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Monetary Policy, Stock Price Misalignments and Macroeconomic Instability

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Abstract: We augment the standard New Keynesian model for monetary policy design with stock prices in the economy and stock traders who use a mix of fundamental and technical analyses. The central question in this paper is whether macroeconomic stability can be achieved by an appropriate policy by the central bank? In contrast with most of previous literature, we argue that the central bank should augment the interest rate rule with a term for stock price misalignments since a determinate and stable rational expectations equilibrium in the economy is then easier to achieve. This equilibrium is stable under least squares learning as well. Another interesting finding is that inertia in monetary policy does not promote macroeconomic stability when technical analysis plays a major role in stock trading. Even worse, if the central bank in its policy only indirectly responds to stock price misalignments via its effect on the inflation rate, a combination of strong inertia in monetary policy and a significant role for technical analysis in stock trading will lead to macroeconomic instability.

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Keywords: Bubble Policy; Fundamental Analysis; Interest Rate Rule; Least Squares Learning; Macroeconomic Stability; Stock Price Bubble; Taylor Rule; Technical Analysis.

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1 Introduction

An important topic of current debate in central banking is the role of asset prices in monetary policy. This topic was especially prevalent during the financial turmoil that started in the U.S. in 2008 and thereafter was spread to the rest of the industrialized world with devastating effects. Among other things, stock prices fell sharply around the world and several of the largest economies were in 2009 in a recessional state. The natural question to pose and answer is therefore: Can a financial crisis and a subsequent real crisis be hindered by an appropriate policy by the central bank? This is the fundamental question that we would like to answer in this paper.

Glenn Rudebusch’s three questions Glenn Rudebusch (2005), who is a senior vice president of the Federal Reserve Bank of San Francisco, provides a decision tree with three crucial questions to find out whether the central bank should deflate an asset price bubble in the economy or not.

The first question in the decision tree asks whether an asset price bubble has been identified. This is not always self-evident. One reason is that when stock markets around the world were booming at the turn of the new century, it was not obvious that stock prices could be misaligned and the reason was the widespread belief that a ‘new economy’ was born. It is therefore understandable that minor stock price misalignments are even harder to detect for central banks. This, however, is not an issue in the present paper. Instead, we assume that the central bank knows the complete structure of the economy as well as past and current values of all variables in it. Consequently, the central bank is able to detect even the smallest differences between fundamental and de facto stock prices.

The second question in Rudebusch’s (2005) decision tree asks whether the asset price bubble may cause macroeconomic problems that monetary policy cannot readily offset. Following Rudebusch’s (2005) advice, the central bank should follow the standard policy of not trying to deflate the bubble when it only has conventional effects on the economy. In contrast, an unconventional effect that also is a severe macroeconomic problem is to have an unstable economy. Let us, for this reason, reformulate our question above somewhat: Can macr
economic instability be hindered by an appropriate policy by the central bank?

Is monetary policy the appropriate tool to deflate an asset price bubble in the economy? This is the third and final question in Rudebusch’s (2005) decision tree. Be aware that the central bank normally has other objectives than watching after and maybe also trying to deflate bubbles in the economy. In the euro zone, for example, the primary objective for the European Central Bank is to keep the inflation rate at a low and stable level. Therefore, since bubbles can exist in non-inflationary economies as well, a tighter monetary policy could hinder asset prices from increasing even further, but at the same time, a tighter policy could cause a deflationary economy.

Without some kind of heterogeneity, there is no bubble in the economy This statement is not entirely true, especially if we interpret misaligned asset prices as some sort of asset price bubble. This is because in such an environment it is enough to assume that all asset traders are naive in the sense that they never base their trading on the assets’ fundamental values. However, to build a model of an economy under such an assumption is

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2 Shiller (2000) argues that the booming stock prices during the 1980s and 1990s constituted a speculative bubble not grounded in economic fundamentals. Pástor and Veronesi (2006), on the other hand, argue that it not necessarily was a speculative bubble.

3 When the economy has a determinate equilibrium, a check whether it is stable under least squares learning will be performed. Specifically, we will temporarily assume that the central bank does not know the complete structure of the economy. Instead, the central bank has to learn the economy’s law of motion by repeatedly running least squares regressions using data generated by the economy itself. The crucial question is whether the central bank will learn the determinate equilibrium over time. More on this issue in Section 3.1.
not satisfying. This is because it has no bearing on actual behavior of asset traders, even though it does not mean that asset traders exclusively base their trading on the assets’ fundamental values.  

When it comes to the theoretical literature, it is today much more legitimate than just a couple of decades ago to allow for misaligned asset prices in economic models. Recall the heritage we have from Friedman (1953), but also the strong impact Fama’s (1965) efficient market hypothesis have had in the literature. As the argument is formulated by Friedman (1953): Due to arbitrage at financial markets, sophisticated traders will outperform naive traders and therefore drive them out from the markets. In other words, the only traders we should find at financial markets are the smart traders or, as they also are called in the literature, the rational traders.

A relatively new literature has, however, emerged that theoretically demonstrates why Friedman’s (1953) claim not necessarily is true (see De Long et al., 1990, and Shleifer and Vishny, 1997, on the limits to arbitrage) and that asset prices therefore can be misaligned despite the presence of rational arbitrageurs (see Abreu and Brunnermeier, 2003, for a model with coordination problems; see Adam et al., 2008, for a learning model; see Angeletos and Werning, 2006, for a model with heterogeneous information among traders; see Hong and Stein, 1999, for a model with momentum traders; and see Tirole, 1982, for a model with asymmetric information).

**Bubbles and monetary policy**  What is the role of asset prices or asset price bubbles in monetary policy in the theoretical literature? Is a pro-active policy, or a ‘bubble policy’, generally recommended or is a re-active policy in which the central bank only indirectly responds to stock price misalignments via its effect on the inflation rate to prefer?

Up to this date, a large part of the literature argues that a pro-active policy is either not feasible or could even have devastating effects on the economy (see Bean, 2004, and references therein). In contrast, Bernanke and Gertler (1999) notice that bursting bubbles have had detrimental effects on economies only when monetary policy has remained unresponsive. They, however, argue against a pro-active policy insofar asset prices affect the inflation rate since monetary policy should anyway be activated in this case. A re-active policy by the central bank is therefore recommended by them. Further on, Bullard and Schaling (2002) argue that a pro-active policy could lead to indeterminacy problems, which means that the consequences of monetary policy are not predictable.

There is, however, another strand of literature that is in favor of a pro-active policy when there is an asset price bubble in the economy. Bordo and Jeanne (2002) argue that there is a trade-off between the cost of deviating from short-run objectives in monetary policy, such as price stability, and the risk of devastating effects on the economy in the future when the bubble has burst. Further on, Kontonikas and Ioannidis (2005) and Kontonikas and Montagnoli (2006) come to the conclusion, after allowing for a momentum effect in asset prices, that the central bank should augment the interest rate rule with a term for asset price misalignments.

Certainly, the latter two papers come close to what is accomplished in the present paper. However, even though their models include a momentum effect in asset prices, there is no heterogeneity among agents. This is also a drawback shared by most papers that study the role of asset price bubbles in monetary policy. This drawback is luckily resolved in this paper since we assume that a mix of fundamental and technical analyses is used in stock trading in an otherwise standard New Keynesian model for monetary policy design augmented with stock prices.

**Main findings**  There are three properties of the model economy that we present that should be emphasized. First of all, the central bank should respond directly to stock price misalignments in monetary policy to better avoid macroeconomic instability. Specifically, the central bank should augment the interest rate rule with a

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4 Especially in currency trading, it is a well-documented fact that currency traders to a large extent base their trading on other factors than macroeconomic fundamentals (see Menkhoff and Taylor, 2007, and Oberlechner, 2004).
term for stock price misalignments since a determinate and stable rational expectations equilibrium (REE) in the economy, which is stable under least squares learning, is then easier to achieve. This is an important finding, which is in contrast with most of previous literature.

The other two properties concern the relationship between the role of technical analysis in stock trading and the degree of inertia in monetary policy. Specifically, when technical analysis plays a minor role in stock trading, we replicate the typical finding in the literature that inertia in monetary policy promotes determinacy (see Bask, 2008, and Bullard and Mitra, 2007). This is no longer true when technical analysis plays a major role in stock trading. Even worse, if the central bank in its policy only indirectly responds to stock price misalignments via its effect on the inflation rate, a combination of strong inertia in monetary policy and a significant role for technical analysis in stock trading will lead to macroeconomic instability.

Organization of the paper The model economy is outlined and the properties of it are examined in Section 2 and Section 3, respectively. The paper is thereafter concluded in Section 4 with a short discussion of the main findings.

2 Model economy

The model economy we examine consists of three pieces: (i) the baseline model for monetary policy design in a closed economy that nowadays is very popular in the literature (see Clarida et al., 1999, for an introduction to this literature), which is augmented with asset prices in the economy that we interpret as stock prices; (ii) an asset pricing model with heterogeneous traders; and (iii) a monetary policy rule for the central bank in the form of an interest rate rule (see the seminal contribution by Taylor, 1993).

Baseline model The baseline model is described by two equations and the first of these equations is the ‘IS’ curve:

\[
x_t = E_t [x_{t+1}] - \alpha (r_t - E_t [r_{t+1}]),
\]

where \( x \) is the output gap, \( r \) is the nominal interest rate that is controlled by the central bank, \( \pi \) is the inflation rate and \( E_t [\cdot] \) is the time-\( t \) rational expectations of the variable in focus. Thus, we assume that agents in the model economy, when forming rational expectations of the output gap, the inflation rate and other variables in the economy, have access not only to past values of relevant variables, but also to current values of these variables. The second equation in the baseline model is the ‘AS’ curve:

\[
\pi_t = \beta E_t [\pi_{t+1}] + \gamma x_t,
\]

which also is named the Phillips curve.

A distinguishing feature of our model economy is the inclusion of stock prices in the ‘IS’ curve. Specifically, we assume that aggregate demand depends positively on the change in these prices since they affect household wealth and thereby influence consumption expenditure, they affect the ability of enterprises to raise funds and thereby influence investment spending, and they affect the value of collaterals and thereby the willingness of banks to lend money (see Smets, 1997).\(^5\)

\(^5\) We pose a linear relationship between the change in the real stock price index and aggregate demand. This means that we neglect from a ‘financial accelerator’ in the model economy (see Bernanke et al., 1996). Think, for example, of two enterprises that would like to borrow money from a bank; one enterprise with a high net worth and another with a low net worth. Due to agency costs, the enterprise with the low net worth must pay a higher premium on the bank loan, which means that this firm is more vulnerable at the onset of a recession than the firm with the high net worth. Moreover, the enterprise with the high net worth has (more or less by definition) more internal funds such as liquid (and illiquid) assets, which means that this firm is not forced to obtain external funds from a bank in case of a higher real interest rate. Taken
(3) \[ x_t = E_t[x_{t+1}] - \alpha(r_t - E_t[\pi_{t+1}]) + \delta(\Delta s_t - E_t[\pi_{t+1}]). \]

where \( s \) is the nominal stock price index. Thus, be aware that \( s \) is the nominal and not the real stock price index.

Due to the fact that we below include trend extrapolation, which is a simple form of technical analysis, in the nominal stock price index, we must split the change in the real stock price index, \( \Delta s_t - E_t[\pi_{t+1}] \), into the change in the nominal stock price index, \( \Delta s_t \), and the (expected) inflation rate, \( E_t[\pi_{t+1}] \).

Kontonikas and Montagnoli (2006) and Smets (1997) do not make this split of real asset prices since they do not include technical analysis in asset trading into their model economies, even though Kontonikas and Montagnoli (2006) include a momentum effect in asset prices. Moreover, Kontonikas and Montagnoli (2006) and Smets (1997) incorporate the level in real asset prices in their specifications of aggregate demand, whereas we stick with the change in real asset prices to have flow variables only in our specification. This is also what Goodhart and Hofmann (2000) do in their empirical investigation of an ‘IS’ curve augmented with different asset prices in the economy.

To sum up, our baseline model is (2)-(3).

**Asset pricing model**  What determines the nominal stock price index in the model economy? We assume that this stock price index is determined by a mix of the stocks’ fundamental prices and the effect technical analysis in the form of trend extrapolation has on the stock price index.

According to fundamental analysis, the real stock price index is determined by the following dividend asset pricing model:

(4) \[ s_t^f - E_t[p_{t+1}] = \zeta E_t[x_{t+1}] - \eta(r_t - E_t[\pi_{t+1}]). \]

where \( s^f \) is fundamental stock prices in nominal terms summarized in an index and \( p \) is the price level. This means that

(5) \[ \Delta s_t^f - E_t[\pi_{t+1}] \equiv s_t^f - E_t[p_{t+1}] - (s_{t-1}^f - p_t) = \zeta(E_t[x_{t+1}] - x_t) - \eta(r_t - r_{t-1}) + \eta(E_t[\pi_{t+1}] - \pi_t), \]

is the change in fundamental stock prices in real terms. The intuition behind the dividend asset pricing model in (4) is that expected dividends, which are assumed to depend positively on the expected output gap, affect fundamental stock prices positively, whereas future dividends are discounted more heavily when monetary policy is tighter (see Ioannidis and Kontonikas, 2008, and references therein and Kontonikas and Montagnoli, 2006).

When trend extrapolation is used in stock trading, the nominal stock price index is expected to continue to increase (decrease), if the most recent change is an increase (a decrease) in the stock price index:

(6) \[ \Delta s_t^c = \theta \Delta s_{t-1}, \]

where \( s^c \) is ‘technical’ stock prices in nominal terms summarized in an index. Technical analysis is also called chartism and technical trading in the literature.

together, these two forces would accelerate a downturn in the economy via the credit market. Of course, the reverse of the arguments works at the onset of an expanding economy with the consequence that an upturn in the economy would be accelerated via the credit market. In other words, there is a non-linear relationship between the change in the real stock price index and aggregate demand.
Last but not least, the change in the nominal stock price index is determined by a linear combination of fundamental and technical analyses in stock trading:

\[ \Delta S_t = \omega \cdot \Delta S_t^f + (1 - \omega) \cdot \Delta S_t^t, \]

where \( \omega \in [0,1] \) is the weight attached to technical analysis.

To sum up, our asset pricing model is (5)-(7).

**Monetary policy rule** A monetary policy rule for the central bank in the form of an interest rate rule is finally formulated. Specifically, the central bank uses a Taylor rule in its policy and responds to the interest rate in the previous time period, the current output gap, the current inflation rate and the current change in stock price misalignments when setting the interest rate:

\[ r_t = \kappa_x r_{t-1} + \kappa_x x_t + \kappa_p \pi_t + \kappa_s (\Delta S_t - \Delta S_t^f). \]

Thus, the target values of the variables in the interest rate rule are no output gap, a constant price level and that the change in stock prices is driven by the change in fundamental stock prices only. That the central bank responds to the interest rate in the previous time period means that there is inertia in monetary policy.

Be aware that the term for the change in stock price misalignments in (8) is similar to the corresponding term in Kontonikas and Montagnoli (2006). The only difference is that they include the value of the stocks and not the change in value of the stocks as we do.\(^6\)

3 Properties of the model economy

The central question in the present paper is whether monetary policy should be pro-active (i.e., \( \kappa_x \neq 0 \)) or re-active (i.e., \( \kappa_x = 0 \)) to avoid macroeconomic instability when technical analysis is used in stock trading? Let us now answer this question by examining the properties of the model economy outlined in Section 2.

The complete model economy is (2)-(3) and (5)-(8). However, these equations can be reduced to four equations: (i) an equation showing how the change in the stock price index is determined when incorporating the trading strategies based on fundamental and technical analyses into the dividend asset pricing model (see (9) below); (ii) an equation showing how the interest rate setting by the central bank is determined when incorporating the dividend asset pricing model into the Taylor rule (see (10) below); (iii) an equation showing how firms set their prices (see (11) below); and (iv) an equation showing how the output gap is determined by aggregate demand (see (12) below).

Firstly, substitute (5)-(6) into (7):

\[ \Delta S_t = -\zeta (1 - \omega) x_t + \zeta (1 - \omega) E_t [x_{t+1}] - \eta (1 - \omega) \pi_t + (1 + \eta) (1 - \omega) E_t [\pi_{t+1}] + \eta (1 - \omega) r_{t-1} - \eta (1 - \omega) r_t + \theta \omega \Delta S_{t-1}, \]

which is the equation showing how the change in the stock price index is determined. Secondly, substitute (5) into (8):

\[ r_t = \frac{\zeta x_t + \kappa_x}{1 - \eta \kappa_s} \cdot x_t - \frac{\zeta \kappa_s}{1 - \eta \kappa_s} \cdot E_t [x_{t+1}] + \frac{\eta \kappa_x + \kappa_p}{1 - \eta \kappa_s} \cdot \pi_t - \frac{(1 + \eta) \kappa_s}{1 - \eta \kappa_s} \cdot E_t [\pi_{t+1}] \]

\(^6\) In fact, what Kontonikas and Montagnoli (2006) do is that they derive an optimal policy rule for the central bank. Specifically, the central bank in their model economy is minimizing a loss function that penalizes deviations of the output gap and the inflation rate from their target values. They find that the central bank not only should respond to the output gap and the inflation rate when setting the interest rate, but also to asset price misalignments.
\[-\frac{\eta_{\kappa} - \kappa_r}{1 - \eta_{\kappa}} \cdot r_{t-1} + \frac{\kappa_r}{1 - \eta_{\kappa}} \cdot \Delta S_t,\]

which is the equation showing how the interest rate is determined. Finally, we have the Phillips curve showing how the inflation rate is determined:

\[\pi_t = y_t + \beta E_t[\pi_{t+1}],\]

and the ‘IS’ curve showing how the output gap is determined:

\[x_t = E_t[x_{t+1}] + (\alpha - \delta) \cdot E_t[\pi_{t+1}] - \alpha r_t + \delta \Delta s_t.\]

The analysis of the model economy in (9)-(12) is divided into three steps. In the first step, we examine the properties of the model economy when there is no technical analysis in stock trading (i.e., \(\omega = 0\)), which means that there are no stock price misalignments either in the economy. In the second and third steps, technical analysis is introduced into stock trading (i.e., \(\omega \neq 0\)), where we examine the properties of the model economy when monetary policy is pro-active (i.e., \(\kappa_s \neq 0\)) and when it is re-active (i.e., \(\kappa_s = 0\)), respectively.

### 3.1 No technical analysis in stock trading

After substituting \(\omega = 0\) into the model economy in (9)-(12) and recognizing that \(\omega \neq 0\) is a necessary condition for stock prices to be misaligned, which means that we can substitute \(\kappa_s = 0\) into the same equations without affecting the results, we have the following equation system in matrix form:

\[
\begin{bmatrix}
-\kappa_x & -\kappa_x & 1 \\
\gamma & 1 & 0 \\
1 + \delta \zeta & \delta \eta & \alpha + \delta \eta \\
\end{bmatrix}
\begin{bmatrix}
x_t \\
p_t \\
r_t \\
\end{bmatrix}
= \begin{bmatrix}
0 & 0 & 0 \\
0 & \beta & 0 \\
1 + \delta \zeta & \alpha + \delta \eta & 0 \\
\end{bmatrix}
\begin{bmatrix}
E_t[x_{t+1}] \\
E_t[\pi_{t+1}] \\
E_t[r_{t+1}] \\
\end{bmatrix}
+ \begin{bmatrix}
0 & 0 & \kappa_r \\
0 & 0 & 0 \\
0 & 0 & \delta \eta \\
\end{bmatrix}
\begin{bmatrix}
x_{t-1} \\
p_{t-1} \\
r_{t-1} \\
\end{bmatrix}.
\]

As is clear from (13), we have substituted out the change in the stock price index from the equation system.

**A determinate REE?** Our first results concern the conditions to have a determinate and stable REE in the model economy. To facilitate the derivation of these conditions, a first step is to re-write the model economy in (13) into first-order form and then to compare the number of pre-determined variables with the number of eigenvalues of a certain matrix (that we derive below) that are outside the unit circle (see Blanchard and Kahn, 1980).

Specifically, we make use of the following variable vector when re-writing the model economy in (13):

\[y_t^d = [x_t, \pi_t, r_t, r_t^I \equiv r_{t-1}^I]^\prime = [y_t, r_t^I]^\prime.\]

This means, if we write the model economy in (13) as

\[\Gamma \cdot y_t = \Theta \cdot E_t[y_{t+1}] + A \cdot y_{t-1},\]

that the coefficient matrixes are

\[\Gamma_d = \begin{bmatrix}
0 & \Gamma & 0 \\
0 & 1 & -A_3 \\
\end{bmatrix},\]

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and

\[
\theta_d = \begin{bmatrix}
\theta \\
0_{(1 \times 3)} \\
1
\end{bmatrix},
\]

where \( \Lambda_3 \) is the third column in the matrix \( \Lambda \) and \( \theta \) is the null matrix, because the model economy in first-order form is

\[
\Gamma_d \cdot y_t^d = \theta_d \cdot E_d[y_{t+1}].
\]

Since there is one variable in (14) that is pre-determined (i.e., \( r_t^d \)), exactly one eigenvalue of the matrix \( \Gamma_d^{-1} \cdot \theta_d \) must be outside the unit circle to have a determinate and stable REE. Further on, if more than one eigenvalue are outside the unit circle, the REE is indeterminate, and if all eigenvalues are inside the unit circle, the REE is unstable.

**Numerical analysis** Deriving analytical conditions for determinacy is, however, not meaningful since these expressions would be too large and cumbersome to interpret, even after we have simplified the model economy by assuming that there is no technical analysis in stock trading. We therefore adopt the same strategy as in other papers in the literature and illustrate our findings using calibrated parameters in the model economy.\(^8\)

In fact, we use two sets of parameter calibrations in the numerical analysis, where the first calibration (often used in the literature) comes from Woodford (1999) and is based on U.S. data:

\[
\begin{cases}
\alpha = \frac{1}{0.1357}, \\
\beta = 0.99, \\
\gamma = 0.024.
\end{cases}
\]

The second calibration comes from Clarida et al. (2000) and is also based on U.S. data:

\[
\begin{cases}
\alpha = 1, \\
\beta = 0.99, \\
\gamma = 0.3.
\end{cases}
\]

Clearly, even though the time periods in the Woodford (1999) calibration and the Clarida et al. (2000) calibration are somewhat different, there are still large differences in the magnitudes of the parameters \( \alpha \) and \( \gamma \). We will not discuss possible reasons for these differences in this paper. We will instead utilize the fact that the parameter calibrations are very different to check the robustness of our findings.

If we turn to the parameters that describe the asset pricing model and the effect stock price changes have on aggregate demand, we use the same parameter setting as in Kontonikas and Montagnoli (2006), which is based on U.K. data:

\[
\begin{cases}
\delta = 0.1, \\
\zeta = 0.8, \\
\eta = 0.4.
\end{cases}
\]

Be aware that the parameter for the wealth effect on aggregate demand (i.e., \( \delta \)) refers in Kontonikas and Montagnoli (2006) to the effect the *level* of real asset prices have on aggregate demand, whereas in our model economy, this parameter refers to the effect the *change* in real asset prices have on aggregate demand. Despite this difference, we use the same parameter value (i.e., \( \delta = 0.1 \)) in the numerical analysis. To be able to compare our findings with the baseline case in which there is no wealth effect on aggregate demand, we also examine the properties of the model economy when \( \delta = 0 \).

Finally, when it comes to the degree of inertia in monetary policy, we are especially interested in the following two special cases: (i) there is no inertia in monetary policy (i.e., \( \kappa_r = 0 \)); and (ii) the central bank focus on the change in the interest rate in its policy (i.e., \( \kappa_r = 1 \)), which means that the Taylor rule has the following form:

\[
\Delta r_t = \kappa_x x_t + \kappa_{\pi} \pi_t.
\]

\(^8\) All MATLAB routines that are used in this paper are available on request from the author.
We also examine the intermediate case in which $\kappa_r = 0.5$. Inertia in monetary policy is a well-documented feature of central banking behavior in developed countries (see Bullard and Mitra, 2007). Rudebusch (1995), for example, finds that the Federal Reserve’s policy can be characterized by inertia. It is therefore important to learn the properties of the model economy for varying degrees of inertia in monetary policy.

It may be argued that it is a shortcoming that we rely on numerical conditions and not on analytical conditions for determinacy. However, this is a shortcoming that the present paper shares with most papers that deal with theoretical extensions of the baseline model in (1)-(2). Moreover, the model economy we examine is not an approximation of reality, but instead a caricature of it (see Gibbard and Varian, 1978). This fact is now and then overlooked in the literature when caricature models are fitted to data as they were approximations of reality.

**Findings**  To save space in the paper, we concentrate our discussion to the findings when the Woodford (1999) calibration is used in the numerical analysis and only shortly mention the findings when the Clarida et al. (2000) calibration is used. For the same reason, only the figures that are associated with the Woodford (1999) calibration are shown herein.9

The regions in the parameter space of $(\kappa_y, \kappa_r)$ for which we have a determinate and stable REE as well as an indeterminate REE, respectively, are shown in Figure 1, Figure 2 and Figure 3. See Table 1 for which parameter configurations these figures correspond to.

[Figure 1, Figure 2, Figure 3 and Table 1 about here.]

Let us first recall what we already know from previous literature. Bullard and Mitra (2002) have shown that the condition for a determinate and stable REE does not depend on $\alpha$ when the ‘IS’ curve is specified as in (1) and not as in (3). Thus, it does not matter if $\alpha = \frac{1}{0.157}$ as in the Woodford (1999) calibration or if $\alpha = 1$ as in the Clarida et al. (2000) calibration, the region in the parameter space of $(\kappa_y, \kappa_r)$ for which we have a determinate and stable REE is the same in both cases.

Thus, if a larger effect of the real interest rate on aggregate demand (i.e., a larger $\alpha$) does not affect the determinacy region, it is tempting to claim that a larger effect of the change in the real stock price index on aggregate demand (i.e., a larger $\delta$) does not either affect the determinacy region. The reason is that the term for the wealth effect on aggregate demand is additive in the ‘IS’ curve in (3) as also the term for the real interest rate is. According to the numerical analysis, the determinacy region is also the same for $\delta = 0$ and $\delta = 0.1$, respectively. (In fact, the determinacy region is the same for $\delta \in [0,1]$.)

When it comes to the degree of inertia in monetary policy, we replicate a typical finding in the literature (see Bask, 2008, and Bullard and Mitra, 2007). Namely, that the region in the parameter space of $(\kappa_y, \kappa_r)$ for which we have a determinate and stable REE increases in size when the degree of inertia increases in size (i.e., a larger $\kappa_r$). In fact, when the central bank focus on the change in the interest rate in its policy (i.e., $\kappa_r = 1$), the whole region is associated with a determinate and stable REE in the economy.

Last but not least, we have the same qualitative findings when we use the Clarida et al. (2000) calibration instead of the Woodford (1999) calibration in the numerical analysis.

**An adaptively learnable REE?** When there is a determinate and stable REE in the model economy, we make use of the minimal state variable (MSV) solution, which is the solution of a linear difference equation that depends linearly on a set of variables such that it does not exist a solution that depends linearly on a smaller set of variables (see McCallum, 1983). A common approach to solve an equation for the MSV solution is the method of undetermined coefficients. In our case, this means that the MSV solution of the model economy in (15) has the following form:

---

9 See the Appendix to this paper for the figures that are associated with the Clarida et al. (2000) calibration.
\[ y_t = \hat{\Xi} \cdot y_{t-1}, \]

where \( \hat{\Xi} \) is the coefficient matrix that has to be determined.

It is not by accident that we have decorated the coefficient matrix \( \Xi \) in (23) with a ‘hat’-symbol since there is a close relationship between deriving the MSV solution of an equation and the adaptive learnability of this solution via least squares. Be aware of the fact that the actual computations of the time-paths of economic variables such as the output gap, the inflation rate and the interest rate when agents have rational expectations can be a challenging task. For this reason, one cannot take for granted that agents have perfect knowledge of the economy’s law of motion.

The transmission mechanism for monetary policy is not an exception from this since it is a well-known fact among economists and policy-makers that it has a complicated structure, which means that there are disagreements about the exact nature of this mechanism. The following question arises, however: May agents in the economy such as households, firms and the central bank eventually learn the REE, if they can make use of data generated by the economy itself to improve their knowledge of its law of motion? Yes, agents can learn the REE in the economy under certain conditions (see Evans and Honkapohja, 2001, for an introduction to this literature).

To see how, assume that the MSV solution in (23) also is the agents’ perceived law of motion (PLM) of the economy. This means that the expected PLM of the economy is

\[ E_t^{PLM}[y_{t+1}] = \hat{\Xi} \cdot y_t, \]

where \( E_t^{PLM}[y_{t+1}] \) is the not necessarily rational expectations of the variables in vector \( y \), which in our case are the output gap, the inflation rate and the interest rate in the economy. Thereafter, the expected PLM is substituted into the following linear difference equation:

\[ \Gamma \cdot y_t = \Theta \cdot E_t^{PLM}[y_{t+1}] + A \cdot y_{t-1}, \]

which is the model economy in (15) allowing for non-rational expectations. Thus, we have that

\[ \Gamma \cdot y_t = \Theta \cdot \hat{\Xi} \cdot y_t + A \cdot y_{t-1}, \]

or, if solved for the contemporaneous values of the variables in the model economy,

\[ y_t = (\Gamma - \Theta \cdot \hat{\Xi})^{-1} \cdot A \cdot y_{t-1}. \]

If we compare the corresponding coefficient matrixes in (23) and (27), the coefficient matrix in (23) can be determined after we have solved the following equation in \( \hat{\Xi} \):

\[ \hat{\Xi} = (\Gamma - \Theta \cdot \hat{\Xi})^{-1} \cdot A. \]

Denote the coefficient matrix that solves (28) with \( \hat{\Xi} = \Xi_{MSV} \).

Observe thereafter that there is a mapping, \( M(\cdot) \), from the coefficient matrix in the PLM of the economy in (23) to the coefficient matrix in the economy’s actual law of motion (ALM) in (27):

\[ M(\Xi) = (\Gamma - \Theta \cdot \hat{\Xi})^{-1} \cdot A, \]

and consider the following matrix differential equation:

\[ \frac{\partial \hat{\Xi}}{\partial t} = M(\hat{\Xi}) - \hat{\Xi}, \]
where $\tau$ is artificial time and $\tilde{J} = \tilde{J}_{\text{MSV}}$ is the fix point of the mapping. Then, the REE associated with the MSV solution in (23) with $\tilde{J} = \tilde{J}_{\text{MSV}}$ is expectationally stable (E-stable), if the coefficient matrix $\tilde{J} = \tilde{J}_{\text{MSV}}$ is locally asymptotically stable under (30). Further, if the coefficient matrix $\tilde{J} = \tilde{J}_{\text{MSV}}$ is locally asymptotically stable under (30), it means that the REE in the economy is adaptively learnable in least squares sense (see Marcet and Sargent, 1989, who show that an E-stable REE is both a necessary and a sufficient condition for an REE to be stable under least squares learning). Thus, if the economy is in the neighborhood of the REE, agents are able to learn the REE over time by repeatedly estimating $\tilde{J}$ in (23) with least squares using data generated by the economy itself.

The conditions for E-stability are not derived herein since our primary interest is when there is a determinate and stable REE in the model economy. This simplifies the analysis considerably since it is shown in McCallum (2007) that for a broad class of linear rational expectations models, which includes the model economy in (15), a determinate and stable REE is also an E-stable REE when the dating of expectations is time period $\tau$, which we assume in this paper.\(^{10}\) Thus, the determinacy regions found in the figures herein are also regions for an adaptively learnable REE in least squares sense.

### 3.2 Technical analysis in stock trading and a pro-active monetary policy

Let us now examine the properties of the model economy when we have technical analysis in stock trading and a pro-active policy by the central bank. Thus, there are no restrictions on the model economy in (9)-(12).

With a pro-active policy, we mean that the central bank responds directly to changes in stock price misalignments by allowing $k_s \neq 0$ in the Taylor rule in (8). Be aware that the central bank does not respond to stock price misalignments per se, but to changes in stock price misalignments. In other words, if the change in the stock price index only reflects the changes in fundamental stock prices, then the central bank does not change the interest rate. However, if the change in the stock price index is smaller or larger than the changes in fundamental stock prices, then the central bank changes the interest rate.

If we follow the same road map as in Section 3.1 when we derived the numerical conditions for a determinate and stable REE in the economy, which is stable under least squares learning, the complete model economy in (9)-(12) is first put into matrix form:

$$
\left[ \begin{array}{ccc} 
\zeta(1-\omega) & \eta(1-\omega) & \eta(1-\omega) \\
-\frac{\kappa_s+\kappa_e}{1-\eta_s} & -\frac{\eta_s+\kappa_e}{1-\eta_s} & 1 \\
-\gamma_s & 1 & 0 \\
1 & 0 & \alpha & -\delta 
\end{array} \right] 
\left[ \begin{array}{c} x_t \\
p_t \\
r_t \\
\Delta s_t 
\end{array} \right] 
= 
\left[ \begin{array}{ccc} 
\zeta(1-\omega)(1+\eta)(1-\omega) & 0 & 0 \\
-\frac{\zeta_s}{1-\eta_s} & -(1+\eta)\kappa_e & 0 \\
0 & \beta & 0 \\
1 & \alpha & -\delta 
\end{array} \right] 
\left[ \begin{array}{c} E_t[x_{t+1}] \\
E_t[p_{t+1}] \\
E_t[r_{t+1}] \\
E_t[\Delta s_{t+1}] 
\end{array} \right] 
+ 
\left[ \begin{array}{c} 0 \\
0 \\
0 \\
0 
\end{array} \right] 
\left[ \begin{array}{c} \eta(1-\omega) \\
\theta_s \\
\theta_e \\
\theta_s 
\end{array} \right] 
\left[ \begin{array}{c} x_{t-1} \\
p_{t-1} \\
r_{t-1} \\
\Delta s_{t-1} 
\end{array} \right].
$$

Thereafter, we make use of the following variable vector when re-writing the model economy into first-order form:

$$
\mathbf{y}_t^d = [x_t, p_t, r_t, \Delta s_t, r_t^f \equiv r_{t-1}, \Delta s_t^f \equiv \Delta s_{t-1}]',
$$

\(^{10}\) When the dating of expectations is time period $t - 1$, a determinate and stable REE does not have to be E-stable. See Bask and Selander (2009) for an example that is close to the model economy in this paper. In their model economy, the central bank uses a Taylor rule in its policy that includes contemporaneous expectations of the variables in the rule. Moreover, the baseline model is an open economy version of the baseline model in this paper, but without a stock market. Heterogeneity among agents is instead introduced in currency trading.
This means, if we write the model economy in (31) as in (15), that the coefficient matrices are

\[
\Gamma_d = \begin{bmatrix}
0_{(2x2)} & \Gamma & -\Lambda_3 & -\Lambda_4
\end{bmatrix},
\]

and

\[
\Theta_d = \begin{bmatrix}
0_{(2x2)} & \Theta & 0_{(4x2)} & 0_{(2x2)}
\end{bmatrix},
\]

where \( \Lambda_3 \) and \( \Lambda_4 \) are the third and fourth columns in the matrix \( \Lambda \), respectively, and \( \textbf{1} \) is the unit matrix, because the model economy in first-order form is again (18).

Since there are two variables in (32) that are pre-determined (i.e., \( r_t^x \) and \( \Delta s_t^x \)), exactly two eigenvalues of the matrix \( \Gamma_d^{-1} \cdot \Theta_d \) must be outside the unit circle to have a determinate and stable REE. Further on, if more than two eigenvalues are outside the unit circle, the REE is indeterminate, and if less than two eigenvalues are outside the unit circle, the REE is unstable.

**Numerical analysis** We use the same parameter configurations as in Section 3.1 with the addition of the parameters for the degree of trend extrapolation in technical analysis (i.e., \( \theta \)), the weight attached to technical analysis in stock trading (i.e., \( \omega \)) and the response in monetary policy to the change in stock price misalignments (i.e., \( \kappa_s \)). Specifically, the first of these three parameters is set to \( \theta = 1 \) and \( \theta = 2 \), respectively, the second is set to \( \omega = 1/3 \) and \( \omega = 2/3 \), respectively, and the third is set to \( \kappa_s = 1 \). The case \( \kappa_s = 0 \) is saved to Section 3.3 when we examine how a re-active policy by the central bank affects the economy.

The regions in the parameter space of \( (\kappa_r, \kappa_n) \) for which we have a determinate and stable REE, an indeterminate REE as well as an unstable REE, respectively, are shown in Figure 1, Figure 3, Figure 5 and Figure 7. See Table 2 for which parameter configurations these figures correspond to, where attention is restricted to the cases in which monetary policy is pro-active (i.e., \( \kappa_s = 1 \)). Recall that with time-\( t \) dating of expectations, a determinate and stable REE in the economy is also an adaptively learnable REE in least squares sense.

[Figure 5, Figure 7 and Table 2 about here.]

We divide the analysis into two cases: (i) technical analysis plays a minor role in stock trading, which is the case \( \theta \omega < 1 \); and (ii) technical analysis plays a major role in stock trading, which is the case \( \theta \omega > 1 \). There are two reasons for this. The first is that we have (as we soon will see) an interesting qualitative change among the findings when increasing the role of technical analysis in stock trading. The second reason is that the financial turmoil in 2008, when stock prices fell sharply in the industrialized world, makes the second case interesting to examine from a monetary policy perspective.

**Technical analysis plays a minor role** Let us start with the case when there is no inertia in monetary policy (i.e., \( \kappa_r = 0 \)). In this case, an increase in the degree of trend extrapolation in technical analysis (i.e., a larger \( \theta \)) means that the region in the parameter space of \( (\kappa_r, \kappa_n) \) for which we have a determinate and stable REE increases in size. On the other hand, an increase in the weight attached to technical analysis in stock trading (i.e., a larger \( \omega \)) does not affect the determinacy region.

When the central bank focus on the change in the interest rate in its policy (i.e., \( \kappa_r = 1 \)), neither an increase in the degree of trend extrapolation in technical analysis (i.e., a larger \( \theta \)) nor an increase in the weight attached to technical analysis in stock trading (i.e., a larger \( \omega \)) affect the region in the parameter space of \( (\kappa_r, \kappa_n) \) for which we have a determinate and stable REE. In fact, the whole region is associated with a determinate and stable REE. Thus, we have the same finding as in Section 3.1. Namely, that inertia in monetary policy promotes determinacy.
**Technical analysis plays a major role** Clarida et al. (2000) estimate different interest rate rules to evaluate Federal Reserve’s policy during 1960–1996 utilizing a model economy similar to the one that we analyze in the present paper, but without a stock market. They found that the policy during the Volcker–Greenspan period was more successful to stabilize the U.S. economy than the policy during the pre-Volcker period. Even though their evaluation of Federal Reserve’s policy is somewhat simplistic, it is very intriguing. If we therefore borrow their estimates of \( \kappa_x \approx 1 \) and \( \kappa_{\omega} \approx 2 \) from the Volcker-Greenspan period, we conclude that these parameter values, together with no inertia in monetary policy (i.e., \( \kappa_r = 0 \)), give rise to a determinate and stable REE.

An interesting finding, which is in stark contrast with the case when technical analysis plays a minor role in stock trading, is that a too strong response to the inflation rate (and/or the output gap) in the Taylor rule (i.e., a too large \( \kappa_{\omega} \) and/or a too large \( \kappa_x \)) implies macroeconomic instability. To be more precise, when the product of the degree of trend extrapolation in technical analysis (i.e., \( \theta \)) and the weight attached to technical analysis in stock trading (i.e., \( \omega \)) becomes large, a too strong response to the inflation rate in monetary policy (i.e., a too large \( \kappa_{\omega} \)), which under normal circumstances would secure that the Taylor principle is satisfied, implies an unstable economy. Thus, in this case, an increased role for technical analysis in stock trading can have a devastating effect on the economy.

Let us thereafter examine the case when the central bank focus on the change in the interest rate in its policy (i.e., \( \kappa_r = 1 \)), which means that there is inertia in monetary policy. Normally, one would expect that the region in the parameter space of \((\kappa_x, \kappa_{\omega})\) for which we have a determinate and stable REE would increase in size when the degree of inertia increases in size (i.e., a larger \( \kappa_r \)). This, however, is not the case when technical analysis plays a major role in stock trading. Instead, the determinacy region decreases in size when the degree of inertia increases in size (i.e., a larger \( \kappa_r \)). In fact, if we again utilize the estimates of \( \kappa_x \approx 1 \) and \( \kappa_{\omega} \approx 2 \) from the Volcker-Greenspan period, the decrease of the determinacy region is so sizeable that the economy becomes unstable.

There are two forces at work here. On the one hand, as Bullard and Mitra (2007) explain, when the central bank moves cautiously in response to unfolding events, a determinate and stable REE can more easily be secured. On the other hand, technical analysis in stock trading is destabilizing. Therefore, if the latter force is strong enough, caution on behalf of the central bank may result in macroeconomic instability. Consequently, the central bank should in this case move from a cautious monetary policy to a policy without inertia to achieve macroeconomic stability.

Last but not least, we have the same qualitative findings when we use the Clarida et al. (2000) calibration in the numerical analysis.

### 3.3 Technical analysis in stock trading and a re-active monetary policy

Let us now examine the properties of the model economy when monetary policy is re-active instead of pro-active. This means that we are able to answer the question whether the central bank directly should take into account stock price misalignments in monetary policy to avoid macroeconomic instability since we can compare the findings in this section with those in Section 3.2. With a re-active policy, we mean that the central bank does not respond directly to changes in stock price misalignments by setting \( \kappa_x = 0 \) in the Taylor rule in (8).

Since the only difference between this section and Section 3.2 is that \( \kappa_x = 0 \), the complete model economy in matrix form is again (18) and (32)-(34). Thus, since there are two variables in (32) that are pre-determined (i.e., \( r^*_t \) and \( \Delta s^*_t \)), exactly two eigenvalues of the matrix \( \Gamma^{\dagger} \cdot \Theta_d \) must be outside the unit circle to have a determinate and stable REE. Further on, if more than two eigenvalues are outside the unit circle, the REE is indeterminate, and if less than two eigenvalues are outside the unit circle, the REE is unstable.
**Numerical analysis** The regions in the parameter space of \((\kappa_x, \kappa_r)\) for which we have a determinate and stable REE, an indeterminate REE as well as an unstable REE, respectively, are shown in Figure 1, Figure 3, Figure 4 and Figure 6. See Table 2 for which parameter configurations these figures correspond to, where attention is restricted to the cases in which monetary policy is re-active (i.e., \(\kappa_s = 0\)). Recall that with time-\(t\) dating of expectations, a determinate and stable REE in the economy is also an adaptively learnable REE in least squares sense.

[Figure 4 and Figure 6 about here.]

As we also did in Section 3.2, we divide the analysis into two cases: (i) technical analysis plays a minor role in stock trading, which is the case \(\theta \omega < 1\); and (ii) technical analysis plays a major role in stock trading, which is the case \(\theta \omega > 1\).

**Technical analysis plays a minor role** Let us start with the case when there is no inertia in monetary policy (i.e., \(\kappa_r = 0\)). In this case, neither an increase in the degree of trend extrapolation in technical analysis (i.e., a larger \(\theta\)) nor an increase in the weight attached to technical analysis in stock trading (i.e., a larger \(\omega\)) affect the region in the parameter space of \((\kappa_x, \kappa_r)\) for which we have a determinate and stable REE. In one instance (i.e., \(\theta = 2, \omega = 1/3\) and \(\kappa_r = 0\)), the determinacy region is smaller in size when the central bank does not directly take into account stock price misalignments when setting the interest rate. Thus, a pro-active monetary policy is to prefer.

Let us then move on with the case when the central bank focus on the change in the interest rate in its policy (i.e., \(\kappa_s = 1\)), which means that there is inertia in monetary policy. Again we have the finding that neither an increase in the degree of trend extrapolation in technical analysis (i.e., a larger \(\theta\)) nor an increase in the weight attached to technical analysis in stock trading (i.e., a larger \(\omega\)) affect the region in the parameter space of \((\kappa_x, \kappa_r)\) for which we have a determinate and stable REE. In fact, the whole region is associated with a determinate and stable REE. Thus, we have the same finding as in Section 3.2 when monetary policy was pro-active (i.e., \(\kappa_s = 1\)).

**Technical analysis plays a major role** If we again start with the case when there is no inertia in monetary policy (i.e., \(\kappa_r = 0\)) and again borrow the estimates of \(\kappa_x \approx 1\) and \(\kappa_r \approx 2\) from the Volcker-Greenspan period, we conclude that these parameter values give rise to an unstable REE. Thus, since the outcome in the economy is not a determinate and stable REE, which was the case when monetary policy was pro-active (i.e., \(\kappa_s = 1\)), we also conclude that the central bank directly should take into account stock price misalignments when setting the interest rate. An alternative to this policy is a modest response to the inflation rate (i.e., a small \(\kappa_r\)) since it also gives rise to a determinate and stable REE.

What we again have found is that a too strong response to the inflation rate (and/or the output gap) in the Taylor rule (i.e., a too large \(\kappa_r\) and/or a too large \(\kappa_x\)) implies macroeconomic instability. To be more precise, when the product of the degree of trend extrapolation in technical analysis (i.e., \(\theta\)) and the weight attached to technical analysis in stock trading (i.e., \(\omega\)) becomes large, even a one-to-one response to the inflation rate in monetary policy (i.e., \(\kappa_r = 1\)), which under normal circumstances would secure that the Taylor principle is satisfied, implies an unstable economy. Thus, the situation is even worse compared to when monetary policy was pro-active (i.e., \(\kappa_s = 1\)).

The central bank focus on the change in the interest rate in its policy (i.e., \(\kappa_r = 1\)) in the final case. Then, having the findings in Section 3.2 in mind, we expect that the region in the parameter space of \((\kappa_x, \kappa_r)\) for which we have a determinate and stable REE decreases in size when the degree of inertia increases in size (i.e., a larger \(\kappa_r\)). This is also the case. In fact, the decrease of the determinacy region is so sizeable that the whole region is associated with an unstable REE. Further on, since a determinate and stable REE could be achieved when monetary policy was pro-active (i.e., \(\kappa_s = 1\)), we conclude that the central bank directly should take into account stock price misalignments when setting the interest rate.
Last but not least, we have almost the same qualitative findings when we use the Clarida et al. (2000) calibration instead of the Woodford (1999) calibration in the numerical analysis. However, the single finding that differs between the two parameter calibrations is of negligible importance and does not belong to any of the main findings put forward in this paper.

A pro-active or a re-active policy? Let us end this section by answering the question posed in the introductory section: Can macroeconomic instability be hindered by an appropriate policy by the central bank?

Yes, monetary policy can do that (in our model economy). This is because the only case (i.e., \( \theta = 2, \omega = 2/3 \) and \( \kappa_r = 1 \)) in which the whole region in the parameter space of \((\kappa_s, \kappa_m)\) is associated with an unstable REE is when monetary policy is re-active (i.e., \( \kappa_s = 0 \)). However, if monetary policy is pro-active (i.e., \( \kappa_s = 1 \)) in this case, it is possible to achieve a determinate and stable REE in the economy, which is stable under least squares learning. Specifically, the response to the inflation rate in monetary policy should be modest (i.e., a small \( \kappa_m \)) to achieve such an REE. Also recall that whenever the determinacy region is affected by the choice of a pro-active or a re-active monetary policy, it is always easier to achieve the sought-after REE when monetary policy is pro-active (i.e., \( \kappa_s = 1 \)).

4 Concluding discussion

We have augmented the standard New Keynesian model for monetary policy design with stock prices in the economy and stock traders who use a mix of fundamental and technical analyses. This is because our aim has been to answer the following fundamental question: Can macroeconomic instability be hindered by an appropriate policy by the central bank when there is a stock price bubble in the economy? The background to this question is the financial turmoil that started in the U.S. in 2008 and thereafter was spread to the rest of the industrialized world with devastating effects. Among other things, stock prices fell sharply around the world and several of the largest economies were in 2009 in a recessional state.

In contrast with most of previous literature, we have argued that the central bank should augment the interest rate rule with a term for stock price misalignments. This is because a determinate and stable REE in the economy, which is stable under least squares learning, is then easier to achieve. At the same time, it should be emphasized that a large part of the literature on the desirability to deflate stock price bubbles in the economy argues that it is difficult for a central bank to detect stock price misalignments. The central bank should therefore avoid deflating bubbles in the economy. We have shown that if we sidestep the argument that it is difficult to detect bubbles in the economy, it is better with a pro-active policy than a re-active policy to achieve macroeconomic stability.

Moreover, inertia in monetary policy does not promote macroeconomic stability when technical analysis plays a major role in stock trading. This is an otherwise standard result in model economies without an asset market. Even worse, if the central bank in its policy only indirectly responds to stock price misalignments via its effect on the inflation rate, a combination of strong inertia in monetary policy and a significant role for technical analysis in stock trading will lead to macroeconomic instability. Thus, since inertia in monetary policy is a well-documented feature of central banking behavior in developed countries, we will have macroeconomic instability when technical analysis becomes an important trading technique in stock trading.

References


Figures and Tables

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<td>( \delta = 0.1, \kappa_r = 0 )</td>
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Table 1  The Woodford (1999) calibration in (19) is used as well as the parameter setting in Kontonikas and Montagnoli (2006) in (21) with the exception that the parameter for the wealth effect on aggregate demand (i.e., \( \delta \)) varies in the table. The degree of inertia in monetary policy (i.e., \( \kappa_r \)) varies also. There is no technical analysis in stock trading.

Figure 1
Regions for a determinate and stable REE (light area) and an indeterminate REE (dark area)

Figure 2

Region for a determinate and stable REE (light area)

Figure 3
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<td>Figure 7</td>
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</table>

Table 2  The Woodford (1999) calibration in (19) and the parameter setting in Kontonikas and Montagnoli (2006) in (21) are used. The degree of trend extrapolation in technical analysis (i.e., $\Theta$), the weight attached to technical analysis in stock trading (i.e., $\omega$), the degree of inertia in monetary policy (i.e., $\kappa_r$) and the response in monetary policy to the change in stock price misalignments (i.e., $\kappa_z$) varies in the table.
Figure 4

Figure 5
Output gap response in the Taylor rule

Inflation rate response in the Taylor rule

Region for an unstable REE (white area)

Figure 6

Regions for a determinate and stable REE (light area) and an unstable REE (white area)

Figure 7
Appendix

<table>
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<tr>
<th>Parameter configuration</th>
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<td>$\delta = 0, \kappa_r = 1$</td>
<td>Figure 3</td>
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<td>$\delta = 0.1, \kappa_r = 0$</td>
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**Table A.1** The Clarida et al. (2000) calibration in (20) is used as well as the parameter setting in Kontonikas and Montagnoli (2006) in (21) with the exception that the parameter for the wealth effect on aggregate demand (i.e., $\delta$) varies in the table. The degree of inertia in monetary policy (i.e., $\kappa_r$) varies also. There is no technical analysis in stock trading.

---

**Figure A.1**

Regions for a determinate and stable REE (light area) and an indeterminate REE (dark area)
Regions for a determinate and stable REE (light area) and an indeterminate REE (dark area)

Figure A.2
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**Table A.2** The Clarida et al. (2000) calibration in (20) and the parameter setting in Kontonikas and Montagnoli (2006) in (21) are used. The degree of trend extrapolation in technical analysis (i.e., $\theta$), the weight attached to technical analysis in stock trading (i.e., $\omega$), the degree of inertia in monetary policy (i.e., $\kappa_r$) and the response in monetary policy to the change in stock price misalignments (i.e., $\kappa_z$) varies in the table.
Regions for a determinate and stable REE (light area) and an indeterminate REE (dark area)

Figure A.3

Regions for a determinate and stable REE (light area) and an indeterminate REE (dark area)

Figure A.4
Output gap response in the Taylor rule

Inflation rate response in the Taylor rule

Regions for a determinate and stable REE (light area) and an unstable REE (white area)

Figure A.5

Regions for a determinate and stable REE (light area) and an unstable REE (white area)

Inflation rate response in the Taylor rule

Figure A.6
Regions for a determinate and stable REE (light area) and an unstable REE (white area)

Figure A.7
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