What can we learn from behavioural macroeconomics?

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Introduction

- The Great Financial Crisis erupted 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
- I wish to analyze how far we can get with alternative modeling that does not make these implausible assumptions.

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.
- This is the natural way to introduce rationality in a world of extreme uncertainty

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
- Fundamentalist rule: agents forecast output gap to return to steady state (negative feedback rule)

$$\widetilde{\mathrm{E}}_{\mathrm{t}}^{\mathrm{f}} \mathrm{y}_{\mathrm{t}+1} = 0$$

- Extrapolative rule: agents extrapolate past output gap (positive feedback rule)

$$\widetilde{\mathrm{E}}_{\mathrm{t}}^{\mathrm{e}} y_{\mathrm{t}+1} = y_{t-1}$$

Inflation forecasting

- Follow Brazier et al. (2006), we have two inflation forecasting rules.
  - One rule is based on the announced inflation target which provides anchor

$$\widetilde{\mathrm{E}}_t^f \pi_{t+1} = \pi^*$$

  - the other rule extrapolates inflation from the past into the future.

$$\widetilde{\mathrm{E}}_t^e \pi_{t+1} = \pi_{t-1}$$

- Market forecasts are weighted average of fundamentalist and extrapolative forecasts

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

$$\tilde{E}_t \pi_{t+1} = \beta_{f,t} \tilde{E}_t^f \pi_{t+1} + \beta_{e,t} \tilde{E}_t^e \pi_{t+1}$$

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

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

Agents select the rule that forecasts best, they switch from the bad to the good forecasting rule

Applying discrete choice theory

Agents compute **mean squared forecast errors**:

MSE_{ft} and MSE_{et}

Utility of using particular rule is defined as

$$U_{ft} = -\,MSE_{ft} \text{ and } U_{et} = -\,MSE_{ft}$$

Probability of using these rules becomes:

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

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

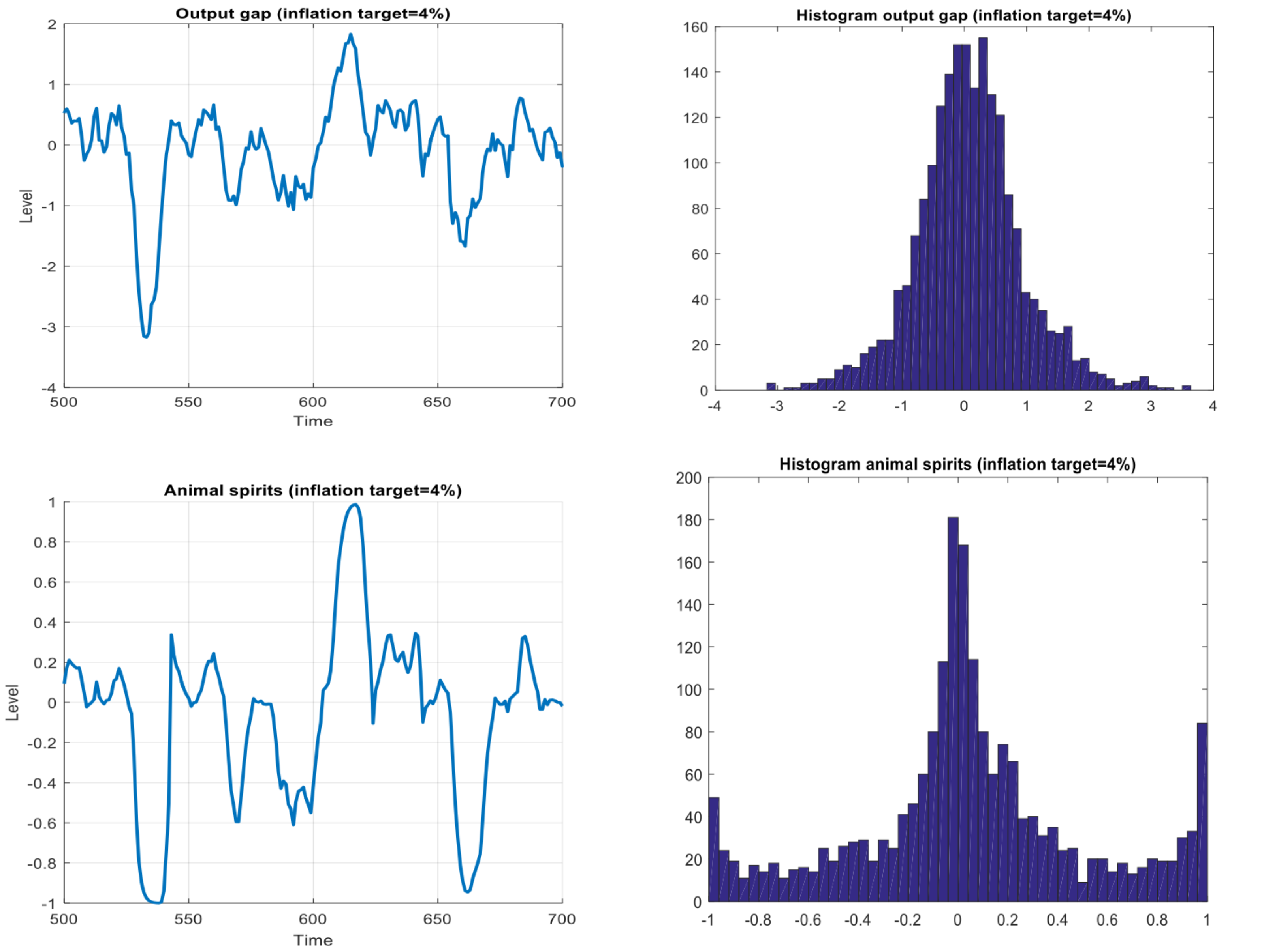
- when forecast performance(utility) of extrapolators improves relative to that of fundamentalists agents are more likely to choose extrapolating rule about the output gap.
- γ intensity of choice parameter

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, S_t, which we call "animal spirits", and which reflects how optimistic or pessimistic these forecasts are.
- S_t can vary between -1 and +1.
  - When $S_t = -1$ all agents expect decline in output gap
  - When $S_t = 1$ all agents expect increase in output gap
  - When $S_t = 0$ optimists and pessimists cancel each other out

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
Histogram output gap (inflation target=4%)
Animal spirits (inflation target=4%)
Level
Time
Histogram animal spirits (inflation target=4%)

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**

Trust and monetary policy

Defining trust

- Two dimensions
  - Trust in capacity of central bank to keep inflation low
  - Trust in capacity of central banks to stabilize the output gap

How to measure trust?

- Inflation trust:
  - We define this as market's expectation of inflation, $\tilde{\mathrm{E}}_t \pi_{t+1}$
  - since π^*= 0, a deviation of $\tilde{\mathrm{E}}_t \pi_{t+1}$ from 0 (positive or negative) amounts to a lack of trust in capacity of central bank to keep inflation close to target
- Output Stability trust:
  - We define this by $\tilde{\mathrm{E}}_{\mathrm{t}} y_{t+1}$
  - $\tilde{\mathrm{E}}_{\mathrm{t}} y_{t+1}$ measures the market's expected deviation of the output gap from the steady state.
  - The larger is this deviation (positive or negative) the lower the trust of agents in the capacity of central bank to stabilize output around its steady state value.

Alternative measures

- $\tilde{E}_t \pi_{t+1} = \beta_{f,t} \tilde{E}_t^f \pi_{t+1} + \beta_{e,t} \tilde{E}_t^e \pi_{t+1} = \beta_{e,t} \tilde{E}_t^e \pi_{t+1}$
  - The deviation of the market's expectations of inflation from 0 increases when the fraction of agents using the extrapolative rule, $\beta_{e,t}$ is high, i.e. when $\beta_{f,t}$ is low.
  - Thus, trust will be low when $\beta_{f,t}$ is low, i.e. few agents use the inflation target as their forecasting rule.
- $\tilde{E}_t y_{t+1} = \alpha_{f,t} \tilde{E}_t^f y_{t+1} + \alpha_{e,t} \tilde{E}_t^e y_{t+1} = \alpha_{e,t} \tilde{E}_t^e y_{t+1}$
  - the deviation of the market's expectations of the output gap from 0 increases when the fraction of agents using the fundamentalist rule, $\alpha_{f,t}$ is low ($\alpha_{e,t}$ is high) .
  - This is because few agents believe that the output gap will converge to the steady state and trust in the capacity of the central bank to stabilize output will be correspondingly low.

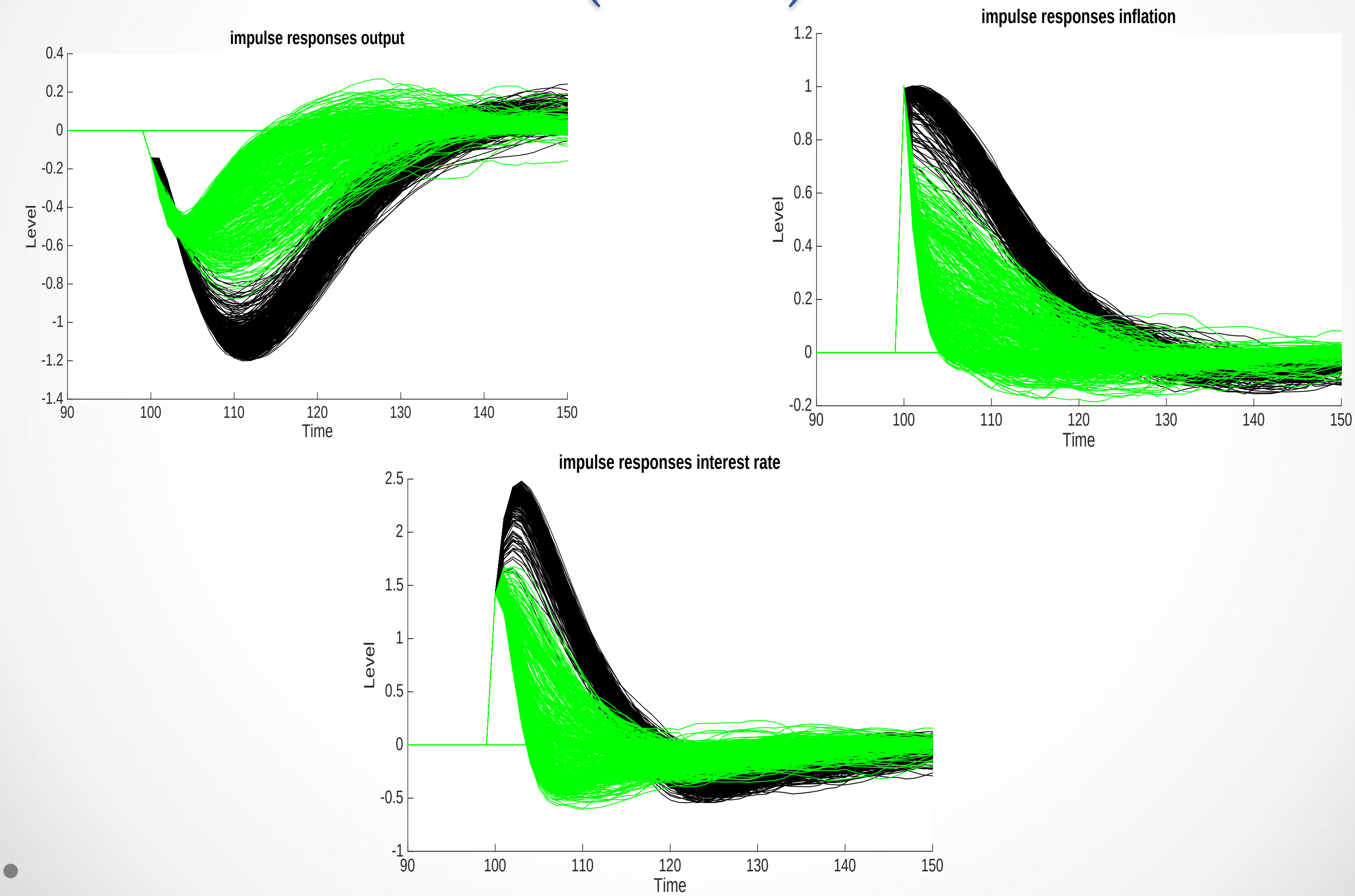
The importance of trust in the transmission of shocks

- We focus first on supply shocks
- and analyze big shocks
- We contrast with demand shocks
- We do sensitivity analysis: large versus small shocks

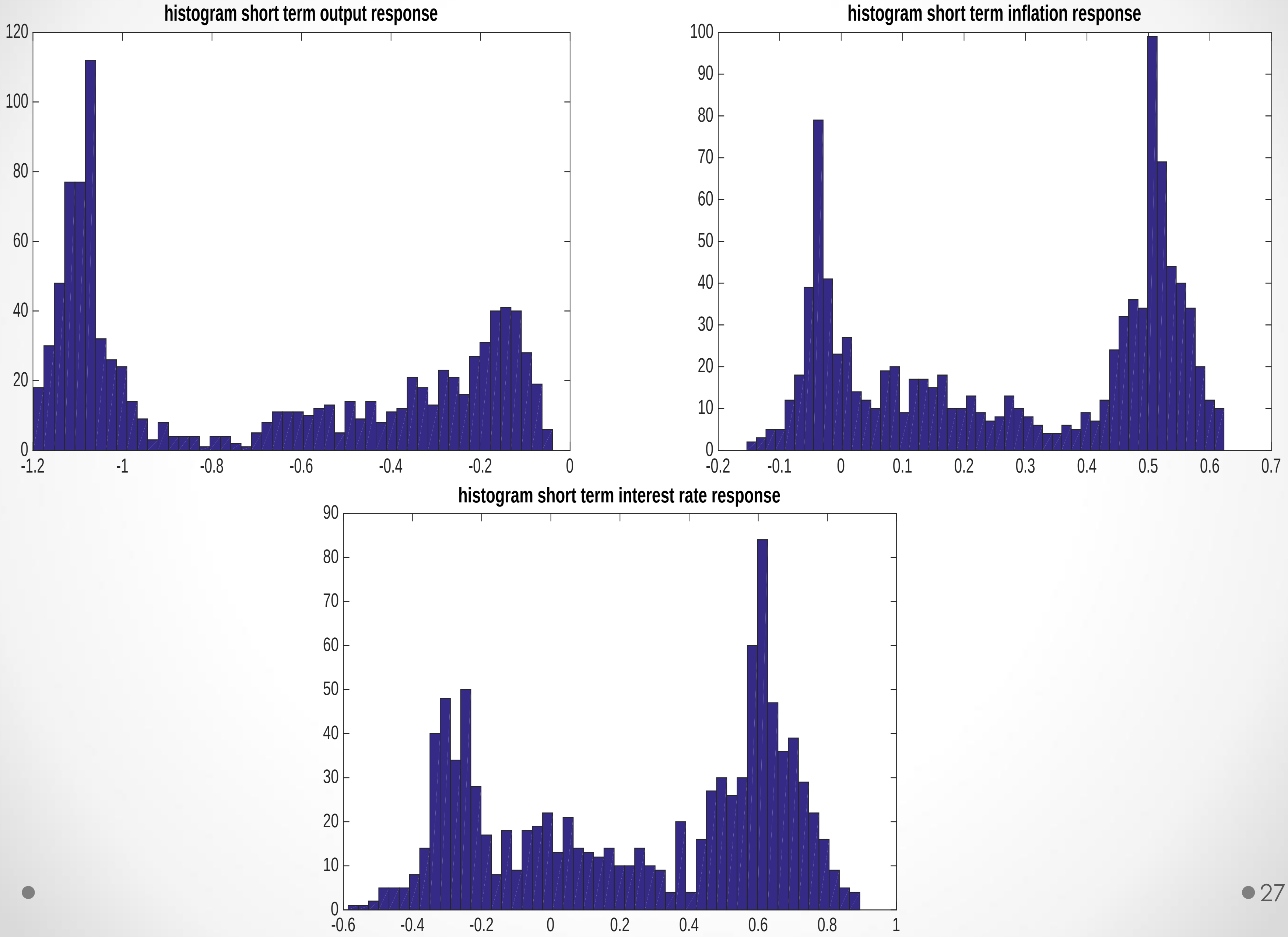
Impulse responses to supply shocks

- We compute 1000 impulse responses to a large supply shock
- Each impulse response is computed for different realizations of the stochastic shocks in the model
- We will see that the initial conditions matter
- A very large shock, i.e. a 10 standard deviation shock.
  - It corresponds to the size of the shock observed in early 2020
  - when GDP dropped by 10% to 20% in many countries as a result of the worldwide shutdown of production.
- Impulse responses are expressed as multipliers, i.e. they are divided by the shock

Impulse responses: Large supply shock (10 std)



Frequency distribution of impulse responses (12 periods after shock)

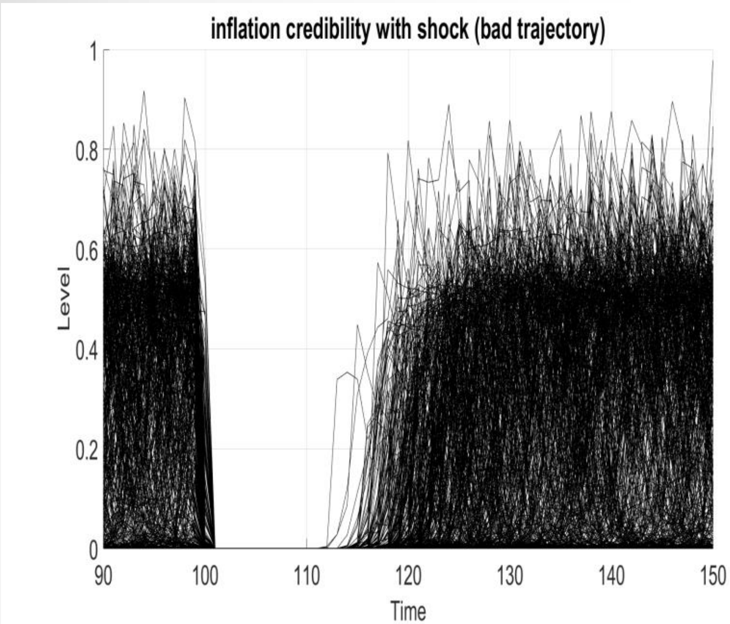


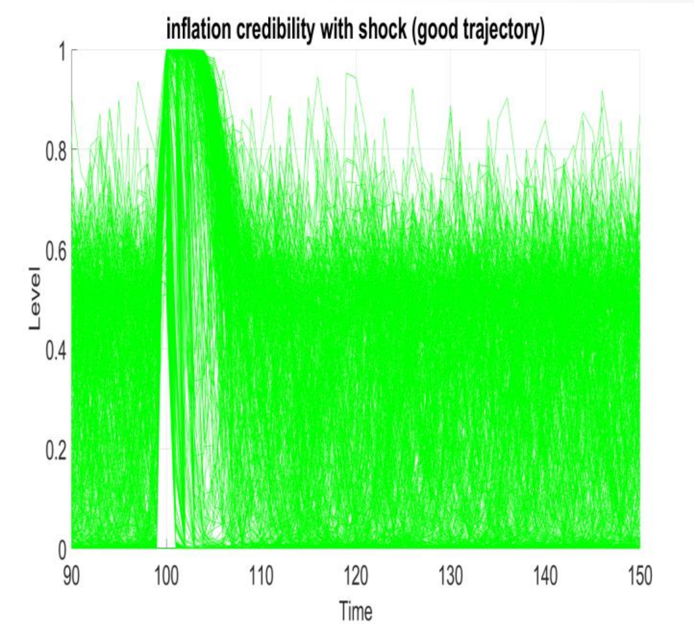
Why do bifurcations occur?

- The bad trajectory is characterized by the fact that immediately after the shock we obtain a limit solution,
    - inflation credibility and output credibility drop to zero.
    - This means that the mean reverting processes (negative feedback rule) in the expectations formations are switched off and only the extrapolating dynamics (positive feedback rule) is left over.
    - This creates a destabilizing dynamics that keeps the output gap low and inflation high.

How are these trajectories connected to our measures of trust?

- We focus on $\alpha_{f,t}$ and $\beta_{f,t}$.
  - When these are low this is a sign that agents do not trust the central bank's capacity to stabilize output around the steady state
  - and to keep inflation close to its target
- In next figure we present $\alpha_{f,t}$ and $\beta_{f,t}$ before and after the supply shock in period 100.
- Since we run the model 1000 times we obtain 1000 trajectories for these two variables.
- We have split these trajectories into two: one corresponding to the bad trajectories and one from the good trajectories


inflation credibility with shock (bad trajectory)
Level
Time
0
0.2
0.4
0.6
0.8
1
90
100
110
120
130
140
150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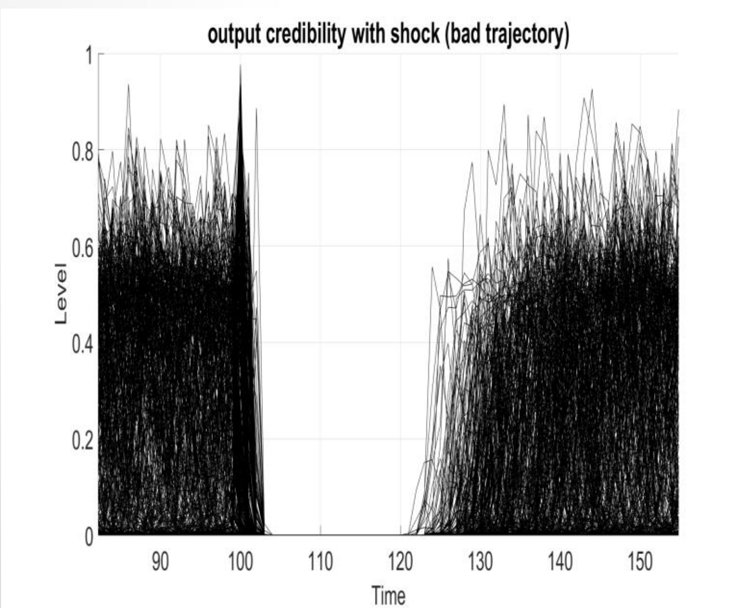
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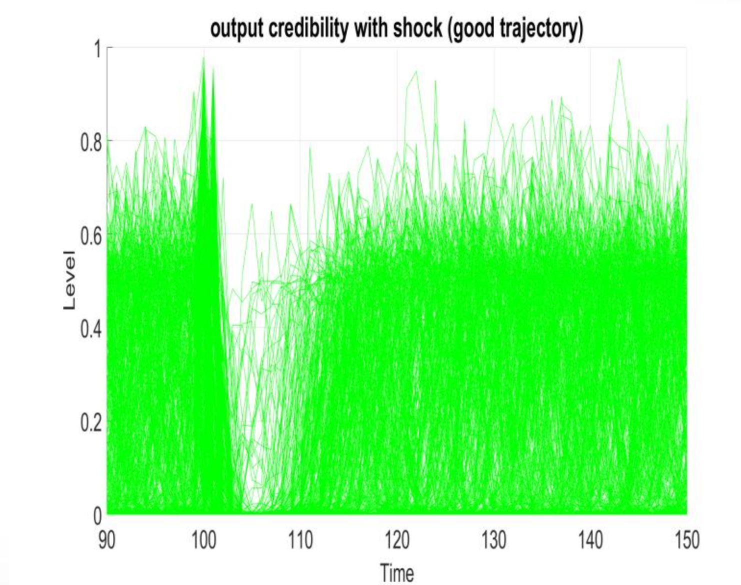
output credibility with shock (good trajectory)
Level
Time
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0.2
0.4
0.6
0.8
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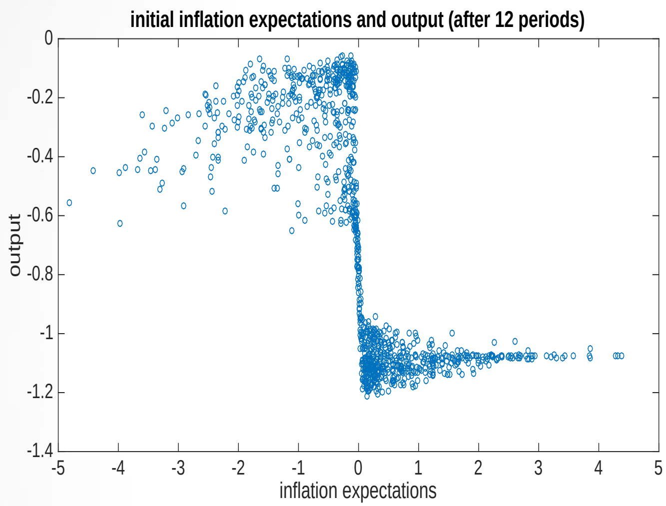
110
120
130
140
150

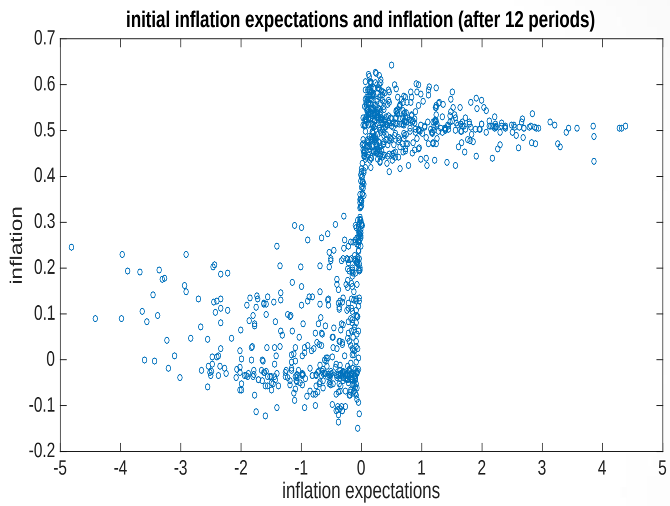
Role played by initial conditions

- In order to get stuck into bad trajectory, initial conditions must be bad:
  - high inflation expectations and low output.
  - these bad initial conditions make it possible for the large negative shock to push the system towards the limits of zero inflation credibility (because initial inflation was high) and zero output credibility (because initially output was low).

- When initial conditions are favorable :
  - low inflation expectations and optimism about the output gap
  - same negative supply shock does not push output and inflation credibilities against their limits.
  - **Mean reverting** processes continue to do their work of softening the impact of the supply shock and one ends up in a good trajectory.
- Thus, favourable initial conditions work as a **buffer** preventing large shocks from hitting the boundaries and preventing a collapse of trust.
- Thus, trust is key in smoothly returning the economy to equilibrium.

Initial inflation expectations, and output gap and inflation 12 periods after shock





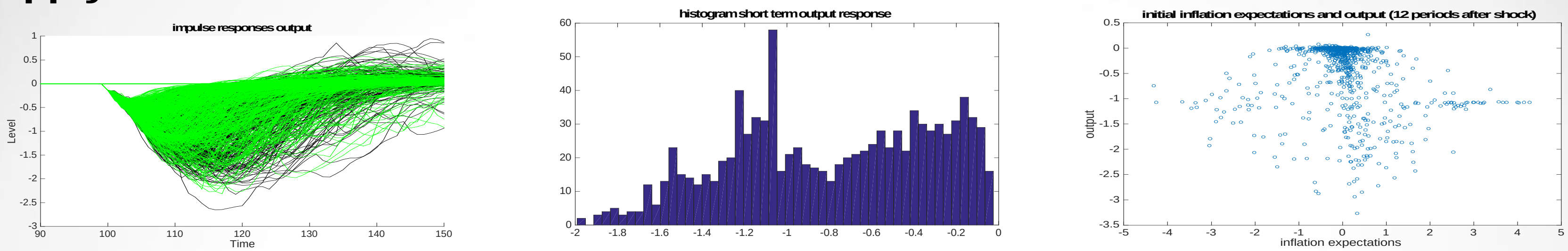
- Initial expectations of inflation area very good predictor of the subsequent trajectory of the output gap and inflation
- Favorable initial inflation expectations (negative numbers) lead to the trajectory of low inflation high output 12 periods later.
- With unfavorable inflation expectations the economy is forced onto the high inflation and low output trajectory.

Demand shocks

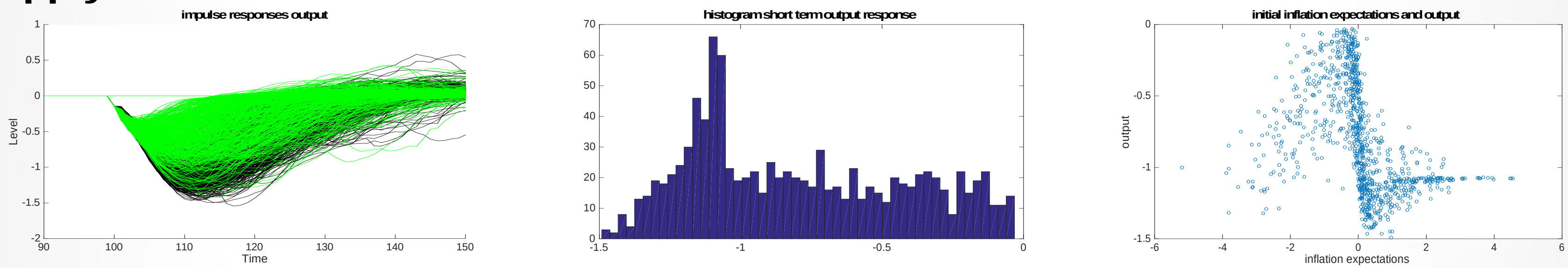
- Large demand shock leads to a similar but less pronounced bifurcation of the output trajectories into a good (green) and a bad one (black).
- Possible explanation:
  - In contrast to a supply shock, a demand shock does not put the central bank in a dilemma situation.
  - Both output and inflation decline and therefore give an unequivocal signal to the central bank that the interest rate should decline.

Sensitivity analysis: size of shocks

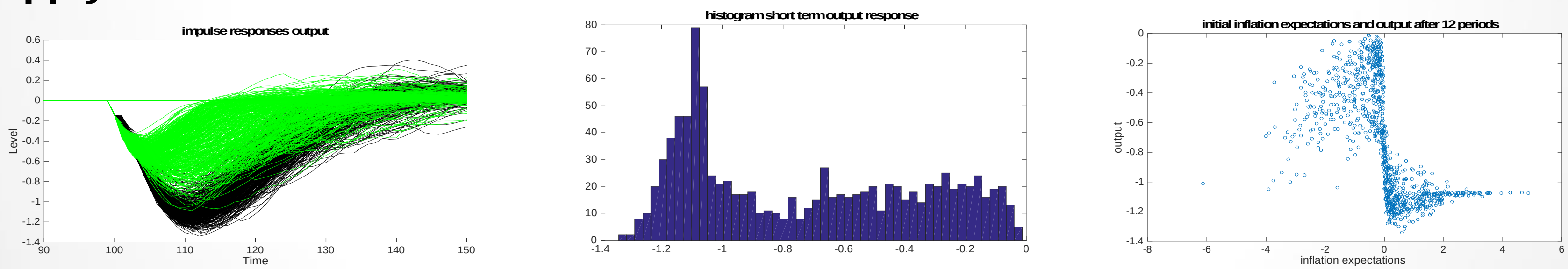
Supply shock = 1



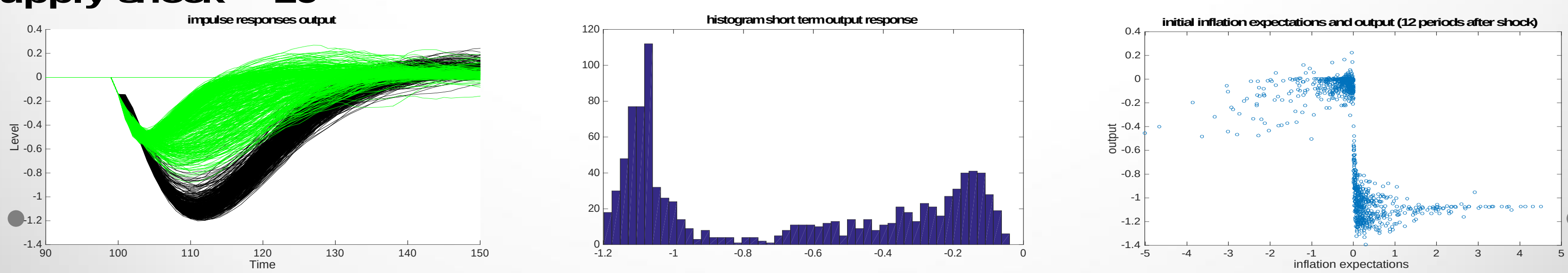
Supply shock = 3



Supply shock = 5



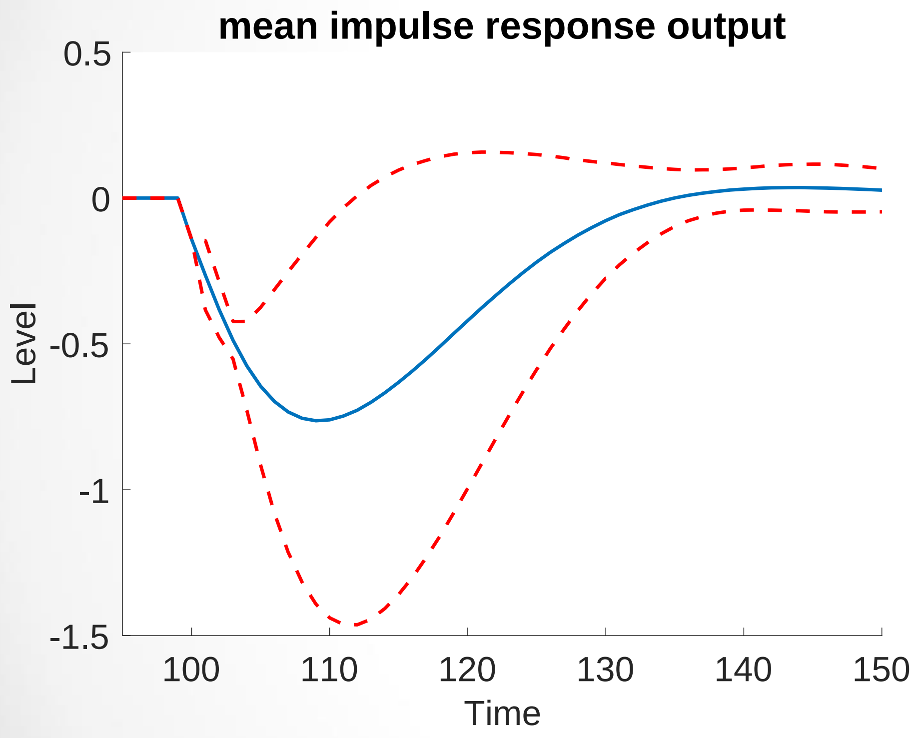
Supply shock = 10

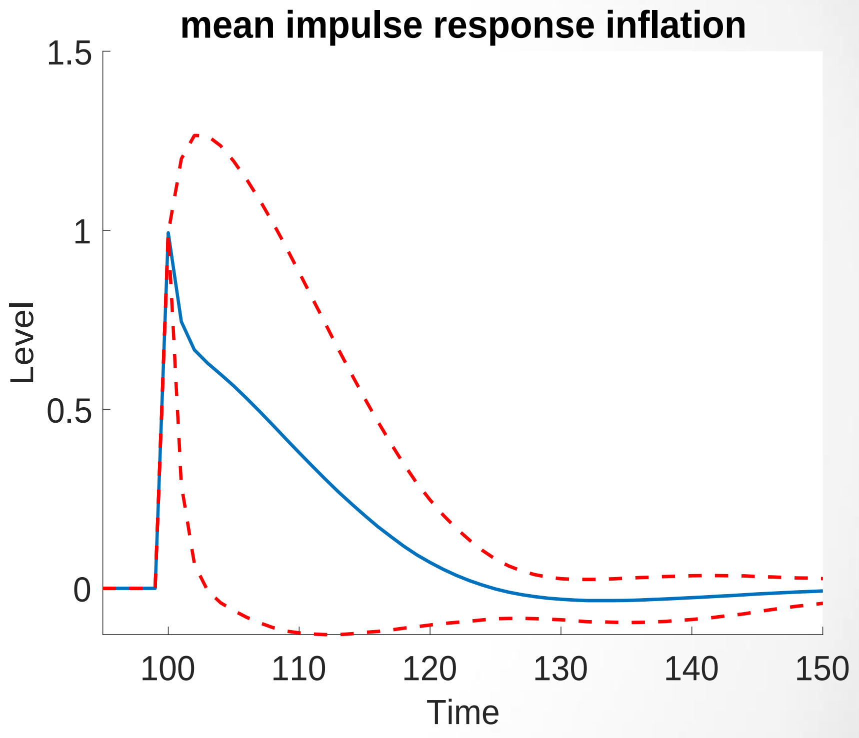


On the nature of uncertainty

- Frequency distribution of impulse responses: strong departure from Gaussian distribution.
- Mean and standard deviation are not informative about the nature of uncertainty.

Mean and standard deviations uninformative





Mean and standard deviations are not useful concepts when distributions are non-Gaussian

- Mean and the standard deviations are not only uninformative,
- but even misleading about the true underlying distribution
    - previous figure gives impression of existence of central tendency, the mean, that is representative of impulse responses.
    - There are almost no observations close to the mean as the impulse responses are clustered away from the mean.
- In addition, the representation of this figure gives the wrong impression that, as one moves away from the mean, observations become less likely.
    - In fact the opposite is true.

- The main business of macroeconomists is to produce conditional forecasts
    - i.e. producing mean effects of some shock and a band of uncertainty around the mean.
    - This could be a policy shock, a demand and supply shock, and many others.
- Macroeconomists ask “what if“ questions when they compute impulse responses.
- In a non-Gaussian world these conditional forecasts cannot be trusted

- This leads to the idea that when making conditional forecasts one has to think in terms of scenarios.
- There are good scenarios and bad scenarios.
- In our model the probability of each of these scenarios is 50%.
- We can, however, make more precise forecasts if we know the initial conditions when the shock occurred

Extensions of the model

- Behavioral model can be extended in many different directions
  - Fiscal policies and interaction with monetary policy
  - Introduction of banking sector: banks magnify animal spirits, De Grauwe and Corrado(2015), JEDC
  - Multi-country model and international propagation of business cycles, De Grauwe and Ji, (2017), OER
  - The model under ZLB, De Grauwe and Ji, Economica, 2019