New Developments in Behavioural Macroeconomics

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Motivations of this presentation

To introduce recent developments in behavioral macroeconomics

Example: use this behavioural approach to explain international synchronisation of business cycles in a monetary union setting

Need for behavioral macroeconomics

The financial crisis came about as a result of

- Bubbles and crashes in the financial markets
- a poor understanding of economic agents about the nature of risks.

Yet mainstream Dynamic Stochastic General Equilibrium models (DSGE-models) are populated by agents who are maximizing their utilities/profits in an inter-temporal framework

Agents in these models have incredible cognitive abilities (i.e. assuming rational expectations).

- They are able to understand the complexities of the world: using all available information including the structure of the model
- They can figure out the probability distributions of all the shocks that can hit the economy.
- These extraordinary assumptions leave the outside world perplexed about what macroeconomists have been doing during the last decades.

Limitations of DSGE models

- We do not fully understand business cycles that actually interact with agent’s cognitive limitations
- Policy discussions based on DSGE models are missing important aspects of reality
- Need to develop different kind of macroeconomic models that do not make implausible assumptions about the cognitive capacities of agents

What has been done in behavioural macro?

- Franke, R., & Westerhoff, F. (2017). Taking stock: A rigorous modelling of animal spirits in macroeconomics. *Journal of Economic Surveys*, *31*(5), 1152-1182.
- Driscoll, J.C. and Holden, S. (2014), "Behavioral Economics and Macroeconomic Models", Journal of Macroeconomics, Elsevier, 41(C), pp. 133-147.
- Levine, Paul & Calvert Jump, Robert, 2019. "Behavioural New Keynesian Models", Forthcoming in *Journal of Macroeconomics*.

What does our behavioural macro do?

- 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

Introducing Rationality

- 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.
- heterogeneous agent, endogenously determined
- This approach can be used to model different macroeconomic issues. See for example:
  - De Grauwe(2012), Hommes and Lustenhouwer(2016), De Grauwe and Macchiarelli (2015), De Grauwe and Ji (2017, 2018) and many others

Other type of behavioural macro models (with representative agents or exogenously determined heterogeneous agents):

Bounded rationality:

Gabaix, X., 2016. *A behavioral New Keynesian model* (No. w22954). National Bureau of Economic Research.

Rational inattention:

Ball, L., Mankiw, N.G. and Reis, R., 2005. Monetary policy for inattentive economies. *Journal of monetary economics*, *52*(4), pp.703-725.

Animal spirits:

Farmer, R.E., 2011. Confidence, crashes and animal spirits. *The Economic Journal*, *122*(559), pp.155-172.

Angeletos, G.M., Collard, F. and Dellas, H., 2018. Quantifying confidence. *Econometrica*, *86*(5), pp.1689-1726.

The basic behavioral model: One country closed economy

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
- Micro-foundation: Hommes & Lustenhouwer (2015)
- See Wren-Lewis (2018) on defending the use of reduced form macro models which can be justified by empirical support.

Aggregate supply: New Keynesian Phillips curve

$$\pi_t = b_1 \hat{E}_t \pi_{t+1} + (1 - b_1)\pi_{t-1} + b_2 \tilde{y}_t + \eta_t$$

Taylor rule describes behavior of central bank

$$r_t = c_1(\pi_t - \pi^*) + c_2 \tilde{y}_t + c_3 r_{t-1} + u_t$$

when $c_2 = 0$ there is strict inflation target

Introducing heuristics: output forecasting

Assume two possible forecasting rules

- A fundamentalist rule
- An extrapolative rule

Fundamentalist rule: agents forecast output gap to return to steady state

Extrapolative rule: agents extrapolate past output gap

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

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

Extrapolative rule

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

Market forecasts are weighted average of fundamentalist and extrapolative forecasts

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

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

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

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

Inflation forecasting

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

Applying discrete choice theory

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

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

•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

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:

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

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

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:

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

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

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 then make a pessimistic forecast since they expect the positive output gap to decline towards the equilibrium value of 0.
- The fraction of agents who make such a forecast is $\alpha_{f,t}$.
- We subtract this fraction of pessimistic forecasts from the fraction $\alpha_{e,t}$ who make a positive forecast.

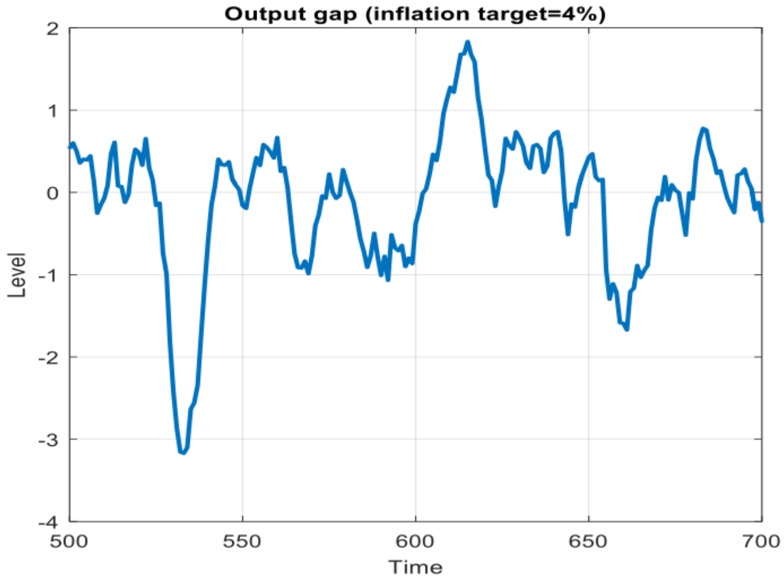
- When these two fractions are equal to each other (both are then 0.5) market sentiments (animal spirits) are neutral, i.e. optimists and pessimists cancel out and $S_t = 0$.
- When the fraction of optimists $\alpha_{e,t}$ exceeds the fraction of pessimists $\alpha_{f,t}$, S_t becomes positive.
- As we will see, the model allows for the possibility that $\alpha_{e,t}$ moves to 1. In that case there are only optimists and $S_t=1$.

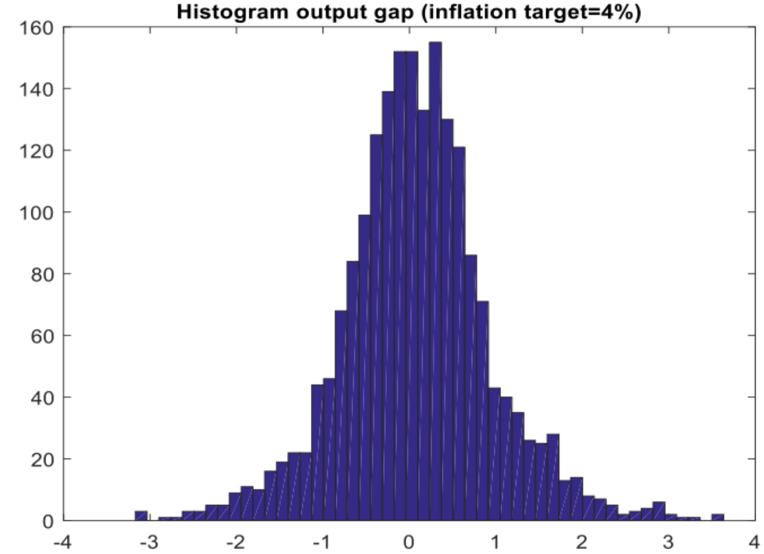
Calibrating the model

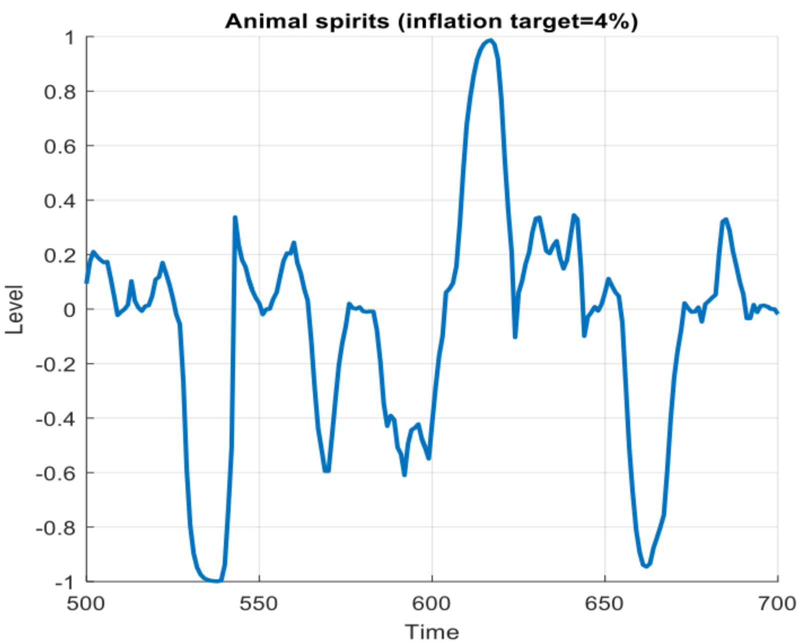
I calibrate the model by giving numerical values to the parameters that are often found in the literature

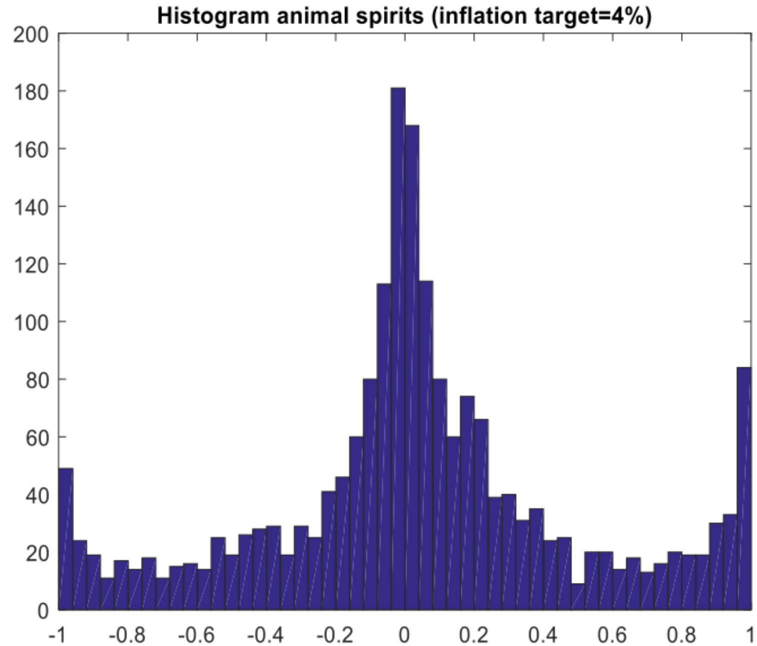
And simulate it assuming i.i.d. shocks with std deviations of 0.5%

I will also perform sensitivity analysis and impulse response analysis later…


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%)

Results: time domain (left panel)

- Strong cyclical movements in the output gap, with high serial correlation of 0.9 without the need to import serial correlation in the error terms.
- The model generates endogenous and cyclical waves of optimism and pessimism---Keynes' "animal spirits"
  - Timing is unpredictable
  - Optimism and pessimism self-fulfilling
- Correlation output gap and animal spirits= 0.9

Results: non-normality distribution (frequency domain, right panel)

Model produces non-normally distributed output gaps

- Excess kurtosis
- Fat tails

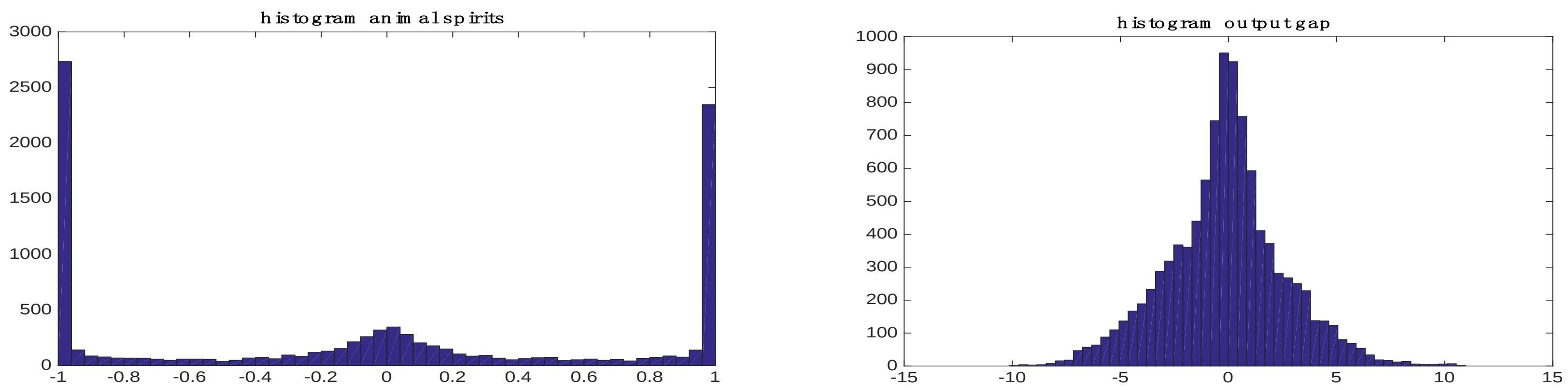
These are produced by animal spirits

- Most of the time: great moderation; market sentiments neutral
- Regularly and unpredictably there is strong optimism (pessimism) that in self-fulfilling way creates boom (bust)

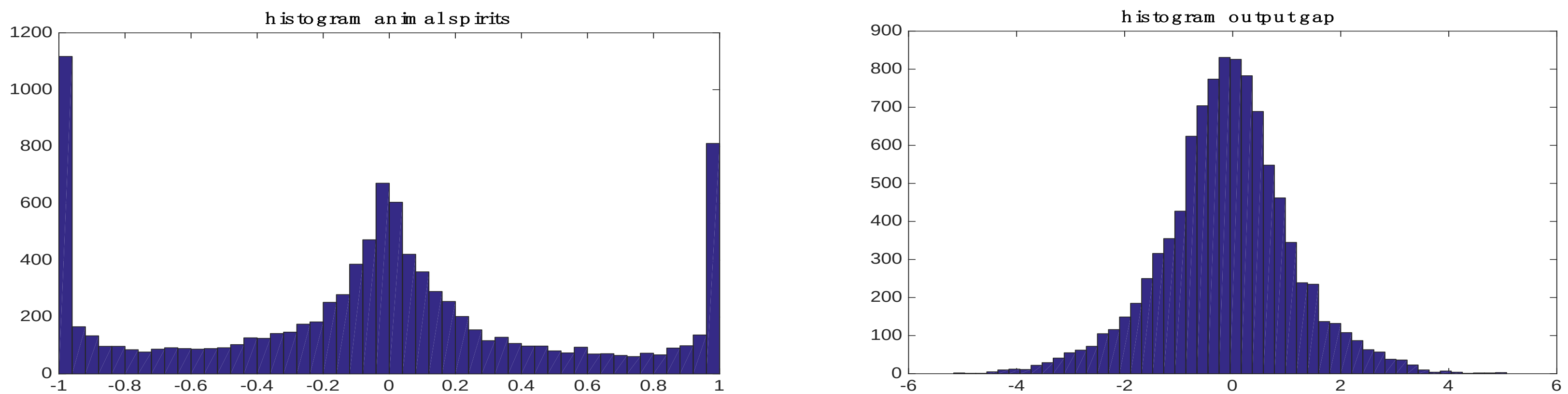
It is also observed empirically and has been recognized even in DSGE literature

Output stabilization (Taylor rule c2) matters

C2=0.2



C2=1



Contrast between our model and the DSGE model

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

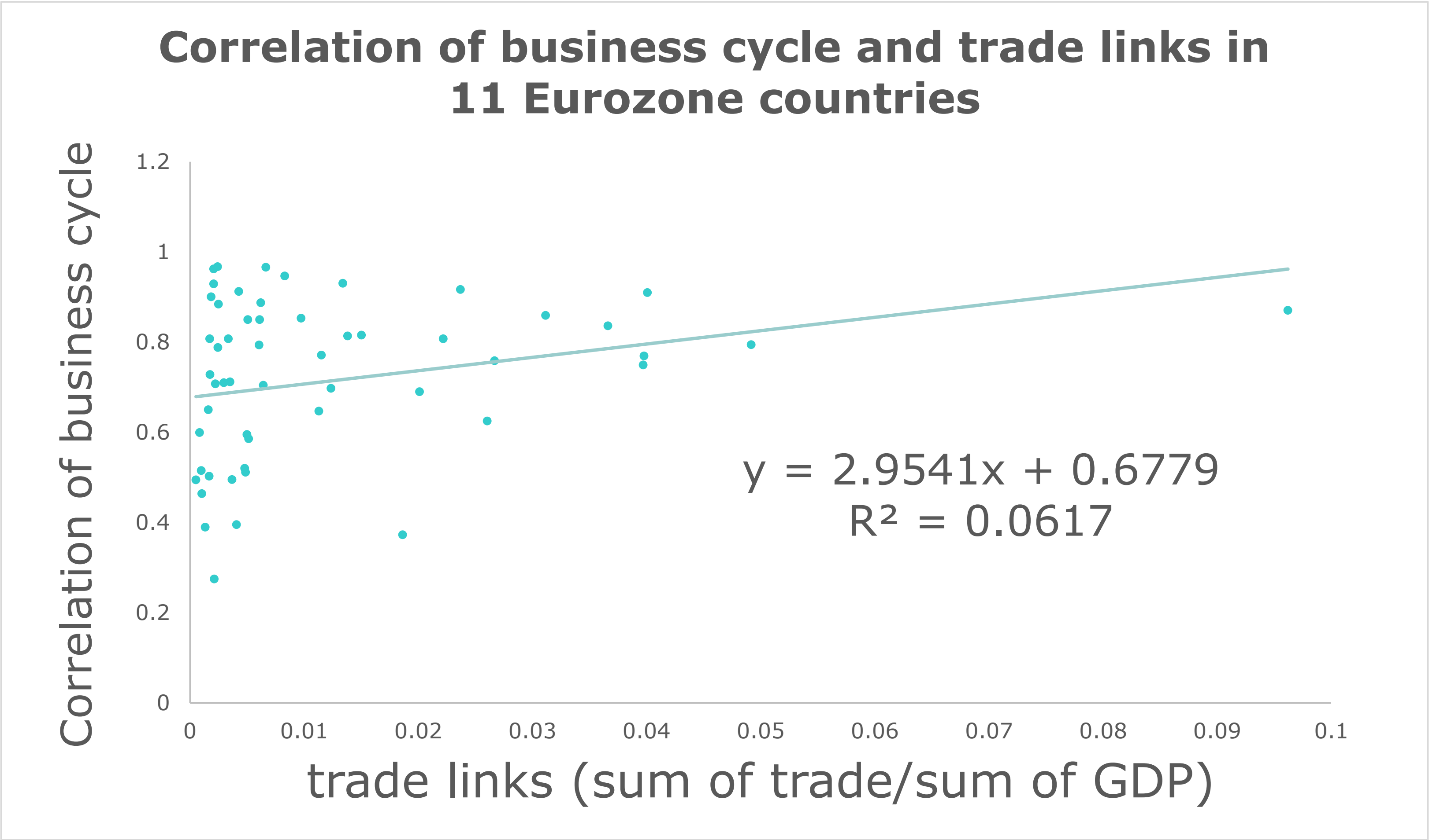
- In DSGE model business cycles are the result of combination of external shocks and slow transmission due to inertia, leading to waves in output gap and inflation
- Large booms and busts can only occur because of large exogenous shocks: they are not created internally
- Thus their business cycle theory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

Animal Spirits and the International Synchronisation of Business Cycles

Bilateral correlations business cycle components GDP growth

	Austria	Belgium	Finland	France	Germany	Greece	Ireland	Italy	Netherl	Portugal	Spain
Austria	1,00										
Belgium	0,97	1,00									
Finland	0,97	0,98	1,00								
France	0,93	0,95	0,97	1,00							
Germany	0,69	0,57	0,55	0,59	1,00						
Greece	0,73	0,82	0,84	0,74	0,09	1,00					
Ireland	0,85	0,89	0,92	0,95	0,41	0,81	1,00				
Italy	0,91	0,96	0,98	0,96	0,50	0,86	0,93	1,00			
Netherlands	0,93	0,94	0,93	0,91	0,60	0,75	0,86	0,90	1,00		
Portugal	0,98	0,89	0,89	0,87	0,37	0,82	0,87	0,90	0,94	1,00	
Spain	0,85	0,91	0,94	0,87	0,27	0,97	0,90	0,95	0,86	0,90	1,00

Trade is not a powerful explanation



Existing DSGE models

- Mainstream open economy DSGE-models have been struggling to provide a good explanation.
- Of course one can “solve” these problems by assuming high positive correlations of exogenous shocks.
- But this is not really an explanation
  - it forces the designers of these models to admit that high correlations of the business cycles across countries are produced outside their models.

- There have been attempts to explain the high synchronization of the business cycles across countries by introducing financial integration in the models
- This goes some way in explaining this synchronization.
- But again too much is “explained” by introducing highly correlated exogenous financial shocks.
- We want to go further and make the explanation endogenous in the model

A two country behavioural model: monetary union setting

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

$$y_t^2 = a_1 \tilde{E}_t y_{t+1}^2 + (1-a_1) y_{t-1}^2 + a_2 \left(r_t - \tilde{E}_t \pi_{t+1}^2 \right) + (x_t^2 - m_t^2) + \varepsilon_t^2 \quad (2)$$

$$\pi_t^1 = b_1 \widetilde{E}_t \pi_{t+1}^1 + (1-b_1) \pi_{t-1}^1 + b_2 y_t^1 + \eta_t^1 \quad (5)$$

$$\pi_t^2 = b_1 \widetilde{E}_t \pi_{t+1}^2 + (1-b_1) \pi_{t-1}^2 + b_2 y_t^2 + \eta_t^2 \quad (6)$$

$$r_t = c_1 (\overline{\pi_t} - \pi^*) + c_2 \overline{y_t} + c_3 r_{t-1} + u_t \quad (7)$$

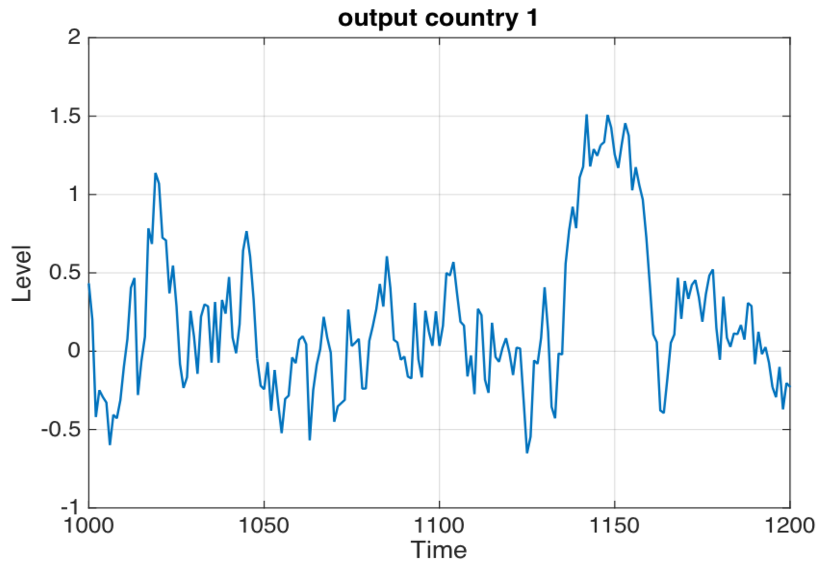
where $\overline{\pi_t} = \frac{1}{2} * (\pi_t^1 + \pi_t^2)$ and $\overline{y_t} = \frac{1}{2} * (y_t^1 + y_t^2)$,

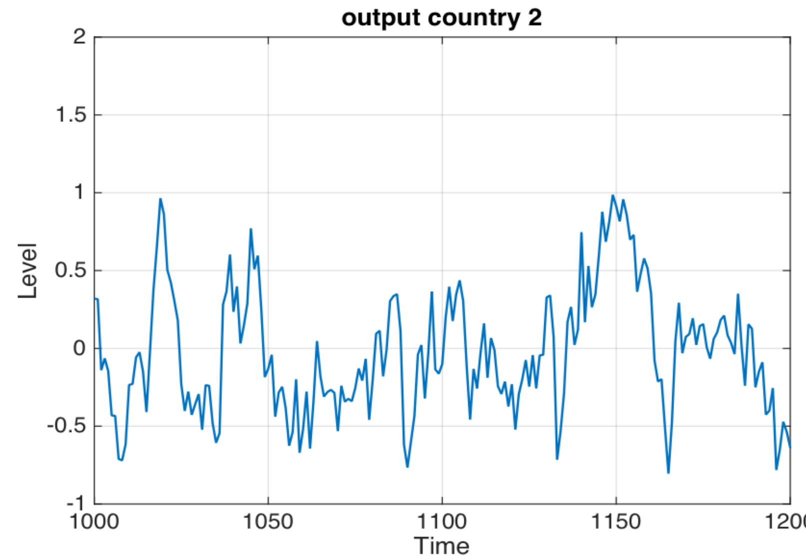
Trade and real exchange rate

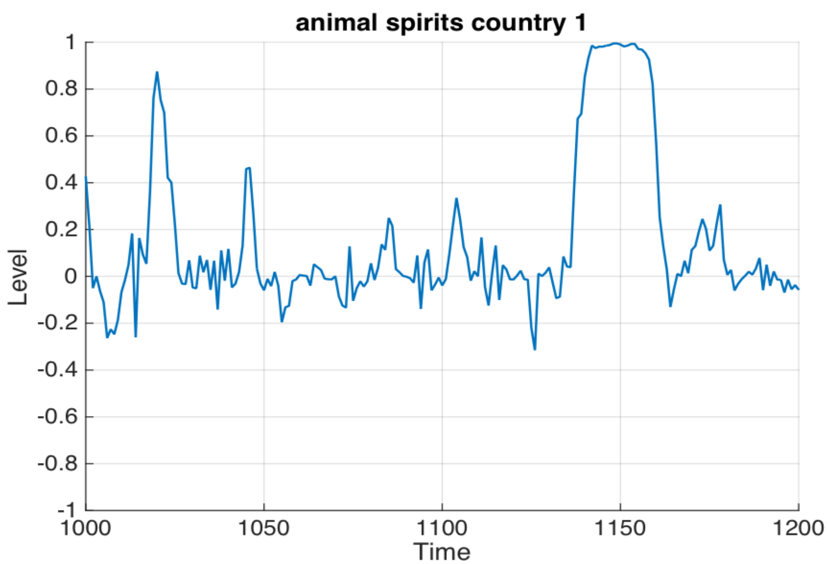
$$m_t^1 = x_t^2 = my_t^1 + \mu(R_{t-1} - 1) \quad (3)$$

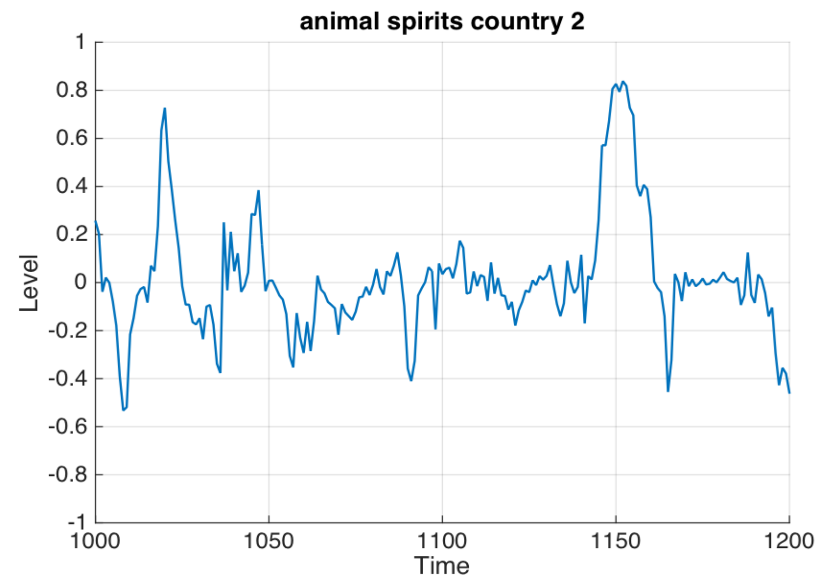
$$m_t^2 = x_t^1 = my_t^2 + \mu(\frac{1}{R_{t-1}} - 1) \quad (4)$$

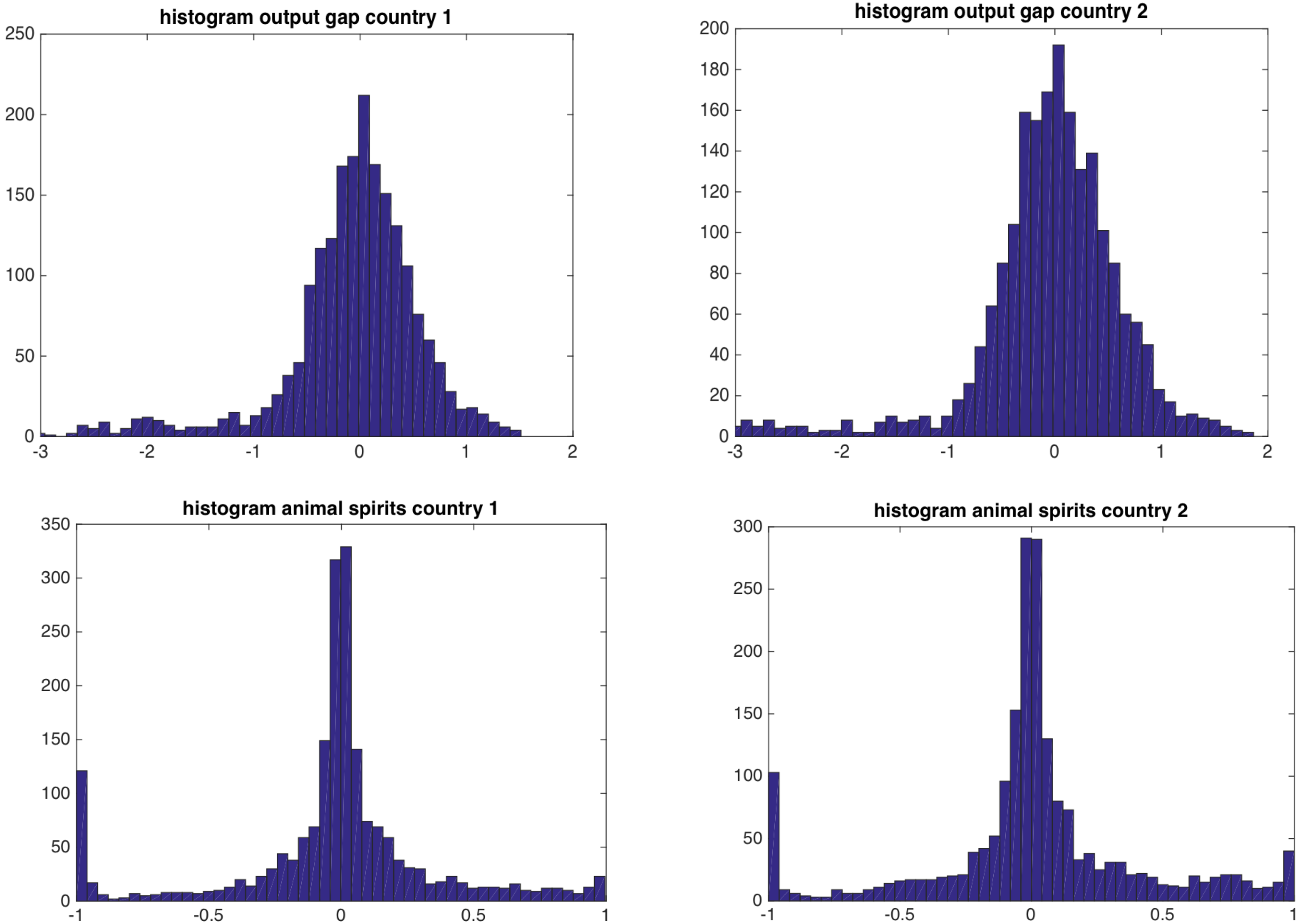
$$R_{t-1} = \frac{(1+\pi_0^1)(1+\pi_1^1)\ldots(1+\pi_{t-1}^1)}{(1+\pi_0^2)(1+\pi_1^2)\ldots(1+\pi_{t-1}^2)} \quad (5)$$


output country 1
Level
Time


output country 2
Level
Time


animal spirits country 1
Level
Time


animal spirits country 2
Level
Time


histogram output gap country 1
250
200
150
100
50
0
-3
-2
-1
0
1
2
histogram output gap country 2
200
180
160
140
120
100
80
60
40
20
0
-3
-2
-1
0
1
2
histogram animal spirits country 1
350
300
250
200
150
100
50
0
-1
-0.5
0
0.5
1
histogram animal spirits country 2
300
250
200
150
100
50
0
-1
-0.5
0
0.5
1

International synchronization

Model produces international contagion of animal spirits.

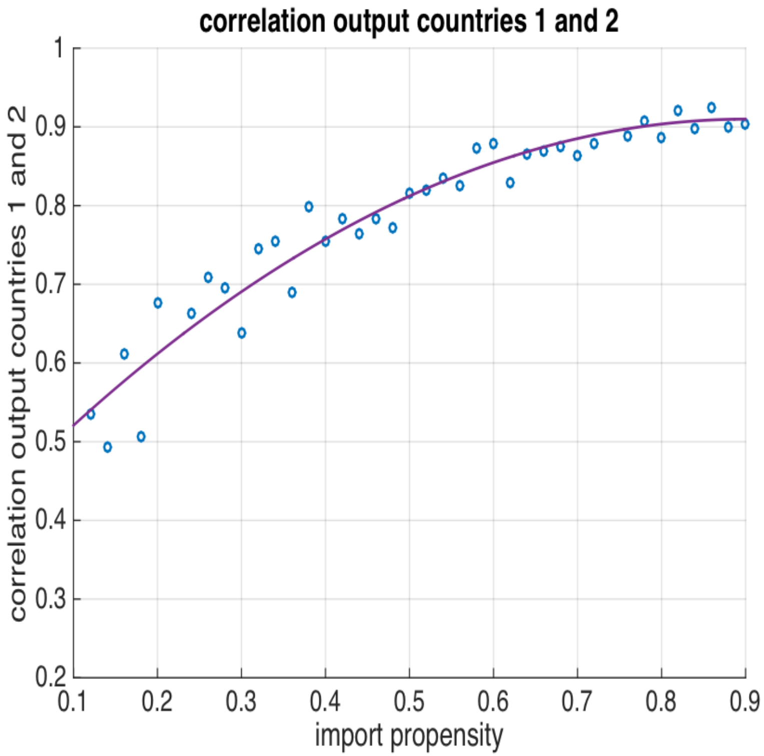
Animal spirits are highly correlated between the two countries reaching 0.95.

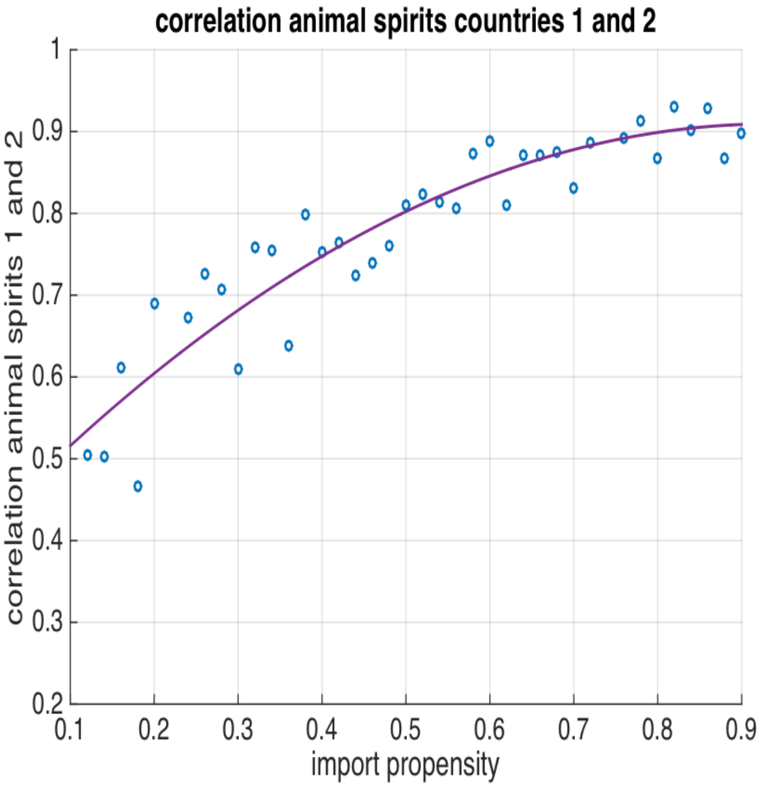
Why? When a wave of optimism is set in motion in country 1, it leads to more output and imports in that country, thereby increasing output in country 2.

Positive transmission, even if small, makes it more likely that agents in country 2 that make optimistic forecasts are vindicated, thereby increasing the fraction of agents in country 2 that become optimists.

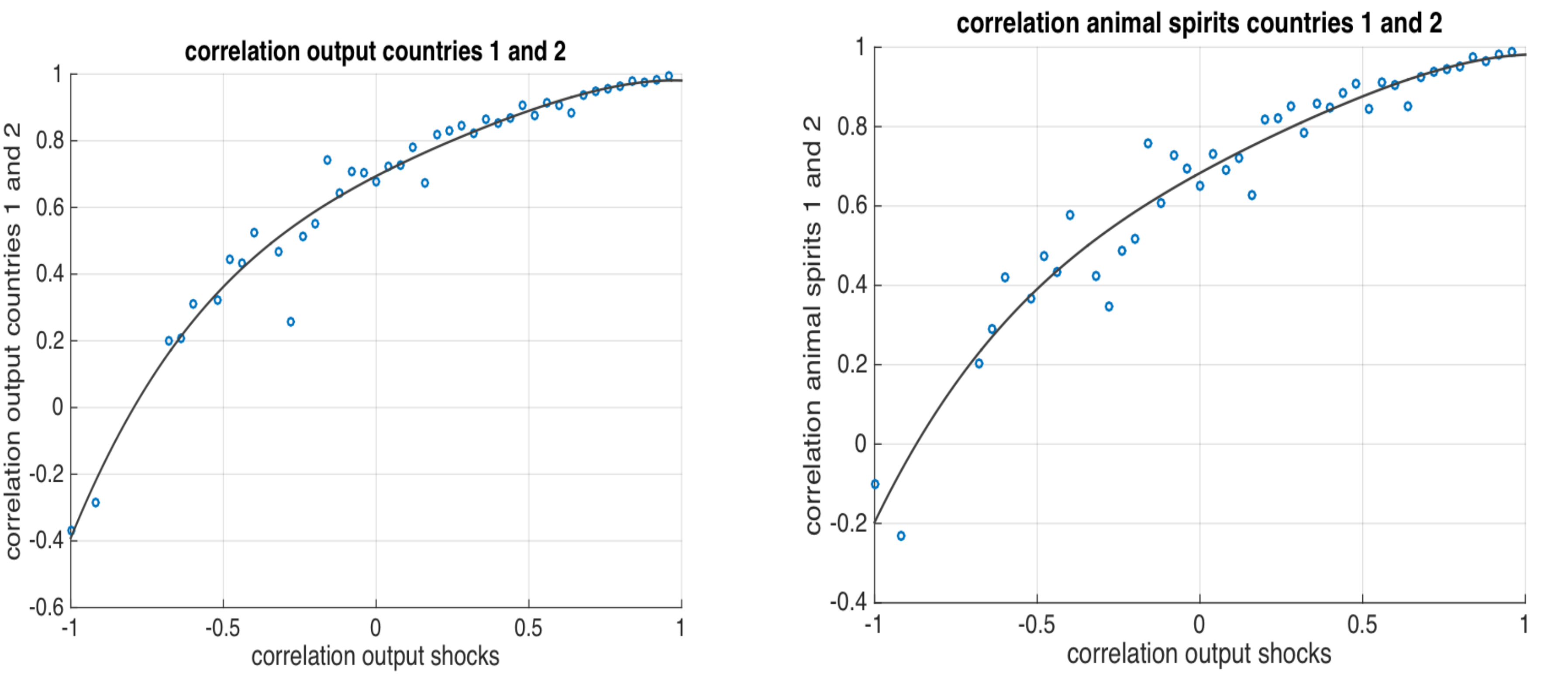
We obtain transmission dynamics that triggered by trade flows is amplified leading to strong synchronization of the business cycles across countries.

Factors affecting synchronization of business cycle: trade (m)

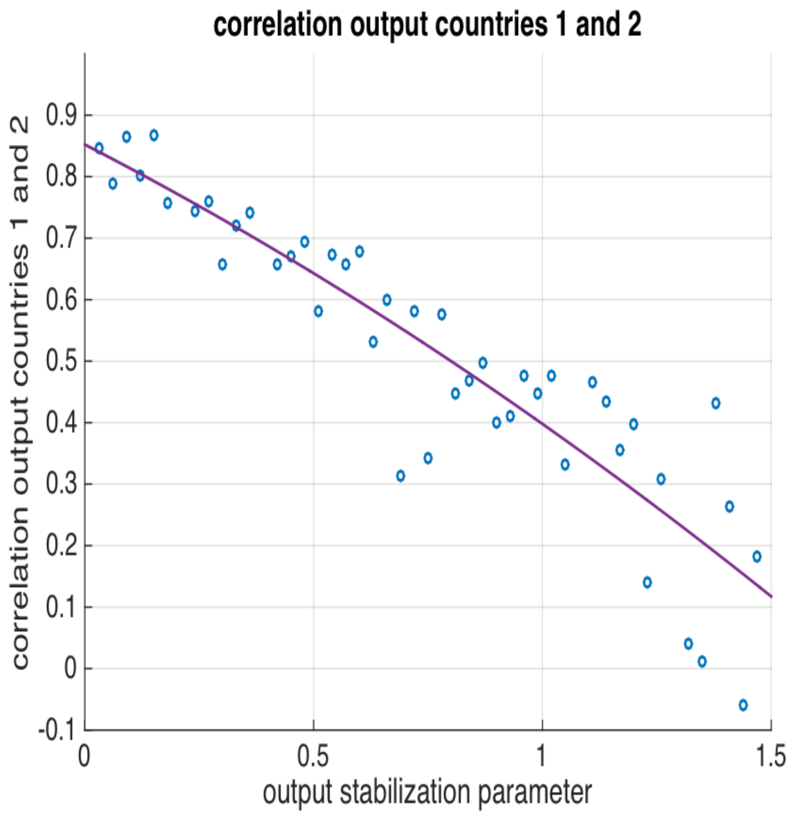


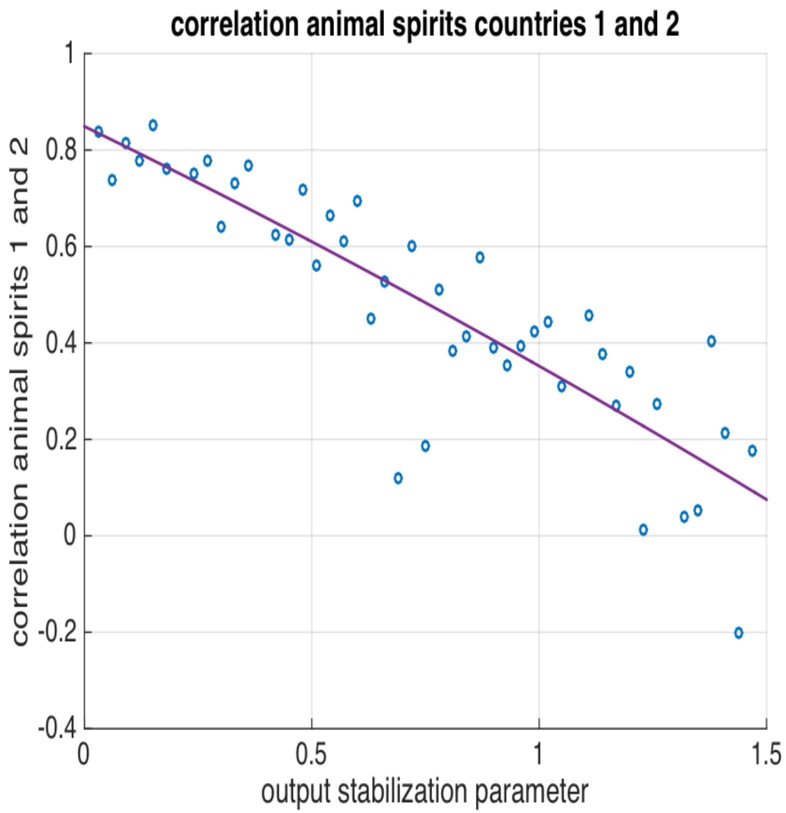


Factors affecting synchronization of business cycle: correlation output shocks



Factors affecting synchronization of business cycle: output stabilization c2





Comparing Behavioral model with RE-model

Behavioral model produces much higher cross-country correlations of the output gaps than the RE model.

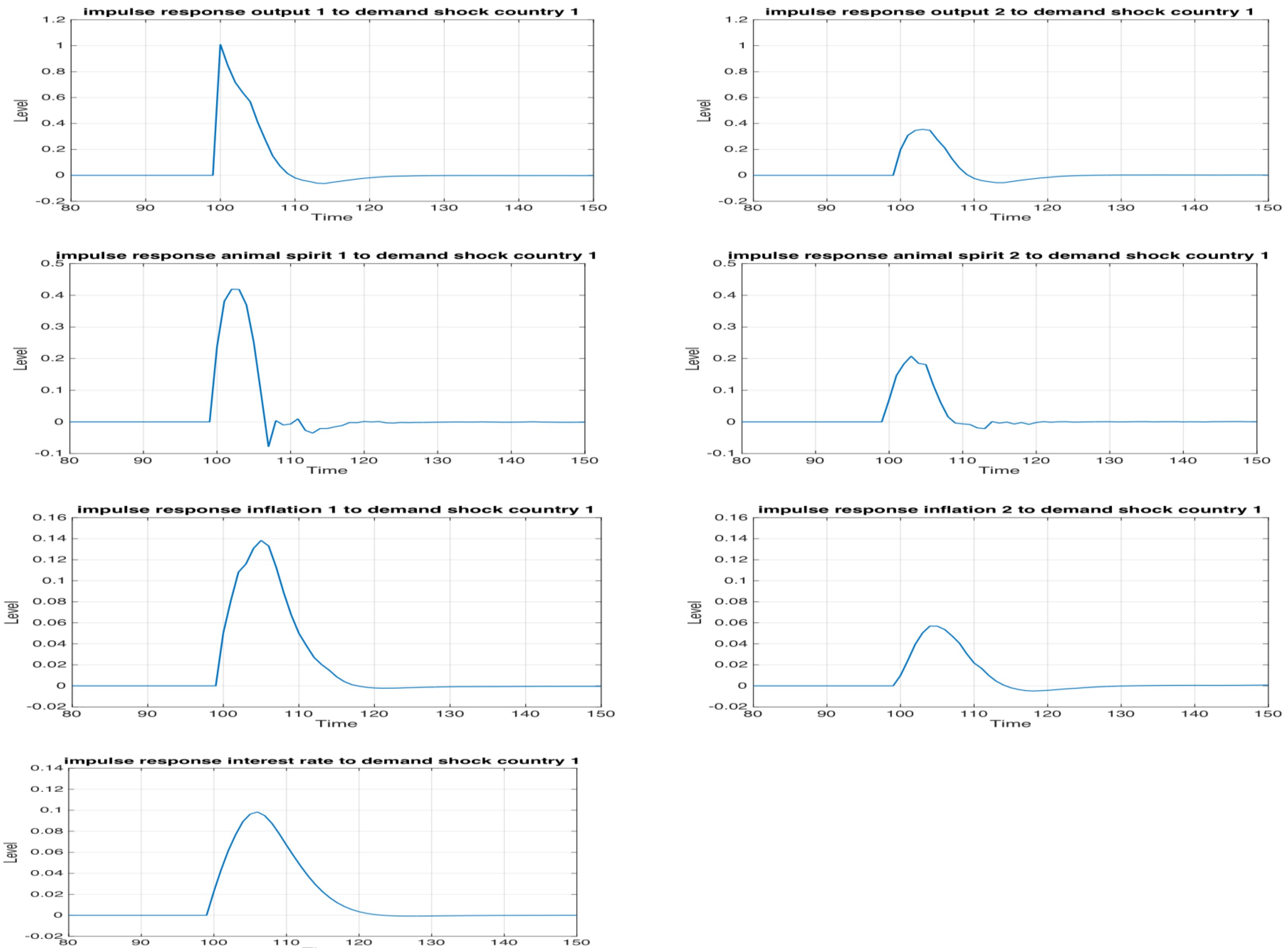
- This illustrates the importance of animal spirits as an independent force in producing international transmissions of the business cycles

Difference in the correlation coefficients produced by the two models narrows as *m* increases.

Table 3: International correlations of the output gaps

m	0,2	0,4	0,6	0,8
Behavioral model	0,61	0,76	0,85	0,91
RE model	0,13	0,39	0,53	0,62

Example: transmission of positive demand shock in country 1



Transmission of demand shock: distribution of output gap at 4th quarter

Figure 17: Short-term output responses to demand shock in country 1

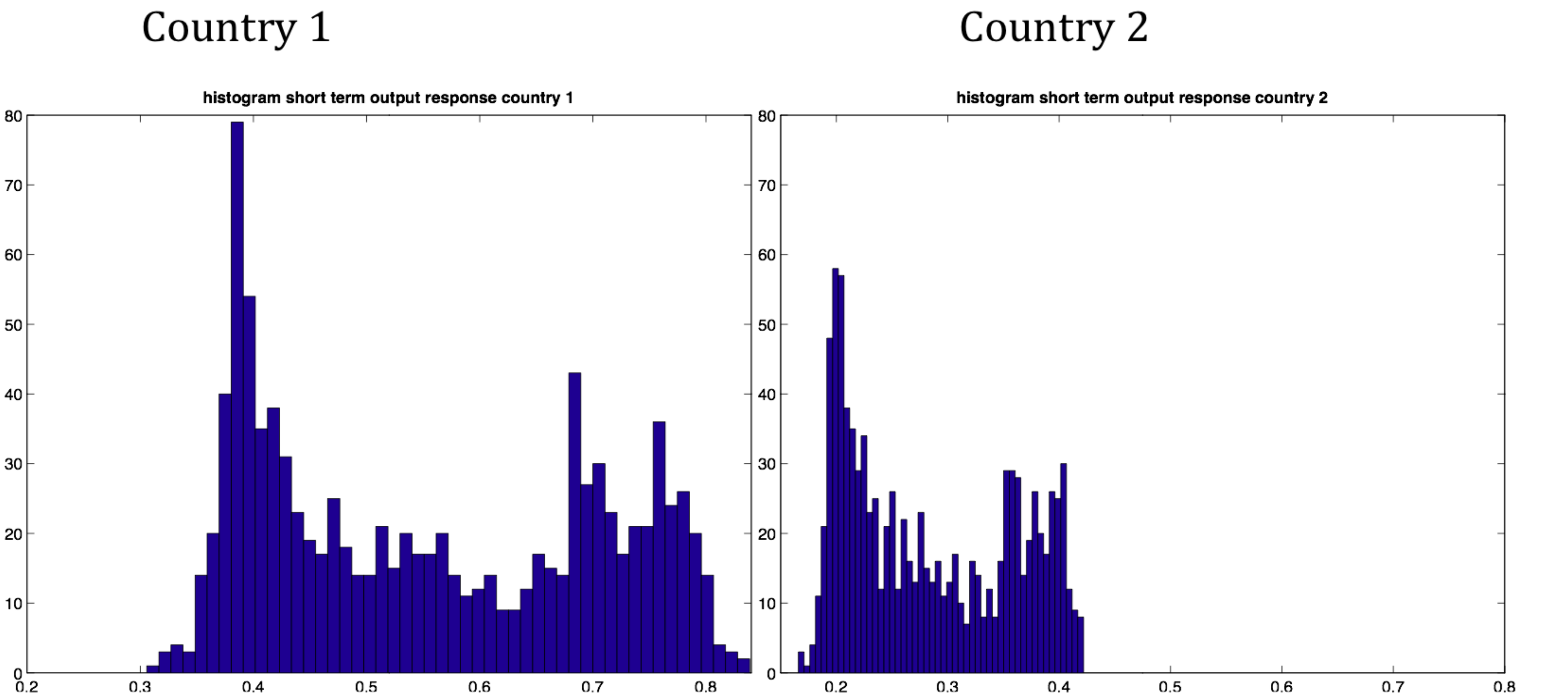
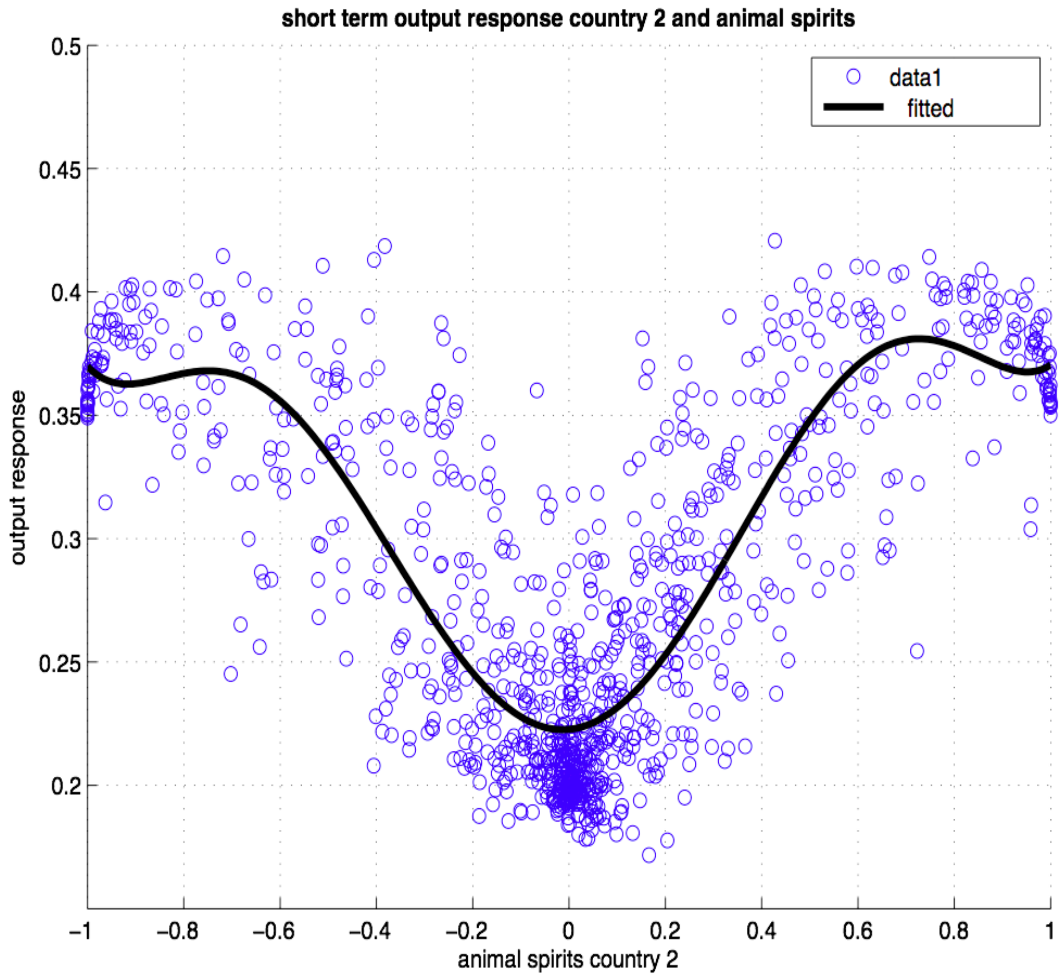


Figure 18: Short-term output responses and animal spirits



Theoretical prediction: non-linear nature of international correlations of business cycles

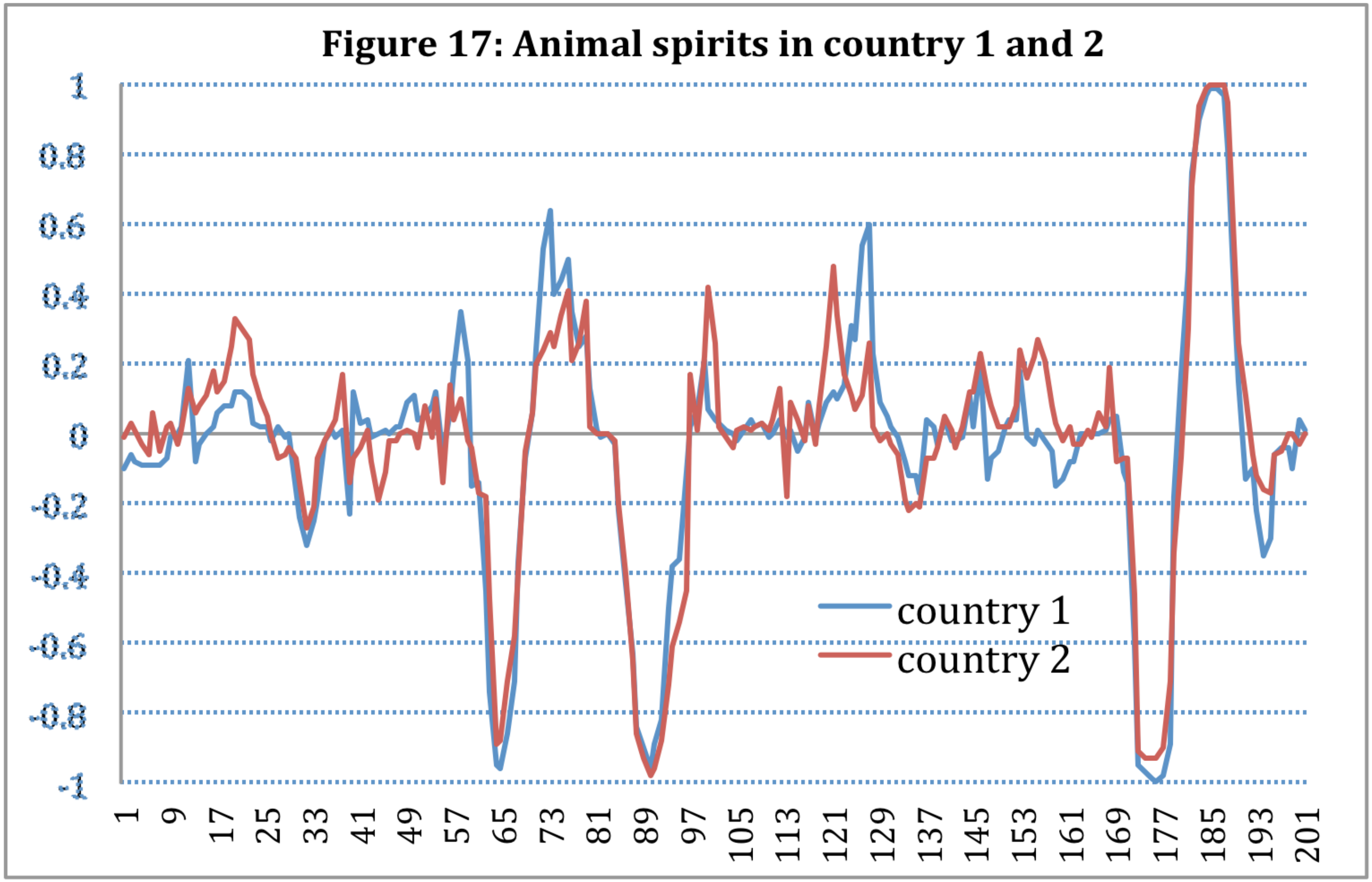


Table 4: Correlation animal spirits countries 1 and 2

<table>
<tr><th>Animal spirit index: from low to high</th><th>Correlation</th><th>Number of observations</th></tr>
<tr><td>|Anspirit|<0.01</td><td>0,09</td><td>180</td></tr>
<tr><td>|Anspirit|<0.05</td><td>0,25</td><td>595</td></tr>
<tr><td>|Anspirit|<0.1</td><td>0,44</td><td>832</td></tr>
<tr><td>|Anspirit|<0.2</td><td>0,60</td><td>1118</td></tr>
<tr><td>|Anspirit|<0.5</td><td>0,79</td><td>1497</td></tr>
<tr><td>Full sample</td><td>0,94</td><td>1998</td></tr>
<tr><td>|Anspirit|>0.5</td><td>0,97</td><td>501</td></tr>
<tr><td>|Anspirit|>0.8</td><td>0,986</td><td>299</td></tr>
<tr><td>|Anspirit|>0.9</td><td>0,991</td><td>234</td></tr>
<tr><td>|Anspirit|>0.95</td><td>0,995</td><td>180</td></tr>
<tr><td>|Anspirit|>0.99</td><td>0,9998</td><td>93</td></tr>
</table>

Note: |Anspirit| is the absolute value of animal spirit of country 1 in our simulation

Empirical evidence on non-linear nature of international correlation confidence indices

Table 8. Correlation of Business Confidence Index (BCI) across Eurozone

German BCI (from low to high)	Average bilateral correlation
99.5-100.5	0.64
Total sample	0.75
<99.5 | >100.5	0.77
<99.2 | >100.8	0.81
<99.1 | >100.9	0.83
<99.0 | >101.0	0.86
<98.0 | >102.0	0.95

Note: The BCI data is obtained from OECD monthly data. The BCI has been scaled to yield a long-term average of 100.

The data on Ireland are incomplete in Ireland is incomplete therefore our calculations of bilateral correlations do not include Ireland.

See Appendix 3 for the matrices which present the bilateral correlations between different Eurozone countries given the range of business confidence index

Conclusions

- Our behavioural macro models have produced rich theoretical results to analyze endogenous business cycles (short-term volatility issues).
- We stress the role of animal spirits and also what central banks can do to influence the animal spirits and hence output gap.
- A lot can be done in this area.
- I showed one example of its application in international macroeconomics. i.e. synchronization of business cycles.

Main channel of international synchronization business cycles occurs through a propagation of “animal spirits”,

- i.e. waves of optimism and pessimism that get correlated internationally.
- this propagation occurs with relatively low levels of trade integration.

One important policy implication: degree of synchronization is influenced by c2,the intensity with which the central bank stabilizes output.

Another lesson we draw from the model is that our capacity to make conditional forecasts is very limited. The results depend very much on initial conditions such as animal spirits

Comparison: different macro models

	Utility/Profit maximization	Rational Expectation	Representitive Agent	Business cycles	Empirical validation
Conventional DSGE model	Yes	Yes	Yes	Exogenous shock	serial correlation and large non-normal distributed shocks
Behavioural DSGE model	Yes	Yes	Yes	Exogenous shock	serial correlation and large non-normal distributed shocks
Our model	Yes/No	No	Endogenous fraction of heterogeneous group of agent	Endogenous movement	
Agent-based model	No	No	Heterogeneous agent	Endogenous movement	

Also different policy implications…