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**STRUCTURAL REFORMS AND  
MONETARY POLICIES IN A  
BEHAVIOURAL MACROECONOMIC  
MODEL**

Paul De Grauwe and Yuemei Ji

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## Abstract

We use a New Keynesian behavioral macroeconomic model to analyze how structural reforms affect the nature of the business cycle and the capacity of the central bank to stabilize output and inflation. We find that structural reforms that increase the flexibility of wages and prices can have profound effects on the dynamics of the business cycle. Our main finding here is that there is an optimal level of flexibility (produced by structural reforms). We also find that in a rigid economy the central bank in general faces a tradeoff between output and inflation volatility. This tradeoff disappears when the economy becomes sufficiently flexible. In that case the central bank's efforts at stabilizing inflation and output are always welfare improving.

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*Abstract:*

We use a New Keynesian behavioral macroeconomic model to analyze how structural reforms affect the nature of the business cycle and the capacity of the central bank to stabilize output and inflation. We find that structural reforms that increase the flexibility of wages and prices can have profound effects on the dynamics of the business cycle. Our main finding here is that there is an optimal level of flexibility (produced by structural reforms). We also find that in a rigid economy the central bank in general faces a tradeoff between output and inflation volatility. This tradeoff disappears when the economy becomes sufficiently flexible. In that case the central bank's efforts at stabilizing inflation and output are always welfare improving.

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## 1. Introduction

As a reaction to the sovereign debt crisis European policy makers intensified calls for structural reforms aiming at making economic systems more flexible. Countries that were subject to financial rescue programs in fact were forced to implement structural reforms mainly in the labour market and in pension systems. The underlying view of this approach was that it is crucial for the recovery that the supply side be made more flexible. No doubt the supply side in many countries needs to be reformed. At the same time, however, aggregate demand matters. Structural reforms imposed on the supply side interact with aggregate demand. It is this interaction that determines what the short-term and long-term effects of structural reforms will be.

The question of how supply-side reforms interact with aggregate demand and how they impact on the economy has been analyzed in DSGE-models. Most of the time these reforms are modeled as leading to a decline in the markup between prices and marginal costs (ECB (2015) Cacciatore, et al. (2012), Cacciatore, et al. (2016), Eggertson, et al.(2014), Sajedi(2017)). This analysis has shed new light on how reforms affect the economy in the short and in the long run.

One of the problems of DSGE-models is that these models do not have an endogenous business cycle theory. In these models, business cycles are triggered by exogenous shocks combined with slow adjustments of wages and prices. There is a need to analyze the effects of structural reforms in models where the business cycle is generated endogenously. This is the case in behavioral macroeconomic models (see De Grauwe(2012) and De Grauwe and Ji(2016)).

In this paper we use a behavioral macroeconomic model based on a New Keynesian framework to analyze the effects of structural reforms. The model is characterized by the fact that agents experience cognitive limitations preventing them from having rational expectations. Instead they use simple forecasting rules (heuristics) and evaluate the forecasting performances of these rules ex-post. This evaluation leads them to switch to the rules that perform best. Thus, it can be said that agents use a trial-and-error learning mechanism. This is also called “adaptive learning”.

This adaptive learning model produces endogenous waves of optimism and pessimism (animal spirits) that drive the business cycle in a self-fulfilling way, i.e. optimism (pessimism) leads to an increase (decline) in output, and the increase (decline) in output in turn intensifies optimism (pessimism), see De Grauwe(2012), and De Grauwe and Ji(2016). An important feature of this dynamics of animal spirits is that the movements of the output gap are characterized by periods of tranquility alternating in an unpredictable way with periods of intense movements of booms and busts. One of the issues we will analyze is how structural reforms affect this dynamics of the business cycle.

We will introduce structural reforms in the context of this behavioral model through two channels. The first one is through the sensitivity of inflation to the output gap in the New Keynesian Philips curve (supply equation). A low sensitivity of the rate of inflation with respect to the output gap is indicative of wage and price rigidities. For example, if wages are rigid an increase in unemployment has a low effect on wage formation and therefore does not transmit into lower inflation. Conversely, when wages are flexible, an increasing level of unemployment leads to a lowering of wages, and as a result is transmitted into a lower rate of inflation.

The second way we will introduce structural reforms is through supply shocks. This is also the way structural reforms have been modeled in standard DSGE models (see e.g. Eggertson, et al. (2014), Cacciatore, et al (2012), Everaert and Schule (2006), Gomes, et al. (2013), ECB (2015)). In these micro-founded models, structural reforms in labour markets include relaxing job protection, cuts in unemployment benefits, etc., and in product markets, reductions in barriers to entry for new firms. These reforms lead to a lowering of mark-ups in the goods and labor markets and move the economy closer to perfect competition. Therefore, these reforms can be seen as shifting the supply curve to the right, increasing the production potential of countries. One common feature of these New Keynesian models is their reliance on the assumption that there are rigidities in nominal prices and wages leading to a relatively flat Philips curve.

The main focus of this paper will be the analysis, first, of how structural reforms that increase flexibility affect the nature of the business cycle, and second, how

these structural reforms affect the capacity of the central bank to stabilize inflation and output.

## **2. The behavioral model**

### **2.1 Model choice**

Mainstream macroeconomics has been based on two fundamental ideas. The first one is that macroeconomic models are micro-founded, i.e. they start from individual optimization and then aggregate these individuals' optimal plans to obtain a general equilibrium model. This procedure has some aggregation problems that cannot easily be solved (Sonnenschein(1972), Kirman(1992)). The DSGE models deal with the problems by introducing the representative agent, i.e. by assuming that demand and supply decisions in the aggregate can be reduced to decisions made at the individual level.

The second idea is that expectations are rational, i.e. take all available information into account, including the information about the structure of the economic model and the distribution of the shocks hitting the economy.

We make a different choice of model. First, we will bring at center stage the heterogeneity of agents in that they have different beliefs about the state of the economy. As will be shown, it is the aggregation of these diverse beliefs that creates a dynamics of booms and busts in an endogenous way. The price we pay is that we do not micro-found the model and assume the existence of aggregate demand and supply equations. Second, we assume that agents have cognitive limitations preventing them from having rational expectations. Instead they will be assumed to follow simple rules of thumb (heuristics). Rationality will be introduced by assuming a willingness to learn from mistakes and therefore a willingness to switch between different heuristics. In making these choices we follow the road taken by an increasing number of macroeconomists, which have developed "agent-based models" and "behavioral macroeconomic models" (Tesfatsion, L., and Judd, (2006), Colander, et al. (2008), Farmer and Foley(2009), Gatti, et al.(2011), Westerhoff and Franke(2012), De Grauwe(2012), Hommes and Lustenhouwer(2016)).

## 2.2 Basic model

The model consists of an aggregate demand equation, an aggregate supply equation and a Taylor rule.

We assume the existence of an aggregate demand equation in the following way:

$$y_t = a_1 \tilde{E}_t y_{t+1} + (1 - a_1) y_{t-1} + a_2 (r_t - \tilde{E}_t \pi_{t+1}) + \varepsilon_t \quad (1)$$

where  $y_t$  is the output gap in period  $t$ ,  $r_t$  is the nominal interest rate,  $\pi_t$  is the rate of inflation. The tilde above  $E$  refers to the fact that expectations are not formed rationally. How exactly these expectations are formed will be specified subsequently.

We follow the procedure introduced in New Keynesian DSGE-models of adding a lagged output in the demand equation. This can be justified by invoking inertia in decision-making. It takes time for agents to adjust to new signals because there is habit formation or because of institutional constraints. For example, contracts cannot be renegotiated instantaneously.

We assume an aggregate supply equation in (2) of the New Keynesian Philips curve type with a forward looking component,  $\tilde{E}_t \pi_{t+1}$ , and a lagged inflation variable<sup>i</sup> Inflation  $\pi_t$  is sensitive to the output gap  $y_t$ . Parameter  $b_2$  measures the degree of flexibility of wages and prices. A low level of  $b_2$  is indicative of wage and price rigidities. As  $b_2$  increases, the degree of flexibility of wage and price increases.

$$\pi_t = b_1 \tilde{E}_t \pi_{t+1} + (1 - b_1) \pi_{t-1} + b_2 y_t + \eta_t \quad (2)$$

Finally the Taylor rule describes the behavior of the central bank

$$r_t = (1 - c_3)[c_1(\pi_t - \pi^*) + c_2 y_t] + c_3 r_{t-1} + u_t \quad (3)$$

where  $\pi^*$  is the inflation target, thus the central bank is assumed to raise the interest when the observed inflation rate increases relative to the announced inflation target. The intensity with which it does this is measured by the coefficient  $c_1$ . Similarly when the output gap increases the central bank is assumed to raise the interest rate. The intensity with which it does this is

measured by  $c_2$ . The latter parameter then also tells us something about the ambitions the central bank has to stabilize output. A central bank that does not care about output stabilization sets  $c_2=0$ . We say that this central bank applies strict inflation targeting. The parameter  $c_1$  is important. It has been shown (see Woodford(2003), chapter 4, or Gali(2008)) that it must exceed 1 for the model to be stable. This is also sometimes called the “Taylor principle”.

Finally note that, as is commonly done, the central bank is assumed to smooth the interest rate. This smoothing behavior is represented by the lagged interest rate  $r_{t-1}$  in equation (3). The long-term equilibrium interest rate is assumed to be zero and thus it does not appear in the equation.

We have added error terms in each of the three equations. These error terms describe the nature of the different shocks that can hit the economy. There are demand shocks  $\varepsilon_t$ , supply shocks  $\eta_t$ , and interest rate shocks  $u_t$ . We will generally assume that these shocks are normally distributed with mean zero and a constant standard deviation.

### ***2.3 Introducing heuristics in forecasting output***

Agents are assumed to use simple rules (heuristics) to forecast the future output gap. The way we proceed is as follows. We assume two types of forecasting rules. A first rule is called a “fundamentalist” one. Agents estimate the steady state value of the output gap (which is normalized at 0) and use this to forecast the future output gap<sup>ii</sup>. A second forecasting rule is an “extrapolative” one. This is a rule that does not presuppose that agents know the steady state output gap. They are agnostic about it. Instead, they extrapolate the previous observed output gap into the future. The two rules are specified as follows:

$$\text{The fundamentalist rule is defined by } \tilde{E}_t^f y_{t+1} = 0 \quad (4)$$

$$\text{The extrapolative rule is defined by } \tilde{E}_t^e y_{t+1} = y_{t-1} \quad (5)$$

This kind of simple heuristic has often been used in the behavioral finance literature where agents are assumed to use fundamentalist and chartist rules (see Brock and Hommes(1997), Branch and Evans(2006), De Grauwe and

Grimaldi(2006)). It is probably the simplest possible assumption one can make about how agents who experience cognitive limitations, use rules that embody limited knowledge to guide their behavior<sup>iii</sup>. They only require agents to use information they understand, and do not require them to understand the whole picture.

Thus the specification of the heuristics in (4) and (5) should not be interpreted as a realistic representation of how agents forecast. Rather is it a parsimonious representation of a world where agents do not know the “Truth” (i.e. the underlying model). The use of simple rules does not mean that the agents are irrational and that they do not want to learn from their errors. We will specify a learning mechanism later in this section in which these agents continuously try to correct for their errors by switching from one rule to the other.

We assume that the market forecast can be obtained as a weighted average of these two forecasts, i.e.

$$\tilde{E}_t y_{t+1} = \alpha_{f,t} \tilde{E}_t^f y_{t+1} + \alpha_{e,t} \tilde{E}_t^e y_{t+1} \quad (6)$$

$$\tilde{E}_t y_{t+1} = \alpha_{f,t} 0 + \alpha_{e,t} y_{t-1} \quad (7)$$

$$\text{and} \quad \alpha_{f,t} + \alpha_{e,t} = 1 \quad (8)$$

where  $\alpha_{f,t}$  and  $\alpha_{e,t}$  are the probabilities that agents use a fundamentalist, respectively, an extrapolative rule.

In order to obtain some intuition about the mechanics arising from the use of these two rules it is useful to substitute (7) and (8) into equation (1). This yields

$$y_t = (1 - a_1 \alpha_{f,t}) y_{t-1} + a_2 (r_t - \tilde{E}_t \pi_{t+1}) + \varepsilon_t$$

It can be seen that when  $\alpha_{f,t} = 1$ , i.e. the probability of all agents using the fundamentalist rule is equal to 1, the coefficient in front of  $y_{t-1}$  is  $1 - a_1$ , while if  $\alpha_{f,t} = 0$ , the probability of all agents using the extrapolative rule is equal to 1, that coefficient is 1. This makes clear that the source of the persistence in the output gap will be coming from the use of the extrapolative rule.

The forecasting rules (heuristics) introduced here are not derived at the micro level and then aggregated. Instead, they are imposed ex post, on the demand and

supply equations. This has also been the approach in the learning literature pioneered by Evans and Honkapohja(2001). Ideally one would like to derive the heuristics from the micro-level in an environment in which agents experience cognitive problems. Our knowledge about how to model this behavior at the micro level and how to aggregate it is too sketchy, however. Psychologists and brain scientists struggle to understand how our brain processes information. There is as yet no generally accepted model we could use to model the micro-foundations of information processing in a world in which agents experience cognitive limitations. We have not tried to do so<sup>iv</sup>.

#### **2.4 Selecting the forecasting rules in forecasting output**

As indicated earlier, agents in our model are willing to learn, i.e. they continuously evaluate their forecast performance. This willingness to learn and to change one's behavior is a very fundamental definition of rational behavior. Thus our agents in the model are rational, not in the sense of having rational expectations. Instead our agents are rational in the sense that they learn from their mistakes. The concept of "bounded rationality" is often used to characterize this behavior.

The first step in the analysis then consists in defining a criterion of success. This will be the forecast performance (utility) of a particular rule. We define the utility of using the fundamentalist and extrapolative rules as follows<sup>1</sup>:

$$U_{f,t} = - \sum_{k=0}^{\infty} \omega_k [y_{t-k-1} - \tilde{E}_{f,t-k-2} y_{t-k-1}]^2 \quad (9)$$

$$U_{e,t} = - \sum_{k=0}^{\infty} \omega_k [y_{t-k-1} - \tilde{E}_{e,t-k-2} y_{t-k-1}]^2 \quad (10)$$

where  $U_{f,t}$  and  $U_{e,t}$  are the utilities of the fundamentalist and extrapolating rules, respectively. These are defined as the negative of the mean squared forecasting

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<sup>1</sup> (9) and (10) can be derived from the following equation:

$$U_t = \rho U_{t-1} + (1 - \rho) [y_{t-1} - E_{t-2} y_{t-1}]^2 \quad (9')$$

where  $\rho$  can be interpreted as a memory parameter. When  $\rho = 0$  only the last period's forecast error is remembered; when  $\rho = 1$  all past periods get the same weight and agents have infinite memory. We will generally assume that  $0 < \rho < 1$ . Using (9') we can write

$$U_{t-1} = \rho U_{t-2} + (1 - \rho) [y_{t-2} - E_{t-3} y_{t-2}]^2 \quad (9'')$$

Substituting (9'') into (9') and repeating such substitutions ad infinitum yields the expression (9) where

$$\omega_k = (1 - \rho) \rho^k$$

errors (MSFEs) of the forecasting rules;  $\omega_k$  are geometrically declining weights. We make these weights declining because we assume that agents tend to forget. Put differently, they give a lower weight to errors made far in the past as compared to errors made recently. The degree of forgetting turns out to play a major role in our model. This was analyzed in De Grauwe(2012).

The next step consists in evaluating these utilities. We apply discrete choice theory (see Anderson, de Palma, and Thisse, (1992) and Brock & Hommes(1997)) in specifying the procedure agents follow in this evaluation process. If agents were purely rational they would just compare  $U_{f,t}$  and  $U_{e,t}$  in (9) and (10) and choose the rule that produces the highest value. Thus under pure rationality, agents would choose the fundamentalist rule if  $U_{f,t} > U_{e,t}$ , and vice versa. However, psychologists have stressed that when we have to choose among alternatives we are also influenced by our state of mind (see Kahneman(2002)). The latter is to a large extent unpredictable. It can be influenced by many things, the weather, recent emotional experiences, etc. One way to formalize this is that the utilities of the two alternatives have a deterministic component (these are  $U_{f,t}$  and  $U_{e,t}$  in (9) and (10)) and a random component  $\varepsilon_{f,t}$  and  $\varepsilon_{e,t}$ . The probability of choosing the fundamentalist rule is then given by

$$\alpha_{f,t} = P[(U_{f,t} + \varepsilon_{f,t}) > (U_{e,t} + \varepsilon_{e,t})] \quad (11)$$

In words, this means that the probability of selecting the fundamentalist rule is equal to the probability that the stochastic utility associated with using the fundamentalist rule exceeds the stochastic utility of using an extrapolative rule. In order to derive a more precise expression one has to specify the distribution of the random variables  $\varepsilon_{f,t}$  and  $\varepsilon_{e,t}$ . It is customary in the discrete choice literature to assume that these random variables are logistically distributed (see Anderson, Palma, and Thisse(1992), p.35). One then obtains the following expressions for the probability of choosing the fundamentalist rule:

$$\alpha_{f,t} = \frac{\exp(\gamma U_{f,t})}{\exp(\gamma U_{f,t}) + \exp(\gamma U_{e,t})} \quad (12)$$

Similarly the probability that an agent will use the extrapolative forecasting rule is given by:

$$\alpha_{e,t} = \frac{\exp(\gamma U_{e,t})}{\exp(\gamma U_{f,t}) + \exp(\gamma U_{e,t})} = 1 - \alpha_{f,t} \quad (13)$$

Equation (12) says that as the past forecast performance (utility) of the fundamentalist rule improves relative to that of the extrapolative rule, agents are more likely to select the fundamentalist rule for their forecasts of the output gap. Equation (13) has a similar interpretation. The parameter  $\gamma$  measures the “intensity of choice”. It is related to the variance of the random components. Defining  $\varepsilon_t = \varepsilon_{f,t} - \varepsilon_{e,t}$ , we can write (see Anderson, Palma and Thisse(1992)):

$$\gamma = \frac{1}{\sqrt{\text{var}(\varepsilon_t)}}.$$

When  $\text{var}(\varepsilon_t)$  goes to infinity,  $\gamma$  approaches 0. In that case agents decide to be fundamentalist or extrapolator by tossing a coin and the probability to be fundamentalist (or extrapolator) is exactly 0.5. When  $\gamma = \infty$  the variance of the random components is zero (utility is then fully deterministic) and the probability of using a fundamentalist rule is either 1 or 0. The parameter  $\gamma$  can also be interpreted as expressing a willingness to learn from past performance. When  $\gamma = 0$  this willingness is zero; it increases with the size of  $\gamma$ .

As argued earlier, the selection mechanism used should be interpreted as a learning mechanism based on “trial and error”. When observing that the rule they use performs less well than the alternative rule, agents are willing to switch to the more performing rule. Put differently, agents avoid making systematic mistakes by constantly being willing to learn from past mistakes and to change their behavior. This also ensures that the market forecasts are unbiased.

### ***2.5 Heuristics and selection mechanism in forecasting inflation***

Agents also have to forecast inflation. A similar simple heuristics is used as in the case of output gap forecasting, with one rule that could be called a fundamentalist rule and the other an extrapolative rule. (See Brazier et al. (2008) for a similar setup). We assume an institutional set-up in which the central bank announces an explicit inflation target. The fundamentalist rule then is based on this announced inflation target, i.e. agents using this rule have confidence in the

credibility of this rule and use it to forecast inflation. Agents who do not trust the announced inflation target use the extrapolative rule, which consists in extrapolating inflation from the past into the future.

The fundamentalist rule will be called an “inflation targeting” rule. It consists in using the central bank’s inflation target to forecast future inflation, i.e.

$$\tilde{E}_t^{tar} \pi_{t+1} = \pi^* \quad (14)$$

where the inflation target is  $\pi^*$

The “extrapolators” are defined by

$$\tilde{E}_t^{ext} \pi_{t+1} = \pi_{t-1} \quad (15)$$

The market forecast is a weighted average of these two forecasts, i.e.

$$\tilde{E}_t \pi_{t+1} = \beta_{tar,t} \tilde{E}_t^{tar} \pi_{t+1} + \beta_{ext,t} \tilde{E}_t^{ext} \pi_{t+1} \quad (16)$$

$$\text{or} \quad \tilde{E}_t \pi_{t+1} = \beta_{tar,t} \pi^* + \beta_{ext,t} \pi_{t-1} \quad (17)$$

$$\text{and} \quad \beta_{tar,t} + \beta_{ext,t} = 1 \quad (18)$$

The same selection mechanism is used as in the case of output forecasting to determine the probabilities of agents trusting the inflation target and those who do not trust it and revert to extrapolation of past inflation, i.e.

$$\beta_{tar,t} = \frac{\exp(\gamma U_{tar,t})}{\exp(\gamma U_{tar,t}) + \exp(\gamma U_{ext,t})} \quad (19)$$

$$\beta_{ext,t} = \frac{\exp(\gamma U_{ext,t})}{\exp(\gamma U_{tar,t}) + \exp(\gamma U_{ext,t})} \quad (20)$$

where  $U_{tar,t}$  and  $U_{ext,t}$  are the forecast performances (utilities) associated with the use of the fundamentalist and extrapolative rules in equation (21) and (22). These are defined in the same way as in (9) and (10), i.e. they are the negatives of the weighted averages of past squared forecast errors of using fundamentalist (inflation targeting) and extrapolative rules, respectively.

$$U_{tar,t} = - \sum_{k=0}^{\infty} \omega_k [\pi_{t-k-1} - \tilde{E}_{f,t-k-2} \pi_{t-k-1}]^2 \quad (21)$$

$$U_{ext,t} = -\sum_{k=0}^{\infty} \omega_k [\pi_{t-k-1} - \tilde{E}_{e,t-k-2} \pi_{t-k-1}]^2 \quad (22)$$

This inflation forecasting heuristics can be interpreted as a procedure of agents to find out how credible the central bank's inflation targeting is. If this is very credible, using the announced inflation target will produce good forecasts and as a result, the probability that agents will rely on the inflation target will be high. If on the other hand the inflation target does not produce good forecasts (compared to a simple extrapolation rule) the probability that agents will use it will be small.

Finally it should be mentioned that the two prediction rules for the output gap and inflation are made independently. This is a strong assumption. What we model is the use of different forecasting rules. The selection criterion is exclusively based on the forecasting performances of these rules. Agents in our model do not have a psychological predisposition to become fundamentalists or extrapolators. However, it is possible that despite the assumption of independence, the realized choices generated from our model are actually correlated due to the interactions of the different variables in the model. We will come back to this when we implement the model and we will compute the realized correlation between the probabilities of being a fundamentalist for the output gap and a fundamentalist for inflation.

## **2.6 Defining animal spirits**

The forecasts made by extrapolators and fundamentalists play an important role in the model. In order to highlight this role we define an index of market sentiments, which we call "animal spirits", and which reflects how optimistic or pessimistic these forecasts are.

The definition of animal spirits is as follows:

$$S_t = \begin{cases} \alpha_{e,t} - \alpha_{f,t} & \text{if } y_{t-1} > 0 \\ -\alpha_{e,t} + \alpha_{f,t} & \text{if } y_{t-1} < 0 \end{cases} \quad (23)$$

where  $S_t$  is the index of animal spirits. This can change between -1 and +1. There are two possibilities:

- When  $y_{t-1} > 0$ , extrapolators forecast a positive output gap. The fraction of agents who make such a positive forecasts is  $\alpha_{e,t}$ . Fundamentalists, however, then make a pessimistic forecast since they expect the positive output gap to decline towards the equilibrium value of 0. The fraction of agents who make such a forecast is  $\alpha_{f,t}$ . We subtract this fraction of pessimistic forecasts from the fraction  $\alpha_{e,t}$  who make a positive forecast. When these two fractions are equal to each other (both are then 0.5) market sentiments (animal spirits) are neutral, i.e. optimists and pessimists cancel out and  $S_t = 0$ . When the fraction of optimists  $\alpha_{e,t}$  exceeds the fraction of pessimists  $\alpha_{f,t}$ ,  $S_t$  becomes positive. As we will see, the model allows for the possibility that  $\alpha_{e,t}$  moves to 1. In that case there are only optimists and  $S_t = 1$ .
- When  $y_{t-1} < 0$ , extrapolators forecast a negative output gap. The fraction of agents who make such a negative forecasts is  $\alpha_{e,t}$ . We give this fraction a negative sign. Fundamentalists, however, then make an optimistic forecast since they expect the negative output gap to increase towards the equilibrium value of 0. The fraction of agents who make such a forecast is  $\alpha_{f,t}$ . We give this fraction of optimistic forecasts a positive sign. When these two fractions are equal to each other (both are then 0.5) market sentiments (animal spirits) are neutral, i.e. optimists and pessimists cancel out and  $S_t = 0$ . When the fraction of pessimists  $\alpha_{e,t}$  exceeds the fraction of optimists  $\alpha_{f,t}$   $S_t$  becomes negative. The fraction of pessimists,  $\alpha_{e,t}$ , can move to 1. In that case there are only pessimists and  $S_t = -1$ .

We can rewrite (23) as follows:

$$S_t = \begin{cases} \alpha_{e,t} - (1 - \alpha_{e,t}) = 2\alpha_{e,t} - 1 & \text{if } y_{t-1} > 0 \\ -\alpha_{e,t} + (1 - \alpha_{e,t}) = -2\alpha_{e,t} + 1 & \text{if } y_{t-1} < 0 \end{cases} \quad (24)$$

## **2.7 Solving the model**

The solution of the model is found by first substituting (3) into (1) and rewriting in matrix notation. This yields:

$$\begin{aligned}
& \begin{bmatrix} 1 & -b_2 \\ -a_2c_1 & 1 - a_2c_2 \end{bmatrix} \begin{bmatrix} \pi_t \\ y_t \end{bmatrix} \\
& = \begin{bmatrix} b_1 & 0 \\ -a_2 & a_1 \end{bmatrix} \begin{bmatrix} \tilde{E}_t \pi_{t+1} \\ \tilde{E}_t y_{t+1} \end{bmatrix} + \begin{bmatrix} 1 - b_1 & 0 \\ 0 & 1 - a_1 \end{bmatrix} \begin{bmatrix} \pi_{t-1} \\ y_{t-1} \end{bmatrix} + \begin{bmatrix} 0 \\ a_2c_3 \end{bmatrix} r_{t-1} \\
& + \begin{bmatrix} \eta_t \\ a_2u_t + \varepsilon_t \end{bmatrix}
\end{aligned}$$

i.e.

$$\mathbf{AZ}_t = \mathbf{B}\tilde{\mathbf{E}}_t \mathbf{Z}_{t+1} + \mathbf{CZ}_{t-1} + \mathbf{b}r_{t-1} + \mathbf{v}_t \quad (25)$$

where bold characters refer to matrices and vectors. The solution for  $\mathbf{Z}_t$  is given by

$$\mathbf{Z}_t = \mathbf{A}^{-1}[\mathbf{B}\tilde{\mathbf{E}}_t \mathbf{Z}_{t+1} + \mathbf{CZ}_{t-1} + \mathbf{b}r_{t-1} + \mathbf{v}_t] \quad (26)$$

The solution exists if the matrix  $\mathbf{A}$  is non-singular, i.e.  $(1-a_2c_2)-a_2b_2c_1 \neq 0$ . The system (26) describes the solutions for  $y_t$  and  $\pi_t$  given the forecasts of  $y_t$  and  $\pi_t$ . The latter have been specified in equations (4) to (22) and therefore can be substituted into (26). Finally, the solution for  $r_{t-1}$  is found by substituting  $y_t$  and  $\pi_t$  obtained from (26) into (3).

The model has non-linear features making it difficult to arrive at analytical solutions. That is why we will use numerical methods to analyze its dynamics. In order to do so, we have to calibrate the model, i.e. to select numerical values for the parameters of the model. In Table 1 the parameters used in the calibration exercise are presented. The values of the parameters are based on what we found in the literature (see Gali(2008) for the demand and supply equations and Blattner and Margaritov(2010) for the Taylor rule). The model was calibrated in such a way that the time units can be considered to be quarters. The three shocks (demand shocks, supply shocks and interest rate shocks) are independently and identically distributed (i.i.d.) with standard deviations of 0.5%. These shocks produce standard deviations of the output gap and inflation that mimic the standard deviations found in the empirical data using quarterly observations for the US and the Eurozone.

**Table 1: Parameter values of the calibrated model**

---

$a_1 = 0.5$	coefficient of expected output in output equation
$a_2 = -0.2$	interest elasticity of output demand
$b_1 = 0.5$	coefficient of expected inflation in inflation equation
$b_2 = 0.05$	coefficient of output in inflation equation, rigid case
$b_2 = 1$	coefficient of output in inflation equation, flexible case
$\pi^* = 0$	inflation target level
$c_1 = 1.5$	coefficient of inflation in Taylor equation
$c_2 = 0.5$	coefficient of output in Taylor equation
$c_3 = 0.5$	interest smoothing parameter in Taylor equation
$\gamma = 2$	intensity of choice parameter
$\sigma_\varepsilon = 0.5$	standard deviation shocks output
$\sigma_\eta = 0.5$	standard deviation shocks inflation
$\sigma_u = 0.5$	standard deviation shocks Taylor
$\rho = 0.5$	memory parameter (see footnote 1)

---

### 3. Main results

We use the behavioral model developed in the previous section to study how different types of structural reforms affect the macroeconomy. We will distinguish between two types of structural reforms. The first type has the effect of increasing the flexibility of wages and prices. Such an increase in flexibility has the effect of increasing the coefficient  $b_2$  in the New Keynesian Philips curve (equation(2)), i.e. when structural reform increases flexibility we will observe that changes in the output gap have a stronger effect on wages and prices, so that the rate of inflation reacts strongly to such changes.

The second type of structural reforms (e.g. increasing the degree of participation in the labour market, extending the retirement age) has the effect of raising potential output. These structural reforms therefore can be seen as producing a positive supply shock. We will analyze these two types of structural reforms consecutively, but we will also focus on their interactions.

#### 3.1 The power of animal spirits: rigidity versus flexibility

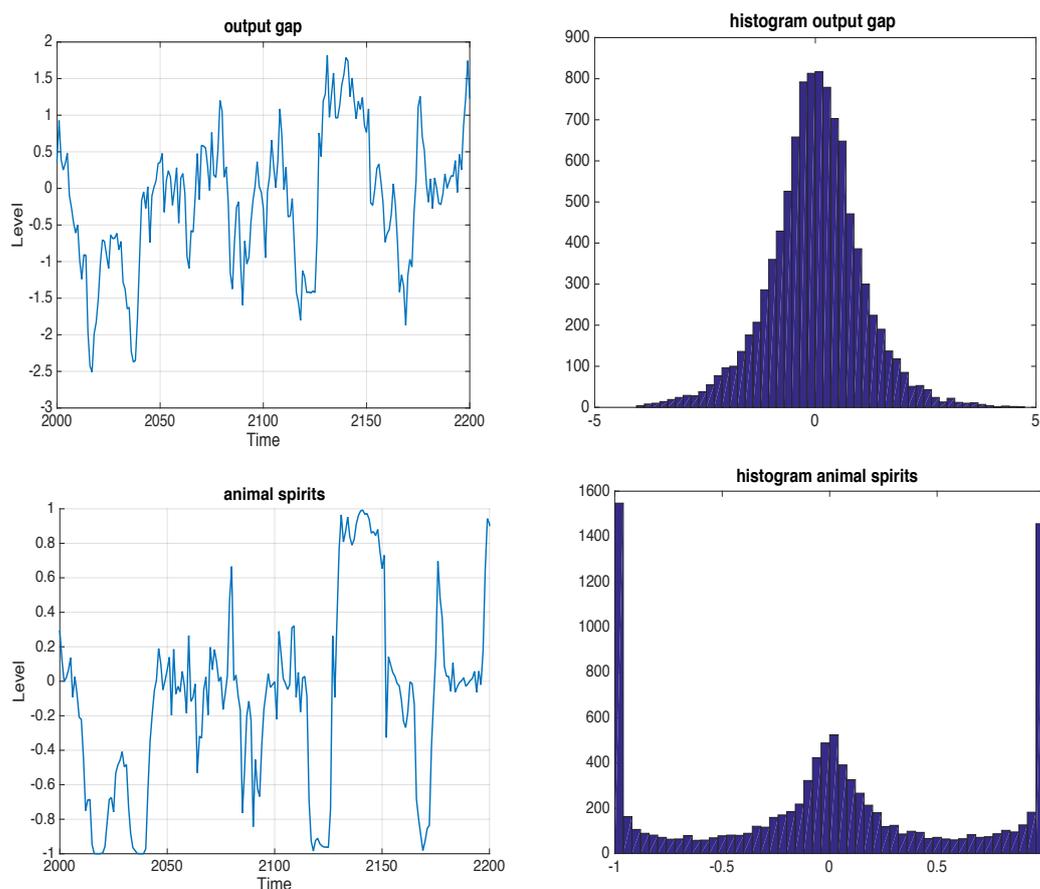
Figure 1 shows the movements of the output gap and animal spirits in the time domain (left hand side panels) and in the frequency domain (right hand side panels) as simulated in our model. It is assumed that the economy has a lot of rigidities. We select a low value for the flexibility parameter ( $b_2=0.05$ ). We

observe that the model produces waves of optimism and pessimism (animal spirits) that can lead to a situation where everybody becomes optimist ( $St = 1$ ) or pessimist ( $St = -1$ ). These waves of optimism and pessimism are generated endogenously and arise because optimistic (pessimistic) forecasts are self-fulfilling and therefore attract more agents into being optimists (pessimists).

As can be seen from the left hand side panels, the correlation of these animal spirits and the output gap is high, reaching 0.95. Underlying this correlation is the self-fulfilling nature of expectations. When a wave of optimism is set in motion, this leads to an increase in aggregate demand (see equation (1)). This increase in aggregate demand leads to a situation in which those who have made optimistic forecasts are vindicated. This attracts more agents using optimistic forecasts. This leads to a self-fulfilling dynamics in which most agents become optimists. It is a dynamics that leads to a correlation of the same beliefs. The reverse is also true. A wave of pessimistic forecasts can set in motion a self-fulfilling dynamics leading to a downturn in economic activity (output gap). At some point most of the agents have become pessimists.

The right hand side panels show the frequency distribution of output gap and animal spirits. We find that the output gap is not normally distributed, with excess kurtosis and fat tails. A Jarque-Bera test rejects normality of the distribution of the output gap. The origin of the non-normality of the distribution of the output gap can be found in the distribution of the animal spirits. We find that there is a concentration of observations of animal spirits around 0. This means that much of the time there is no clear-cut optimism or pessimism. We can call these "normal periods". There is also, however, a concentration of extreme values at either -1 (extreme pessimism) and +1 (extreme optimism). These extreme values of animal spirits explain the fat tails observed in the distribution of the output gap. The interpretation of this result is as follows. When the market is gripped by a self-fulfilling movement of optimism (or pessimism) this can lead to a situation where everybody becomes optimist (pessimist). This then also leads to an intense boom (bust) in economic activity.

**Figure 1. Output and animal spirits ( $b_2 = 0.05$ , rigid case)**



In De Grauwe(2012) and De Grauwe and Ji(2016) empirical evidence is provided indicating that observed output gaps in industrial countries exhibit non-normality and that the output gaps are highly correlated with empirical measures of animal spirits. Our model mimics these empirical observations and is particularly suited to understand the nature of business cycle which is characterized by periods of “tranquility” alternated by periods of booms and busts.

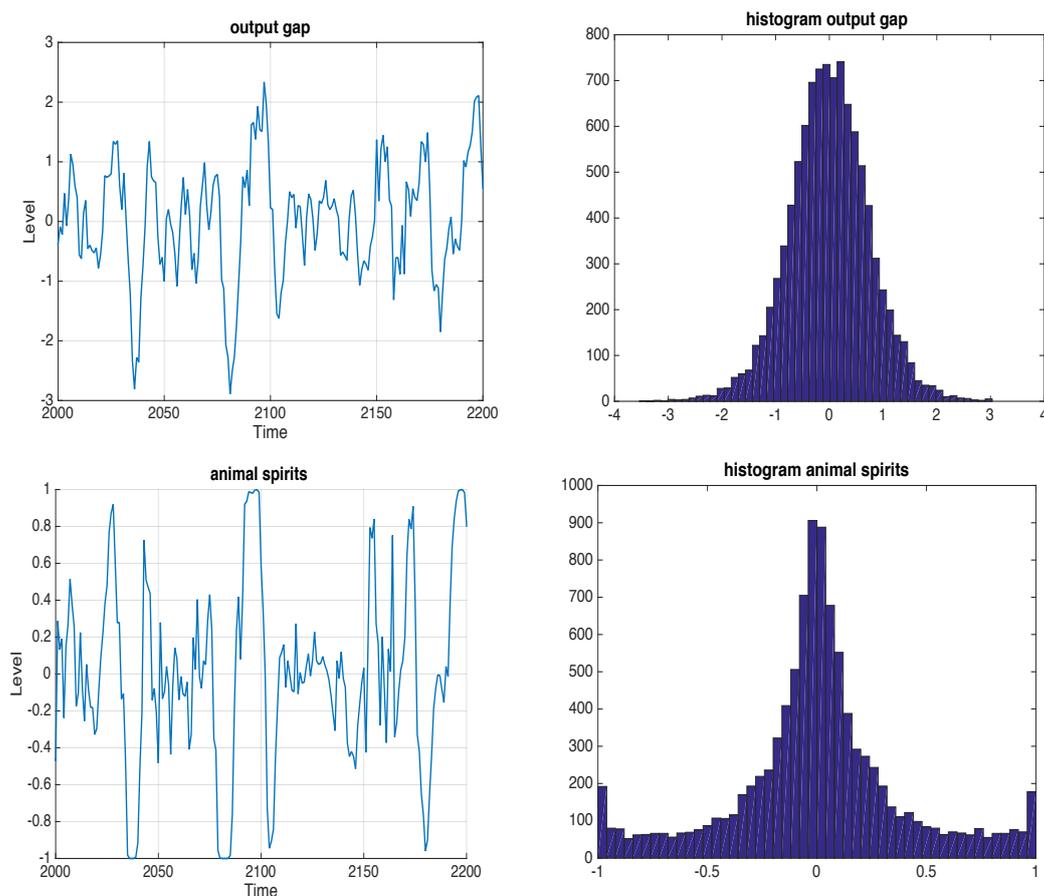
Let us now assume that structural reforms increase the degree of flexibility in the economy. As indicated earlier, this increases the parameter  $b_2$  in the New Keynesian Philips curve (equation(2)). We now analyze how the increase in flexibility affects the nature of the business cycle. We set the parameter  $b_2 = 1$  and compare the results with those obtained in a rigid economy (Figure 1). The results of the simulation of a flexible economy are shown in Figure 2.

Compared to the case of the rigid economy, we find two interesting results. First, in a flexible economy the power of animal spirits is significantly reduced. The extreme levels of optimism ( $St=1$ ) or pessimism ( $St=-1$ ) become less frequent. On the other hand the concentration of the animal spirits around zero is much higher.

Second, as can be seen in the left panel of Figure 2, the correlation between the output gap and animal spirits appears to be lower much lower. We find a correlation of 0.85. This contrasts with 0.95 which is obtained in the rigid economy. As a result, the output gap in Figure 2 is also less volatile.

Thus we find that an economy that is more flexible is less prone to the boom-bust nature of the business cycle produced by waves of optimism and pessimism (animal spirits) than a more rigid economy.

**Figure 2. Output and animal spirits ( $b_2 = 1$ , flexible case)**



The previous analysis compared the results obtained for two different values of  $b_2$ . In order to obtain more general results, it is important to subject the analysis to a more precise sensitivity analysis. The way we do this is to compute the correlation between output and animal spirits for different values of the level of the flexibility of the economy. The results are shown in Figure 3. We find that the correlation between output and animal spirits decreases when  $b_2$  increases (i.e. the flexibility of the economy increases). The correlation starts at around 0.95 when  $b_2$  is close to zero and then decreases to 0.85 when  $b_2$  reaches 1. When  $b_2$  increases further to 5, the correlation decreases slowly to about 0.5.

Figure 3.

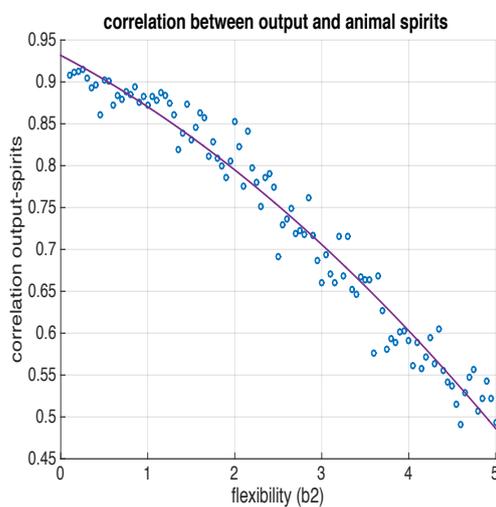
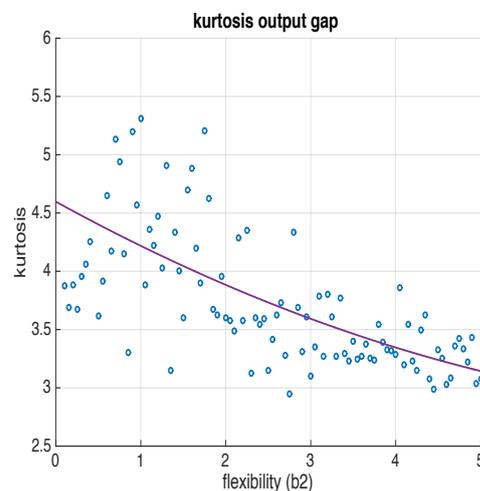


Figure 4.



As flexibility reduces the power of animal spirits, this also leads to fewer extreme values of the output gap. As a result, we are more likely to have a normally distributed output gap. Figure 4 informs us about this relationship. When  $b_2=0$  the kurtosis exceeds 4.5 which is too high for the output gap to be normally distributed. The kurtosis gradually declines as  $b_2$  increases and approaches 3 when  $b_2=5$  suggesting that the output gap is normally distributed.

### 3.2 Impulse responses to positive supply shock

In the previous sections we modeled one dimension of structural reforms. These are the structural reforms that increase the degree of flexibility of wages and prices. We saw that these can have a strong effect on the dynamics of the business cycle. In this section we add a second dimension to structural reforms.

We consider structural reforms that increase the degree of competition in the economy and that raise the potential output. We will therefore apply a positive supply shock to the model as our measure of structural reforms. Noting that the output gap  $y_t$  can be written as :

$$y_t = Y_t - Y_t^*$$

where  $Y_t$  = observed output and  $Y_t^*$  = potential output, we apply a positive shock to  $Y_t^*$ . Note that this produces a negative shock to inflation in the supply equation (2).

We show the results of this positive supply shock (measured as one standard deviation of  $\eta_t$  in equation (2)) in both the rigid and the flexible economies (as defined in the previous section) by plotting the impulse responses to this shock. These impulse responses are shown in Figure 5 in the rigid (left column) and the flexible economy (right column). The blue lines represent the mean impulse responses and the red dotted lines “+” and “-” 2-standard deviations from the mean respectively. We do this because in our non-linear model the exact path of the impulse responses depends on the initial conditions, i.e. the realizations of the stochastic shocks at the moment the supply shock occurs.

The results of Figure 5 lend themselves to the following interpretation. First, there is more uncertainty surrounding the transmission of the positive supply shock in the rigid than in the flexible economy. This can be seen by the fact that the dotted red lines are farther apart in the rigid than in the flexible economy. In addition, it takes longer in the former for this uncertainty to die out than in the latter. Put differently, the impulse responses to the same supply shock are more sensitive to initial conditions in the rigid than in the flexible economy. This is related to the result we found in the previous section. We noted there that in the rigid economy the power of animal spirits is higher than in the flexible economy. These animal spirits create the potential for fat tails in the output gap. As a result, initial conditions (including the state of animal spirits) have a stronger effect on the transmission of the supply shock in the rigid economy.

Second, the duration it takes to adjust to the long-term equilibrium is different in the two types of economy. It takes much longer in the rigid economy to adjust to

the long-term equilibrium compared to the flexible economy where the adjustment takes only a few quarters.

Third, we observe that the short-term impact of the positive supply shock on output and inflation are higher in the flexible economy than in the rigid one. In addition the central bank reacts more strongly by lowering the interest rate in the flexible economy than in the rigid one.

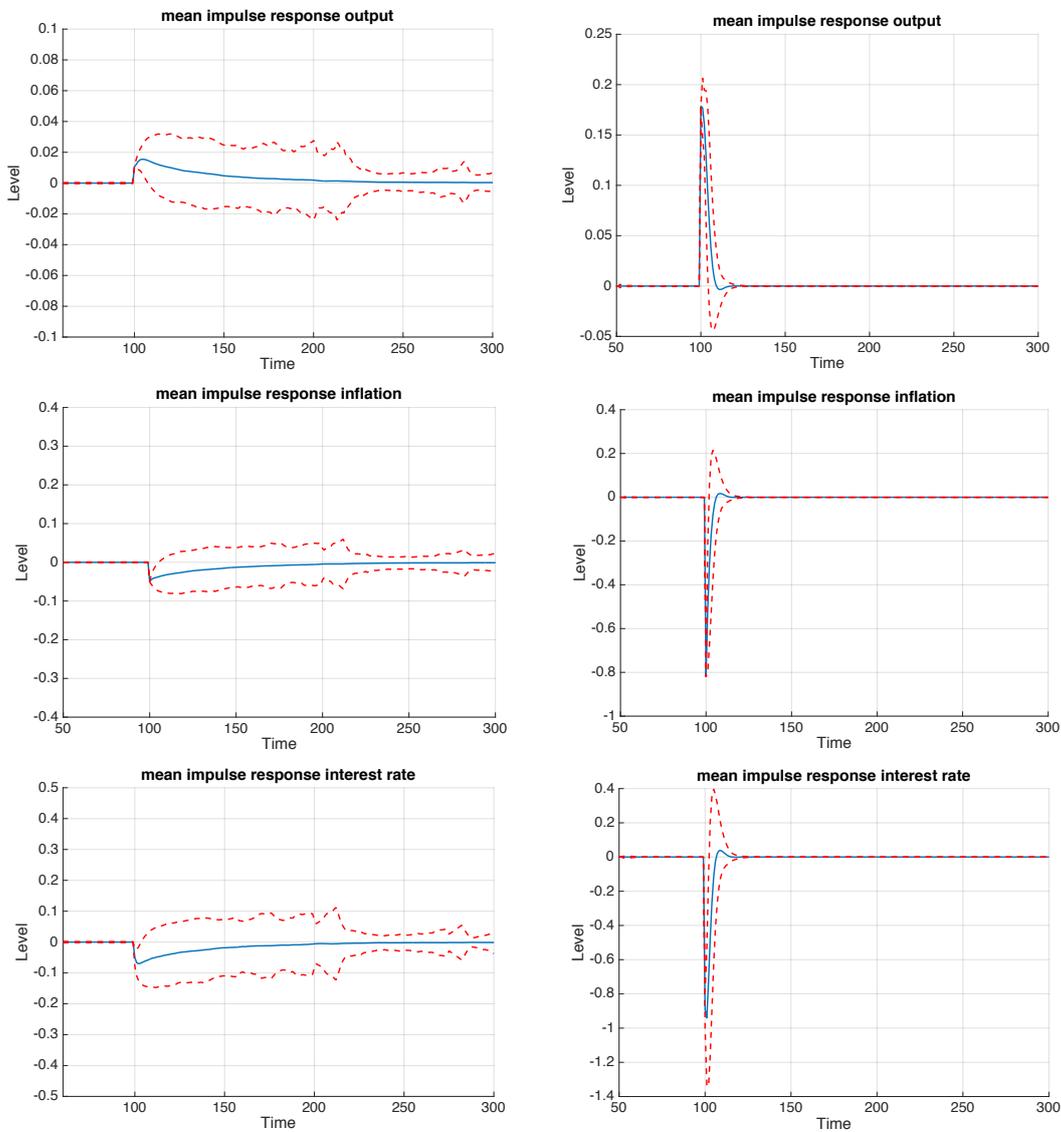
How can these results be interpreted? The positive supply shock has a stronger negative effect on inflation in the flexible economy than in the rigid one because prices react more to the increase in excess supply generated by the positive shock in potential output. This leads to a strong decline in inflation in the flexible economy. Since the central bank attaches a high weight to inflation, it is led to reduce the rate of interest significantly more in the flexible than in the rigid economy. This creates a stronger boom in aggregate demand in the flexible economy than in the rigid one. Thus in a flexible economy, the same supply shock initiated by structural reforms leads to a stronger boom in economic activity than in a rigid economy because the central bank, observing a steep drop in inflation, is induced to fuel this boom more than in a rigid economy. We assume, of course, that the central bank does not adjust its monetary policy rule (Taylor rule) when the economy moves from a rigid to a flexible one.

Note that the uncertainty around the impulse responses (shown by the red dotted lines in Figure 5) is much larger in the rigid economy than in the flexible one. This difference is related to the fact that in the rigid economy the animal spirits play a bigger role in producing business cycle movements. These animal spirits are the source of uncertainty.

**Figure 5: Impulse responses to positive supply shock**

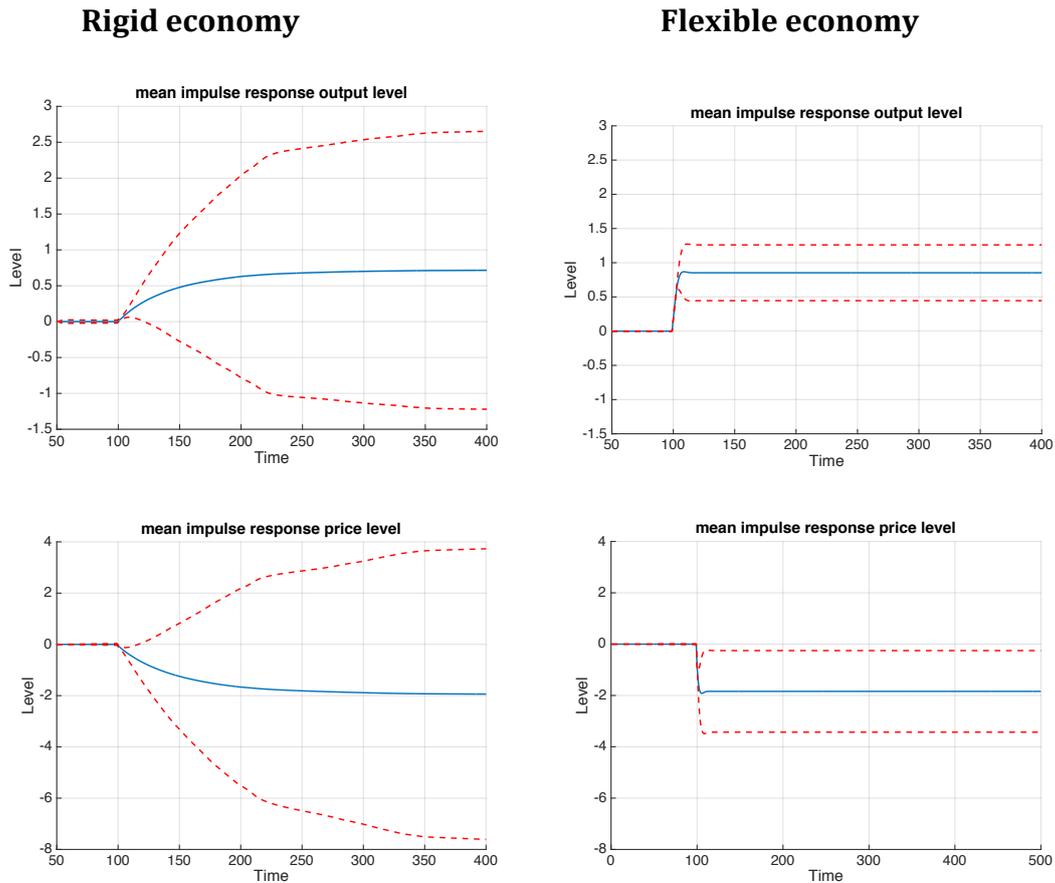
**Rigid economy**

**Flexible economy**



It is also important to analyze the long-term impact of the supply shock on the level of output in the rigid and flexible economies. We obtain these by computing the cumulative effects of the supply shock on the output gap and on inflation. This yields the effects on the output level and the price level. We show the results in Figure 6.

**Figure 6 : Effects of positive supply shock on output and price levels**



Again we find that the uncertainty surrounding the effects of the supply shock to be much greater in the rigid than in the flexible economy. We also find that the level effects of the positive supply shock in the flexible economy are higher than in the rigid economy. Thus a structural reform program that raises potential output has a stronger long-term effect on output and tends to reduce the price level more than in a rigid economy.

#### 4. The model under rational expectations

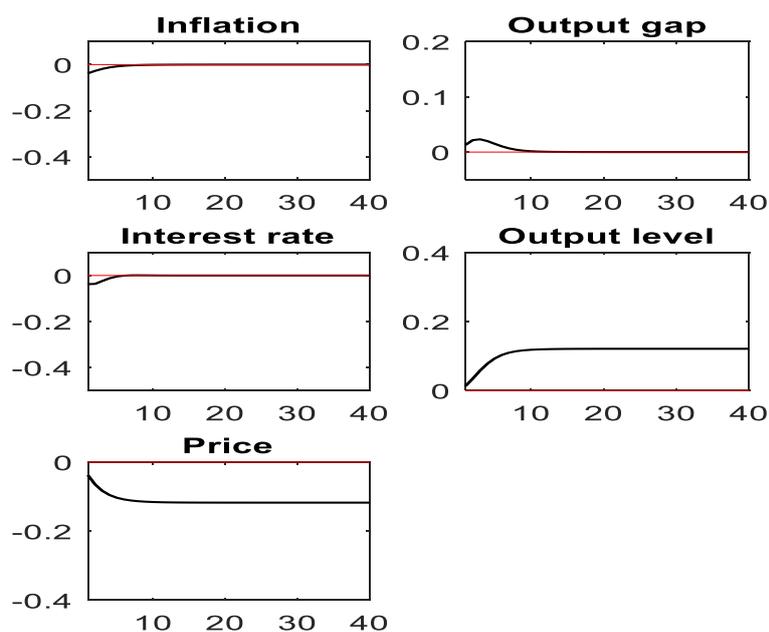
The model consisting of the aggregate demand function (1), the aggregate supply function (2) and the Taylor rule (3) can be solved assuming rational expectations (RE). We do this in the present section using the same parameter values as those used in the behavioral model. In both models we assume the same distributions of the stochastic shocks (iid with zero mean and std = 0.5) and compare the results obtained under RE with the results of our behavioral model. We perform

this exercise both for the rigid economy ( $b_2=0.05$ ) and the flexible economy ( $b_2=1$ ). We focus on the impulse responses following a positive supply shock. We show these impulse responses in Figures 7 and 8. These should be compared to the impulse responses to a positive supply shock in our behavioral model (Figures 5 and 6).

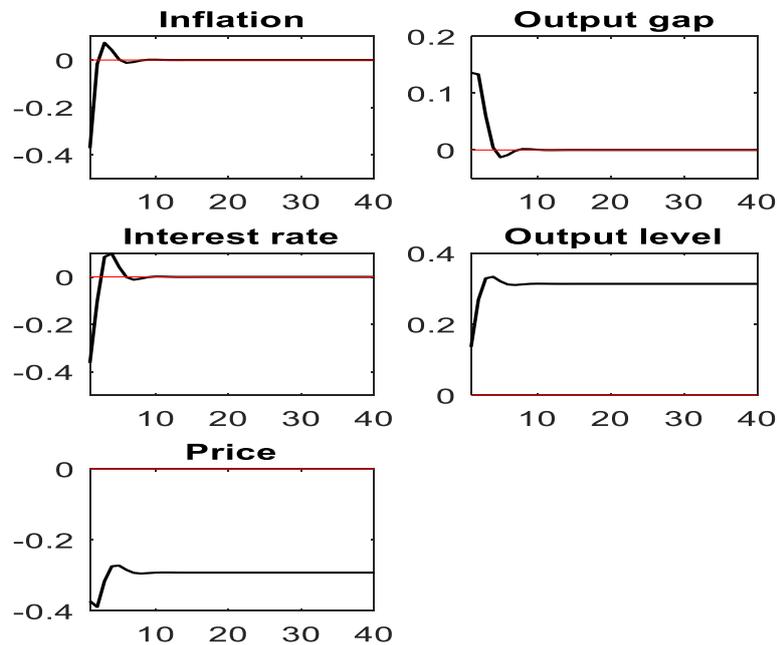
As in the behavioral model, the output and price level effects of a positive supply shock are higher in a flexible than in a rigid economy.

What differs in the result? We find that the rational expectations model produces weaker output and inflation effects of the same supply shocks than the behavioral model. This difference is related to the fact that the animal spirits tend to amplify the supply shock. This holds both in the rigid and the flexible economy. As a result, the level effects (output and price levels) are higher in the behavioral model. We also find that the economy takes a much longer time to adjust to its long-term equilibrium in the behavioral model than in the rational expectation model. This difference is large: if the economy is rigid it takes approximately 50 periods in the behavioral model to go back to equilibrium versus less than 10 periods in the rational expectations model.

**Figure 7: Impulse responses to positive supply shock in a rigid economy ( $b_2=0.05$ )**



**Figure 8: Impulse responses to positive supply shock in a flexible economy (b2=1)**



## 5. The optimal level of flexibility

How much structural reform is optimal? This is the question we analyze in this section. The question of optimality here only concerns the problem of stabilization. There are other dimensions, which relate to efficiency and growth. These are outside the scope of the analysis of this paper.

The way we proceed is to first analyze how the degree of flexibility affects the volatility of output and inflation. In a second stage we will derive the relationship between the volatilities of output and inflation which is produced by increasing flexibility. We will call it the flexibility tradeoff.

We show the relation between the degree of flexibility (horizontal axis) and the standard deviation of the output gap (vertical axis) in Figure 9. The degree of flexibility is measured, as before, by the coefficient  $b_2$  in the New Keynesian Philips Curve. We obtained this figure by simulating the model for different values of  $b_2$  and computing the standard deviations of the output gap for each of these  $b_2$ 's.

The results shown in Figure 9 show how an increase in flexibility reduces the volatility of the output gap. The relation is non-linear, i.e. starting from zero, increases in flexibility lead to strong initial declines in the volatility of output. This effect weakens considerably for higher levels of flexibility.

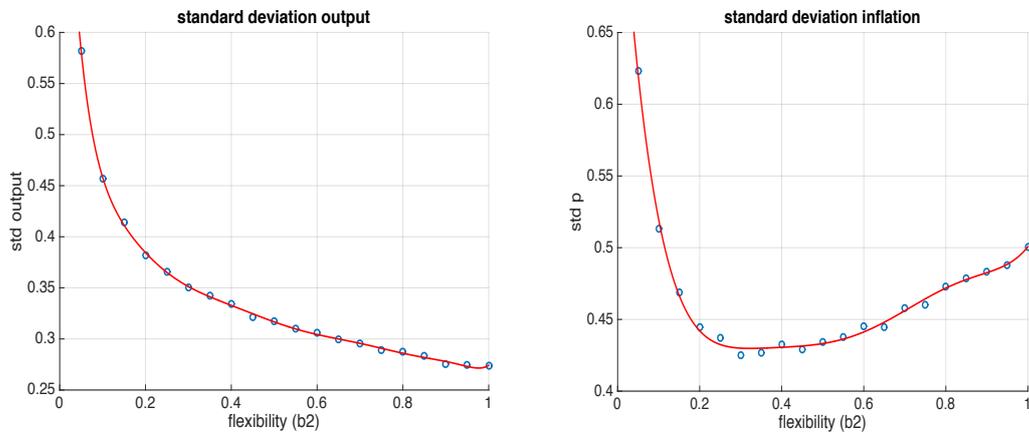
In Figure 10 we present the relation between inflation variability (measured by the standard deviation) and flexibility ( $b_2$ ). We find a non-linear relation. Starting with  $b_2 = 0$  an increase in flexibility first tends to reduce the standard deviation of inflation. At some point (for values of  $b_2$  between 0.2 and 0.6) the standard deviation of inflation tends to increase when  $b_2$  is raised further. Thus focusing on inflation volatility there is an optimal level of flexibility, i.e. one that minimizes the volatility of inflation. When one exceeds this optimal level of flexibility the volatility of inflation tends to increase.

Figure 11 presents the relationship between output and inflation variability that we obtain for increasing levels of flexibility. It is obtained by combining the previous two figures. The horizontal axis shows the standard deviations of output; the vertical axis the standard deviations of inflation. We obtain a non-linear relationship. In order to understand this, start from point A. This point is obtained when flexibility ( $b_2$ ) is zero. As we increase the degree of flexibility we move down along the downward sloping segment of the line. This downward movement implies that increasing flexibility creates a “win-win” situation in that both the volatility of output and inflation decline with increasing flexibility. Put differently, as we move down from point A there is an unambiguous increase in welfare. However, when we go too far with structural reforms we go beyond the minimum point on the line (when  $b_2$  is approximately 0.4). From that point on we obtain a negatively sloped relationship, i.e. further increases in flexibility lead to less volatility of output at the expense of increasing inflation volatility. Note that point B is obtained for a value of the flexibility parameter  $b_2 = 1$ .

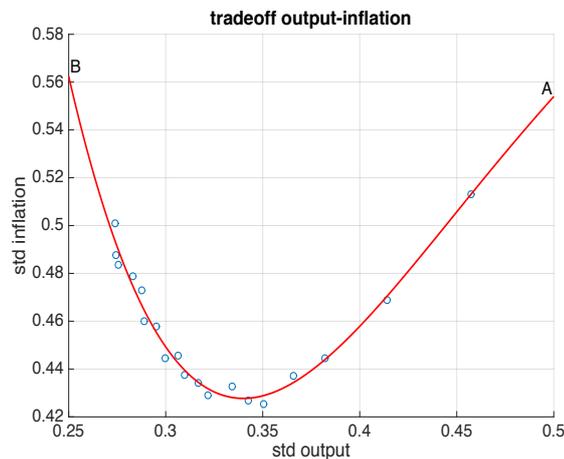
Figure 11 allows us to obtain some insights about the optimal level of flexibility. Clearly this must be located to the left of the minimum point of the relationship. Any point on the positively sloped part can be improved by increasing flexibility. Beyond the minimum point further increases in flexibility lead to lower output volatility at the expense of higher inflation volatility. Where the optimum

flexibility will be reached then depends on the preferences about inflation versus output volatility. If society values output stability more than inflation stability the optimal level of flexibility will be located close to the minimum point. Increasing preferences towards inflation stability moves this optimal point towards point B. If preferences have the usual convex properties the optimal point will be located between the two extremes, B and the minimum point.

**Figure 9: Flexibility and output volatility**      **Figure 10: Flexibility and inflation volatility**



**Figure 11: The Optimal level of flexibility**



## 6. Structural reforms and monetary policy tradeoffs.

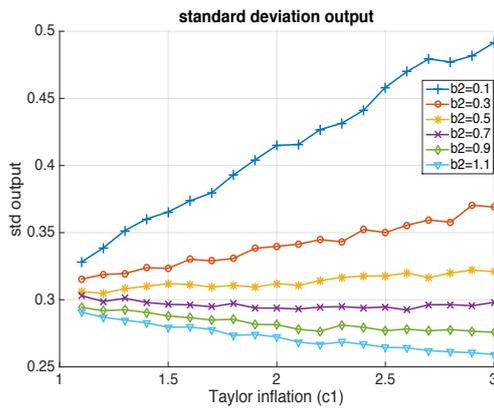
In this section we analyze the question of how structural reforms affect the choices monetary authorities face.

We first derive a monetary policy tradeoff that measures how increasing the intensity with which the central bank stabilizes inflation affects its choice between inflation and output volatility. We do this by varying the parameter  $c_1$  (the inflation parameter in the Taylor rule) and compute the standard deviations of output gap and inflation for increasing values of  $c_1$ . We repeat the exercise for different values of the flexibility parameter,  $b_2$ . The results are shown in Figures 14 and 15. They lend themselves to the following interpretation. Increasing  $c_1$  leads to an unambiguous decline in inflation volatility (see Figure 15) for all levels of flexibility,  $b_2$ . This is not the case for output volatility. As Figure 14 shows, when  $b_2$  is low (there is much rigidity) an increase in  $c_1$  raises output volatility. For sufficiently high levels of flexibility, however, ( $b_2 > 0.5$ ) increases in  $c_1$  lead to declines in output volatility.

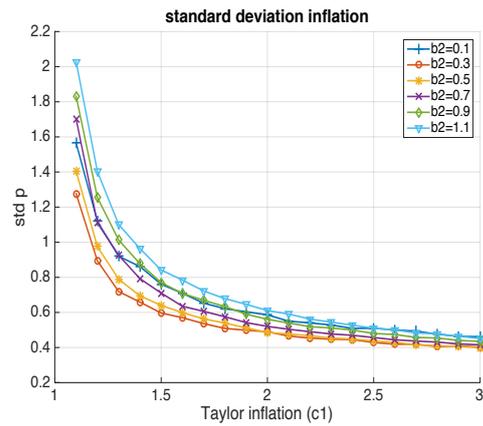
By combining the information of Figures 14 and 15 we obtain the monetary policy tradeoffs (Figure 16). These measure the inflation and output volatility choices the central bank face when it increases  $c_1$ . In order to understand Figure 16 let us first concentrate on the case of low flexibility ( $b_2 = 0.1$ ). In this case the tradeoff is negatively sloped. Starting from the top of that tradeoff, we see that increasing  $c_1$  leads to a decline of inflation volatility at the expense of more output volatility. As the degree of flexibility increases we observe that the tradeoff curves shift to the left and become less negatively sloped. For values of  $b_2$  exceeding 0.5 these tradeoffs become positively sloped, i.e. when  $c_1$  increases both inflation and output volatility decline.

Thus, one can conclude that when the economy is very rigid, a central bank that pursues its inflation target with increasing intensity faces a classical negatively sloped tradeoff between inflation and output volatility. This tradeoff disappears when the economy is sufficiently flexible. In that case the central bank can pursue a tighter inflation target without paying a price in terms of a higher output volatility. Put differently, in a flexible economy attempts of the central bank to better stabilize inflation are welfare improving. This is not so when the economy is too rigid.

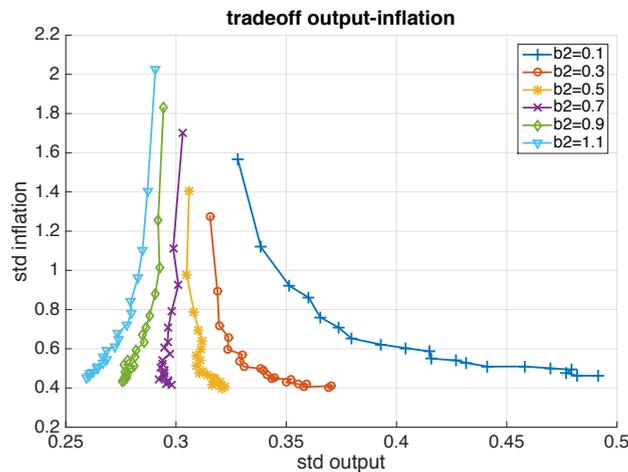
**Figure 14**



**Figure 15**



**Figure 16: Monetary policy tradeoffs and flexibility**



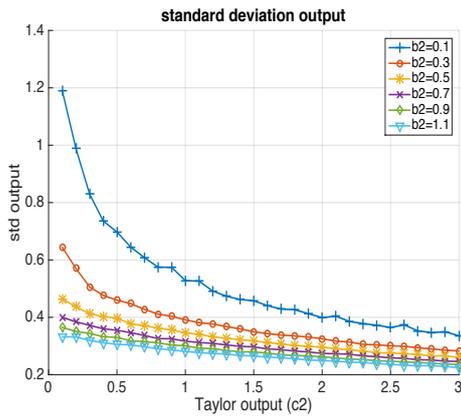
One can derive similar monetary policy tradeoffs that reflect the choices the central bank faces when it increases the intensity with which it pursues output stabilization (as measured by increasing the output parameter  $c_2$  in the Taylor rule). We do this in a similar way as in the case of inflation stabilization. In Figures 17 and 18 we show how increases in  $c_2$  affect inflation and output volatility for different values of the flexibility parameter  $b_2$ . When  $c_2$  increases output volatility declines for all values of the flexibility parameter  $b_2$  (see Figure 17). Note, however, that this decline is steeper when flexibility is lower. From Figure 18 we observe that in a very rigid economy ( $b_2=0.1$ ) we obtain a non-linear relationship, i.e. initial increases in  $c_2$  lead to a strong decline the standard deviation of inflation; however when  $c_2$  exceeds 1 further increases in  $c_2$  lead to

more inflation volatility. This non-linearity disappears for sufficiently high levels of flexibility. In more flexible economies an increase in  $c_2$  leads to a decline in inflation volatility.

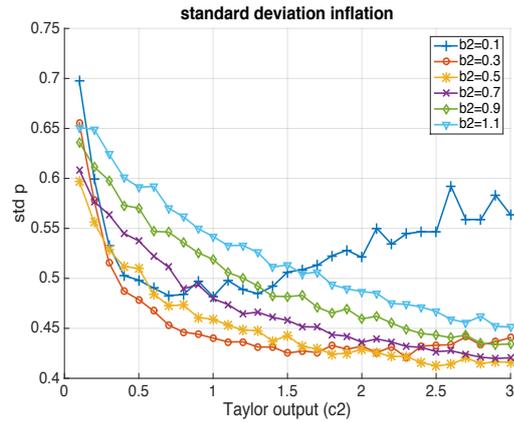
As in the case of inflation stabilization, we can now construct monetary policy tradeoffs by combining Figures 17 and 18 into one. This is done in Figure 19. To understand Figure 19 let us consider the tradeoff associated with a low flexibility parameter,  $b_2$ . This is a highly non-linear tradeoff. Let us start from point A on that tradeoff. This is the point obtained when  $c_2 = 0.1$  (there is almost no output stabilization). When the central bank increases its output stabilization we move down along that tradeoff. Thus by increasing  $c_2$  the central bank reduces both output and inflation volatility (a “win-win” situation). Welfare improves unambiguously. At some point however, when  $c_2$  becomes too large, the tradeoff becomes negatively sloped. This means that more intense attempts at stabilizing output lead to a reduction of output volatility at the expense of more inflation volatility; the classical negatively sloped tradeoff reappears when the central bank does too much output stabilization.

Such a negatively sloped tradeoff does not appear when the economy is sufficiently flexible. We see this in Figure 19 by the fact that as  $b_2$  increases the corresponding tradeoffs become less non-linear. When  $b_2$  is sufficiently large ( $b_2 > 0.5$ ) we obtain positively sloped tradeoffs. This means that in a sufficiently flexible economy, a central bank that increases its efforts at stabilizing output does not pay a price in terms of more inflation volatility. This is the same conclusion as the one derived when the central bank increases its effort at stabilizing inflation. In a flexible economy the central bank unambiguously improves welfare when it increases its effort at stabilizing output. No uncomfortable choices have to be made.

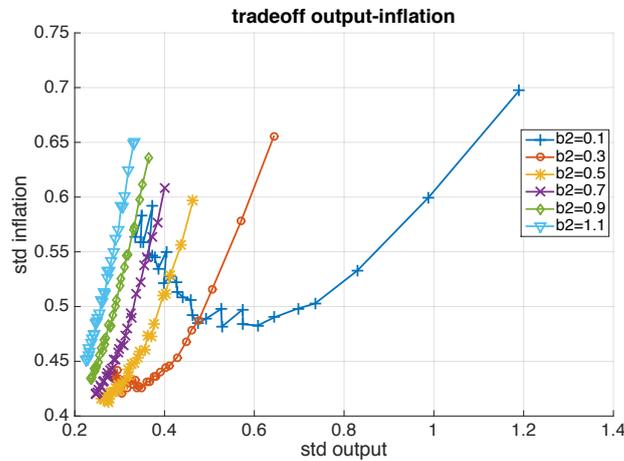
**Figure 17**



**Figure 18**



**Figure 19: Monetary policy tradeoffs and flexibility**



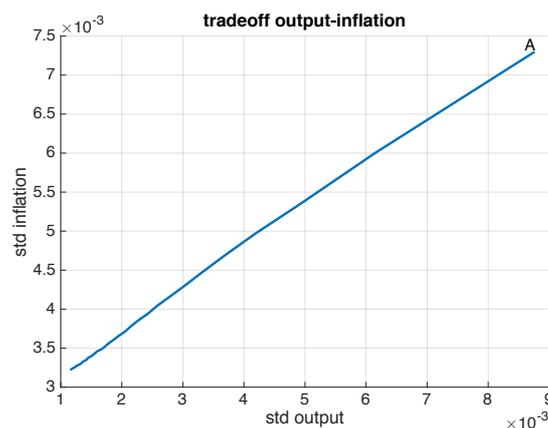
## 7. Tradeoffs under rational expectations (RE)

In this section we systematically compare the tradeoffs obtained in our behavioral model with those one obtains in the RE version of the model. We proceed as in section 4, i.e. we use the model consisting of the aggregate demand function (1), the aggregate supply function (2) and the Taylor rule (3) and solve it assuming rational expectations (RE). We then proceed in constructing similar tradeoffs as in the previous sections.

### 7.1 Optimal flexibility under rational expectations

Figure 20 shows the relationship between output and inflation volatility when we increase the degree of flexibility<sup>2</sup>. We obtain a positively sloped line, which should be interpreted as follows. Point A on the tradeoff corresponds to the lowest degree of flexibility ( $b_2=0.1$ ) in our simulations. As we increase  $b_2$  and the economy becomes more flexible we move downwards along the curve, which means that increasing the degree of flexibility reduces the volatility of output and inflation. This implies that structural reforms that increase the degree of flexibility have an unambiguously positive effect on welfare. More flexibility is always welfare improving. This was not the conclusion we arrived at in our behavioral model (section 5). There we found that the relation is non-linear: as the economy becomes more flexible this has the effect of reducing the volatility of output and inflation, so that welfare improves unambiguously. However, there is a critical level of flexibility that will produce a negatively sloped tradeoff, indicating that further efforts at increasing flexibility will reduce output volatility and the expense of more inflation volatility. Further efforts at structural reforms may not be welfare improving anymore.

**Figure 20: Optimal level of flexibility in RE-model**

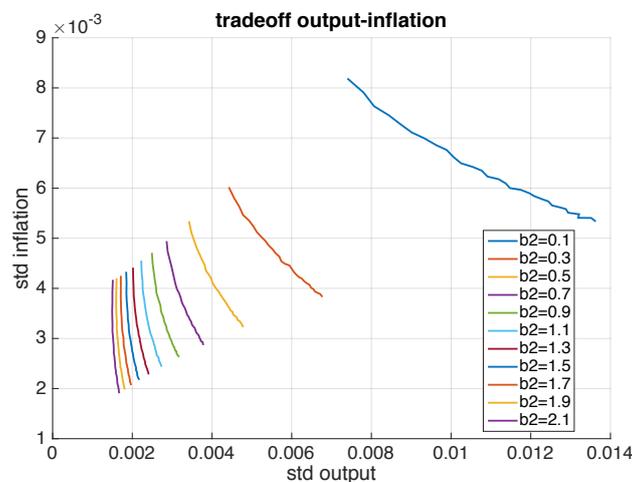


Our next step consisted in deriving the tradeoffs monetary authorities face in a RE-world when flexibility increases. We do this in the same way as in section 6.

<sup>2</sup> As in the previous sections this is obtained by computing the standard deviations of the output gaps and inflation for different levels of flexibility and then combining this information into one chart. We show the underlying relationships between volatilities and flexibility in appendix.

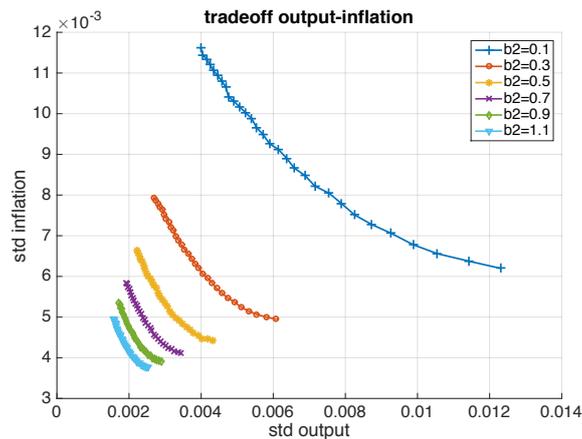
We concentrate first how flexibility affects attempts to stabilize inflation. We obtain Figure 21. This shows the tradeoffs obtained when the central bank increases its effort to stabilize inflation: this always comes at a price in the form of more output volatility. We also find that more flexibility shifts the tradeoff curves downwards. Thus more flexibility is welfare improving and facilitates the central bank in its effort to control inflation.

**Figure 21 Tradeoffs in RE-model**



In Figures 22 we show the results of a similar exercise when the central bank increases its efforts to stabilize output ( $c_2$  Taylor parameter). Our results are very similar as in the previous case. We obtain tradeoffs that show first that attempts at controlling output come at a price, in the form of more inflation volatility. Second, flexibility always improves these tradeoffs. In other words when flexibility increases the central bank faces more favorable tradeoffs, making it easier to control output.

**Figure 22: Tradeoffs in RE-model**



These results obtained under rational expectations are very different from those we obtained in our behavioral model. We summarize the differences as follows.

First, in the RE-model structural reforms that increase flexibility are always welfare improving in that they lead to better tradeoffs for the monetary authorities. This contrasts with the results obtained in the behavioral model where we found that flexibility does not always improve welfare. We found that when flexibility is sufficiently high ( $b_2 > 0.5$ ) further increases in flexibility create negative tradeoffs forcing monetary authorities to make painful choices.

Second, in the RE-model we obtain the traditional result that output and inflation stabilization by the central bank produce tradeoffs, i.e. the central bank can increase its control over inflation only at the expense of more output volatility; similarly it can only control output better at the expense of more inflation volatility. This result contrasts very much with the results obtained in the behavioral model. There we find that if flexibility is high enough the central banks does not face a negatively sloped tradeoff, i.e. it can increase its effort to control inflation, respectively output without having to accept more output, respectively inflation volatility. Put differently, in a flexible economy, stabilization of inflation and output come at no cost. They are unambiguously welfare improving. This result has to do with the existence of animal spirits in the behavioral model. By stabilizing either output or inflation the central bank “tames the animal spirits” and enhances overall stability in the model. Only when

flexibility is too low does the central bank face the traditional negatively sloped tradeoff.

## **8. Conclusion**

In this paper we have analyzed how different types of structural reforms affect the economy. We have used a New Keynesian behavioral macroeconomic model to perform this analysis. This is a model characterized by the fact that agents experience cognitive limitations preventing them from having rational expectations. Instead they use simple forecasting rules (heuristics) and evaluate the forecasting performances of these rules ex-post. This evaluation leads them to switch to the rules that perform best. This adaptive learning model produces endogenous waves of optimism and pessimism (animal spirits) that drive the business cycle in a self-fulfilling way, i.e. optimism (pessimism) leads to an increase (decline) in output, and the increase (decline) in output in turn intensifies optimism (pessimism).

Exercises evaluating the impact of structural reforms have been done using standard DSGE-models (see e.g. Eggertsson, et al. (2014)). Doing this in the framework of a behavioral macroeconomic model is a novel attempt.

We considered two types of structural reforms. The first one increases the flexibility of wages and prices; the second one raises potential output in the economy. We find that structural reforms that increase the flexibility of wages and prices can have profound effects on the dynamics of the business cycle. In particular in a more flexible economy (more wage and price flexibility) the power of animal spirits is reduced and so is the potential for booms and busts in the economy. This has to do with the fact that in more flexible economies prices and wages have a greater role to play in adjustments to emerging disequilibria. This reduces the amplitude of the business cycles and as a result creates less scope for waves of optimism and pessimism in creating booms and busts.

We also analysed how structural reforms that increase potential output (e.g. reforms that increase labour participation) interact with reforms that increase

the flexibility in the economy. We found that in a more flexible economy the permanent effects on output of a positive supply shock induced by structural reforms are higher than in a more rigid economy. We concluded that a structural reform program that raises potential output has a stronger long-term effect on output and tends to reduce the price level more in a flexible than in a rigid economy.

We also compared the results obtained in our behavioral model with the results in the same New Keynesian model under Rational Expectations (RE). In general we find that a positive supply shock has less intense effects on output and the price level in the RE-model as compared to the behavioral model. This has to do with the amplification effects produced by animal spirits in the behavioral model.

We analyzed the optimal level of flexibility where optimality refers to the issue of how flexibility affects the stability of output and inflation. Our main finding here is that there is an optimal level of flexibility (produced by structural reforms). As we increase the degree of flexibility this at first creates a win-win situation in that both the volatility of output and inflation decline with increasing flexibility. However, when we go too far with structural reforms this is no longer the case i.e. further increases in flexibility lead to less volatility of output at the expense of increasing inflation volatility. The optimal level of flexibility will then depend on society's preferences between inflation versus output volatility.

We also found that the degree of flexibility affects the tradeoffs faced by the central banks. Monetary policies that aim to making the inflation-targeting regime tighter (in the sense of selecting a higher inflation parameter in the Taylor rule) face a tradeoff when the economy is rigid. Such a tighter inflation targeting will reduce inflation volatility at the expense of more output volatility. In contrast, when the economy is flexible a tighter inflation targeting can achieve its objective without increasing output volatility. In a similar way, when the central bank increases its efforts at stabilizing output this will in a rigid economy lead to a point where it faces a negative tradeoff between output and inflation volatility. This negative tradeoff disappears when the economy is sufficiently

flexible. Thus, structural reforms that increase the flexibility of wages and prices create more comfort for the central bank. Attempts by the latter to stabilize output and inflation are unambiguously welfare improving.

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## Appendix

In this appendix we present the Figures that underlie the Figures 20, 21 and 22

Figure 20a: Flexibility and output volatility    Figure 20b: Flexibility and inflation volatility

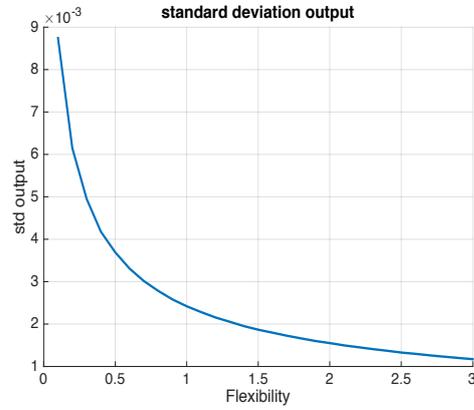
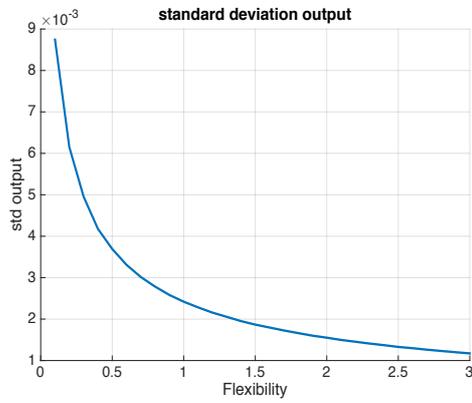


Figure 21a

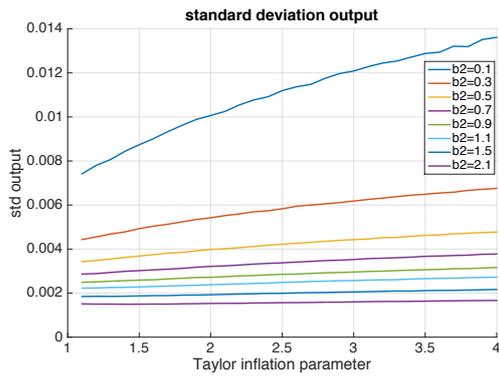


Figure 21b

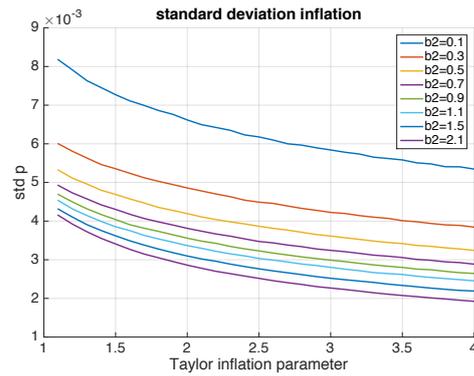


Figure 22a

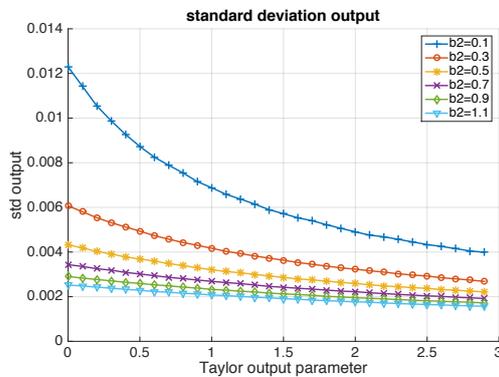
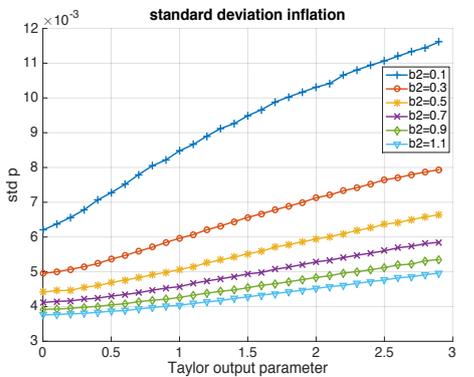


Figure 22b



## Endnotes

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<sup>i</sup> It is now standard in DSGE-models to use a pricing equation in which marginal costs enter on the right hand side. Such an equation is derived from profit maximization in a world of imperfect competition. It can be shown that under certain conditions the aggregate supply equation (2) is equivalent to such a pricing equation (see Gali(2008), Smets and Wouters(2003)).

<sup>ii</sup> In De Grauwe(2012) more complex rules are used, e.g. it is assumed that agents do not know the steady state output gap with certainty and only have biased estimates of it. This is also the approach taken by Hommes and Lustenhouwer(2016).

<sup>iii</sup> Note that according to (4) fundamentalists expect a deviation of the output gap from the equilibrium to be corrected in one period. We have experimented with lagged adjustments using an AR(1) process. These do not affect the results in a fundamental sense. We show and discuss the results in Appendix.

<sup>iv</sup> There are some attempts to provide micro-foundations of models with agents experiencing cognitive limitations, though. See e.g. Kirman, (1992), Delli Gatti, et al.(2005). A recent attempt is provided by Gabaix(2014). See also Hommes and Lustenhouwer(2015) who derive microfoundations of a model similar to the one used here, but assuming quite strong cognitive capacities of agents. We have not pursued this here.