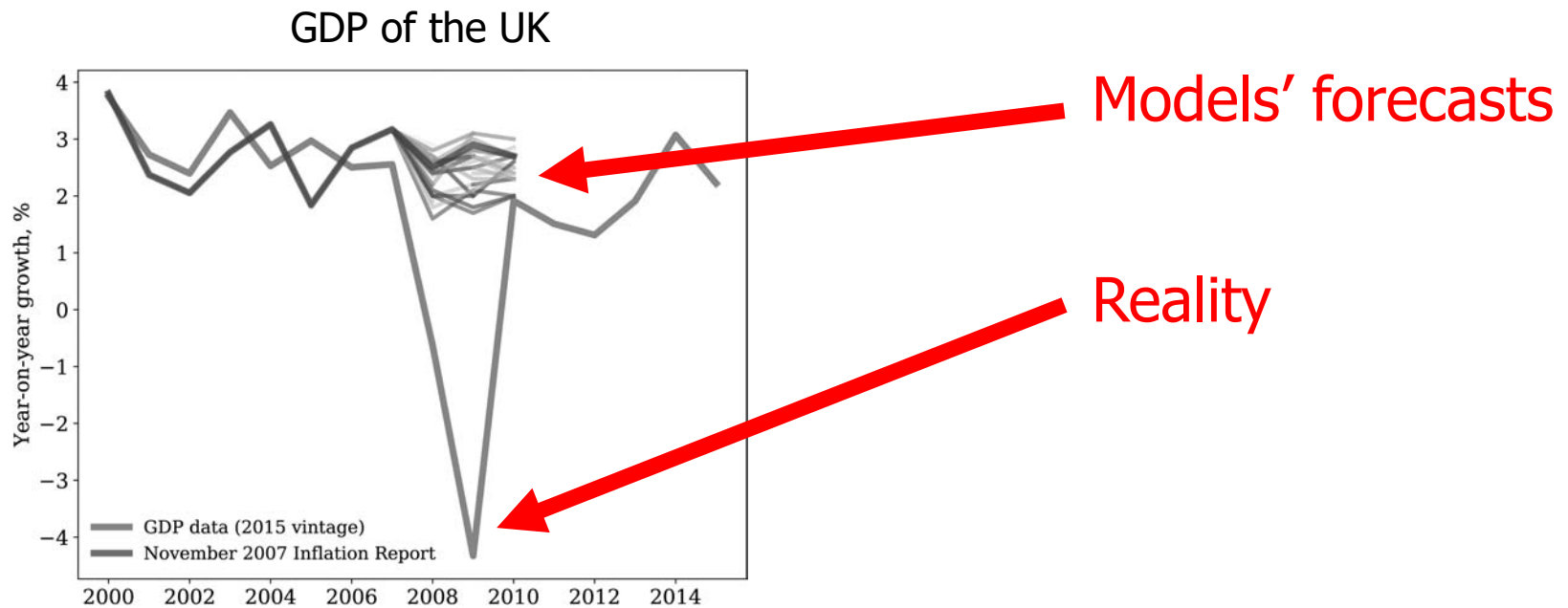# IIASA work on agent-based modelling of national economies: Macroeconomic forecasting, endogenous crises, and resilience to natural hazards

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Why an agent-based model?

"[The] benchmark DSGE model that shares many features with models currently used by central banks and large international institutions has difficulty explaining both the depth and the slow recovery of the Great Recession." (Lindé, Smets & Wouters 2016)

GDP of the UK

Models' forecasts

Reality

GDP data (2015 vintage)
November 2007 Inflation Report

(Haldane 2016)

Why an agent-based model?

A new macroeconomic model requires (*Rebuilding Macroeconomic Theory Project*, Vines and Wills, 2018):

- Introducing heterogeneous agents;
- Incorporating financial frictions rather than assuming that financial intermediation is costless;
- Relaxing the requirement of rational expectations;
- Underpinning the model with more appropriate microfoundations

"... ABMs are a promising complement to the current crop of macroeconomic models, especially when making sense of the types of extreme macroeconomic movements the world has witnessed for the past decade." (Haldane & Turrell 2018)

IIASA's macroeconomic ABM fulfills these requirements!

IIASA's macroeconomic ABM
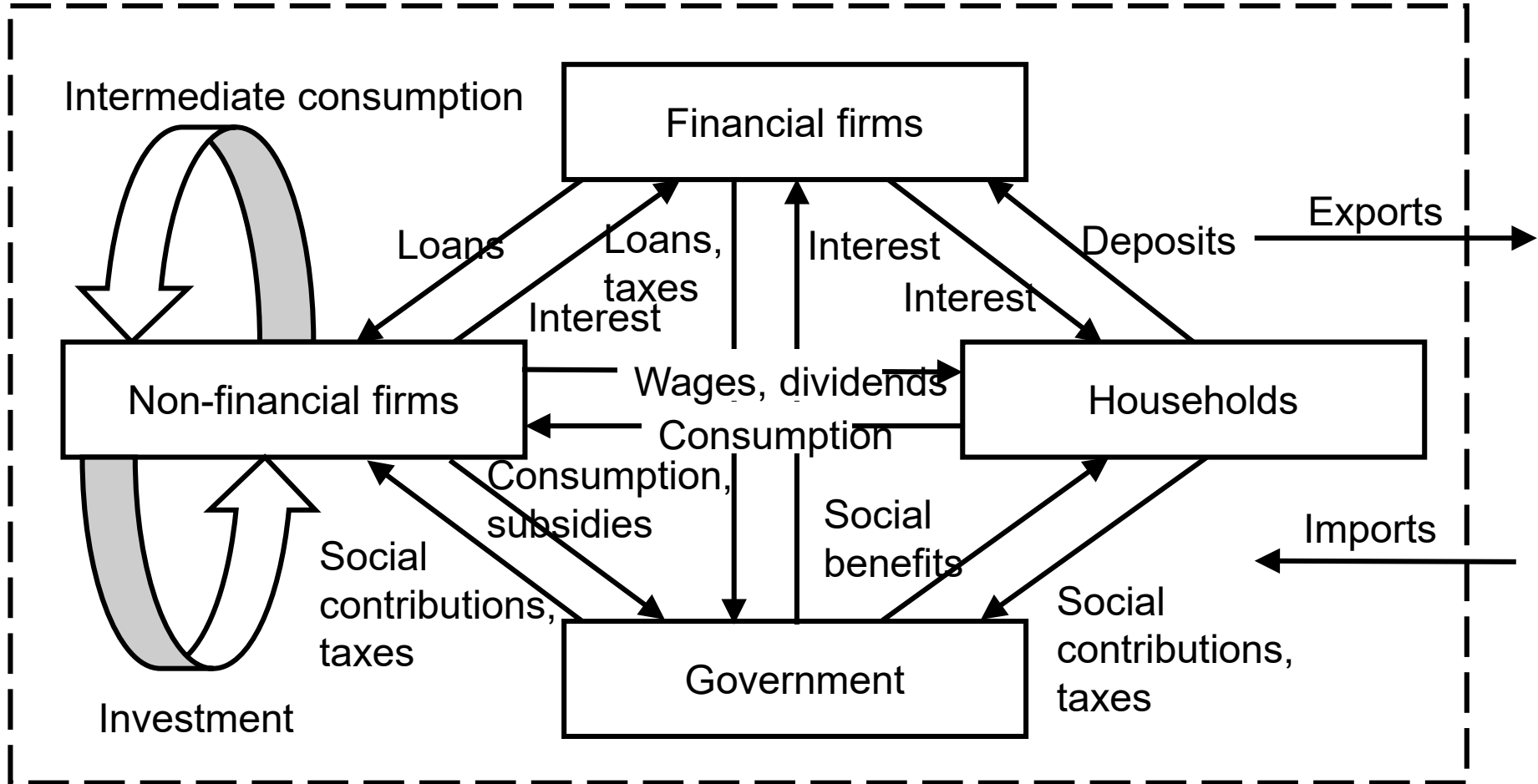
IIASA's macroeconomic ABM

- Includes all sectors (financial, non-financial, households, a general government) populated with hundreds of millions of heterogenous agents (firms)

- Incorporates financial frictions with a financial accelerator and debt-financed investment (Bernanke, Gertler, & Gilchrist 1996)

- Rational expectations of firms regarding future demands are relaxed with (parameter-free) adaptive learning (Hommes and Zhu, 2014)

- These and other model assumptions, arguably, make the model "more realistic" in terms of microfoundations

Macroeconomic forecasting

"In principle it might even be possible to create an agent-based economic model capable of making useful forecasts of the real economy, although this is ambitious ... like climate modelling, [it's] a huge undertaking." (Farmer & Foley 2009)

Case of the Euro area

- Out-of-sample prediction, sample of 28 forecasts

- Data used for model estimation: between 1996:Q2 and T, where T varies between 2005:Q1 and 2011:Q4

- Forecast horizons: T+Q1, T+Q2, T+Q3, T+Q4, T+Q8, and T+Q12

- A DSGE model used for comparison: based on the benchmark model from (Smelts & Wouters 2007)

- Comparison is relative to an AR(1) model

- Forecasting performance is described by the Root Mean Square Error (RMSE)

Case of the Euro area

|	GDP	Inflation	Euribor	Household consumption	Investment
AR(1)	*RMSE-statistic for different forecast horizons*				
1q	0.7	0.18	0.11	0.39	1.54
2q	1.59	0.19	0.19	0.73	3.06
4q	3.65	0.19	0.3	1.55	5.64
8q	8.71	0.21	0.41	3.11	9.67
12q	15.48	0.2	0.43	4.57	12.3
ABM	*Percentage gains (+) or losses (-) relative to AR(1) model*				
1q	6.4 (0.82)	-13.4 (0.21)	12.2 (0.11)	-1.8 (0.92)	5.6 (0.20)
2q	17.9 (0.48)	-1.2 (0.92)	10 (0.28)	12.1 (0.47)	5.6 (0.39)
4q	33.6 (0.29)	-10.6 (0.40)	6.2 (0.46)	15 (0.43)	29.7 (0.31)
8q	68.2 (0.19)	14.5 (0.28)	14.8 (0.05)	33.4 (0.17)	33.6 (0.24)
12q	76.8 (0.11)	-17.1 (0.07)	27.9 (0.00)	40 (0.14)	23.1 (0.24)
DSGE	*Percentage gains (+) or losses (-) relative to AR(1) model*				
1q	8.6 (0.78)	-6.8 (0.42)	13.6 (0.18)	-7.3 (0.43)	-0.9 (0.93)
2q	23.5 (0.39)	2.8 (0.68)	2.4 (0.84)	-6.3 (0.71)	3 (0.86)
4q	38.4 (0.34)	-11.1 (0.20)	-17.2 (0.32)	-3.9 (0.85)	4.5 (0.85)
8q	60.7 (0.22)	-36.8 (0.24)	-45.1 (0.18)	6.2 (0.71)	15 (0.58)
12q	76.8 (0.10)	-47.1 (0.29)	-64.6 (0.14)	17 (0.21)	26.3 (0.26)

IIASA's ABM demonstrates

- A comparable forecasting power to a DSGE model in terms of the GDP

- A better forecasting accuracy than a DSGE model for the interest rate, household consumption and investment

- In terms of inflation, both models exhibit similar results

Endogenous crises

Forecasting financial crisis 2008/09 for the Euro area

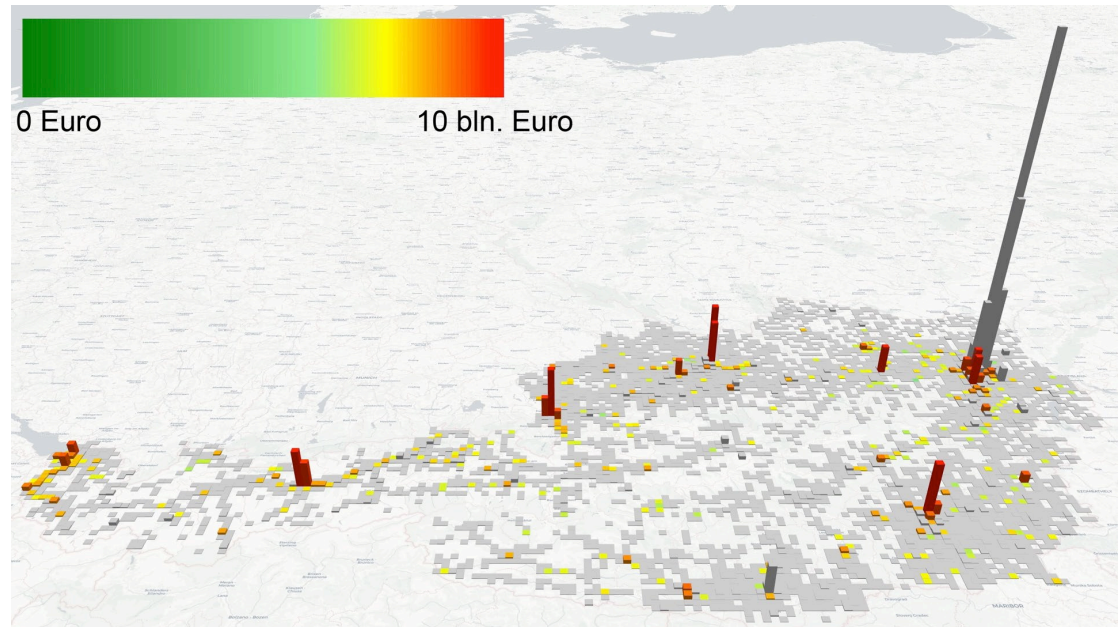Data used for estimation: 1996:Q2 – 2006:Q4
Forecast horizon: 12 quarters

GDP growth (quarterly)

DATA
AR(1)
DSGE
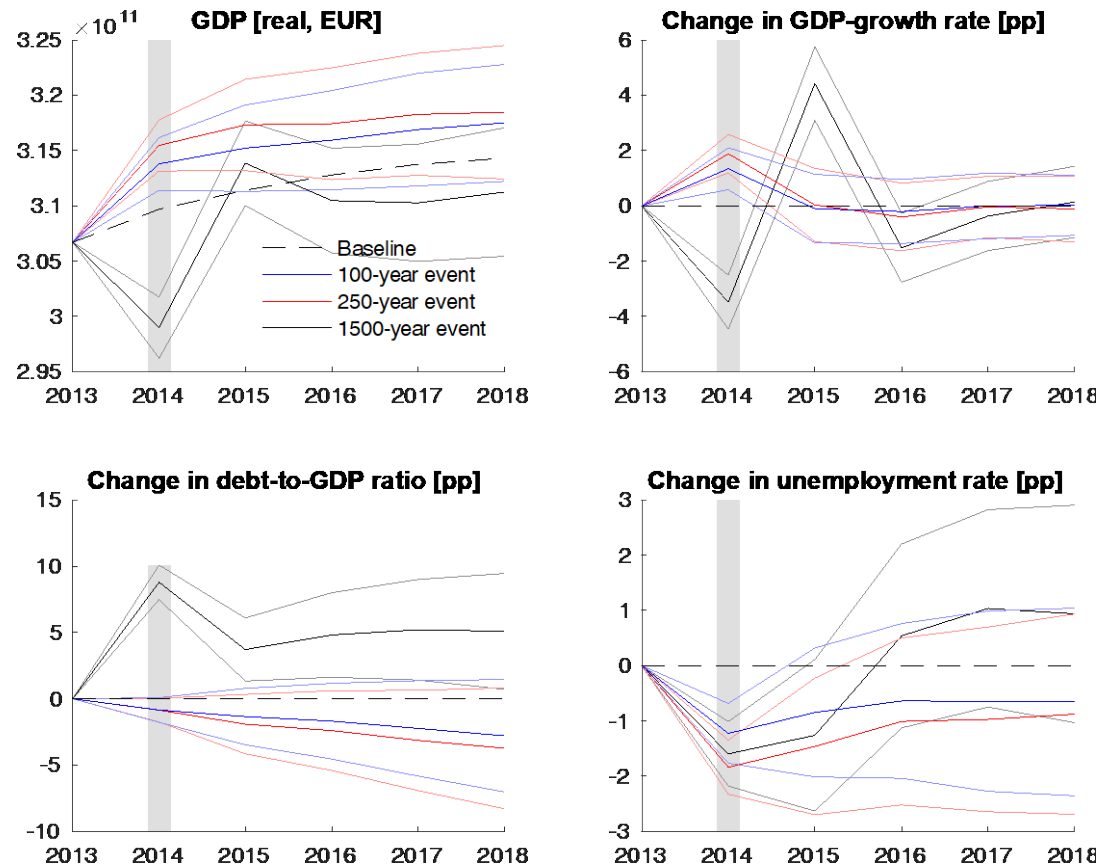ABM

GDP of the UK
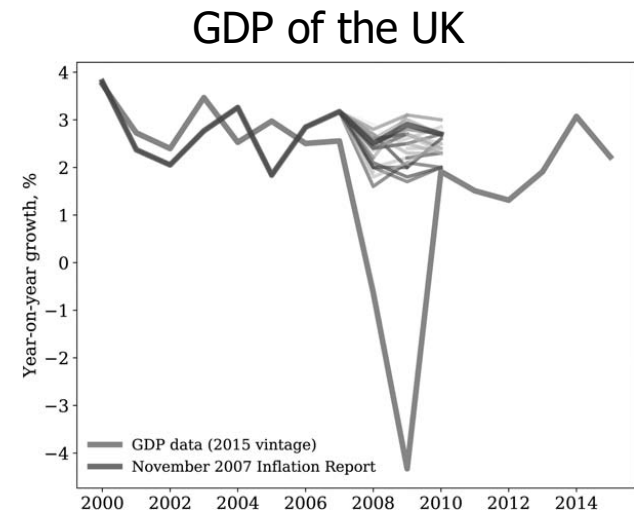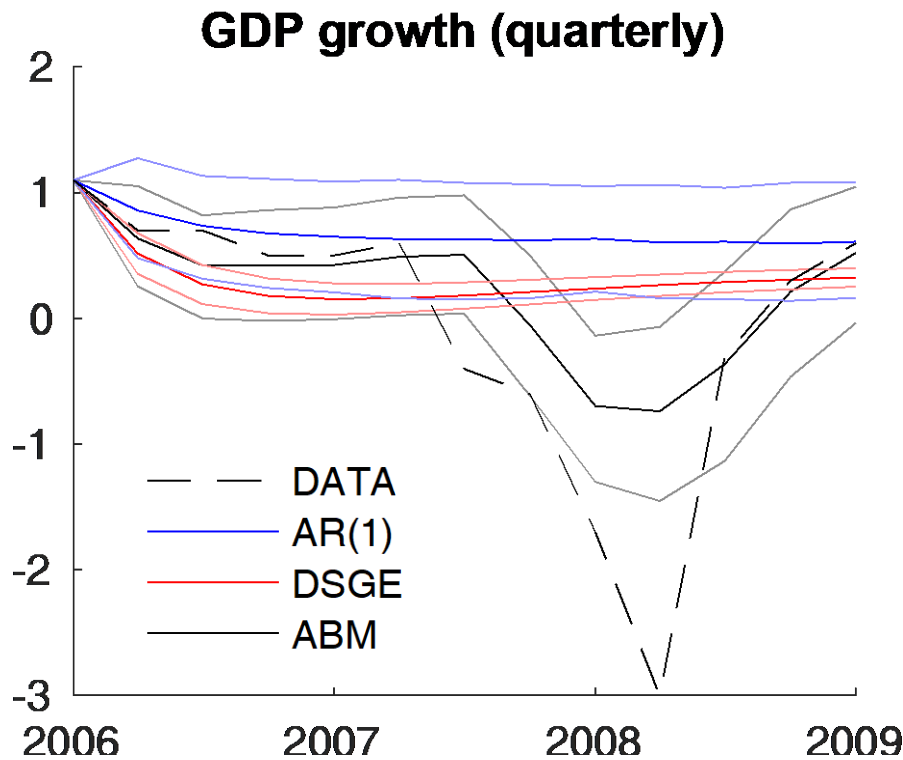
(Haldane 2016)

Resilience to natural hazards

Case of Austria: Economic effects of flood events

- Geospatial version of the ABM
- Floods affect capital in different locations

0 Euro   10 bln. Euro

Affected capital in flooded areas, a 250-year flood event (Poledna et al 2018)

Indirect losses from natural disasters

Natural disasters can substantially affect the government debt-to-GDP ratio

Questions?
Comments?
Suggestions?

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