Behavioral Macroeconomics: A new way to think about the macroeconomy

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Introduction

- The financial crisis came about as a result of
  - inefficiencies in the financial markets (bubbles and crashes)
  - and a poor understanding of economic agents of the nature of risks.
- Yet mainstream Dynamic Stochastic General Equilibrium models (DSGE-models) are populated by agents who are maximizing their utilities in an inter-temporal framework using all available information including the structure of the model

- In other words, agents in these models have incredible cognitive abilities.
  - They are able to understand the complexities of the world
  - and they can figure out the probability distributions of all the shocks that can hit the economy.

- Extraordinary assumptions that leave the outside world perplexed about what macroeconomists have been doing during the last decades.
- Need to develop different kind of macroeconomic models
- that do not make these implausible assumptions about the cognitive capacities of individual agents

Objective of this lecture

- To present a model in which agents have **cognitive limitations** and do not understand the whole picture (the underlying model).
  - Instead they only understand small bits and pieces of the whole model
  - and use simple rules to guide their behavior.
- Rationality will be introduced through a **selection mechanism** in which agents evaluate the performance of the rule they are following
- and decide to **switch** or to stick to the rule depending on how well the rule performs relative to other rules.
- **Two applications**
  - Model when ZLB on nominal interest rate applies
  - Analyze monetary policy tradeoffs in rigid and flexible economies

The basic behavioral model

Model structure: New Keynesian

- **Aggregate demand**

$$\tilde{y}_t = a_1 \hat{E}_t \tilde{y}_{t+1} + (1 - a_1)\tilde{y}_{t-1} + a_2 (r_t - \hat{E}_t \pi_{t+1}) + \varepsilon_t$$

  - Forward and backward looking term (habit formation)
  - ^ above *E* means: non rational expectation

- **Aggregate supply**: New Keynesian Phillips curve

$$p_t = b_1 \hat{E}_t p_{t+1} + (1 - b_1) p_{t-1} + b_2 y_t + h_t$$

- **Taylor rule** describes behavior of central bank

$$r_t = c_1 (p_t - p^*) + c_2 y_t + c_3 r_{t-1} + u_t$$

when $c_2 = 0$ there is strict inflation target

Introducing heuristics: output forecasting

- Two possible forecasting rules
  - A fundamentalist rule
  - An extrapolative rule
- Fundamentalist rule: agents estimate equilibrium output gap and forecast output gap to return to steady state (negative feedback rule)
- Extrapolative rule: agents extrapolate past output gap (positive feedback rule)
- Note: more complicated rules can be introduced. Surprisingly they do not affect the dynamics much
- Aim: how far can we get with such simple rules?

Output forecasting

- Fundamentalist rule

$$\hat{E}_t^f y_{t+1} = 0$$

- Extrapolative rule

$$\hat{E}_t^e y_{t+1} = y_{t-1}$$

- Market forecasts are weighted average of fundamentalist and extrapolative forecasts

$$\hat{E}_t y_{t+1} = a_{f,t} \hat{E}_t^f y_{t+1} + a_{c,t} \hat{E}_t^e y_{t+1}$$

$\alpha_{f,t}$ = probability agents choose fundamentalist rule

$\alpha_{e,t}$ = probability agents choose extrapolative rule

$$\alpha_{f,t} + \alpha_{e,t} = 1$$

Inflation forecasts

- I also allow inflation forecasters to be heterogeneous.
- I follow Brazier et al. (2006) in allowing for two inflation forecasting rules.
  - One rule is based on the announced inflation target which provides anchor
  - the other rule extrapolates inflation from the past into the future.
  - Here also agents select the rule that forecasts best
  - They switch from the bad to the good forecasting rule

Introducing discipline

- The beauty of rational expectations theory is that it is a disciplining device
- Expectations must be model consistent
- This determines how we can specify the expectations formation of agents
- The problem of this disciplining device is that it assumes extraordinary cognitive abilities on human beings

- We propose a different way to introduce discipline
- So as to avoid that everything becomes possible
- This is a discipline provided by a selection mechanism based on **fitness** of the rules agents use

How to do this?

- We apply notions of **discrete choice theory** (see Brock & Hommes(1997)) in specifying the procedure agents follow in this evaluation process
- Discrete choice theory takes the view that agents are **boundedly rational**: utility has a deterministic component and a random component

- The first step in the analysis then consists in defining a criterion of success.
- This will be the forecast performance of a particular rule.
- Thus in this first step, agents compute the forecast performance of the two different forecasting rules as follows:

Utility of rule: Forecast performance

Agents compute mean squared forecast errors obtained from using the two forecasts

This determines the utility of using a particular rule:

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

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

- Then agents make a choice between these two rules by comparing their performances U_f and U_e
- But taking into account the stochastic nature of their preferences
- This then yields the following expression of the probabilities of choosing these two rules:

Applying discrete choice theory

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

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

- when forecast performance of the extrapolators (utility) improves relative to that of the fundamentalists agents are more likely to choose the extrapolating rule about the output gap for their future forecasts.

- γ intensity of choice parameter; it parametrizes the extent to which the deterministic component of utility determines actual choice

Note on learning

- this is a model of learning based on **"trial and error"**
- Contrast with the rational expectations forecasting rule.
  - rational expectations implies that agents understand the complex structure of the underlying model.
  - Since there is only one underlying model (there is only one "Truth), agents understand the same "Truth".
  - They all make the same forecast.

Defining animal spirits

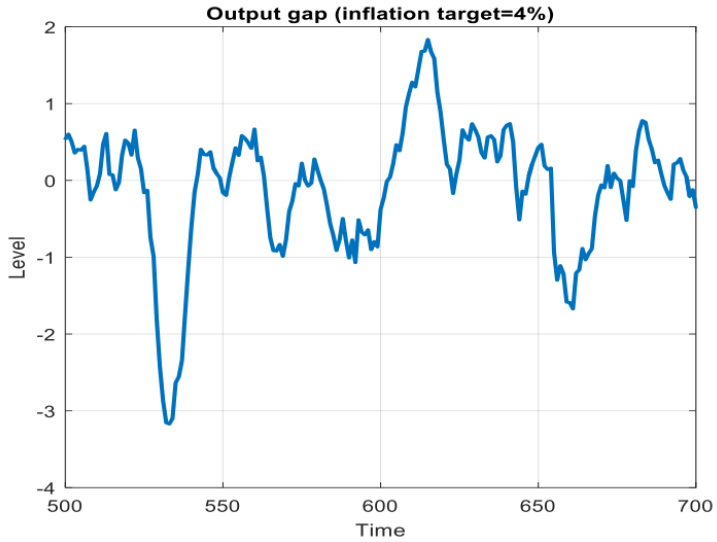
- The forecasts made by extrapolators and fundamentalists play an important role in the model.
- In order to highlight this role we define an index of market sentiments, which we call "animal spirits", and which reflects how optimistic or pessimistic these forecasts are.
- The definition of animal spirits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

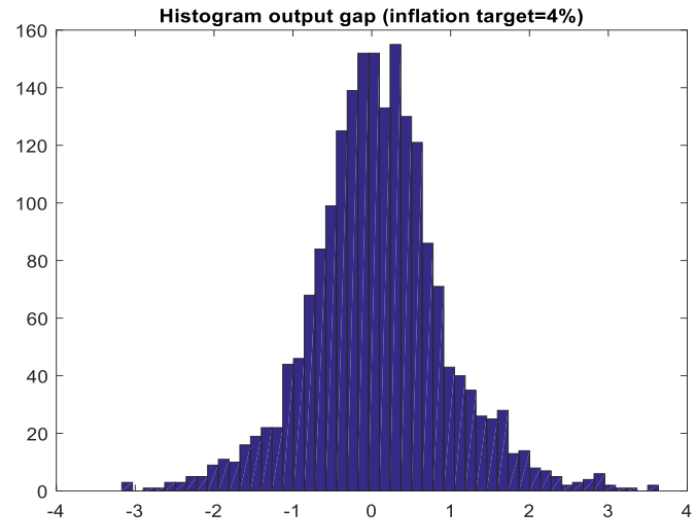
$$S_t = \begin{cases} \alpha_{e,t} - \alpha_{f,t} & if\ y_{t-1} > 0 \\ -\alpha_{e,t} + \alpha_{f,t} & if\ y_{t-1} < 0 \end{cases} \tag{23}$$

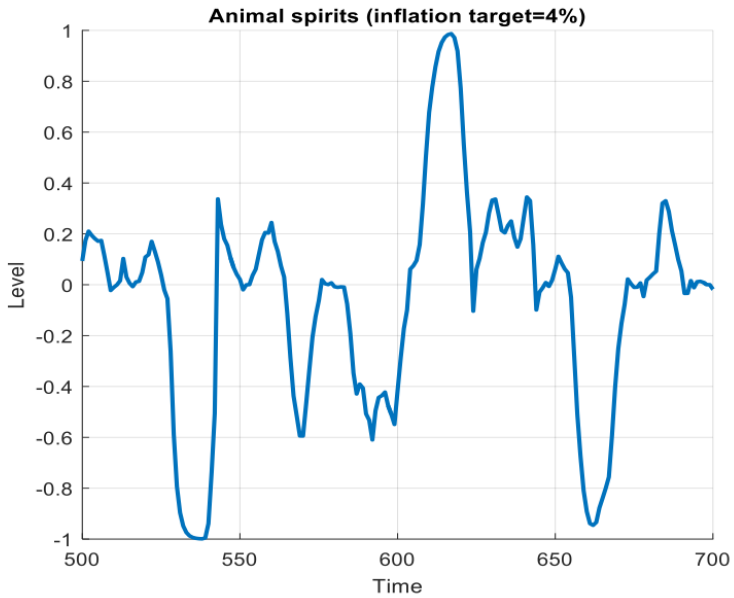
  - where S_t is the index of animal spirits. This can change between -1 and +1.

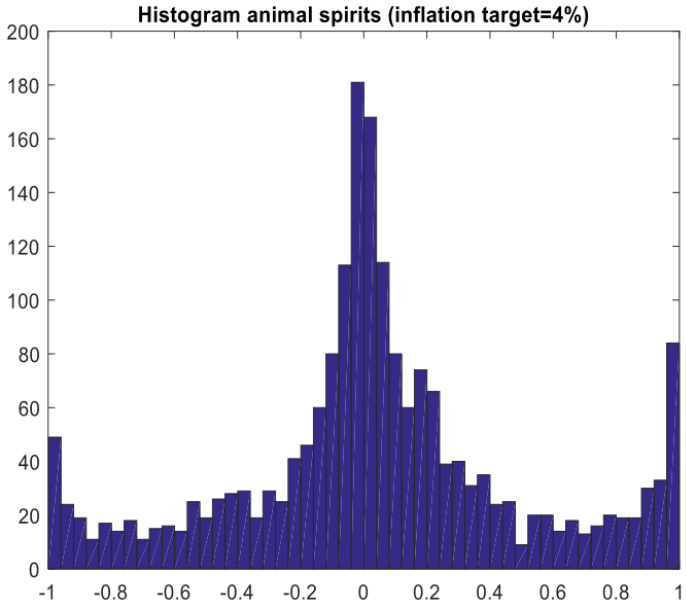
Calibrating the model

- We calibrate the model by giving numerical values to the parameters that are often found in the literature
- And simulate it assuming i.i.d. shocks with std deviations of 0.5%
- We will also perform sensitivity analysis


Output gap (inflation target=4%)
Level
Time
2
1
0
-1
-2
-3
-4
500
550
600
650
700


Histogram output gap (inflation target=4%)
160
140
120
100
80
60
40
20
0
-4
-3
-2
-1
0
1
2
3
4


Animal spirits (inflation target=4%)
Level
Time
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
500
550
600
650
700


Histogram animal spirits (inflation target=4%)
200
180
160
140
120
100
80
60
40
20
0
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1

Discussion

- Strong cyclical movements in the output gap.
- The model generates endogenous waves of optimism and pessimism
- Keynes' "animal spirits"
- Its origin is to be found in strong correlation of beliefs (optmistic or pessimistic ones)
- Timing is unpredictable
- Optimism and pessimism self-fulfilling
- Correlation output gap and animal spirits = 0.8-0.9

Behavioral model produces endogenous business cycles

- Behavioral model predicts that large swings in output gap are a regular feature of reality.
- And that this is made possible by dynamics of animal spirits
- Empirical evidence suggests that distribution of output gap is non-Gaussian (excess kurtosis and fat tails)

In DSGE models business cycles result from exogenous shocks

- In DSGE model business cycles are the result of combination of external shocks and slow transmission due to inertia
- leading to waves in output gap and inflation
- Large booms and busts can only occur because of large exogenous shocks: they are not created internally
- Thus business cycle theory is **exogenous**
- DSGE-model produces meteor theory of the business cycle and have to ask other scientists for explanations

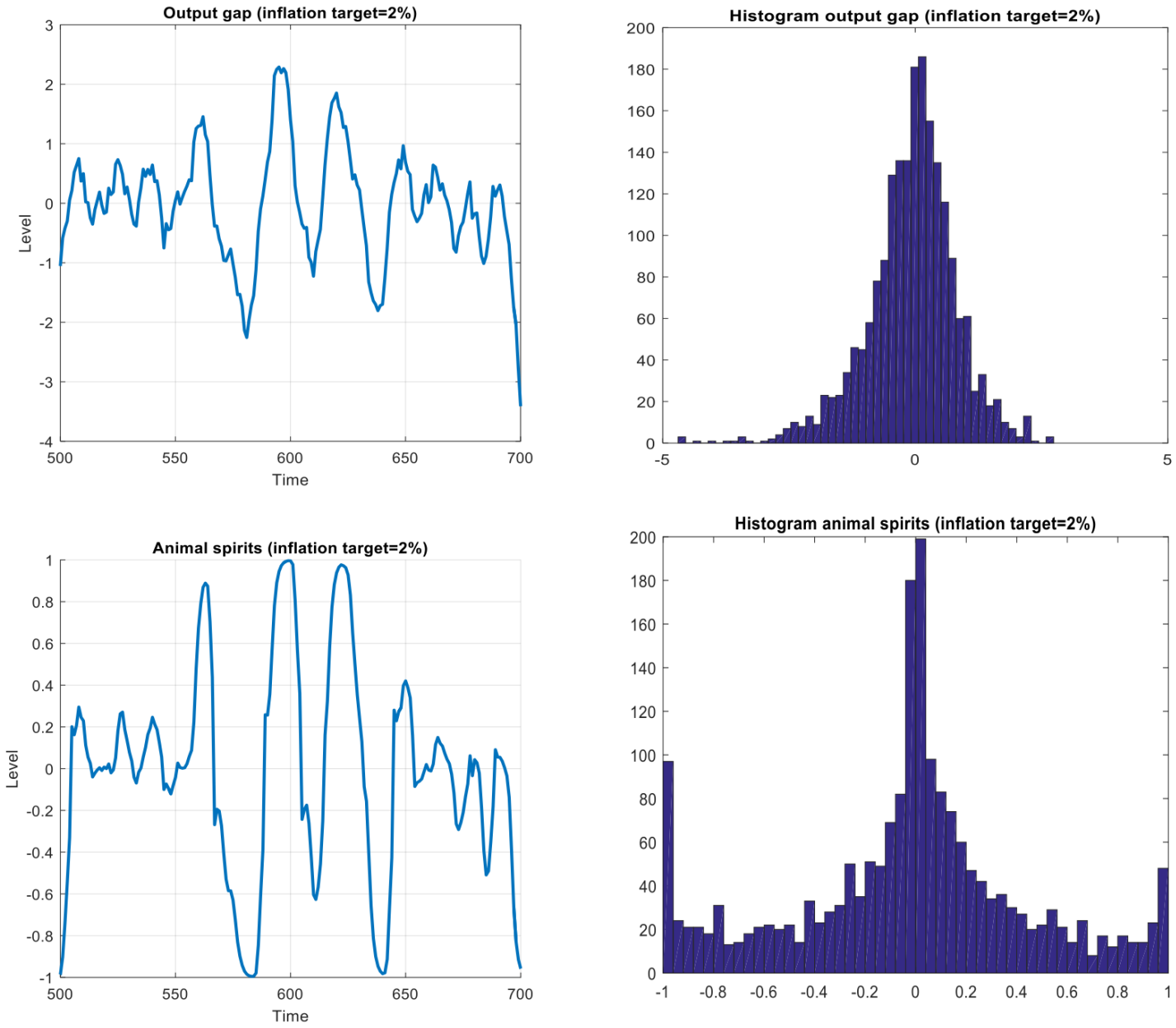
INFLATION TARGETS AND THE ZLB IN A BEHAVIORAL MODEL

Introduction

- An inflation target too close to zero risks pushing the economy into a negative inflation territory even when mild shocks occur.
- Such an outcome is generally considered to be dangerous.
- During periods of deflation the nominal interest rate is likely to hit the lower zero bound.
- When this happens the real interest rate cannot decline further.
- The central bank loses its capacity to stimulate the economy in a recession, thereby risking prolonged recessions (Eggertson and Woodford(2003), Blanchard, et al. (2010), Ball(2014)).

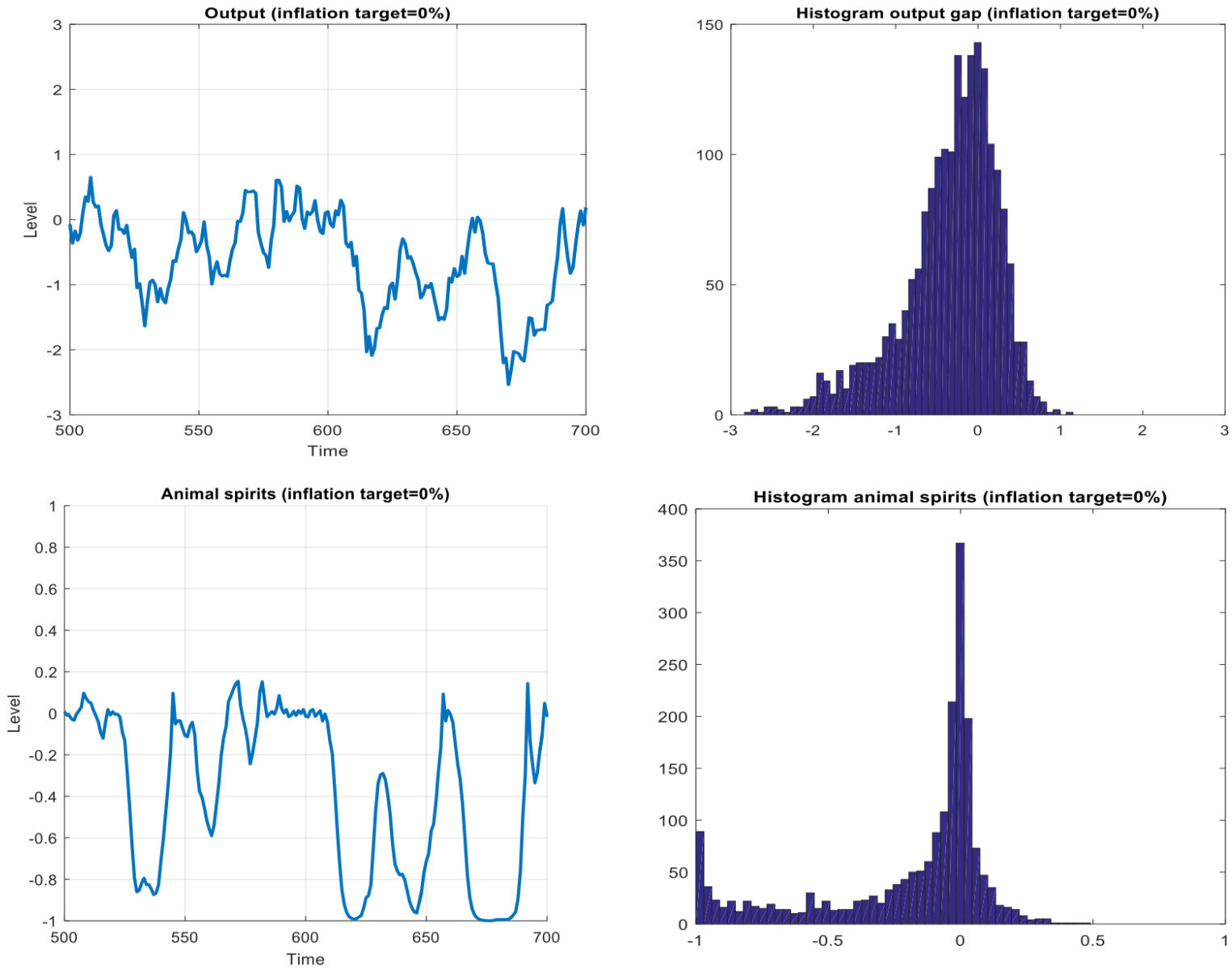
- Standard linear DSGE models have tended to underestimate the probability of hitting the ZLB as was shown by Chung, et al., (2012).
- Most of these models have led to the prediction that when the central bank keeps an inflation target of 2%, it is very unlikely for the economy to be pushed into the ZLB._ (Coenen(2003), Schmitt-Grohe and Uribe(2007)).
- We apply behavioral macromodel to shed new light on this issue

Figure 1: Output gap and animal spirits in time and frequency domains (Inflation target = 2%)



- How are these results are affected by the level of the inflation target?
- We start by noting that the output gap in Figure 1 is slightly skewed to the left. (skewness = -0.66).
- This skewness finds its origin in the fact that the distribution of animal spirits is also skewed to the left, i.e. there are more periods of pessimism than optimism.

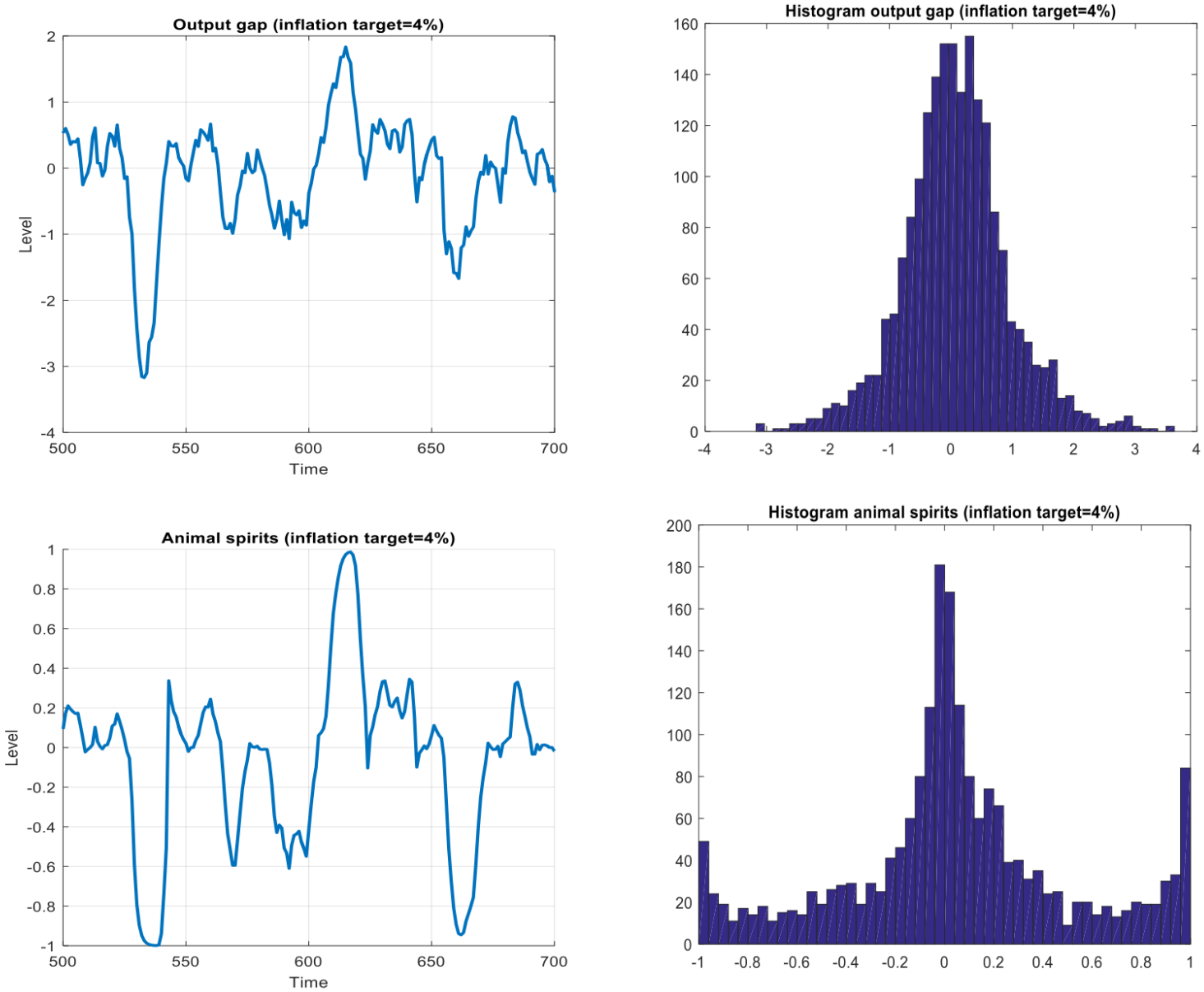
Figure 2: Output gap and animal spirits in time and frequency domains (Inflation target = 0%)



Inflation target =0%

- Most of the time animal spirits are negative with many periods of extreme pessimism.
- Thus when the central bank sets an inflation target equal to zero pessimism prevails most of the time
- and recession is a chronic feature of the business cycle with very few periods of optimism and optimism.

Figure 3: Output gap and animal spirits in time and frequency domains (Inflation target = 4%)



Inflation target = 4%

- the distribution output gap and animal spirits is symmetric.
- Skewness of output gap is not statistically different from 0 and animal spirits are 0 on average.
- Periods of optimism and pessimism occur equally frequently.

Sensitivity analysis

Figure 4:

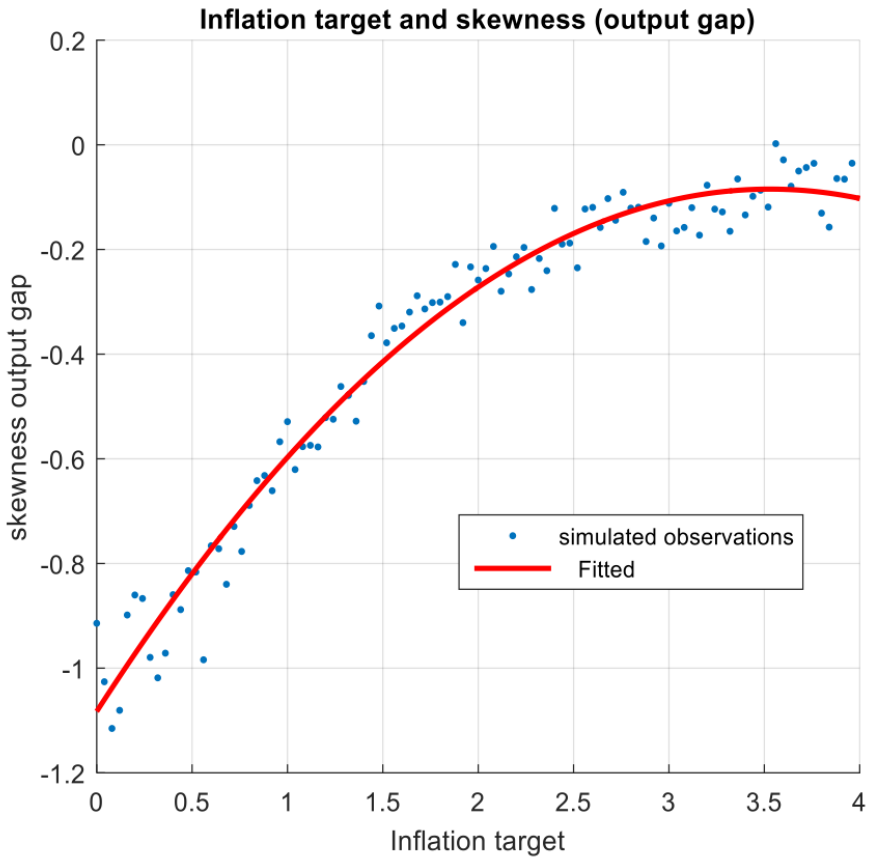
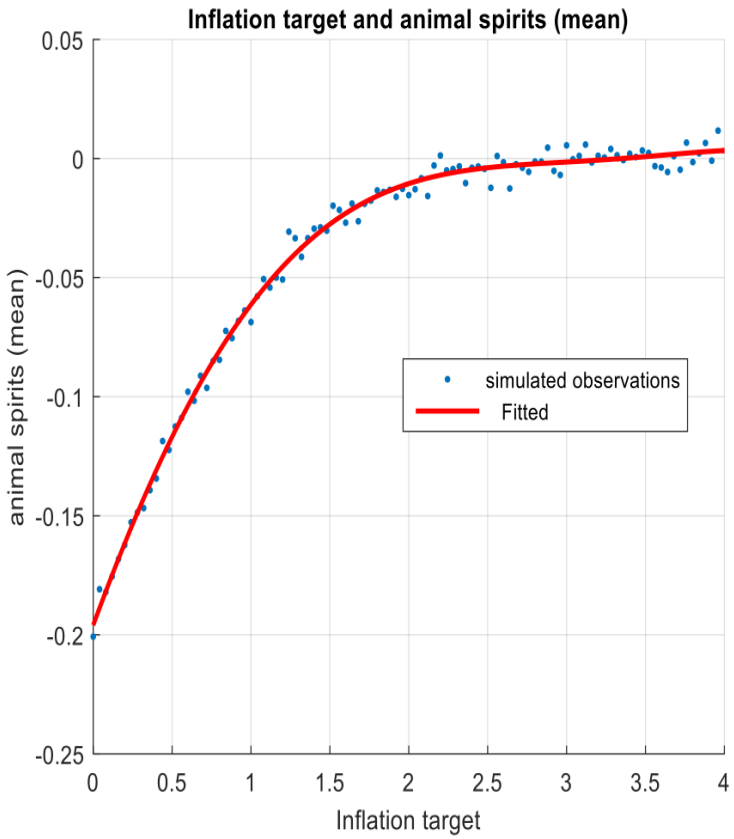


Figure 5


Inflation target and animal spirits (mean)
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
animal spirits (mean)
0
0.5
1
1.5
2
2.5
3
3.5
4
Inflation target
simulated observations
Fitted

Interpretation

- When inflation target is 0% cyclical movements in output gap and animal spirits lead to recessions that drive inflation into negative territory.
- When that happens the zero bound constraint makes it impossible for the central bank to lower the real interest rate.

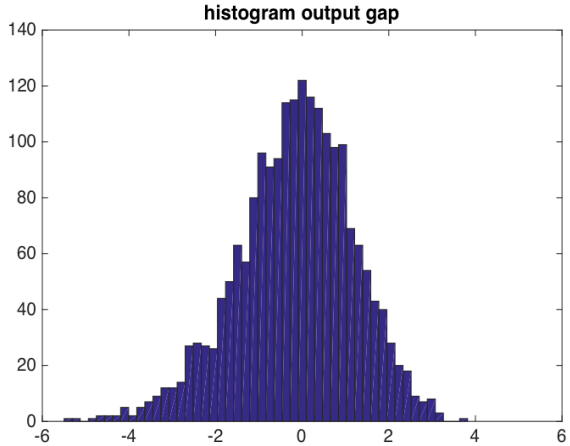
Chronic pessimism

- If the recession is deep and deflation intense the real interest rate is likely to increase significantly.
- Thus the recession becomes protracted.
- Pessimism sets in and amplifies the recession, deflation and validates pessimism.
- As the central bank loses its stabilizing capacity the economy gets stuck in pessimism, recession and deflation.

- We conclude that an inflation target of 0% becomes a breeding ground for pessimism and recession.
- The way out is to increase the inflation target.
- Our results suggest that an inflation target of 3%-4% is probably better than 2% in making sure that the economy does not get stuck in the chronic pessimism trap.

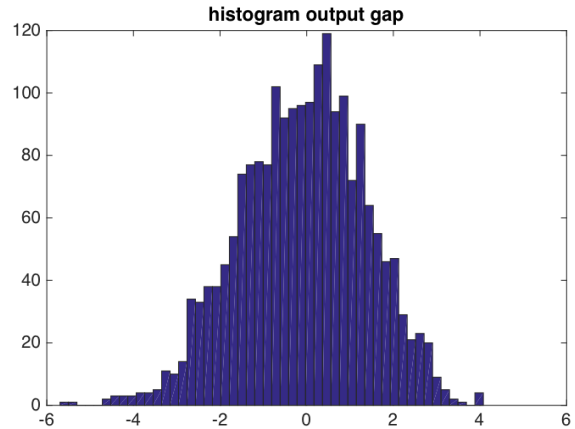
Results in model with rational expectations

Inflation target=0%



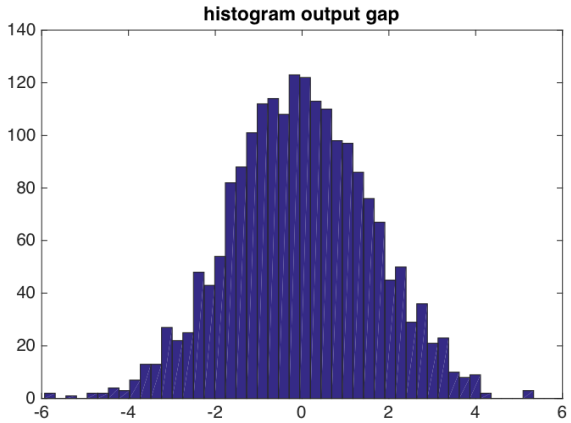
Skewness = -0.37
ZLB= 47%; mean ZLB-spell=3.1

Inflation target=2%



Skewness = -0.20
ZLB = 8%; mean ZLB-spell=1.6

Inflation target = 4%



Skewness=0.01
ZLB= 0.5%; mean ZLB-spell=1.3

- In behavioral model we hit the ZLB more often than in RE-model
- Reason: fat tail property of behavioral model
- Extreme movements occur more often in behavioral model pushing us in negative territory
- Once we are in negative territory we stay in there quite long.

Structural reforms and monetary policy

Modeling structural reforms

We introduce structural reforms in the context of our behavioral model by changing the sensitivity of inflation to the output gap in the New Keynesian Philips curve (supply equation):

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

- Micro-foundations of the model shows that b_2 is related to Calvo pricing, i.e. probability, θ, that firm can adjust its price in period t
- If θ= *0* b_2=0 : complete rigidity
- If θ= *1* b_2 is some positive number that we will set at 1 (we will call this a flexible economy)

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

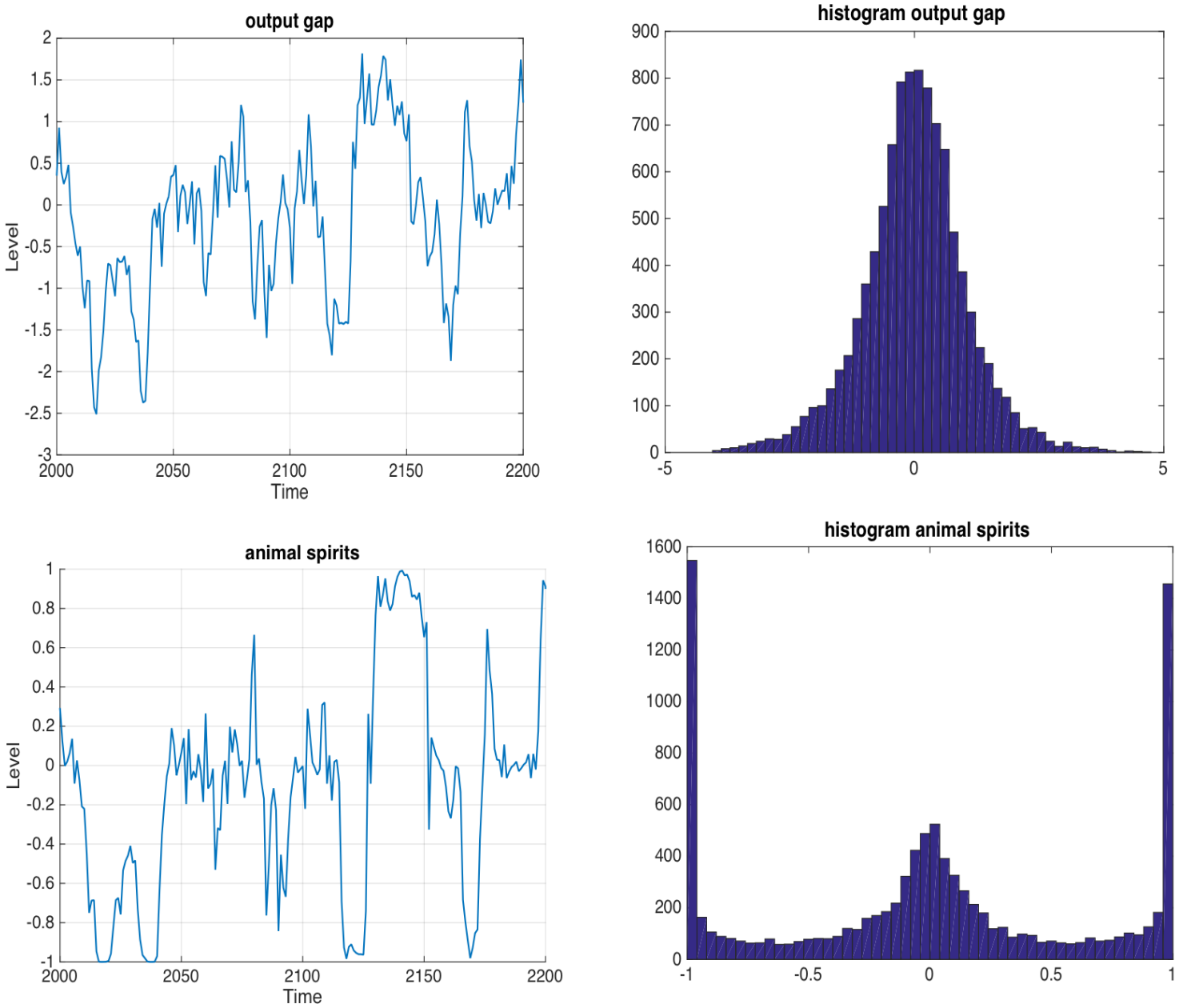
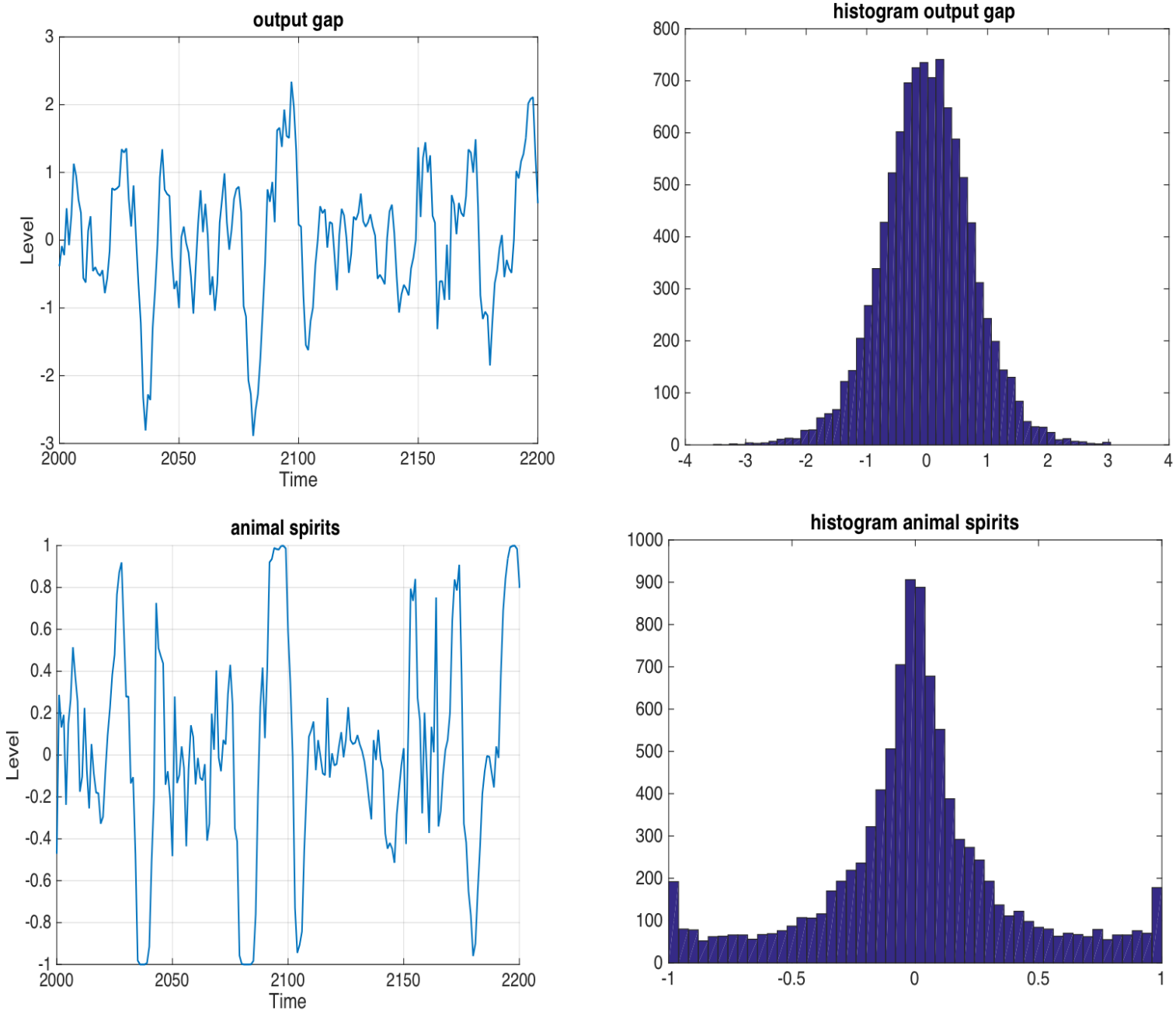


Figure 2. Output and animal spirits (b2 = 1, flexible case)



Interpretation

- First, in a flexible economy the power of animal spirits is significantly reduced..
- Second, in flexible economy the correlation between the output gap and animal spirits is 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 is also less volatile.
- Thus 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.

Sensitivity analysis

Figure 3.

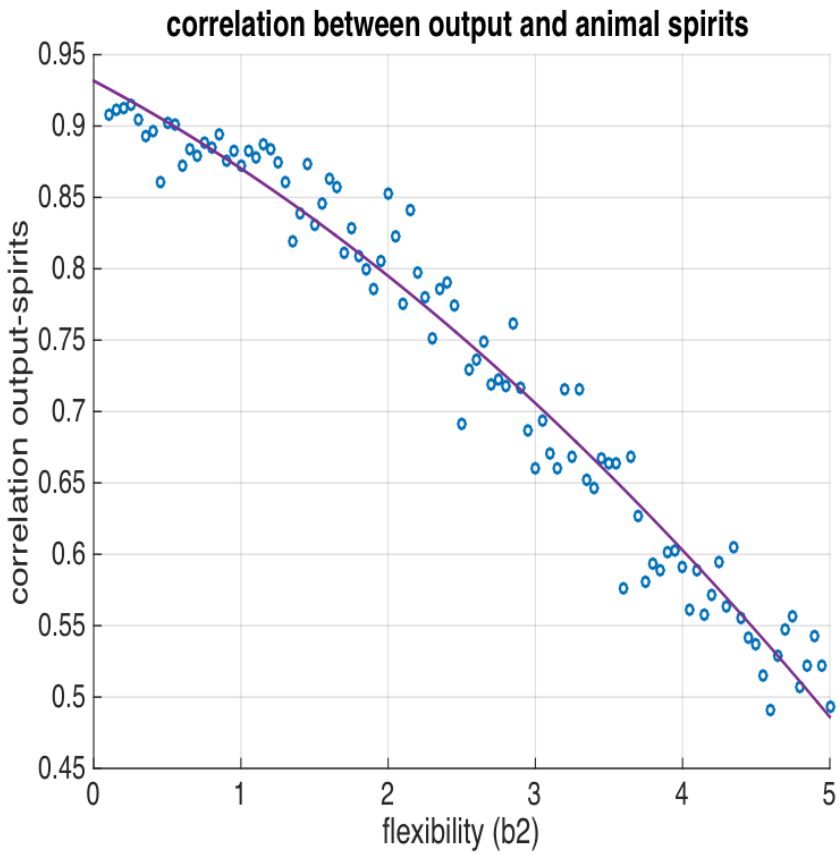
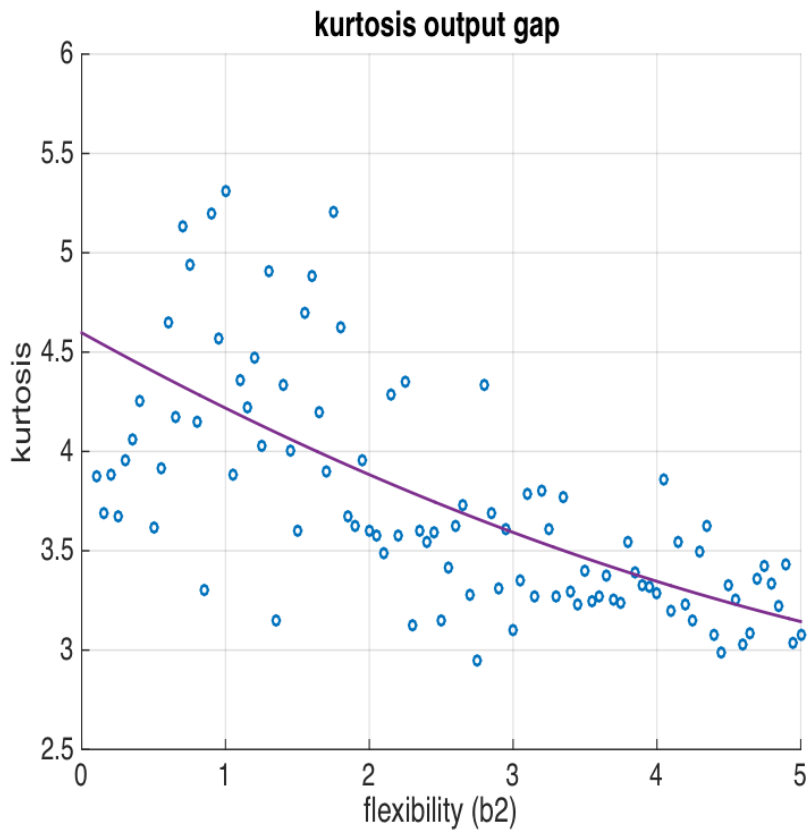


Figure 4.

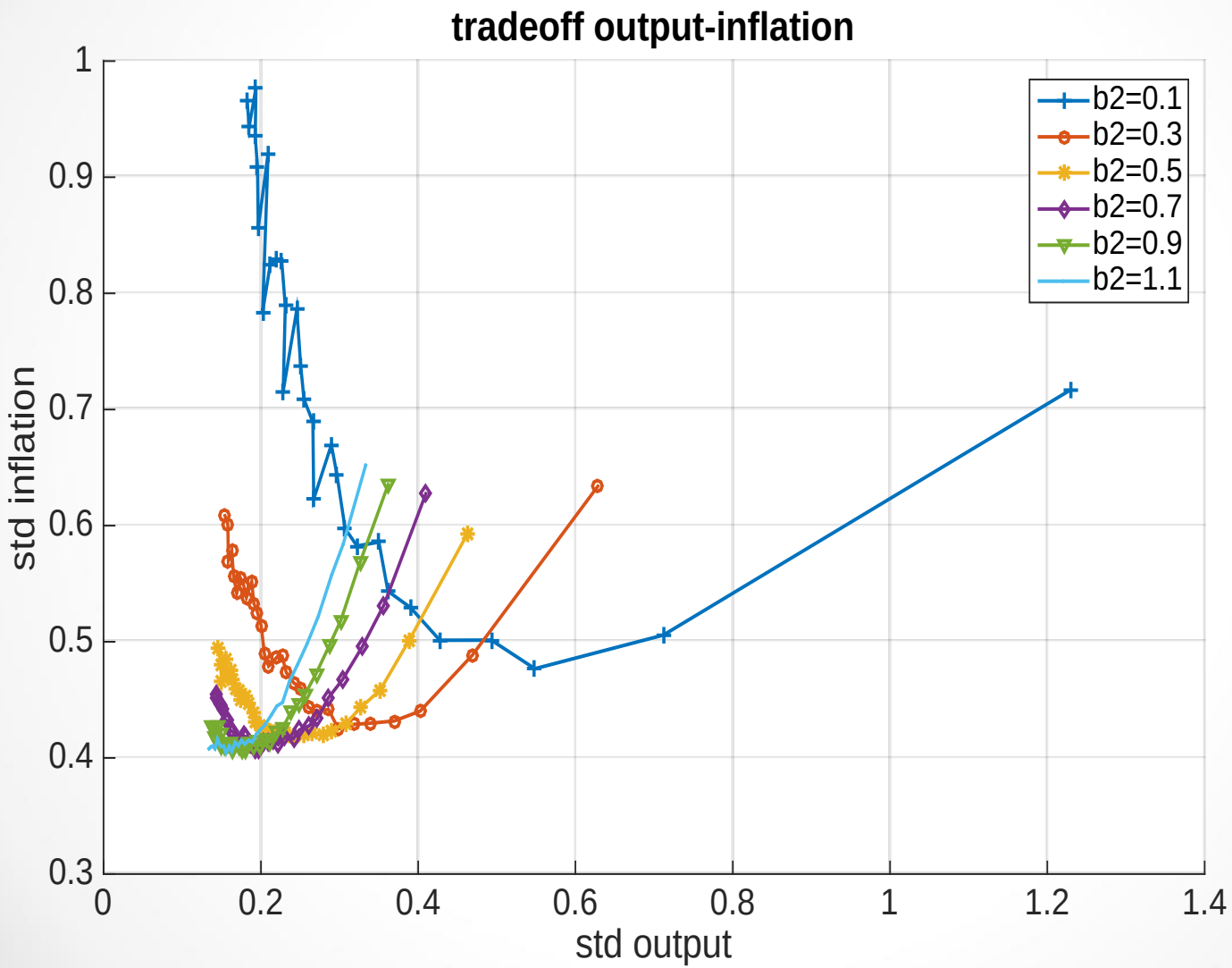


Interpretation

- 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.
  - When b_2=0 the average kurtosis exceeds 4.5 which is too high for the output gap to be normally distributed.
  - kurtosis gradually declines as b_2 increases and approaches 3 when b_2=5 suggesting that the output gap is normally distributed.

Structural reforms and monetary policy tradeoffs

- How do structural reforms affect the choices monetary authorities face in output stabilization ?
- We derive a monetary policy tradeoff that measures how increasing the intensity with which the central bank stabilizes the output gap affects its choice between inflation and output volatility.


tradeoff output-inflation
std inflation
std output
b2=0.1
b2=0.3
b2=0.5
b2=0.7
b2=0.9
b2=1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0
0.2
0.4
0.6
0.8
1
1.2
1.4

Interpretation of trade-offs

- We compute tradeoffs for different levels of flexibility
- Low-flexibility tradeoff
  - Start from A
  - When central banks 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, when c_2 becomes too large, the tradeoff becomes negatively sloped.
  - 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.
- Interpretation:
  - output stabilization by central bank reduces power of animal spirits and the fat tails in distribution of output gap (less extreme boom-bust)
  - This reduces volatility of both output and inflation
  - When fat tails disappear normal tradeoff

Flexibility improves trade-offs of central banks

- The non-linearity in tradeoff is reduced as flexibility increases
  - Win-win situation is larger in rigid economy than in flexible economy
  - But risk (in the form of steeper negative trade-off) is also higher in rigid economy

Conclusion

- We have developed a New Keynesian behavioral macroeconomic model.
  - 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).

- Behavioral model can be extended in many different directions
  - Fiscal policies and interaction with monetary policy
  - Introduction of banking sector: banks magnify animal spirits
  - Multi-country model and international propagation of business cycles