynamics, but acts as an amplifying force to both stabilizing and destabilizing influences in the model.

To close with this descriptive analysis of the model's functioning of this section, it should be pointed out that so far a single monetary policy rule was assumed in which the nominal interest rate depended on the output gap and the inflation gaps with the only – implicit – restriction of the validity of the Taylor Principle (after which $\phi_\pi > 1$). In the next section a more detailed investigation of the performance of a variety of alternative monetary policy rules is undertaken also by means of numerical simulations.

3 On the Performance of Alternative Monetary Policy Rules under Behavioral FX Trading

In the following analysis of the performance of alternative monetary policy rules with respect to macroeconomic stabilization we focus on three of the most representative monetary policy rules: A flexible PPI inflation targeting rule

$$i_t = \phi_i i_{t-1} + (1-\phi_i)\left[\, i_o + \phi_\pi(\pi_{t-1} - \pi_o) + \phi_y\, y_{t-1}\right],$$

a flexible CPI targeting rule

$$i_t = \phi_i i_{t-1} + (1-\phi_i)\left[\, i_o + \phi_\pi(\pi^c_{t-1} - \pi_o) + \phi_y\, y_{t-1}\right],$$

and an interest rate rule with a nominal exchange rate (NFX) target and an output gap target

$$i_t = \phi_i i_{t-1} + (1-\phi_i)\left[\, i_o + \phi_s \Delta s_{t-1} + \phi_y\, y_{t-1}\right].$$

It should be pointed out that in all three cases an interest rate smoothing term is included in order to remain consistent with the dynamic adjustment analysis of the previous section. Table 2 shows the parameter values of the alternative monetary policy rules used in the following simulations.

Table 2: Alternative Monetary Policy Rules Specifications

	I. PPI Inflation Target	II. CPI Inflation Target	III. NFX Target
ϕ_i	0.7	0.7	0.7
ϕ_π	1.5	1.5	0
ϕ_y	0.5	0.5	0.5
ϕ_s	0	0	1.5

In order to evaluate the performance of these monetary policy rules concerning a comprehensive macroeconomic stabilization after an aggregate demand and a nominal exchange rate shock, let us assume the following central bank (CB) loss function[11]

$$\mathcal{L}_{\mathrm{T}}^{CB} = \sum_{t=1}^{T} \left[\underbrace{(\pi_t - \pi_o)^2}_{\text{Inflation Rate Term}} + \underbrace{(y_t)^2}_{\text{Output Gap Term}} + \underbrace{(\Delta s_t)^2}_{\text{NFX Term}} \right] \tag{15}$$

whereas the inflation term consists of PPI inflation and T represents the evaluation horizon, which in the following will be equal to $T = 60$, i.e. 5 years given the monthly frequency assumed here.

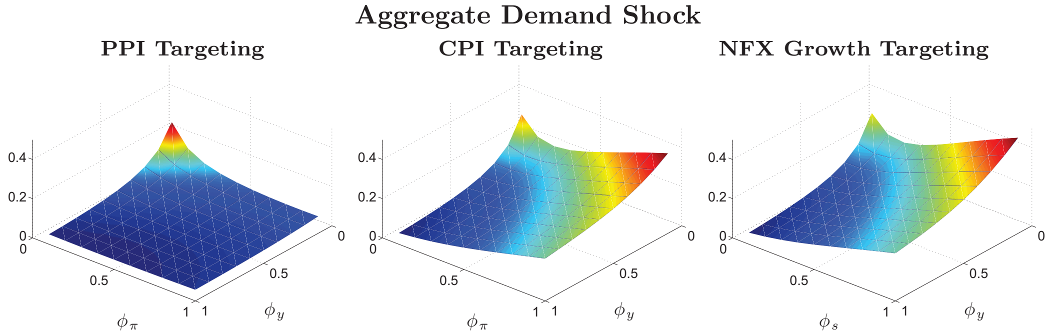

Figure 5: Central Bank (CB) Loss $\mathcal{L}^{CB}$ following a domestic aggregate demand at 5 Year Horizon for different values of respective reaction coefficients

Figure 5 shows the CB Loss $\mathcal{L}^{CB}$ at the 5 year horizon resulting from a domestic aggregate demand shock for different values of the respective reaction coefficients of the different interest rate rules analyzed here (the same qualitative results are observable at all horizons).

The insights illustrated by Figure 5 can be summarized in the following manner: First, among the three analyzed interest rate rules, the rule with the PPI inflation and the output gap target generates the lowest loss for the central bank. Furthermore, as clearly observable in Figure 5, higher values of both ϕ_π and ϕ_y in this first rule lead to lower values of $\mathcal{L}^{CB}$. In contrast, concerning the rules with the CPI and the nominal exchange rate targets, while increasing values of ϕ_y convey lower CB losses in both rules, higher values of ϕ_π in the former and of ϕ_s in the latter rule work in the opposite direction.

[11]In the NOEM/DSGE literature the performance of monetary and fiscal policy is evaluated using a welfare criterion based on the utility function of the representative agent(s) and the flexible-price equilibrium under rational expectations, see e.g. Rotemberg and Woodford (1997). However, since the stylized framework discussed here is not "microfounded" in the sense of the NOEM/DSGE literature and is not

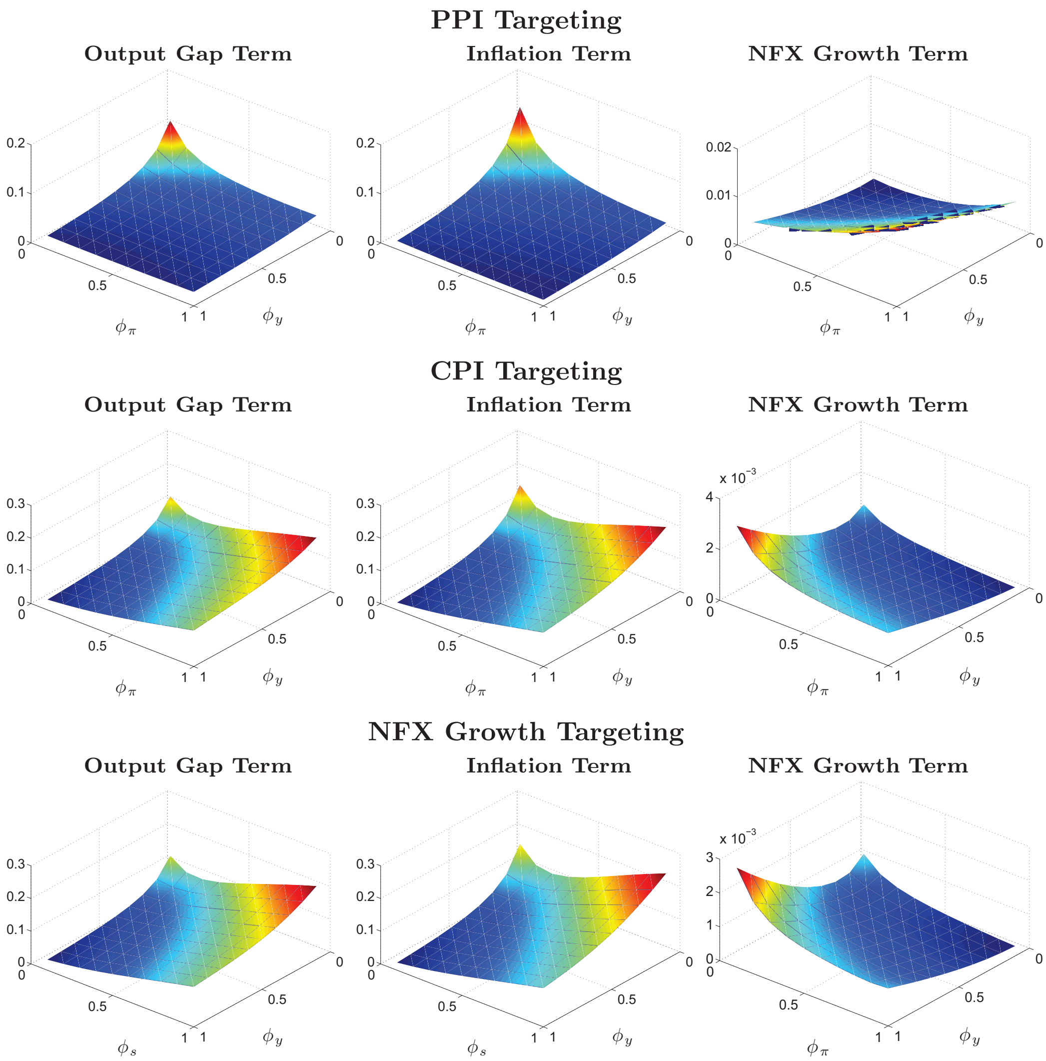

Figure 6: Components of Central Loss $\mathcal{L}^{CB}$ following a domestic aggregate demand shock at 5 Year Horizon for different values of respective reaction coefficients

The reason for this outcome is illustrated in Figure 6, where the single components of the CB loss function are shown. As it can be clearly observed, while in the PPI targeting rule increasing values of ϕ_π and ϕ_y convey – following an aggregate demand shock – a higher stabilization of the output- and inflation gap terms, which overcompensates the larger loss

built on the rational expectations assumption, such an evaluation strategy is not applicable here.

resulting in the NFX term, in the two other cases the opposite holds. This implies that if the dynamics of the nominal exchange rate feature an excess volatility resulting from the FX trading based on the discussed behavioral forecasting rules, the monetary authorities should not react to nominal exchange rate fluctuations, and by extension also not to CPI inflation developments, but focus on PPI and output gap developments after an aggregate demand shock.

Figure 7, in turn, shows the Central Bank (CB) Loss $\mathcal{L}^{CB}$ at the 5 year horizon resulting from a nominal exchange rate shock.

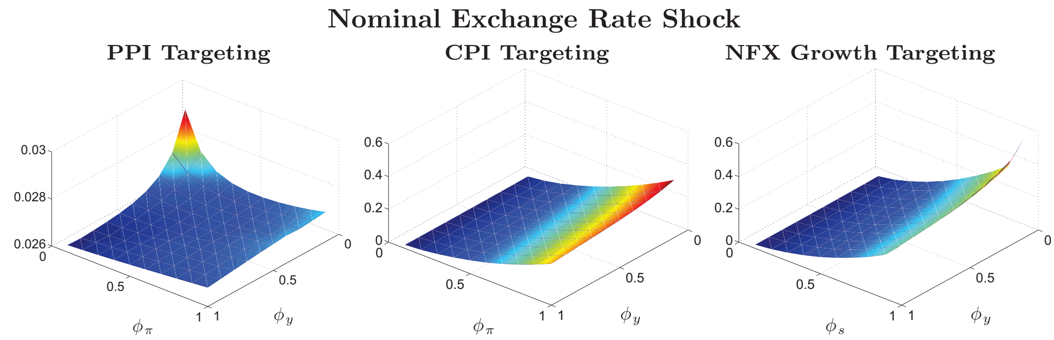

Figure 7: Central Bank Loss $\mathcal{L}^{CB}$ following a nominal exchange rate shock at 5 Year Horizon for different values of respective reaction coefficients

As it can be clearly observed, the performance of the analyzed monetary policy rules in the case of a nominal exchange rate shock is analogous to the previous case: As in the case of a domestic aggregate demand shock, in this case the rule with the PPI inflation target delivers a by far lower CB loss than the two other interest rules. Furthermore, it is also interesting to note that a systematic reaction of monetary policy to nominal exchange rate fluctuations – either in a direct manner or in an indirect manner through CPI targeting – seems to generate a larger CB loss.

Again, it is worth taking a look at the single components of the CB loss function. As it can be clearly observed in Figure 8, a systematic response of monetary policy to nominal exchange rate fluctuations seems to have – for the given parameter constellation – counter-productive effects, because when the domestic nominal interest rate follows a nominal exchange rate growth target (which in this case was $\Delta s_{t-1} = 0$) or a CPI target, the existing volatility of the FX market is transported in a greater extent to the real side of the economy through the adjustment of the nominal interest rate to nominal exchange

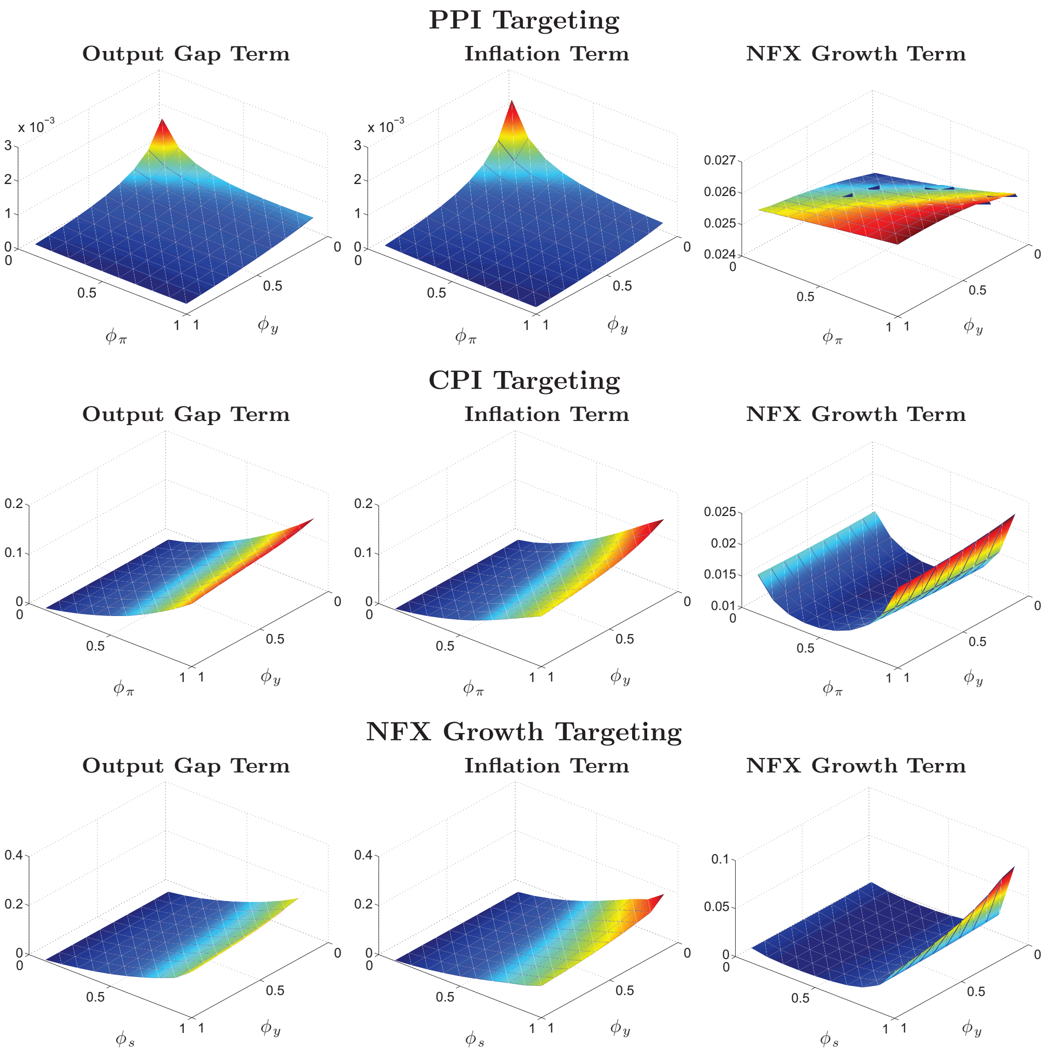

Figure 8: Components of Central Loss $\mathcal{L}^{CB}$ following a nominal exchange rate shock at 5 Year Horizon for different values of respective reaction coefficients

rate changes. Additionally, the nominal interest rate movements affect also the dynamics of the FX market returns differentials, therefore also feed-backing also in the nominal exchange rate dynamics.

Given the fact that the theoretical framework underlying the present analysis is not based on "microfounded" in the Neoclassical sense, a direct comparison between the results of this paper and those of the NOEM literature is not possible. However, it is worth pointing out that the model results just discussed interestingly corroborate, to a certain extent, previous studies on monetary policy and exchange rates of the NOEM literature. For instance, the findings of the present analysis are by and large along the lines of Galí and Monacelli (2005) who, using a open-economy, rational expectations DSGE model, find that a Taylor rule in which the monetary authorities react to domestic inflation delivers a higher welfare than a similar rule based on the CPI index, in contrast to the previous findings of Svensson (2000) and Dennis (2000). Concerning Deveraux, Lane and Xu (2006), in turn, the present paper's results corroborate their findings in the sense that a higher exchange-rate pass-through (related here with the parameter ξ in the CPI index) complicate the conduction of monetary policy in the present of external shocks. Furthermore, on more empirical grounds, the findings of this paper are for example also along the lines of Chadha, Sarno and Valente (2004), who find that U.S. Federal Reserve, the Bank of England and the Bank of Japan do not – systematically – react to exchanges rate (or asset prices), but may have done it in certain occasions. Indeed, because the model results just discussed apply for given – and constant – parameter values, situations are thinkable where a monetary policy reaction with respect to extreme exchange rate changes (as during a currency crises) may indeed be more advantageous than sticking to the PPI inflation target.[12]

4 Concluding Remarks

In this paper the interaction between exchange rate dynamics driven by traders with behavioral forecasting rules and the macroeconomy was investigated. Though mainly theoretic, this study delivered a variety of important insights not only on FX-market/macroeconomy interactions, but also on the performance of alternative monetary policy rules under behavioral FX trading. Indeed, given the importance that, according to empirical evidence, different expectations and behavioral trading schemes have for the dynamics of the nominal exchange rate, the analysis of the performance of economic policy in macroeconomic environments not driven by "rational" economic agents is not only an interesting academic

[12]Numerous studies on monetary policy, currency crises and the liability dollarization phenomenon such as Aghion, Bacchetta and Banerjee (2001, 2004), Christiano, Gust and Roldos (2004), and Proaño, Flaschel and Semmler (2008), among others, have focused on the optimal reaction of monetary policy on the onset of currency crises.

exercise, but in fact an important task which has been left aside in the academic literature in recent years due to the widespread use of the rational expectations paradigm.

Despite the fact that the present paper focused on the FX market, the insights of this analysis are also applicable to other financial markets. Indeed, as the actual global financial crisis shows, financial markets might a) not function as perfect or b) economic agents might not be as well informed or act as rational as it is assumed in the standard NOEM/DSGE modeling framework. Against this background, one of the main results of the model discussed here was that a standard monetary policy rule with inflation and output targets is not likely to bring about macroeconomic stability if financial markets are subject to explosive trend-chasing forces and large nominal exchange rate shocks. Alternative strategies – as the reaction of the Federal Reserve Bank during the 2007/2008 financial crisis has shown – might be necessary to bring about stability if the financial markets (such as the FX market in this paper) are driven by destabilizing expectations.

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