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# Monetary Policy and Financial Stability: In Search of Trade-offs

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# Monetary Policy and Financial Stability:

In Search of Trade-offs<sup>\*</sup>

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#### Abstract

In the aftermath of the 2008 global financial crisis, it has been argued that monetary policy should prevent raising financial risk by responding actively to financial imbalances. This paper investigates the extent to which a central bank's reaction to financial instability may be incompatible with its other macroeconomic stability objectives. The analytical framework relies on a New Keynesian model with an endogenous financial bubble, where it is assumed that tightening monetary policy can dampen raising financial risk. The paper concludes that a leaning against the wind strategy can generate trade-offs between the traditional inflation-output stability and financial stability objectives.

*Keywords*: Monetary policy objectives, financial stability, trade-offs.

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# 1 Introduction

The concern for financial stability has long been a critical question for central banks, since monetary policy is set to contribute to the overall economic stability. The relevance of the financial stance in the conduct of monetary policy has been strengthen more recently in the literature by highlighting the close connection between financial stability and the monetary policy setting. Monetary policy can feed financial imbalances in various ways. According to the risk-taking channel (Borio and Zhu, 2012), maintaining low interest rates for a protracted period of time increases financial risks through higher incentives to search for yields (Rajan, 2005). Moreover, for financial firms, low interest rates increase interest margins, augmenting the firm's value and thereby their leverage and their risk exposure (Adrian and Shin, 2010). A credible and predictable monetary policy can also favor risk-taking by reducing uncertainties and leading to an underestimation of risk by financial market participants. For households and entrepreneurs, low interest rates increase the value of their collateral and can fuel credit, raising concerns for financial stability.

Until 2007, the debate, both inside and outside central banks, was somewhat focused on whether or not monetary policy should respond to financial imbalances (the "clean" versus "lean" debate). According to the "cleaning" approach, central banks should not play an active role in preventing financial bubbles, but rather just clean up after they burst (the so-called "Greenspan put"). The arguments claim that bubbles are hard to detect, the short term interest rate may be ineffective or too blunt to target a particular asset price bubble, and more importantly, the costs associated to the cleaning policy may be much lower than those related to a policy of leaning against the wind. Conversely, proponents of active monetary policy, designed to prevent or dampen financial risks (the "leaning" view), argue that central banks should carefully scrutinize developments in the financial sector and respond adequately to rising financial imbalances such as asset price bubbles. According to this view, the main monetary policy instrument, the short term interest rate, can slow the bubble's growth, thereby preventing its burst or resulting in less damaging effects for the economy once the bubble bursts. Moreover, if the central bank doesn't act preventively, once the risk materializes, the policy rate can become inefficient because of the zero lower bound constraint. The cleaning approach seemed to prevail before the crisis. The latter has however underlined two major limits of this strategy. First, the 2007 crash of the housing price bubble has shown that the economic costs of a financial crisis can be very high and persistent. As pointed out by Woodford (2012), in spite of unprecedented measures undertaken by number of central banks in the aftermath of the global financial crisis, authorities were unable to avoid the sharp contraction of the global economic activity. Years after the subprime crisis, many economies are still struggling with its harmful effects. Second, the pre-crisis period showed that a trade-off can emerge between macroeconomic stability and financial stability. Despite the central banks' success in maintaining a low and stable inflation since the early 2000s, financial risks accumulated during this period and culminated in the crash of the house price bubble. De Grauwe and Gros (2009) show that a trade-off between inflation and financial stability can emerge when the economy faces a technological shock, or when the investors' behavior is characterized by too optimistic beliefs on the financial markets ("animal spirits").

Consequently, the leaning against the wind view, as a way to keep the financial sector safe, has gained importance. The debate has moved from the question of whether to act, to the issue of how to act. Raising the interest rate would help dampen excessive risk taking. As stated by Rudebusch (2005), ideally, a moderate adjustment of the interest rate could constrain the bubble and reduce the risk of an important macroeconomic disturbance. However, the tradeoff between macroeconomic and financial stability remains a relevant issue when adopting a leaning against the wind strategy. Recent research takes interest in the existence of trade-offs in this scenario, as detailed below.

A trade-off can emerge because of the violation of the Tinbergen principle. Relying on a single instrument for two objectives may lead to undesirable policy achievements. Mishkin (2011) argues that it may be dangerous to use monetary policy to promote financial stability because such a framework can require tightening monetary policy when it is not needed at the macroeconomic level. De Nicolo et al. (2010) state that, in a context of low inflation and high risk-taking, tightening monetary policy generates a trade-off between financial stability and the inflation stabilization objective. In the same line of arguments, Issing (2003) argues that the inflation and financial stability trade-off is more likely to show up in the short run. King (2012) identifies three cases in which a trade-off can emerge between monetary and financial stability. The first one is the (too optimistic) misperception on the part of households, businesses and financial institutions about future incomes, leading to unsustainable spending and increase in the level of debt. Assuming that these misperceptions can be identified by the central bank, taking actions to correct them may generate a trade-off between stabilizing the financial system and hitting the inflation target. The second, referred to as the "cycle of confidence", suggests that prolonged periods of stability (both macroeconomic and financial stability) can encourage exuberant behaviors, on the credit market for example, and generate subsequent instability. In the third case, trade-offs can appear due to the risk-taking channel, as described earlier. King (2012) further points out that, as compared with the traditional Taylor curve<sup>1</sup> which reflects inflation and output volatility, adding financial shocks moves the frontier upper and to the right (what he calls the Minsky-Taylor frontier). In other words, adding financial stability to the traditional macroeconomic stabilization objectives increases the volatility of both inflation and output.

In the above mentioned literature, the authors reach their conclusions with respect to the trade-off only by analyzing economic conditions and without explicitly resorting to a model.<sup>2</sup> To provide evidence in support of this idea, this paper theoretically investigates the existence of trade-offs between macroeconomic and financial stability, when the central bank responds to financial imbalances by setting the short term interest rate. To conduct our analysis, we start from a standard reduced form New Keynesian model that we supplement with a fourth equation which reflects the evolution of an asset price bubble. It is assumed that the deviation of an asset price from its fundamental value (the bubble process) captures the risk accumulation in the financial sector. We endogenize the bubble process by supposing that the policy interest rate has an influence on the probability of bubble burst. In the end, monetary policy affects both the bubble's duration and its amplitude. Furthermore, the financial bubble has an impact on the aggregate demand in the economy. In order to assess the extent to which monetary

 $<sup>^{1}</sup>$  The Taylor curve depicts the standard central bank's objectives, namely inflation and output stabilization, and suggests that a trade-off can emerge between these objectives in the context of supply shocks.

 $<sup>^{2}</sup>$  To the best of our knowledge, no other paper explicitly takes interest in the existence of trade-offs in a leaning against the wind setup. However, the issue is partly addressed in the presence of macroprudential policies in several DSGE models like Agenor et al. (2012), Beau et al. (2013) or Christensen et al. (2011). For an empirical assessment of trade-offs, see End (2010).

policy is effective in achieving its objectives, we explore the changes in inflation, output gap and bubble volatilities for various types of shocks and different responses of the central bank.

Our results suggest that, when the central bank directly responds to financial imbalances, a trade-off indeed emerges between its primary objective of macroeconomic stability and the financial stability objective. This finding emphasizes a limit of the leaning against the wind strategy. More precisely, employing such a strategy may generate a conflict between the objectives of the monetary authority. While financial stability remains a major concern, central banks should focus on their traditional inflation (and output gap) stability objective and rely on other (macroprudential) instruments to deal with financial imbalances.

The remainder of the paper is organized as follows. Section 2 presents the model with an emphasize on the bubble process. Section 3 discusses the results of the different scenarios considered. Robustness tests are conducted in section 4 and section 5 concludes.

## 2 The Model

The discussion relies on a reduced form New Keynesian model describing the economy through the equations for aggregate demand, aggregate supply, and the central bank's reaction function. This conventional three-equation model is supplemented with a fourth relation describing risk accumulation in the financial market, *i.e.* an asset price bubble. The bubble's equation is presented in the first part of this section, before introducing the whole macroeconomic model.

#### 2.1 The Bubble

Inspired by the Blanchard and Watson (1982) rational asset price bubble, we consider the following linear form of a bubble process:

$$b_{t} = \begin{cases} \frac{1+\bar{i}}{\bar{q}}(b_{t-1} - \tilde{q}_{t}) + \varepsilon_{t}^{b} & \text{if the bubble persists, } (q_{t}) \\ \\ \varepsilon_{t}^{b} & \text{otherwise, } (1 - q_{t}) \end{cases}$$
(1)

where  $b_t$  denotes the asset price deviation from its fundamental value at time t. The bubble is assumed to persist with probability  $q_t$  and to burst with probability  $(1-q_t)$ . We define  $\bar{q}$  as the threshold value of the probability  $q_t$  above which the bubble bursts. Further,  $\tilde{q}_t$  is the difference between  $q_t$  and  $\bar{q}$ . Finally,  $\bar{i}$  is the equilibrium interest rate and  $\varepsilon_t^b$  is an exogenous shock with zero mean. According to the above equation, the bubble depends on its past value, as well as on its probability to persist. The bubble is self-fulfilling and grows without any connection to fundamentals, with  $\frac{1+\bar{i}}{\bar{q}}$  superior to 1. Holding an asset experiencing a price bubble can be therefore motivated by the expectation that the price will continue to grow in subsequent periods.

At this stage of the discussion, the bubble process is strictly exogenous since it is not affected by any economic or policy changes. Although exogenous bubbles have already been used in macroeconomic models (Bernanke and Gertler, 1999, Cecchetti et al., 2000, Badarau and Popescu, 2014, among others), it is well recognized that asset prices are responsive to changes in the economic environment. Especially, since the 2008/2009 global financial crisis, the monetary policy stance has been considered as one of the main drivers of financial market activities, and potentially (at least in part) responsible of stakeholders' risk-taking behavior. Therefore, we rely on the realistic assumption that the asset price bubble is affected by monetary policy through the short term interest rate. Precisely, it is hypothesized that the central bank can influence the probability  $q_t$  as follows:

$$\widetilde{q}_t = -\gamma \Delta i_{t-1} \tag{2}$$

where  $\Delta i_{t-1}$  is the variation of the short term interest rate from one period to another. Equation (2) suggests that monetary policy can lower the lasting probability of the bubble by raising the short term interest rate. Doing so will, by construction, increase the bursting probability, thus diminish the duration of the bubble. Such an action from the monetary authority may be well justified by the willingness to limit the disruptive consequences of a bubble collapse. As a means of prevention, the central bank may wish to prick the bubble before the risk accumulation becomes excessive. However, this policy affects not only the duration, but also the size of the bubble. Indeed, increasing the interest rate will translate in an upward reaction of the bubble.<sup>3</sup>

 $<sup>^{3}</sup>$  Gali (2014) also argues that an increase in the policy rate in reaction to a growing bubble will entail a positive effect on the bubble's growth.

In the expression of  $\tilde{q}_t$ , it is assumed that changes in the interest rate matter more for the financial sector than the level of this rate. Consider for example a first situation in which the short term rate rises from 1 to 2%, and a second one where the rate goes from 1.5 to 2%. In both situations, the interest rate reaches the same level, however, in the first case, the rate increases by 1 percentage point, whereas the increase is of only 0.5 in the second case. We argue that financial markets will be more affected in the first scenario as compared with the second one.<sup>4,5</sup>

Substituting equation (2) in the bubble's expression (1) yields:

$$b_t = \left[\frac{1+\bar{i}}{\bar{q}}(b_{t-1} + \gamma \Delta i_{t-1})\right] D + \varepsilon_t^b \tag{3}$$

where D is a dummy variable which takes the value of 1 as long as the bubble lasts, and 0 when it bursts (*i.e.* when  $q_t > \bar{q}$ ). The macro-model describing the economic framework, discussed in the next subsection, will be augmented with this expression of the asset price bubble.

## 2.2 The Macroeconomic Framework

A three-equation New Keynesian model is used to describe the macroeconomic framework considered for the purpose of the investigation. The log-linear inter-temporal relations take the following form:

$$\pi_t = \alpha \mathbb{E}_t(\pi_{t+1}) + (1 - \alpha)\pi_{t-1} + \lambda y_t + \varepsilon_t^{\pi}$$
(4)

$$y_t = \delta \mathbb{E}_t(y_{t+1}) + (1 - \delta)y_{t-1} + \sigma \Big(i_t - \mathbb{E}_t(\pi_{t+1})\Big) + \varphi b_t + \varepsilon_t^y$$
(5)

$$i_t = \beta_i i_{t-1} + (1 - \beta_i)(\beta_\pi \pi_t + \beta_y y_t + \beta_b b_t)$$
(6)

where  $\pi_t$ ,  $y_t$  and  $i_t$  represent respectively the inflation rate, the output gap, and the short term nominal interest rate under the central bank's control. The  $\varepsilon s$  are exogenous shocks normally

<sup>&</sup>lt;sup>4</sup> The main conclusions from our model do not change if we consider the levels rather than the changes of the short term rate in equation (2). See the robustness section for more details.

<sup>&</sup>lt;sup>5</sup> Gruen et al. (2005) use a similar approach to make the bubble process endogenous to policy setting. They build a macroeconomic model that includes a role for an asset price bubble and compare the optimal monetary policy response for two types of policymakers: a skeptic one which implements a (standard) inflation targeting-type policy, and an activist one which responds to asset price bubbles. In their sensitivity analysis, they assume that the bursting probability of the bubble is affected (with a lag) by the difference between the short term rate and its optimal path, chosen by the skeptic policymaker.

distributed, and  $\mathbb{E}_t$  denotes the expectation operator.  $\alpha$ ,  $\lambda$ ,  $\delta$ ,  $\sigma$ ,  $\varphi$ ,  $\beta_i$ ,  $\beta_{\pi}$ ,  $\beta_y$ , and  $\beta_b$  are the model's parameters.

The model consists of a hybrid New Keynesian Phillips curve (equation (4)) where current inflation is affected by both past and expected inflation, and by the current level of output gap. The hybrid IS curve (equation (5)) describes the current output gap as a function of its lagged and expected values, and of the real interest rate. This equation differs from the conventional hybrid IS curve in the presence of the bubble term. More precisely, it is assumed that the output gap is also positively affected by the asset price bubble. As argued in Filardo (2004), the fundamental component of asset prices does not really matter for output or its components. Conversely, the asset price bubble (the non-fundamental component) can affect aggregate demand by distorting economic decisions: changes in consumption through a wealth effect, changes in investment via the cost of capital, changes in government spending through the tax channel.<sup>6</sup>

Finally, equation (6) represents the central bank's reaction function. The monetary policy instrument is set in response to deviations of inflation from its target, the output gap, as well as deviations of asset prices from their fundamental value (the bubble). Moreover, a smoothing component is included in order to limit interest rate volatility. The central bank's reaction function portrays an augmented Taylor rule with a financial variable, suggesting a leaning against the wind policy. Such a policy has been advocated in recent discussions on the monetary policy stance among both academics and practitioners. The objective is to reinforce financial stability by reacting to increasing and unsustainable asset prices which can culminate in a financial crisis with significant real economic effects. However, as we argue in the introduction, the central bank's efficiency in achieving its primary objectives can be affected in such a framework.

<sup>&</sup>lt;sup>6</sup> Even though the presence of the bubble in the aggregate demand equation has no microfoundations, the above arguments are more in favor of including the bubble in the IS curve rather than in the Phillips curve. Note however that, given the model specification, and more precisely, the fact that the aggregate demand enters the Phillips curve, asset price bubbles also affect aggregate supply, although indirectly.

## 2.3 Model solution and calibration

To solve the model described by the four equations presented in the above subsections, we rely on the Blanchard-Kahn method (Blanchard and Kahn, 1980). This is a commonly used approach in the literature. However, the specification of the bubble equation gives our model a structure that is less standard. In this respect, the model is solved for two states of nature: first, when the bubble is persistent (D is equal to 1 in equation (3)) and second, when the bubble only equals a random shock (D is equal to 0).<sup>7</sup> Next, for each period of time, we switch between the two states of nature depending on the value of D, which in turn depends on whether the lasting probability of the bubble is above or below the threshold,  $\bar{q}$ .

In the calibration of the model, the parameters for the standard New Keynesian equations are taken from the estimated model of Smets (2000) and correspond to annual data for the euro area. Two other (non-standard) parameters are introduced in our model, namely  $\gamma$  and  $\varphi$ . As there exists no estimation for such parameters, we set their values relying on some ad-hoc assumptions,<sup>8</sup> and we check the robustness of our main conclusions to changes in the values of those parameters. Table 1 in the appendix presents the baseline values of the parameters used to perform the simulations.

## **3** Results

The framework depicted in the reduced-form model characterized by equations (3), (4), (5) and (6) is used to investigate the existence of a trade-off between macroeconomic (inflation and/or output) stability and financial stability, when the central bank reacts to a financial variable. We rely on a simple procedure which can be summarized as follows: the economy is hit by exogenous shocks (supply and/or bubble shocks) which are assumed to randomly occur each period of time.<sup>9</sup> Central banks respond to these shocks by setting the short term interest

<sup>&</sup>lt;sup>7</sup> When the dummy is equal to 0, the Blanchard-Kahn conditions are verified, therefore the model is stable. When D is equal to 1, the model is unstable due to the way in which the bubble's equation is specified. However, on the long run the economy converges in probability to the steady state.

<sup>&</sup>lt;sup>8</sup> It is assumed that the effect of the interest rate on the bubble is of the same magnitude as the effect of the real interest rate on the output gap. It is also assumed that the asset price bubble affects the aggregate demand to a lesser extent than the real interest rate.

<sup>&</sup>lt;sup>9</sup> The shocks and the probability  $q_t$  are set according to a random process, following a normal and a uniform distribution, respectively.

rate more or less aggressively. Given the aggressiveness of this response, we generate series of variances, calculated on 1000 periods, for each argument of the central bank's reaction function (inflation, output gap and bubble). We then compare the evolution of these variances to assess the monetary policy efficiency in achieving its objectives.

Confronted with the same shocks, central banks may react differently, both in terms of measures undertaken and in terms of intensity (or aggressiveness) of the policy. For example, faced with an asset price bubble shock, a central bank may decide to react indirectly through a stronger response to output gap (since the bubble affects aggregate demand), thus increasing  $\beta_y$ . Another central bank may rather react directly by strengthening its response to the bubble, increasing  $\beta_b$ . Moreover, in both cases, the responses may be more or less aggressive (a sharp or a more progressive increase in  $\beta$ ). For each type of shock and each value of the  $\beta s$ , we generate the corresponding variances of  $\pi_t$ ,  $y_t$  and  $b_t$ . We then represent these variances (in pairs) on graphs, in the spirit of a Taylor-type curve, in order to investigate potential trade-offs.

The analysis conducted here should not be view as an attempt to derive the optimal monetary policy stance. The purpose is much more modest and simply aims at investigating, through comparative statics, the challenges central banks can face when reacting to financial variables. More precisely, we focus on trade-offs between policy objectives. In addition, the differences in parameters in the central bank's reaction function can be viewed as responses from different central banks to the same shocks, and not necessarily as changes in a single central banks response over time.

The main results are discussed considering successively the central banks responses to each type of shock: supply shocks, bubble shocks and a combination of the two.

Before addressing the issue of trade-offs, we investigate the response of the model to bubble shocks, by looking at how the output gap, inflation and the interest rate react to deviations of the asset price from its fundamentals (Figure 1). In response to positive bubble shocks, the output gap increases as expected. Given the policy rule, the short term interest rate rises in reaction to higher output gap, but also in response to the bubble. The higher level of the policy rate reduces inflation in the economy with respect to its steady state value.

We turn now to the investigation of potential trade-offs between central banks' objectives



Figure 1: Model's response to bubble shocks deviation from the steady-state

Note: The response of the variables (output gap, inflation and interest rate) to consecutive bubble shocks.

when responding to real or financial shocks. The economy is assumed to face (small) shocks in each period. We observe the variables' responses during 1000 periods and generate the corresponding variances.

## Supply shocks

Faced with positive supply shocks, central banks may respond by tightening monetary policy (increase in  $\beta_{\pi}$ ). In Figure 2, a stronger response to inflation shocks results in better inflation stabilization, but at the cost of higher output and bubble volatility. The standard trade-off between inflation and output stabilization in a context of supply shocks emerges, but there also seems to be a trade-off between inflation and the asset price bubble. This implies that the stronger the central bank's reaction to inflation shocks, the higher the asset price bubble volatility. This finding is in line with the argumentation in De Grauwe and Gros (2009). In addition, there seems to be no trade-off between the output gap and the asset price bubble in case of cost push shocks.

## Asset price bubble shocks

Since the asset price bubble enters the central bank's reaction function, the short term interest rate rises in response to positive bubble shocks. This type of reaction, intended to strengthen





Note: Variances of inflation, output gap and the bubble following supply shocks. The response to inflation varies between 1.5 and 2.5 and all other parameters remain the same. The arrows indicate an increase in  $\beta_{\pi}$ .

financial market stability, corresponds to the leaning against the wind strategy. Being more aggressive to the bubble (increase in  $\beta_b$ ) reduces indeed the bubble volatility, as shown in Figure 3. However, this better financial market stabilization is achieved at the cost of higher macroeconomic instability, since both inflation and output volatilities increase. These results suggest that a direct central bank's response to financial imbalances may be harmful for the monetary authorities' primary objectives. While such a strategy may be effective in containing a financial bubbles, it leads to a deterioration of the macroeconomic stance, generating a tradeoff between this main monetary policy objective and the concern for financial stability.

Alternatively, the central bank may choose to react indirectly to bubble shocks through a



Figure 3: Bubble shocks (Response to the bubble)

Note: Variances of inflation, output gap and the bubble following bubble shocks. The response to the bubble varies from 0 to 0.75 and all other parameters remain the same. The arrows indicate an increase in  $\beta_b$ .

stronger response to output gap (increase in  $\beta_y$ ), since it is assumed that the bubble positively

affects aggregate demand. This approach seems to provide a better outcome than the former as it reduces not only the bubble, but also the output gap volatility. However, inflation volatility increases (recall that both output and inflation volatilities increase with the former central bank's response), making this strategy questionable. As a result of the central bank's actions, a trade-off between inflation and financial stability emerges, but the bubble and the output gap seem to stabilize (Figure 4).<sup>10</sup> To some extent, this result suggests that a standard Taylor rule provides a better outcome than a pure leaning against the wind strategy, even when facing financial shocks. Although not satisfactory, the standard rule seems to be less costly.

#### Figure 4: Bubble shocks (Response to output gap)



Note: Variances of inflation, output gap and the bubble following bubble shocks. The response to output gap varies between 0.5 and 1.5 and all other parameters remain the same. The arrows indicate an increase in  $\beta_y$ .

## Supply and asset price bubble shocks

We assume now that the economy is faced with supply and bubble shocks at the same time. The results in this scenario are in line with the above discussion. A stronger response to output gap results in better bubble and output gap stabilization, while inflation variability increases as shown in Figure 5. There is a trade-off between inflation and bubble stability, but also one between price stability and output gap stability.

If monetary authorities are more adverse to the bubble (increase in  $\beta_b$ ), the bubble's variability decreases, whereas inflation and output volatilities increase. The results in Figure 6

<sup>&</sup>lt;sup>10</sup> Figure 4 also shows that there is a trade-off between inflation and the output gap. Such a trade-off is not to be expected in the context of demand shocks in standard models. Note however that our model is different from the standard New Keynesian one, in the sense that it includes a bubble process which is assumed to affect aggregate demand. When removing this assumption, we reach the common conclusion of no trade-off between inflation and output.

Figure 5: Supply and bubble shocks (Response to output gap)



Note: Variances of inflation, output gap and the bubble following supply and bubble shocks. The response to output gap varies from 0.5 to 1.5 and all other parameters remain the same. The arrows indicate an increase in  $\beta_y$ .

also show that, in a later stage, when the central bank's reaction becomes more aggressive, all policy objectives are negatively affected (increase in output, inflation and bubble volatilities). In other words, when the central bank's response to the bubble exceeds a certain threshold, the effect on the economy becomes counterproductive, leading not only to a deterioration of the macroeconomic stability, but also to an increase in the bubble's volatility. This finding is in line with Gali (2014) who argues that increasing the interest rate in response to a growing bubble generates higher fluctuations in the latter, as the interest rate positively affects the bubble's growth. In a different framework with another definition for financial instability, Svensson (2013) also concludes to a counterproductive effect of tightening monetary policy to stabilize the financial system.<sup>11</sup>

In response to supply and bubble shocks, an increase in the reaction to inflation lowers its volatility, while there is an increase in output gap and bubble volatilities (Figure 7). A trade-off between inflation and bubble stability emerges, in addition to the standard inflation – output gap trade-off.

Globally, these results seem all against the leaning against the wind strategy. Regardless of the type of shock, a trade-off between inflation stability and financial stability is always present. At best, responding to the bubble by increasing  $\beta_b$  achieves financial stability, but endangers the main objectives of the central bank, as in this scenario both inflation and output

<sup>&</sup>lt;sup>11</sup> Considering household indebtedness as an indicator of financial stability, Svensson (2013) shows that a tighter monetary policy to control the level of debt leads to an increase in the debt to GDP ratio. Tightening monetary policy more than necessary for inflation stabilization, will raise the real household debt and dampen the nominal GDP, increasing the debt to GDP ratio.





Note: Variances of inflation, output gap and the bubble following supply and bubble shocks. The response to the bubble varies from 0 to 0.75 and all other parameters remain the same. The arrows indicate an increase in  $\beta_b$ .



Figure 7: Supply and bubble shocks (Response to inflation)

Note: Variances of inflation, output gap and the bubble following supply and bubble shocks. The response to inflation varies from 1.5 to 2.5 and all other parameters remain the same. The arrows indicate an increase in  $\beta_{\pi}$ .

volatilities increase. The best outcome, although not ideal, is to increase the response of the policy rate to the output gap. This allows monetary authorities to attain both financial and output gap stability, but the price stability objective is left aside in this case. Several authors now (De Grauwe and Gros, 2009, Woodford, 2012) seem in favor of this strategy, where the central bank neglects its main objective in the short run, in order to avoid or to diminish the harmful effects of a financial bubble.

# 4 Robustness Checks

To check the robustness of our results, various analyses are conducted. First, the bubble is assumed to be affected by the levels of the short term interest rate rather than the changes. Second, we assess the extent to which our results are sensitive to changes in the values of the parameters  $\varphi$  and  $\gamma$ . Third, we examine different random selections for supply and financial shocks. And finally, an alternative random selection of the probability  $q_t$  is considered.

### Bubble affected by levels rather than changes in interest rate

In section 2.1, it is assumed that changes in the short term interest rate matter more for the financial sector than levels. However, it can be argued that the levels of the policy rate also matter since they can have important effects on the private sector's risk taking behavior. We assess the extent to which our main results remain relevant if the bubble is affected by the level of the short term interest rate rather than its changes (in equation (3),  $\Delta i_{t-1}$  is replaced by  $i_{t-1}$ ). With such a framework, our findings are the same as in the baseline model when supply shocks are considered. We also reach the same conclusions regarding bubble shocks. When the central bank responds to the bubble, a trade-off emerges between macroeconomic and financial stability. An indirect reaction through a response to the output gap produces a better outcome, as in the baseline analysis. When the economy is hit by the two shocks simultaneously, responding to the output gap and inflation produces the same effects found in section 3. The response to the bubble generates a trade-off between inflation and the bubble stabilization, but also between output gap and bubble stability. Overall, considering the levels of the policy rate does not change our conclusions highlighting the existence of trade-offs (Appendix 2, Figure 1).

## Robustness to different values of the parameters $\varphi$ and $\gamma$

For robustness to parameters' values, we focus only on the trade-off between inflation and bubble stabilization. Indeed, our main conclusions so far suggest that this trade-off always emerges, regardless of the nature of the shock and of the central bank's reaction.

In a context of asset price bubble shocks and with the central bank responding either directly to the bubble or indirectly, through a response to the output gap, we investigate the existence of this trade-off for different values of  $\varphi$  (between 0.01 and 0.025). The results presented in Appendix 2, Figure 2 show that whatever the value of  $\varphi$  considered, there is always a trade-off between inflation and financial stability.

The same investigation is conducted for different values of  $\gamma$  (with  $\gamma$  taking values between 0.02 and 0.07). The economy is hit by asset price bubble shocks and the central bank responds to the bubble or to the output gap. The findings are in line with our previous conclusions that there is always a trade-off between inflation and bubble stability (Appendix 2, Figure 3).

#### Robustness to an alternative selection of shocks

As discussed earlier, the shocks are drawn on a random basis from a normal distribution. We perform a robustness check by considering another random selection of shocks and we conduct the same analysis as above. Regarding the responses to supply shocks, the findings are the same as in the baseline model. We also reach the same conclusions when the central bank reacts to bubble shocks. There is a trade-off between macroeconomic (inflation and output) stability and financial stability (although small and limited policy rate adjustments seem to succeed in reducing bubble and output volatilities). When the central bank is faced with the combination of the two shocks, the results are also in line with the baseline model. A response to the bubble, while decreasing the bubble volatility, raises both inflation and output variability. A response to output gap lowers output and bubble instability, but generates a greater variability of inflation. Finally, a response to inflation leads to the inflation – output trade-off, but also to an inflation – bubble trade-off (Appendix 2, Figure 4).

#### Robustness to an alternative selection of $q_t$

The values of  $q_t$  are selected randomly following a uniform distribution. To reinforce our results, we also draw an alternative series of  $q_t$  following the same process and we conduct the same analysis. The findings regarding supply shocks are the same as in the baseline model. For bubble shocks, at first, tightening monetary policy by increasing the response to the bubble lowers the bubble's volatility, but at the cost of higher output gap and inflation volatility. However, in a later stage, when the response is more aggressive, all three volatilities increase, leading to a deterioration of macroeconomic, as well as financial stability. Central banks which respond strongly to output gap in the context of bubble shocks seem to perform better, although not satisfactorily. As in the baseline model, the bubble and output volatilies decline, while inflation volatility rises. Considering the combination of the two shocks, a monetary authorities' response to the bubble reduces the bubble and the output gap volatilities at first, but worsens macroeconomic and financial stability later on, when this response is stronger. The responses to the output gap and inflation reveal the same outcome as in the baseline model.<sup>12</sup>

Overall, the alternative analyses conducted in this section highlight the robustness of our main result. A leaning against the wind strategy in which central responds directly to financial instability is subject to trade-off between the primary inflation stabilization objective and financial stability.

# 5 Conclusions and Policy Implications

This paper explores the extent to which trade-offs can emerge between macroeconomic and financial stability when the central bank responds directly to financial imbalances. The macroeconomic framework is described through a New Keynesian model consisting of aggregate demand and aggregate supply equations, and the central bank's reaction function (an augmented Taylor-type rule in which the policy rate responds to a financial bubble). This basic model is supplemented with a fourth equation capturing risk accumulation in the financial sector, the asset price bubble equation. We endogenously modeled the bubble assuming that it can be affected by monetary policy.

Various forms of central bank's responses and the strength of these responses are assessed when the economy is confronted with different shocks. The main conclusion of the analysis is that, central banks practicing the leaning against the wind strategy will face trade-offs between traditional macroeconomic objectives (inflation and output stabilization) and financial stability. More precisely, when the central bank responds to financial imbalances, in the best-case scenario, such a policy can succeed in dampening financial risks, but at the cost of higher price instability. Our results also seem to highlight the worse-case scenario in which the policy is counterproductive with respect to all the monetary policy objectives (increase in macroeconomic and financial instability).

 $<sup>^{12}</sup>$  We skip these results due to space constraints, but they can be provided upon request to the authors.

While the leaning against the wind strategy may be required, especially since the global financial crisis unfolded, this paper argues that such a policy can lead to trade-offs between objectives. Monetary authorities can face a challenge in achieving their objectives if monetary policy explicitly responds to financial instability. A second instrument is needed to tackle this issue. While central banks should continue to focus on the traditional macroeconomic goals, a macroprudential framework should be developed to address financial imbalances.

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# Appendix 1: Baseline calibration of the model

Parameters	α	λ	δ	$\sigma$	$\varphi$	$\gamma$	$\bar{q}$	$\overline{i}$	$\beta_i$	$\beta_{\pi}$	$\beta_y$	$\beta_b$
Value	0.52	0.18	0.56	-0.06	0.02	0.06	0.8	0.04	0.98	75	25	7.5

# **Appendix 2: Robustness Checks**

## Bubble affected by levels rather than changes in interest rate



Figure (1a) Supply shocks (Response to inflation)

Note: Variances of inflation, output gap and the bubble following supply shocks. The response to inflation varies from 1.5 to 2.5 and all other parameters remain the same. The arrows indicate an increase in  $\beta_{\pi}$ .

Figure (1b) Bubble shocks (Response to the bubble)



Note: Variances of inflation, output gap and the bubble following bubble shocks. The response to the bubble varies from 0 to 0.75 and all other parameters remain the same. The arrows indicate an increase in  $\beta_b$ .





Note: Variances of inflation, output gap and the bubble following bubble shocks. The response to output gap varies from 0.5 to 1.5 and all other parameters remain the same. The arrows indicate an increase in  $\beta_y$ .



Figure (1d) Supply and bubble shocks (Response to output gap)

Note: Variances of inflation, output gap and the bubble following supply and bubble shocks. The response to output gap varies from 0.5 to 1.5 and all other parameters remain the same. The arrows indicate an increase in  $\beta_y$ .

Figure (1e) Supply and bubble shocks (Response to the bubble)



Note: Variances of inflation, output gap and the bubble following supply and bubble shocks. The response to the bubble varies from 0 to 0.75 and all other parameters remain the same. The arrows indicate an increase in  $\beta_b$ .

Figure (1f) Supply and bubble shocks (Response to inflation)



Note: Variances of inflation, output gap and the bubble following supply and bubble shocks. The response to inflation varies from 1.5 to 2.5 and all other parameters remain the same. The arrows indicate an increase in  $\beta_{\pi}$ .

## Robustness to $\varphi$





Note: Left panel – Response to the bubble: Variances of inflation and the bubble following bubble shocks. The response to the bubble varies from 0.15 to 0.75 and all other parameters remain the same. Right panel – Response to the output gap: Variances of inflation and the bubble following bubble shocks. The response to the output gap varies from 0.5 to 1.5 and all other parameters remain the same. We do not present in this panel the result for  $\varphi = 0.025$ , as the volatilities are much reduced and these smaller values make the figure difficult to read. Note however that the trade-off is still present.

## Robustness to $\gamma$



Figure (3) Bubble shocks (Response to the bubble [left] and to the output gap [right])

Note: Left panel - Response to the bubble: Variances of inflation and the bubble following bubble shocks. The response to the bubble varies from 0.15 to 0.75 and all other parameters remain the same. Right panel - Response to the output gap: Variances of inflation and the bubble following bubble shocks. The response to the output gap varies from 0.5 to 1.5 and all other parameters remain the same.

## Robustness to an alternative selection of shocks



Figure (4a) Supply shocks (Response to inflation)

Note: Variances of inflation, output gap and the bubble following supply shocks. The response to inflation varies from 1.5 to 2.5 and all other parameters remain the same. The arrows indicate an increase in  $\beta_{\pi}$ .

Figure (4b) Bubble shocks (Response to the bubble)



Note: Variances of inflation, output gap and the bubble following bubble shocks. The response to the bubble varies from 0 to 0.75 and all other parameters remain the same. The arrows indicate an increase in  $\beta_b$ .



Figure (4c) Bubble shocks (Response to output gap)

Note: Variances of inflation, output gap and the bubble following bubble shocks. The response to output gap varies from 0.5 to 1.5 and all other parameters remain the same. The arrows indicate an increase in  $\beta_y$ .



Figure (4d) Supply and bubble shocks (Response to output gap)

Note: Variances of inflation, output gap and the bubble following supply and bubble shocks. The response to output gap varies from 0.5 to 1.5 and all other parameters remain the same. The arrows indicate an increase in  $\beta_y$ .

Figure (4e) Supply and bubble shocks (Response to the bubble)



Note: Variances of inflation, output gap and the bubble following supply and bubble shocks. The response to the bubble varies from 0 to 0.75 and all other parameters remain the same. The arrows indicate an increase in  $\beta_b$ .

Figure (4f) Supply and bubble shocks (Response to inflation)



Note: Variances of inflation, output gap and the bubble following supply and bubble shocks. The response to inflation varies from 1.5 to 2.5 and all other parameters remain the same. The arrows indicate an increase in  $\beta_{\pi}$ .