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# Analyzing Structural Reforms Using a Behavioral Macroeconomic Model

## Abstract

We use a behavioral macroeconomic model to analyze how structural reforms affect the economy in the short and in the long run. We consider 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 addition, 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. Finally, we analyze how structural reforms change the tradeoffs between output and inflation variability. Our main finding here is that there is an optimal level of flexibility (produced by structural reforms).

JEL-Codes: E000.

Keywords: animal spirits, structural reforms, monetary policy.

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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 term 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. On 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.

## 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:

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

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, $\widetilde{\mathrm{E}}_t \pi_{t+1}$ , and a lagged inflation variable[i] 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.

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

Finally the Taylor rule describes the behavior of the central bank

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

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[ii]. 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:

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

The extrapolative rule is defined by $\widetilde{E}_t^e y_{t+1} = y_{t-1}$ (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[iii]. 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.

$$\widetilde{\mathrm{E}}_t y_{t+1} = \alpha_{f,t} \widetilde{\mathrm{E}}_t^f y_{t+1} + \alpha_{e,t} \widetilde{\mathrm{E}}_t^e y_{t+1} \qquad (6)$$

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

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

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

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

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[iv].

### *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:

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

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

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 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

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

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:

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

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

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

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)):

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

When 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

$$\widetilde{\mathrm{E}}_t^{ext}\pi_{t+1} = \pi_{t-1} \tag{15}$$

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

$$\widetilde{\mathrm{E}}_t\pi_{t+1} = \beta_{tar,t}\widetilde{\mathrm{E}}_t^{tar}\pi_{t+1} + \beta_{ext,t}\widetilde{\mathrm{E}}_t^{ext}\pi_{t+1} \tag{16}$$

or
$$\widetilde{\mathrm{E}}_t\pi_{t+1} = \beta_{tar,t}\pi^* + \beta_{ext,t}\pi_{t-1} \tag{17}$$

and
$$\beta_{tar,t} + \beta_{ext,t} = 1 \tag{18}$$

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.

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

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

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.

$$U_{tar,t} = -\sum_{k=0}^{\infty}\omega_k\left[\pi_{t-k-1} - \widetilde{\mathrm{E}}_{f,t-k-2}\pi_{t-k-1}\right]^2 \tag{21}$$

$$U_{ext,t} = -\sum_{k=0}^{\infty}\omega_k\left[\pi_{t-k-1} - \widetilde{\mathrm{E}}_{e,t-k-2}\pi_{t-k-1}\right]^2 \tag{22}$$

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:

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

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 $\mathrm{S}_t = 1$.

- 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:

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

### *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:

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

i.e.

$$\boldsymbol{AZ_t} = \boldsymbol{B\widetilde{E_t}}\,\boldsymbol{Z_{t+1}} + \boldsymbol{CZ_{t-1}} + \boldsymbol{b}r_{t-1} + \boldsymbol{v_t} \qquad (25)$$

where bold characters refer to matrices and vectors. The solution for $\boldsymbol{Z_t}$ is given by

$$\boldsymbol{Z_t} = \boldsymbol{A^{-1}}\left[\boldsymbol{B\widetilde{E_t}}\,\boldsymbol{Z_{t+1}} + \boldsymbol{CZ_{t-1}} + \boldsymbol{b}r_{t-1} + \boldsymbol{v_t}\right] \qquad (26)$$

The solution exists if the matrix $\boldsymbol{A}$ is non-singular, i.e. $(1\text{-}a_2c_2)\text{-}a_2b_2c_1 \neq 0.$ 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**

| | |
|---|---|
| a1 = 0.5 | coefficient of expected output in output equation |
| a2 = -0.2 | interest elasticity of output demand |
| b1 = 0 | coefficient of expected inflation in inflation equation |
| b2 = 0.05 | coefficient of output in inflation equation, rigid case |
| b2=1 | coefficient of output in inflation equation, flexible case |
| $\pi^*$=0 | inflation target level |
| c1 = 1.5 | coefficient of inflation in Taylor equation |
| c2 = 0.5 | coefficient of output in Taylor equation |
| c3 = 0.8 | 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 | measures the speed of declining weights in mean squares errors (memory parameter) |

## 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.

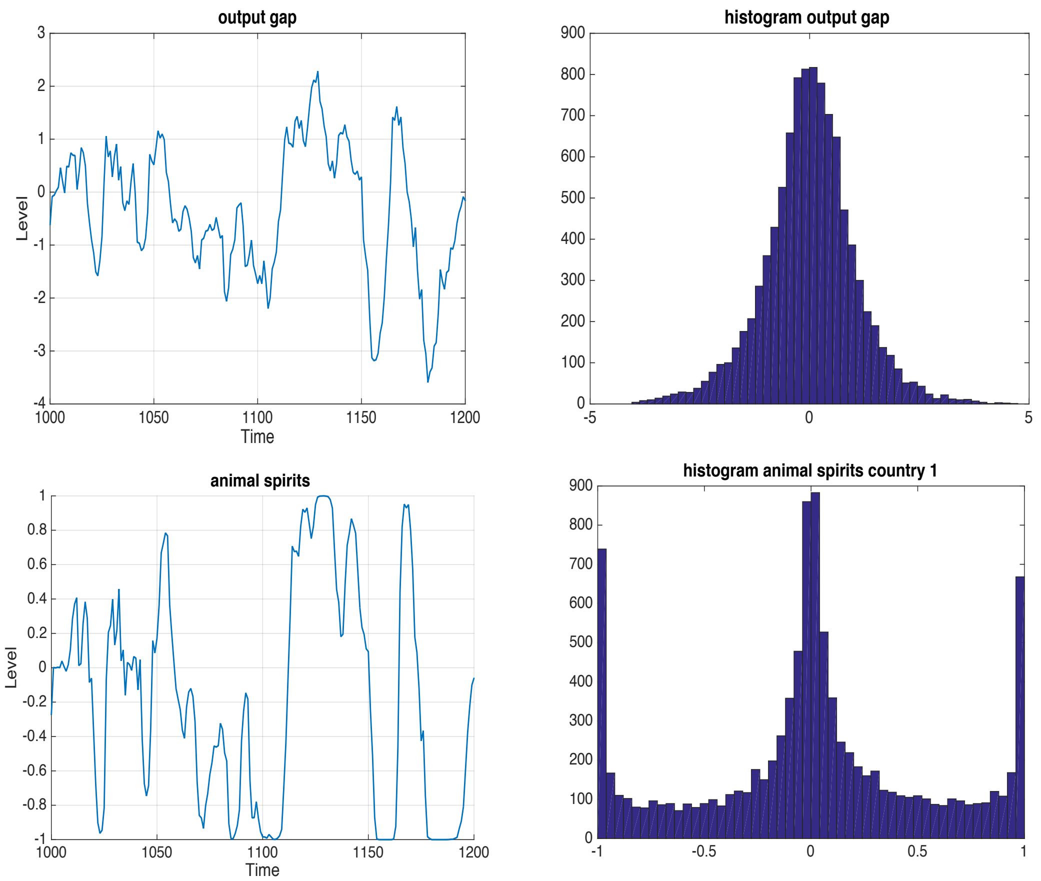
The second type of structural reforms (e.g. increasing the degree of participation in the labour market, extending the retirement age) has the effect of raising potential output. These structural reforms therefore can be seen as producing a positive supply shock. We will analyze these two types of structural 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. This correlation reaches 0.88. 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.

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




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.

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 economy. 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 three interesting results. First, in a flexible economy the power of animal spirits is significantly reduced. St remains at moderate levels between -0.4 to 0.3. The extreme levels of optimism (St=1) or pessimism (St=-1) disappear. 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 is much lower. We find a correlation of 0.55. This is contrast to 0.88 which is obtained in the rigid economy. As a result, the output gap in Figure 2 is also less volatile. The fluctuations are significantly reduced to between -0.7 to 0.7.

Third, we find that the excess kurtosis and fat tails disappear and the output gap appears to be normally distributed. A Jarque-Bera test cannot reject normality of the distribution of the output gap. Thus in a flexible economy, the higher flexibility of prices prevents animal spirits from becoming extreme, and from affecting the business cycles in a self-fulfilling way. As a result, extreme booms and busts become less likely.

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 0.9 when $b_2$ is close to zero and then decreases sharply to 0.55 when $b_2$ reaches 1. When $b_2$ increases further to 5, the correlation decreases slowly to about 0.35.

**Figure 2. Output and animal spirits (b2 = 1, flexible case)**

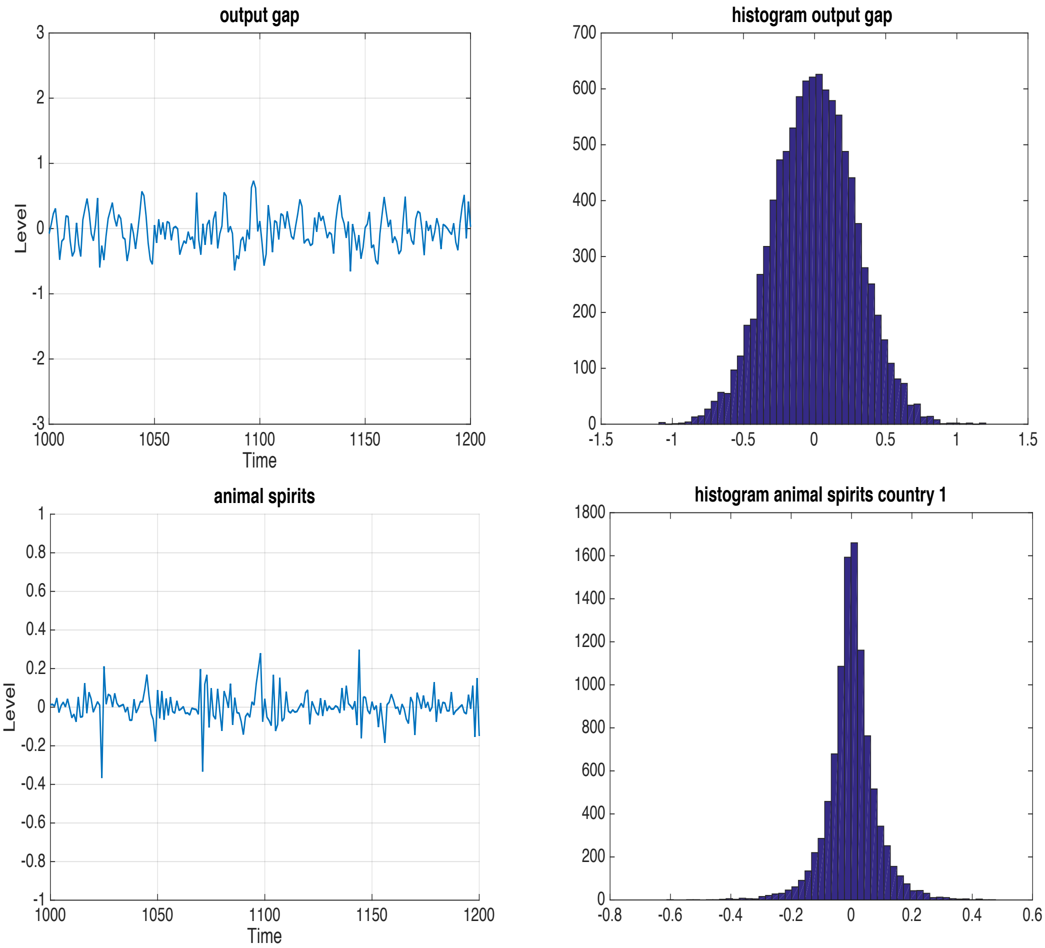


Figure 3.

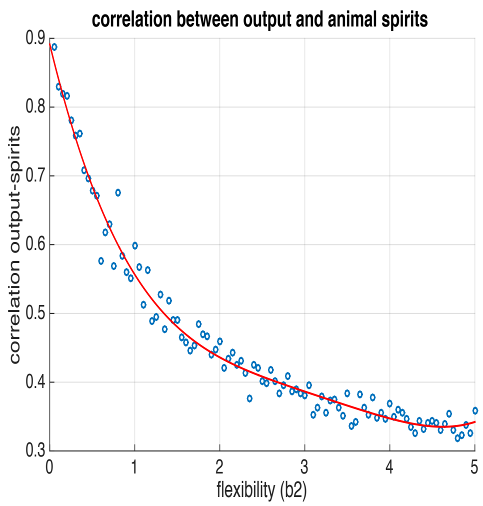
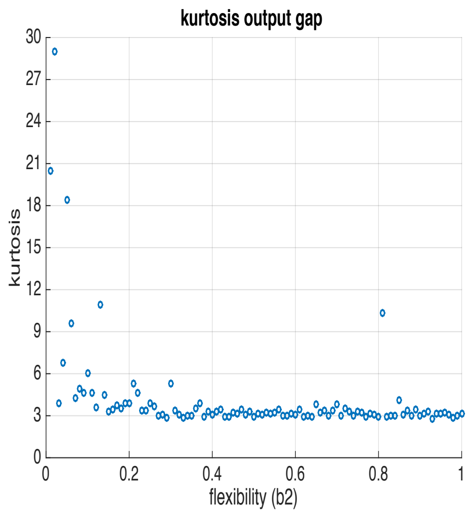



Figure 4.




As flexibility reduces the power of animal spirits, this also leads to fewer extreme value of the output gap. As a result, we are more likely to have normally distributed output gap. Figure 4 informs us about this relationship. The kurtosis of the output gap starts at very high levels when $b_2$ is close to zero. It sharply decreases when $b_2$ increases. At $b_2=1$, the kurtosis approaches 3 indicating that the output gap is almost 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 much 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 as 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 about 80 quarters in the rigid economy to adjust to the long-term equilibrium while the adjustment only takes 20 quarters in the flexible economy.

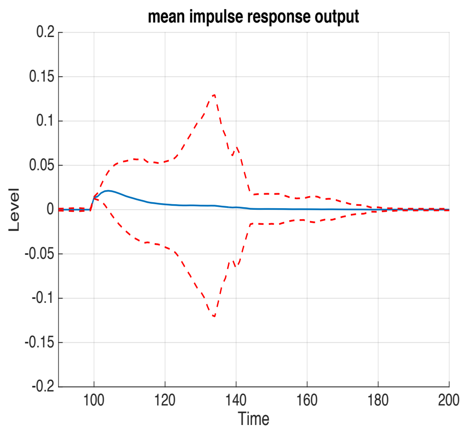
Third, we observe that the short-term impact of the positive supply shock on output and inflation are higher in the flexible economy than in the rigid one. In addition the central bank reacts more strongly by lowering the interest rate in the flexible economy than in the rigid one.

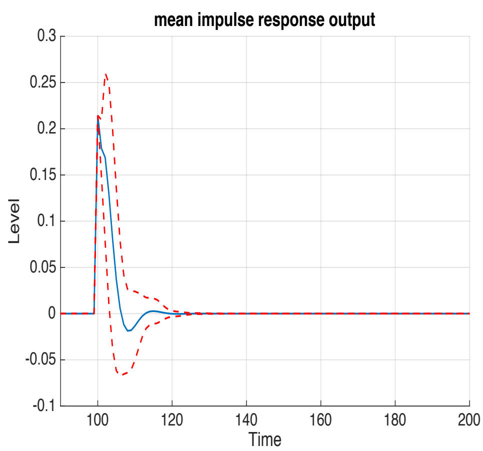
How can these results be interpreted? The positive supply shock has a stronger negative effect on inflation in the flexible economy than in the rigid one because prices react more to the increase in excess supply generated by the positive shock in potential output. This leads to a strong decline in inflation 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.

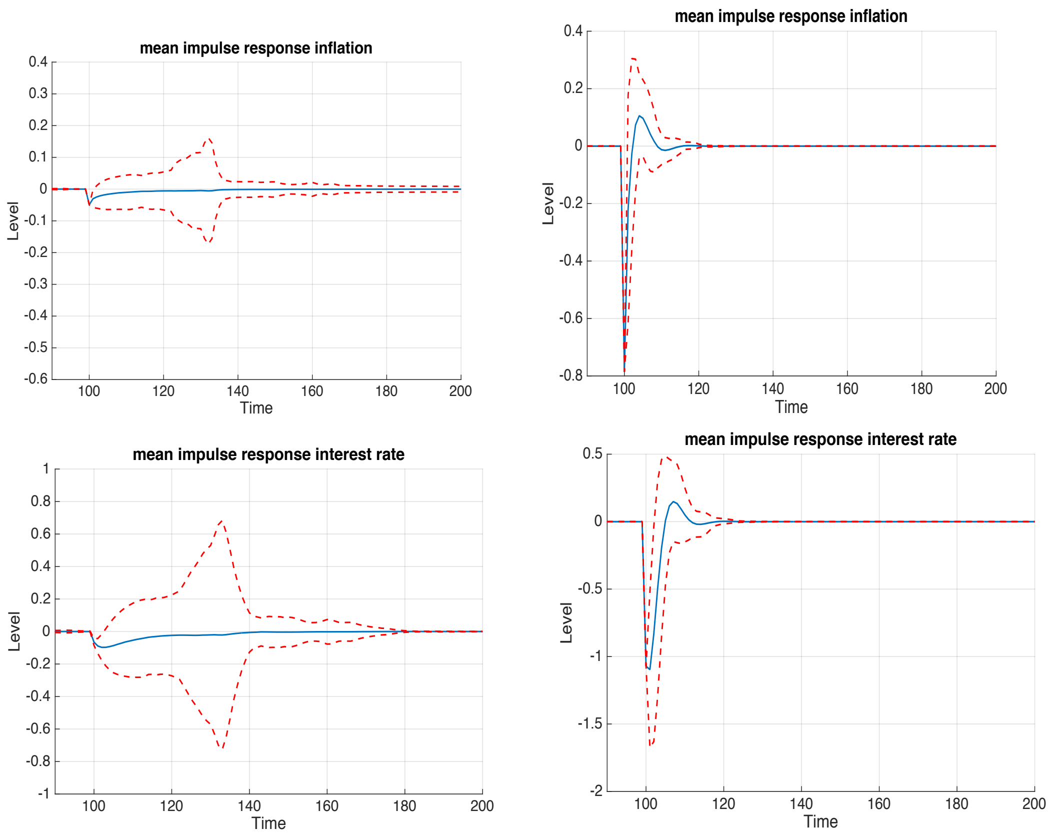
We also note that in the flexible economy the reaction of the central bank to the supply shock leads to a boom followed by a recession. This follows from the fact that the central bank (using a Taylor rule with high weight to inflation) fuels the expansionary effects of the supply shock too much, leading to a correction later on.

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

**Rigid economy** **Flexible economy**



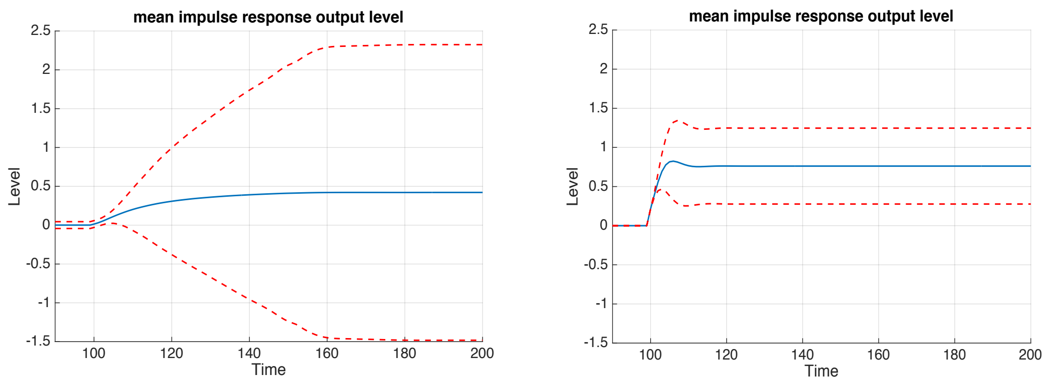



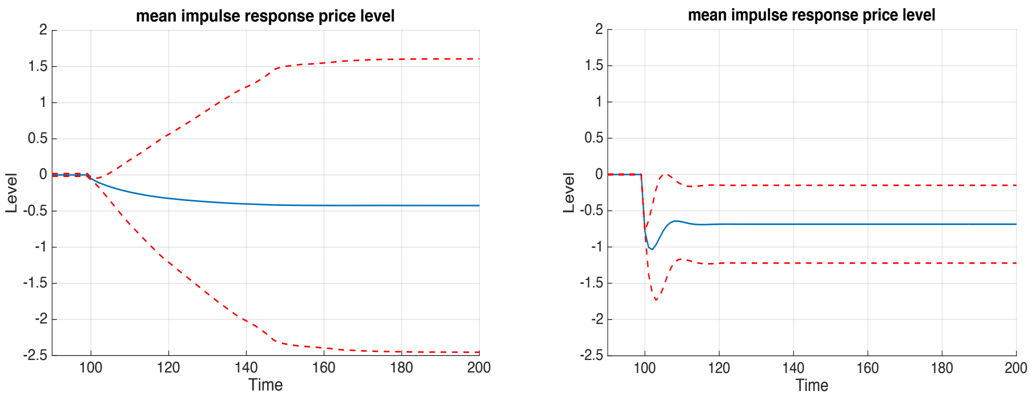



It is also important to analyze the long-term impact of the supply shock on the level of output in the rigid and flexible economies. We obtain these by computing the cumulative effects of the supply shock on the output gap and on inflation. This yields the effects on the output level and the price level.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

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

**Rigid economy** **Flexible economy**






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 about twice as large as in the rigid economy. Thus a structural reform program that raises potential output has a stronger effect long term effect on output and tends to reduce the price level more than in a rigid economy.

### 3.3 Impulse responses to a demand shock

It is useful to also analyze the impact of demand shocks on the rigid and the flexible economies. We do this in this section. We analyze a negative demand shock (one standard deviation of the stochastic term in the demand equation (1)). We proceed as in the previous section by presenting the impulse responses in the rigid and the flexible economies (see Figure 7).

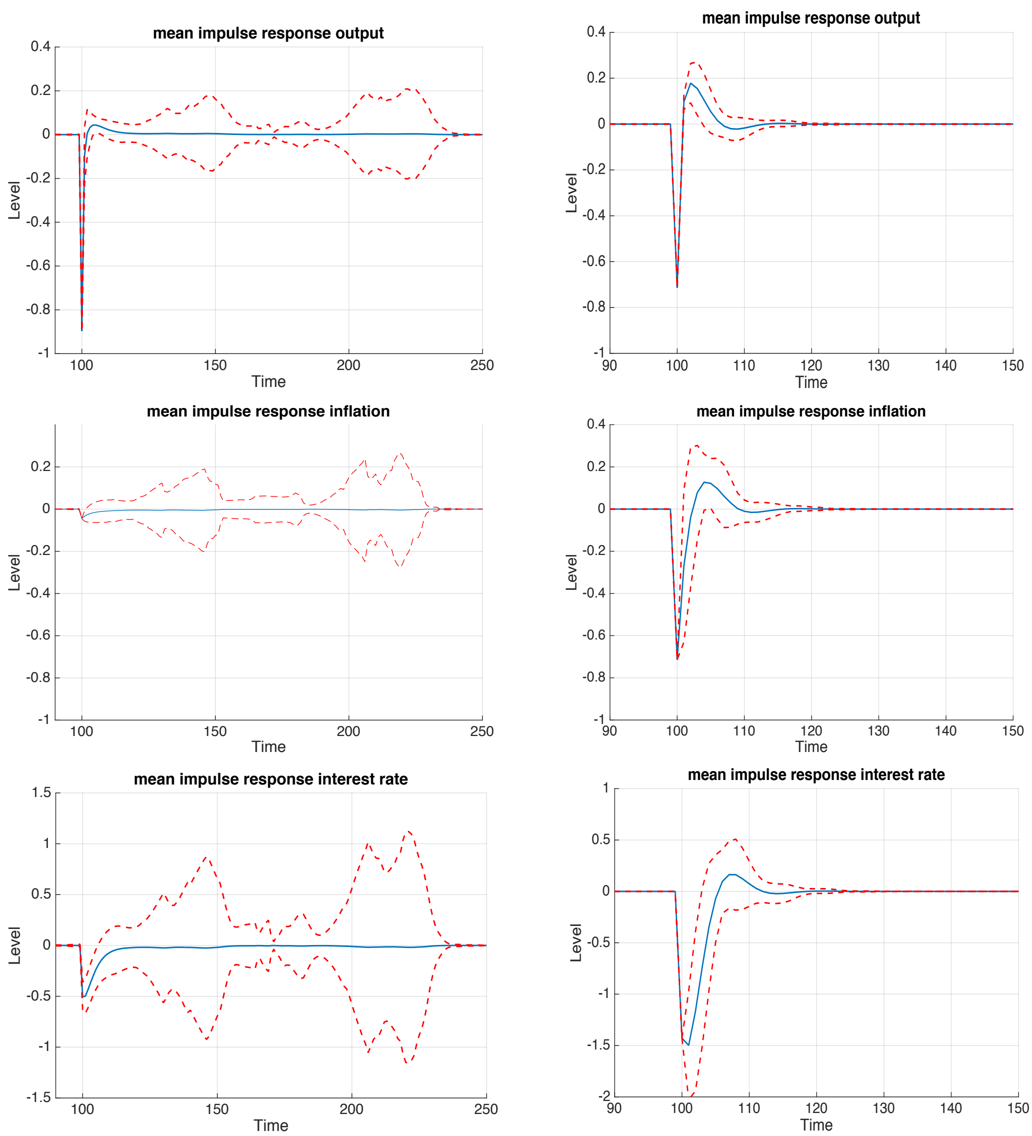
Our results can be interpreted as follows. First, as in the previous section we find that the uncertainty surrounding the impulse responses is significantly higher in the rigid than in the flexible economy. Again this has to do with the existence of animal spirits that are much more pronounced in the rigid economy.

Second, the duration it takes to adjust to the long term equilibrium is different in the two types of economy. It takes about 150 quarters in the rigid economy to adjust to the long-term equilibrium while the adjustment only takes 20 quarters in the flexible economy.

Third, we find (not unexpectedly) that the negative demand shock has a stronger short-term effect on output in the rigid economy than in the flexible one. This result is reversed for the inflation responses. The inflation response to a negative demand shock is much stronger in the flexible economy than in the rigid one. Since the central bank attaches a greater weight to inflation, we find that the central bank reacts more forcefully (by lowering the interest rate) to a negative demand shock in the flexible economy than in the rigid one. This in turn tends to reduce the negative effect of the demand shock on output.

**Figure 7: Impulse responses to negative demand shock**

**Rigid economy** **Flexible economy**



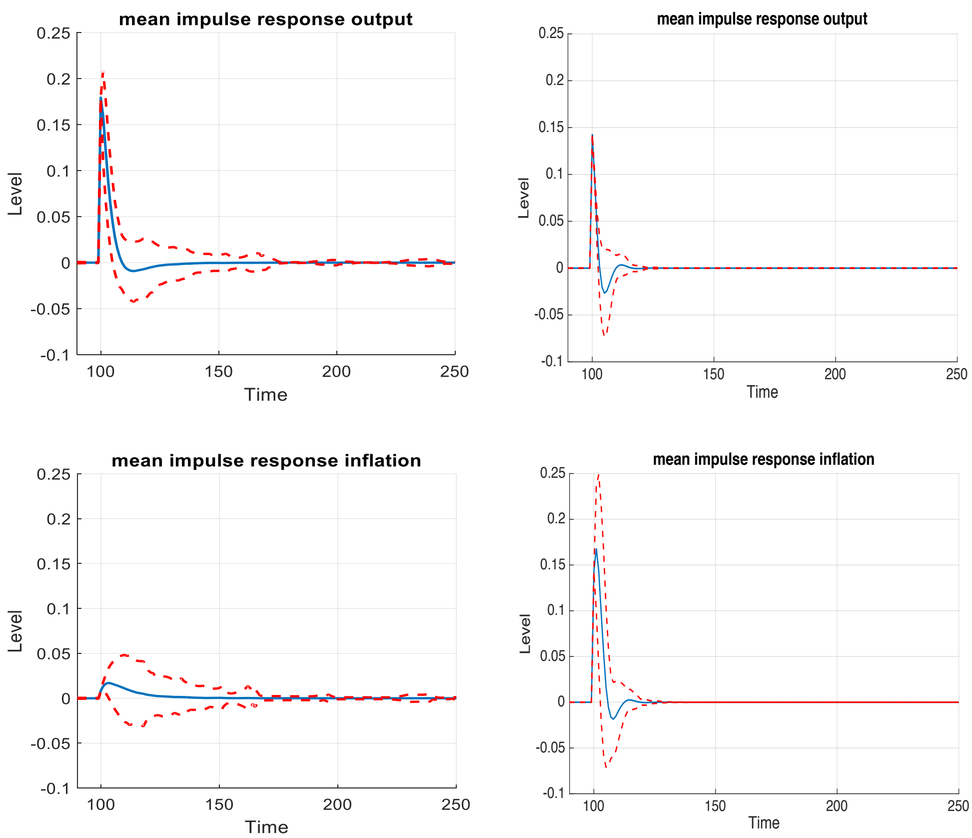
### 3.4 Impulse responses to an interest rate shock

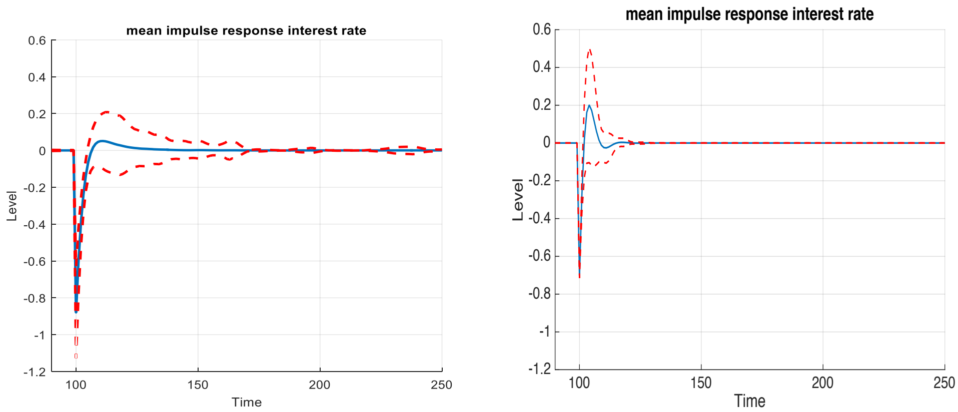
In this section we study how an interest rate shock is transmitted in the economy in both the rigid and the flexible economies. We analyze a negative interest rate shock (one standard deviation of the stochastic variable in the Taylor rule equation (3). The results are shown in figure 8.

Our main result is not really surprising. In a rigid economy, the decline in the interest rate has a stronger output effect than in the flexible economy. As far as the inflation effects are concerned, this result is reversed. The decline in the interest rate leads to a much stronger positive effect on inflation in the flexible economy than in the rigid one. As a result the central bank in a flexible economy corrects for this more quickly by raising the interest rate. The whole adjustment process is again shorter in the flexible economy than the rigid one.

**Figure 8: Impulse responses to negative interest rate shock**

**Rigid economy** **Flexible economy**






### 3.5 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 a tradeoff between the volatilities of output and inflation.

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. We then repeated the exercise for four different values of the $c_1$ parameter in the Taylor rule. This is the parameter that expresses the intensity with which the central bank reacts to changes in the inflation rate.

The results shown in Figure 9 show how an increase in flexibility reduces the volatility of the output gap. The relation is highly 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.

We also note that an increase in the intensity with which the central bank pursues its inflation target (c1) shifts the curve upwards, i.e. increases the volatility of output. As flexibility is increased, however, this upward shift is weakened and tends to disappear for high levels of flexibility. Thus when flexibility is high, a tighter inflation targeting policy does not create costs in terms of more variability of output.

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 $c_1$ between 0.2 and 0.6) the standard deviation of inflation tends to increase when $c_1$ 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.

This minimum point is dependent on the intensity of inflation targeting pursued by the central bank. We find that when $c_1$ increases the lines shift downwards and the minimum points also shift to the right. This means that a more aggressive inflation-targeting stance by the central bank significantly reduces the volatility of inflation for all levels of flexibility.

Figure 11 presents the tradeoffs between output and inflation variability. 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 highly non-linear trade-offs. In order to understand this start from point A on the trade-off obtained when $c_1$ = 1.5. This point is obtained when flexibility ($b_2$) is zero. As we increase the degree of flexibility we move down along the trade-off 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. However, when we go too far with structural reforms we go beyond the minimum point on the trade-off. From that point on we obtain a traditional negatively sloped trade-off, i.e. further increases in flexibility lead to less volatility of output at the expense of increasing inflation volatility.

Finally we find that tighter inflation targeting regimes (increasing $c_1$) shifts the trade-offs downwards. This means that central banks that react more forcefully to changes in inflation tend to improve the trade-off between inflation and output volatility, and create more welfare associated with structural reforms.

**Figure 9**

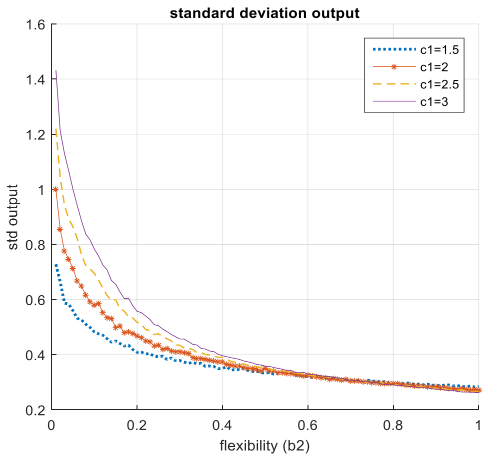



**Figure 10**

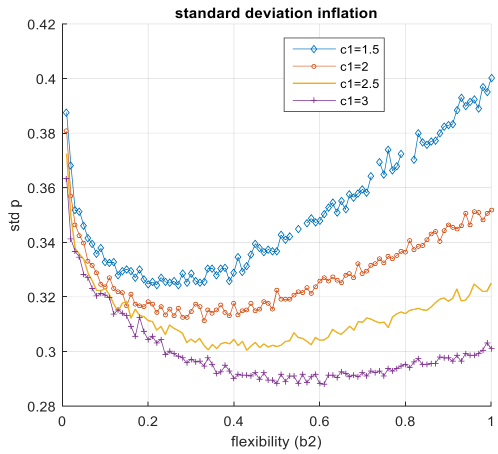
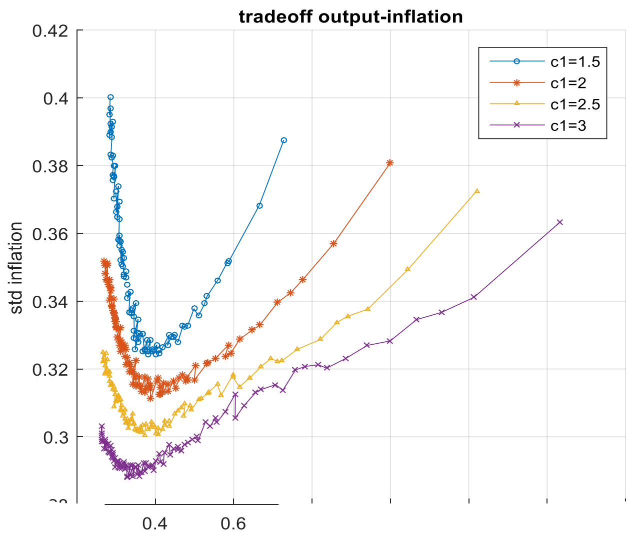



**Figure 11**




As a final exercise we derived similar tradeoffs for different values of the c2 parameter in the Taylor rule. This parameter measures the extent to which the central bank stabilizes the output gap. An increase in c2 means that the central bank is more ambitious in its attempts to stabilize the business cycle by manipulating the interest rate. We show the results in Figures 12 to 14.

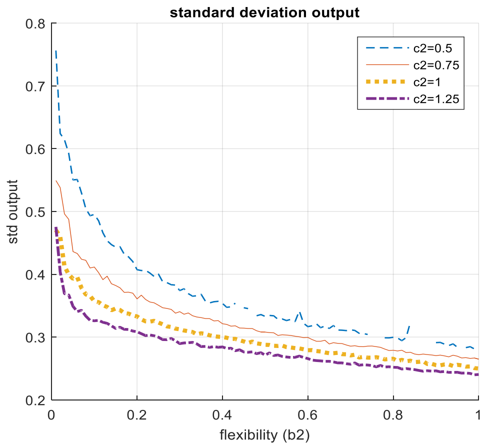
We observe from Figure 12 that, as before more flexibility tends to reduce the volatility in the output gap. This decline is non-linear, i.e. very strong for initial increases in flexibility and tapering off when flexibility is increased further. We also observe that when the central bank increases its effort to stabilize the business cycle (increasing c2) the lines shift downwards. This means that for all levels of flexibility an increase in c2 reduces the variability of the output gap.

Figure 13 shows the relation between flexibility and inflation volatility for different values of c2. The non-linearity in these relationship show that initial increases in flexibility first reduce the volatility of inflation. Beyond a certain level, further increases in flexibility start raising the variability of inflation. We also note that, in contrast with the results involving the parameter c1, the different lines cross each other. For low levels of flexibility a low value of c2 is associated with low levels of inflation volatility; for high levels of flexibility a low value of c2 is associated with high levels of inflation volatility.

This feature makes it difficult to make welfare comparisons of different policies aiming at stabilizing the output gap. This is made clear from the tradeoffs derived from figures 12 and 13. These are shown in Figure 14. We now observe tradeoffs that tend to shift horizontally (and to the left) as c2 increases. Let us start with c2=0.5. We observe that for this (relatively) low value the tradeoff is unfavorable when flexibility is low. Put differently when there are many rigidities in the economy a low ambition to stabilize the business cycle is unfavorable for welfare. In a rigid world the central bank can improve welfare by being more ambitious in stabilizing the economy. The reason is, as we have seen earlier, when there are many rigidities animal spirits play a greater role in driving the business cycles and in creating booms and busts. That's when central banks can be most effective in stabilizing the economy and to create welfare.

When, as a result of structural reforms, the economy becomes more flexible, these results are turned upside down. In a flexible economy there is less need for stabilization of output by the central bank. We can see that from Figure 14 by the fact that with high levels of flexibility, a low c2 produces a more favorable tradeoff than higher c2's. Thus in a flexible economy too much ambition of the central bank to stabilize output reduces welfare.

**Figure 12** **Figure 13**



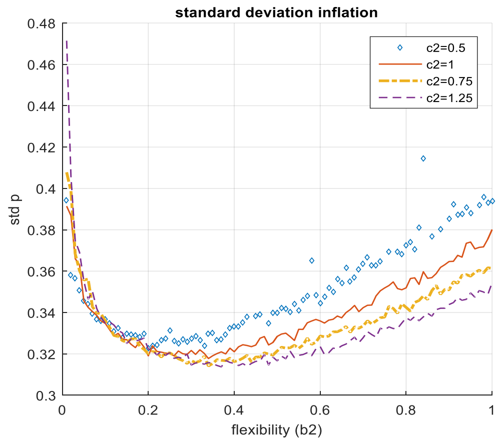
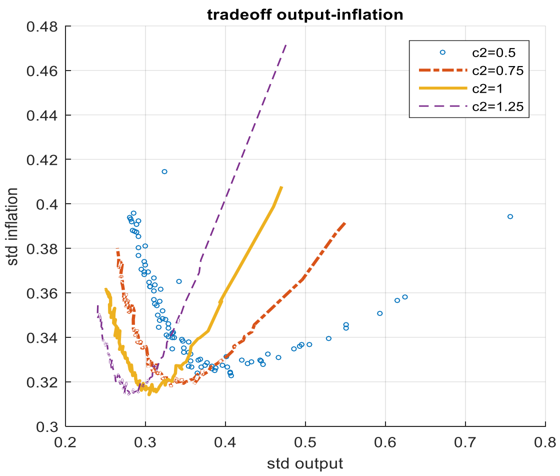




**Figure 14**




## 4. Conclusion

In this paper we have analyzed how different types of structural reforms can be transmitted into the macroeconomy. We have used a 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 term intensifies optimism (pessimism). Such exercises of evaluating the impact of structural reforms have been done using standard DSGE-models. 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 can be significantly 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.

Finally, we analyzed how structural reforms change the tradeoffs between output and inflation variability. Our main finding here is that there is an optimal level of flexibility (produced by structural reforms). As we increase the degree of flexibility we move down along the trade-off line between output and inflation variability. 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. However, when we go too far with structural reforms we go beyond the minimum point on the trade-off. From that point on we obtain a traditional negatively sloped trade-off, i.e. further increases in flexibility lead to less volatility of output at the expense of increasing inflation volatility.

We also found that central banks can affect these tradeoffs. In general a tighter inflation targeting policy pursued by the central bank improves the tradeoffs (shifting them downwards), and as a result increase the welfare gains associated with structural reforms. Monetary policies aimed at stabilizing the output gap, however, have ambiguous effects.  We found that in a rigid economy ambitious output stabilizing monetary policies are welfare improving (improve the tradeoffs). However, structural reforms that increase the flexibility of wages and prices reverse this conclusion. In more flexible economies more prudent monetary policies, i.e. policies giving a lower weight to output stabilization are welfare improving.

## References


Akerlof, G., and Shiller, R., (2009), *Animal Spirits. How Human Psychology Drives the Economy and Why It Matters for Global Capitalism*, Princeton University Press, 230pp.

Anderson, S., de Palma, A., Thisse, J.-F., 1992, Discrete Choice Theory of Product Differentiation, MIT Press, Cambridge, Mass.

Ascari, G., Fagiolo, G., and Roventini, A. (2015). Fat-Tail Distributions And Business-Cycle Models. Macroeconomic Dynamics , 19(02):465-476.

Branch, W., and Evans, G., (2006), Intrinsic heterogeneity in expectation formation, *Journal of Economic theory*, 127, 264-95.

Brazier, A., Harrison, R., King, M., Yates, T., (2008), The danger of inflation expectations on macroeconomic stability: heuristic switching in an overlapping generations monetary model, in *International Journal of Central Banking*, 32:2428-2452.

Brock, W., and Hommes, C., (1997), A Rational Route to Randomness, *Econometrica*, 65, 1059-1095

Cacciatore, M., Duval, R., and Fiori, G., (2012), Short-term gain or pain? A DSGE model-based analysis of the short-term effects of structural reforms in labour and product markets, Economics Department Working paper no. 948, OECD.

Cacciatore, M., Fiori, G. and Ghironi, F.: 2016, Market Deregulation and Optimal Monetary Policy in a Monetary Union, Journal of International Economics

Calvo, G., (1983), Staggered prices in a utility maximizing framework. Journal of Monetary Econonomics12, 383-398.

Colander, David, Peter Howitt, Alan Kirman, Axel Leijonhufvud and Perry Mehrling. 2008. "Beyond DSGE Models: Toward an Empirically Based Macroeconomics." *American Economic Review*, 98(2): 236-40.

De Grauwe, P., and Grimaldi, M., (2006), The Exchange Rate in a Behavioural Finance Framework, Princeton University Press.

De Grauwe, P., (2012), Lectures on Behavioral Macroeconomics, Princeton University Press.

De Grauwe, P., and Ji, Y., (2016), International Correlation of Business Cycles in a Behavioral Macroeconomic Model, CEPR, Discussion Paper, April.

Delli Gatti, D., Di Guilmi, C;, Gaffeo, E., Giuloni, G., Gallegati, M., Palestrini, A., (2005), A new approach to business fluctuations: heterogeneous interacting agents, scaling laws and financial fragility, *Journal of Economic Behavior and Organization*, vol. 56, 489-512

Eggertsson, Gauti, Andrea Ferrero, and Andrea Raffo. "Can structural reforms help Europe?." Journal of Monetary Economics 61 (2014): 2-22.

European Central Bank (E.C.B.), (2015), Progress with structural reforms across the euro area and their possible impacts, Economic Bulletin, 2.

Evans, G., and Honkapohja, S., 2001, Learning and Expectations in Macroeconomics, Princeton University Press, 421pp.

Everaert, Mr Luc, and Werner Schule. Structural Reforms in the Euro Area: Economic Impact and Role of Synchronization Across Markets and Countries. No. 6-137. International Monetary Fund, 2006.

Fagiolo, G., Napoletano, M., Roventini, A., (2008), Are Output Growth Rate Distributions Fat-Tailed: Evidence for OECD-countries, *Journal of Applied Econometrics*, 23: 639–669

Fagiolo, G., Napoletano, M, Piazza, M., Roventini, A., (2009), Detrending and the Distributional Properties of U.S. Output Time Series, Economics Bulletin, 29:4.

Farmer, Roger, E.A., (2006), Animal Spirits, *Palgrave Dictionary of Economics.*

Farmer, J. Doyne, and Duncan Foley. 'The Economy Needs Agent- Based Modelling.' Nature 460 (**2009**): 685-686

Gabaix, X., (2014), A Sparsity-Based Model of Bounded Rationality, *The Quarterly Journal of Economics* (2014), 1661–1710.

Galí, J., (2008), Monetary Policy, Inflation and the Business Cycle, Princeton University Press, 203pp.

Gigerenzer, G., and P.M. Todd, (1999), *Simple Heuristics That Make Us Smart*. New York: Oxford University Press.

Gomes, Sandra, Pascal Jacquinot, Matthias Mohr, and Massimiliano Pisani. "Structural reforms and macroeconomic performance in the Euro Area countries: a model-based assessment." International Finance 16, no. 1 (2013): 23-44.

Hommes, C., (2016), Behavioral Macroeconomics with Heterogeneous Expectations and Interacting Agents, Discussion Paper, CenDEF, University of Amsterdam.

Hommes, C., and Lustenhouwer, J., (2016), Managing Heterogeneous and Unanchored Expectations: A Monetary Policy Analysis, Working Paper, Tinbergen Institute, Rotterdam.

Kahneman, D., 2002, Maps of Bounded Rationality: A Perspective on Intuitive Judgment and Choice, Nobel Prize Lecture, December 8, Stockholm (also published in *American Economic Review*, 2003).

Kirman. A., (1992), Whom or What Does the. Representative Individual Represent?, *Journal of Economic Perspectives* · vol. 6, no. 2, Spring, pp . 117-136.

Kirman, A., (1993), Ants, Rationality and Recruitment, *Quarterly Journal of Economics,* 108: 137-156.

Sajedi, R., (2017), Fiscal Consequences of Structural Reform under Constrained Monetary Policy, paper presented at workshop “Structural Reforms and European Integration”, European Institute, London School of Economics, 8th May

Smets, F. and Wouters, R., (2003), An Estimated Dynamic Stochastic General Equilibrium Model, *Journal of the European Economic Association*, 1, 1123-1175.

Sonnenschein, H. (1972). "Market excess-demand functions". *Econometrica*. **40** (3): 549–563.

Tesfatsion, L., and KL Judd, (2006), Handbook of Computational Economics Volume 2: Agent-Based Computational Economics, Elsevier.

Westerhoff, F., and Franke, R., (2012), Agent-based models for economic policy design: two illustrative examples. Working Paper No. 88, Iowa State University.

Woodford, M., (2003), Interest and Prices: Foundations of a Theory of Monetary Policy, Princeton University Press.

**Endnotes**

[i] 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)).

[ii] 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).

[iii] 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.

[iv] 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.