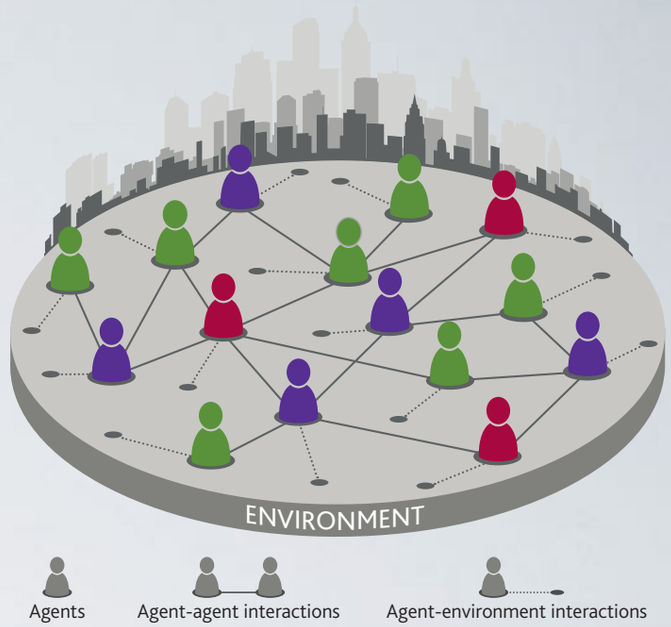
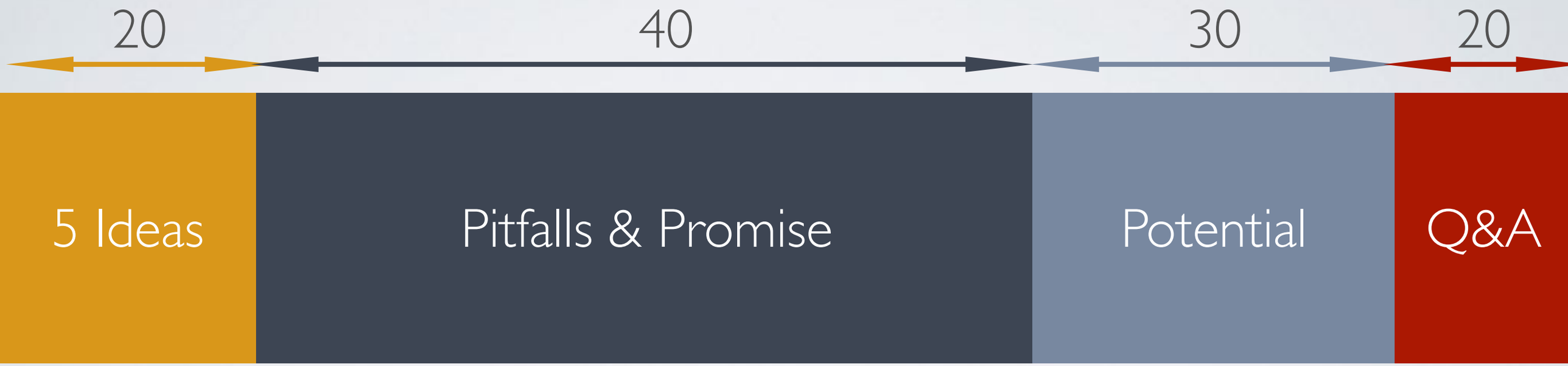


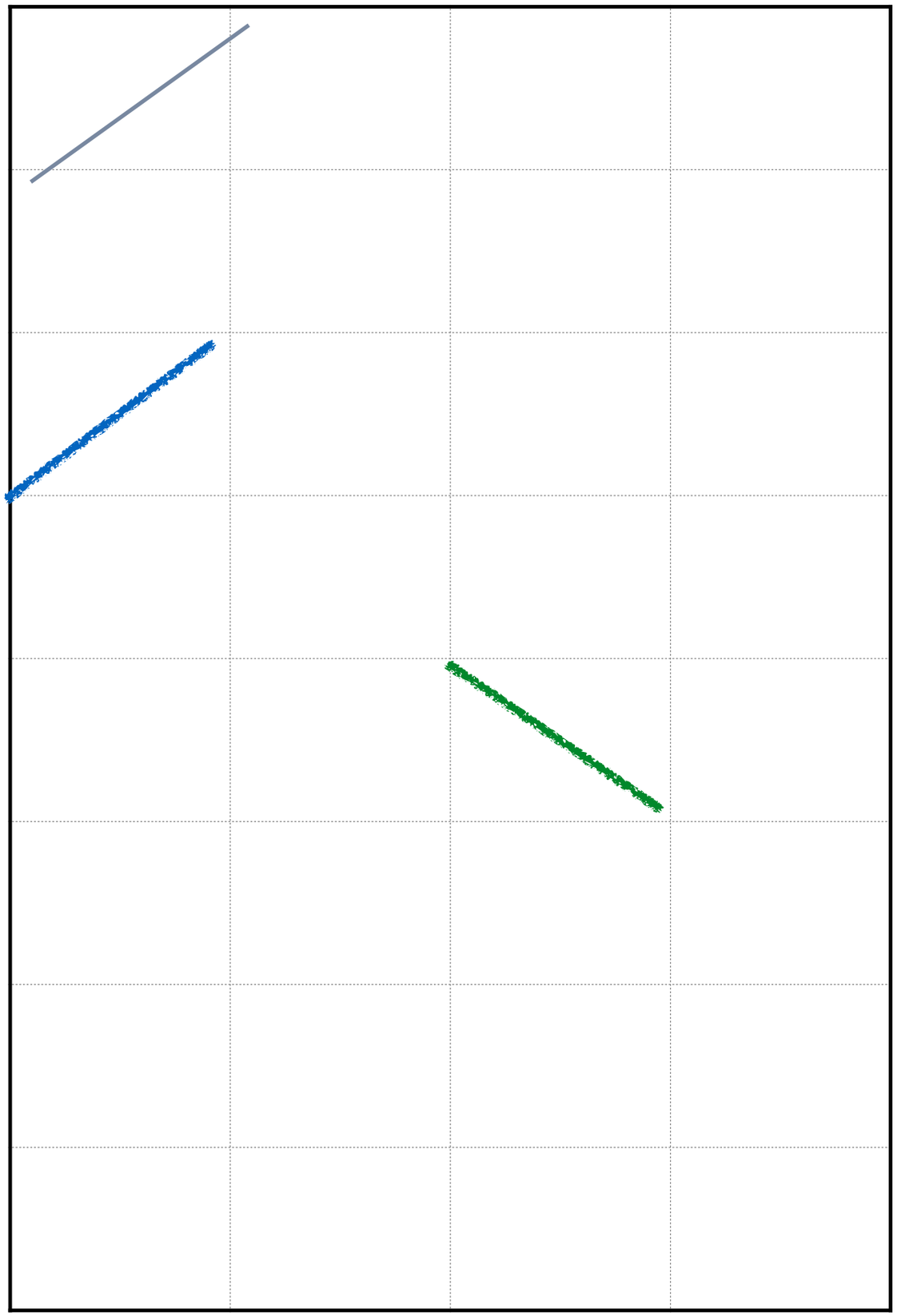
AGENT BASED MACROECONOMICS

Stephen Kinsella, University of Limerick and University of Melbourne

FMM Keynesian Summer School, 3 August 2017

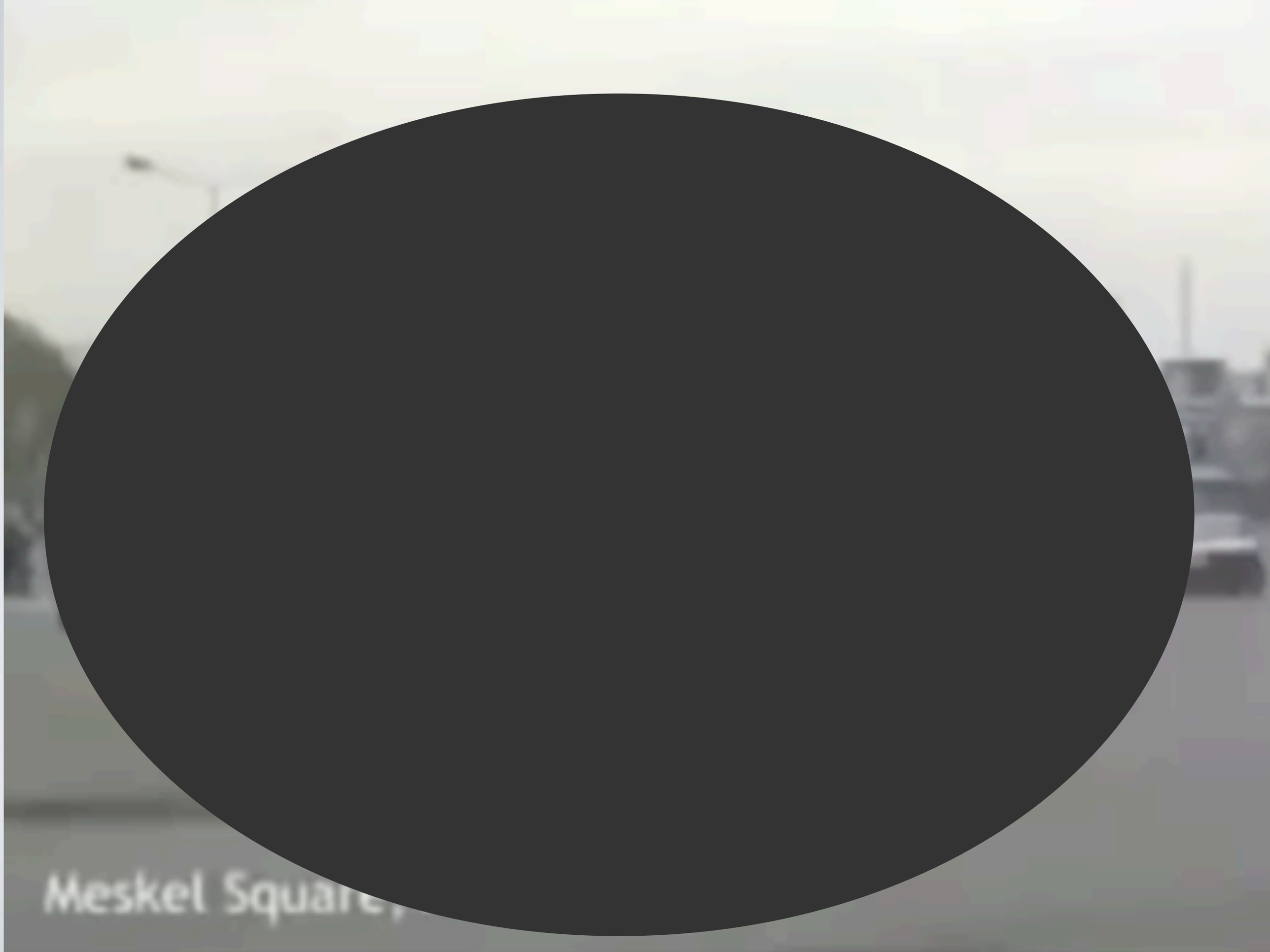

20
40
30
20
5 Ideas
Pitfalls & Promise
Potential
Q&A

When you’re bored



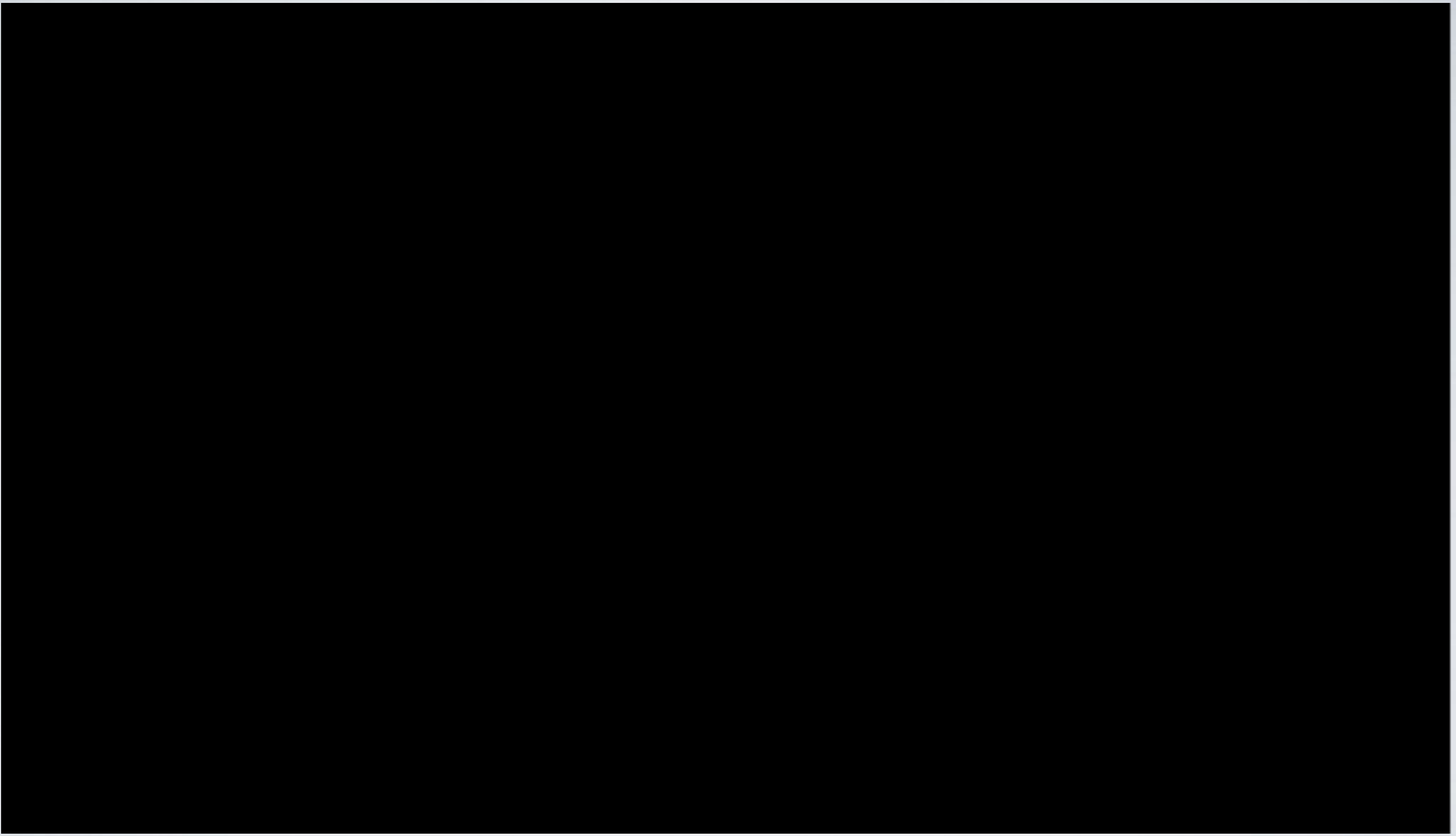
(Ideally) Use 3 Colours.
For each square on the page
{
Draw a Diagonal Stroke in any direction in any colour
OR
Leave it blank
}

5 Ideas


Meskel Square

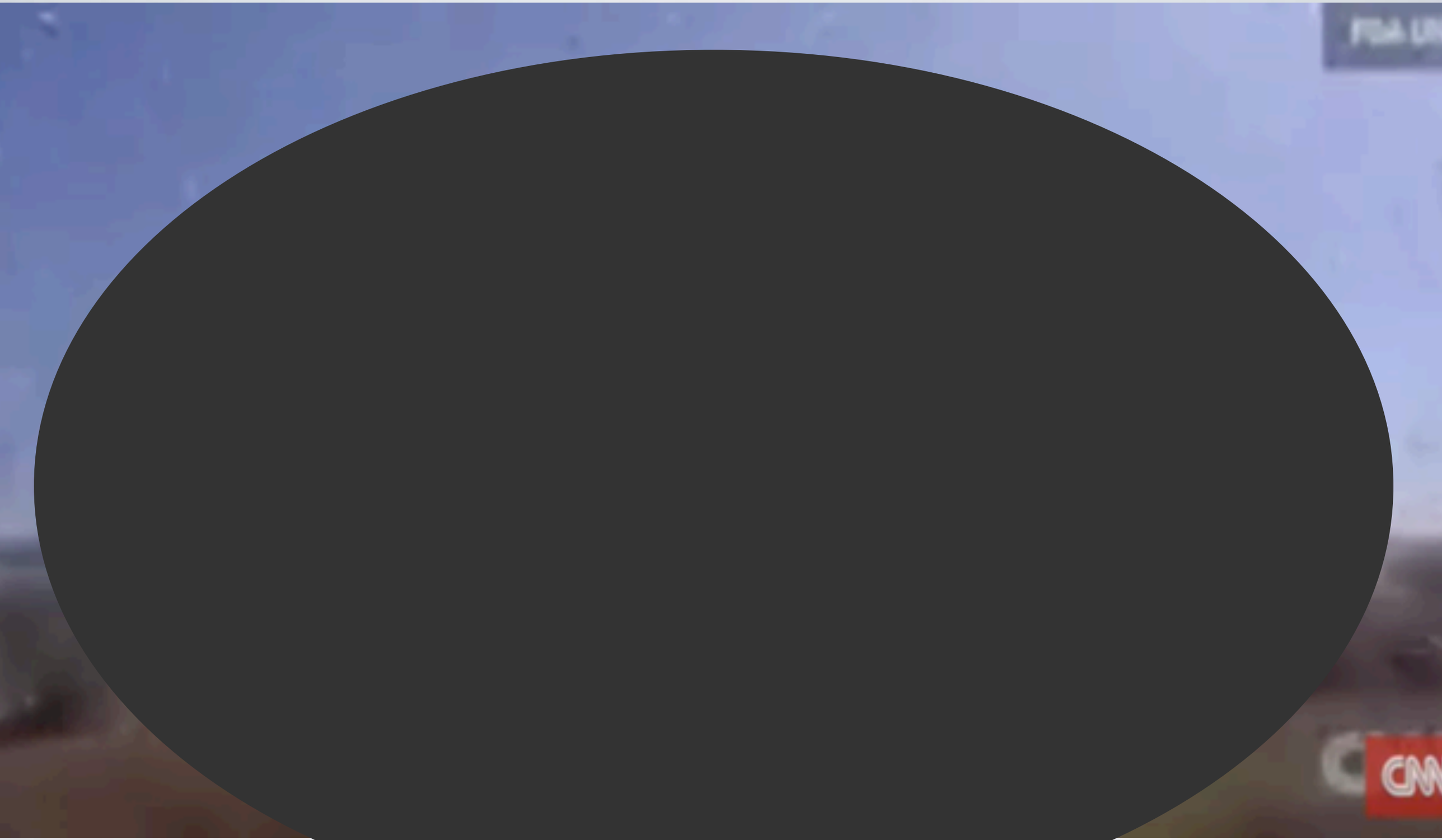
1: BEHAVIOUR DOESN'T NEED EXPLICIT RULES. IT NEEDS INTENTION & INTERACTION.

AN INTERSECTION IN IRELAND.



2: BEHAVIOUR OFTEN DOESN'T HEED EXPLICIT RULES, BECAUSE OF IDEA #1.

LOCUSTS

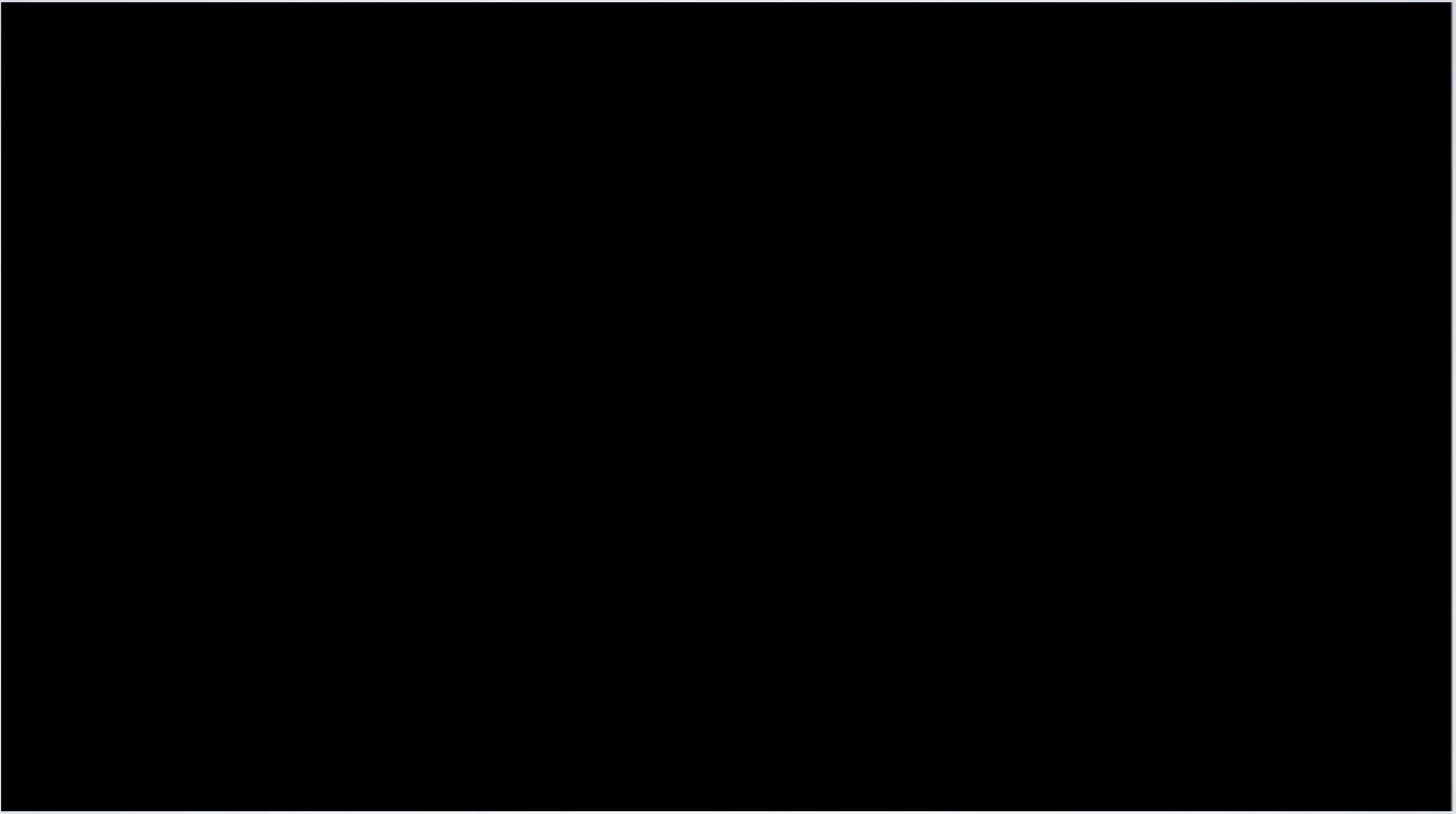


3: UNCOORDINATED BEHAVIOUR CAN APPEAR COORDINATED

JAPAN'S SHUDAN KOUDOU

4: COORDINATED BEHAVIOUR CAN BE REALLY, REALLY COORDINATED

SAND PILE EXPERIMENTS



5: MICRO BEHAVIOUR CAN HAVE MACRO EFFECTS INDEPENDENT OF MICRO LEVEL

0:01 / 7:22

SOMETIMES MODELS ARE NOT GOOD REPRESENTATIONS OF REALITY

40

Ideas

Pitfalls & Promise

Potential

Q&A

ENVIRONMENT

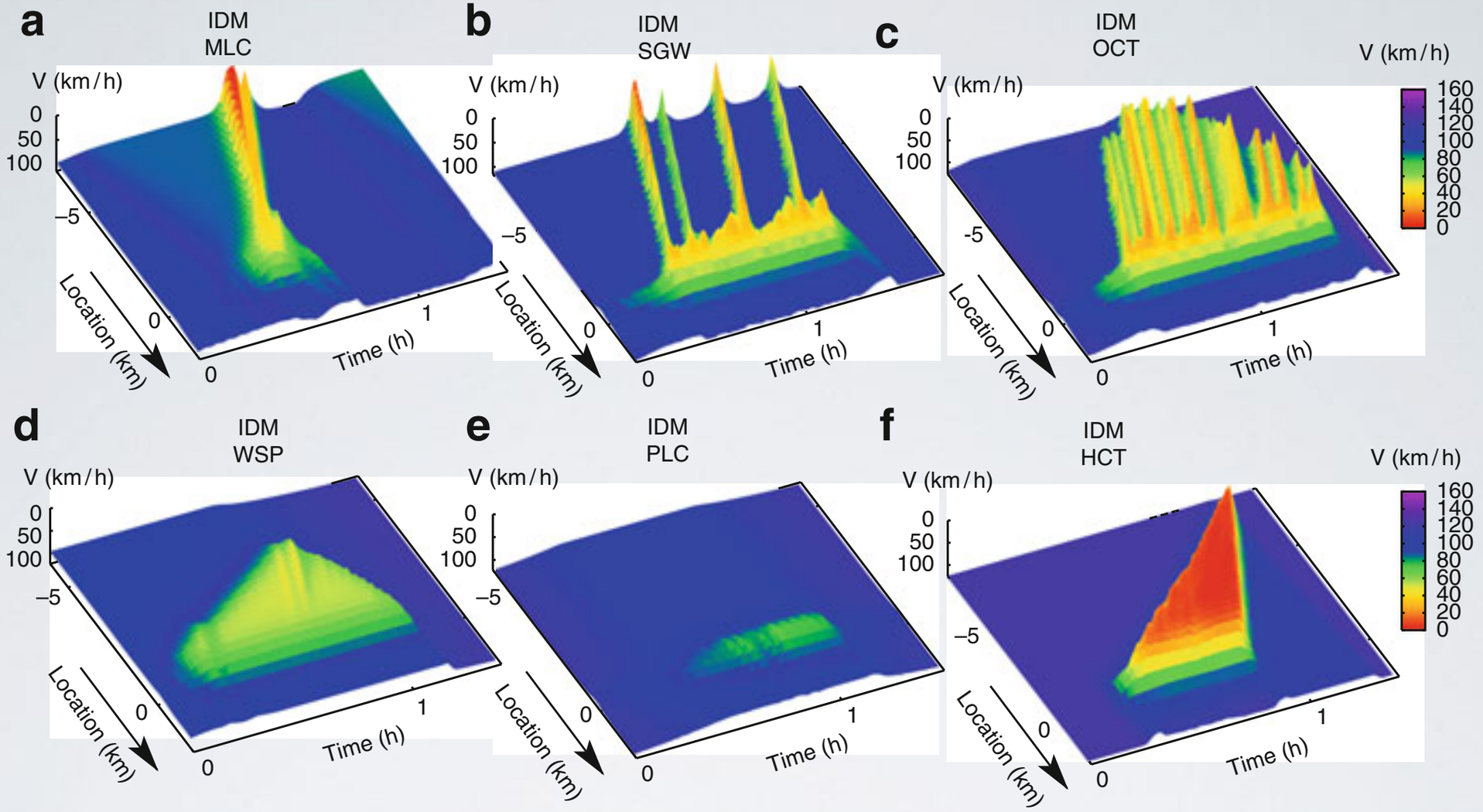
Agents

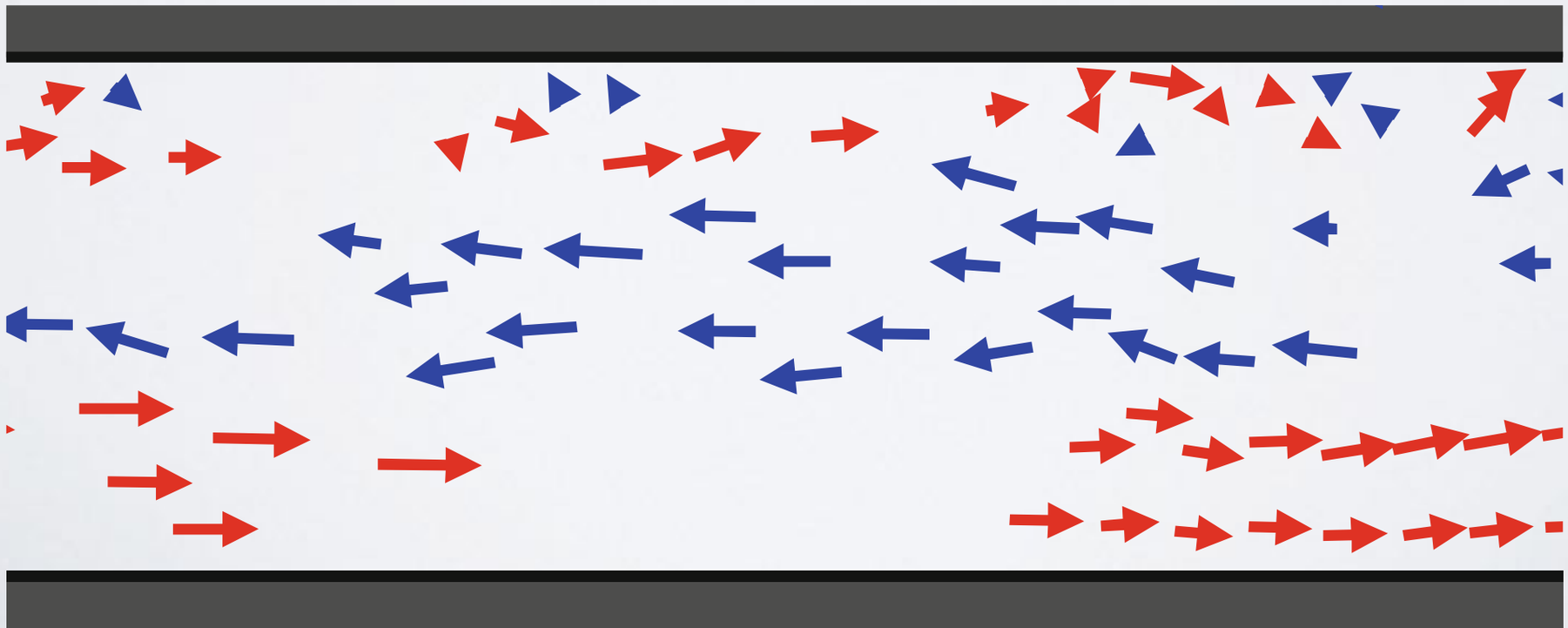
Agent-agent interactions

Agent-environment interactions

"[ABMs] allow one to start off with the descriptive power of verbal argumentation and to determine the implications of different hypotheses. From this perspective, computer simulation can provide "an orderly formal framework and explanatory apparatus"

–Helbing, 2012


a
IDM
MLC
b
IDM
SGW
c
IDM
OCT
V (km/h)
160
140
120
100
80
60
40
20
0
d
IDM
WSP
e
IDM
PLC
f
IDM
HCT
V (km/h)
0
50
100
–5
0
1
Location (km)
Time (h)

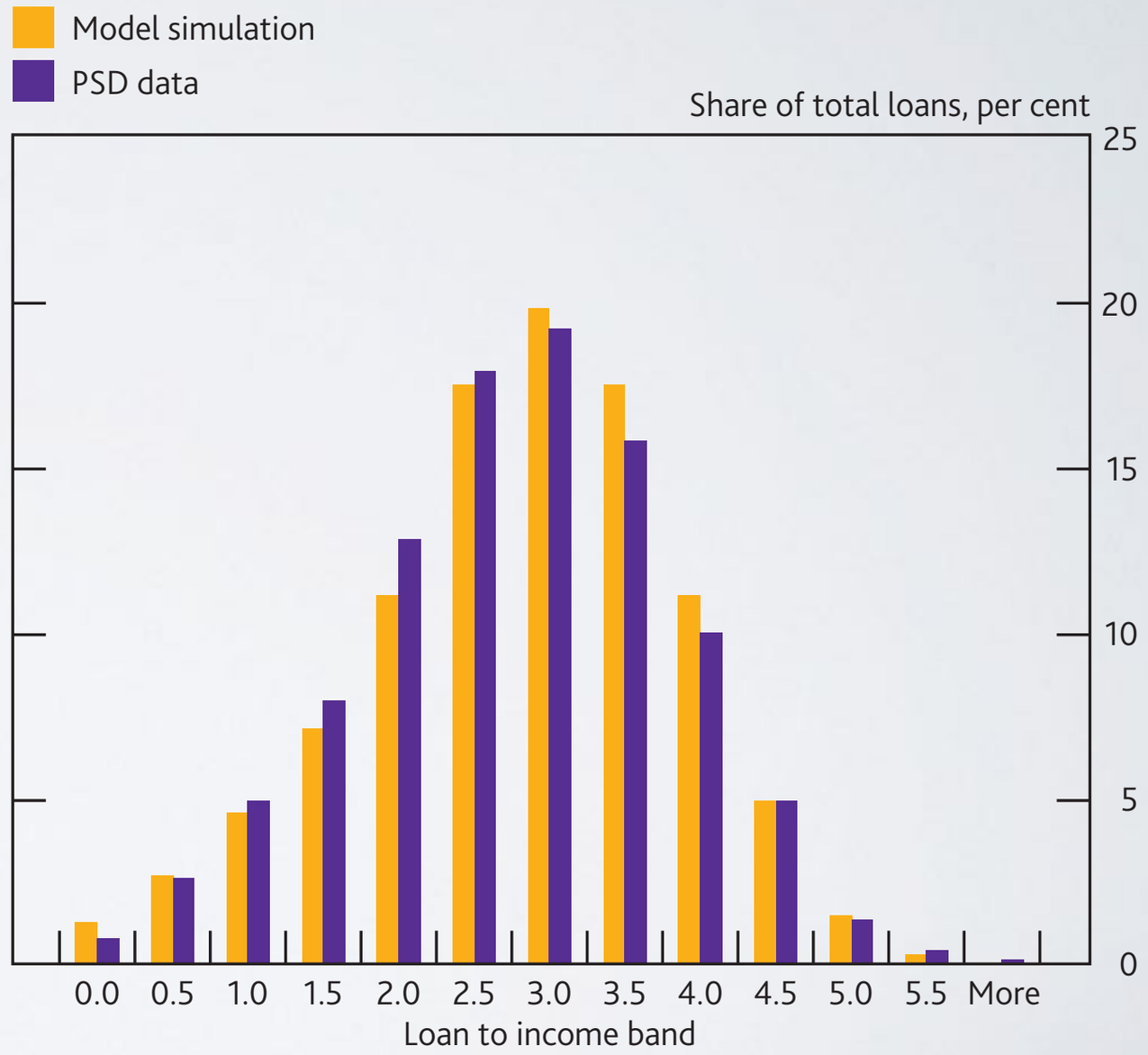


"To whatever degree we might imagine our knowledge of the properties of the several ingredients of a living body to be extended and perfected, it is certain that no mere summing up of the separate actions of those elements will ever amount to the action of the living body itself."

–JS Mill, *A System of Logic*, 1843

PRECEPTS

- Asynchronous behaviour
- Interactivity
- Mobility
- Distribution
- Non-determinism/ emergence



KNOWING IN ABM VS KNOWING IN MAINSTREAM MACRO

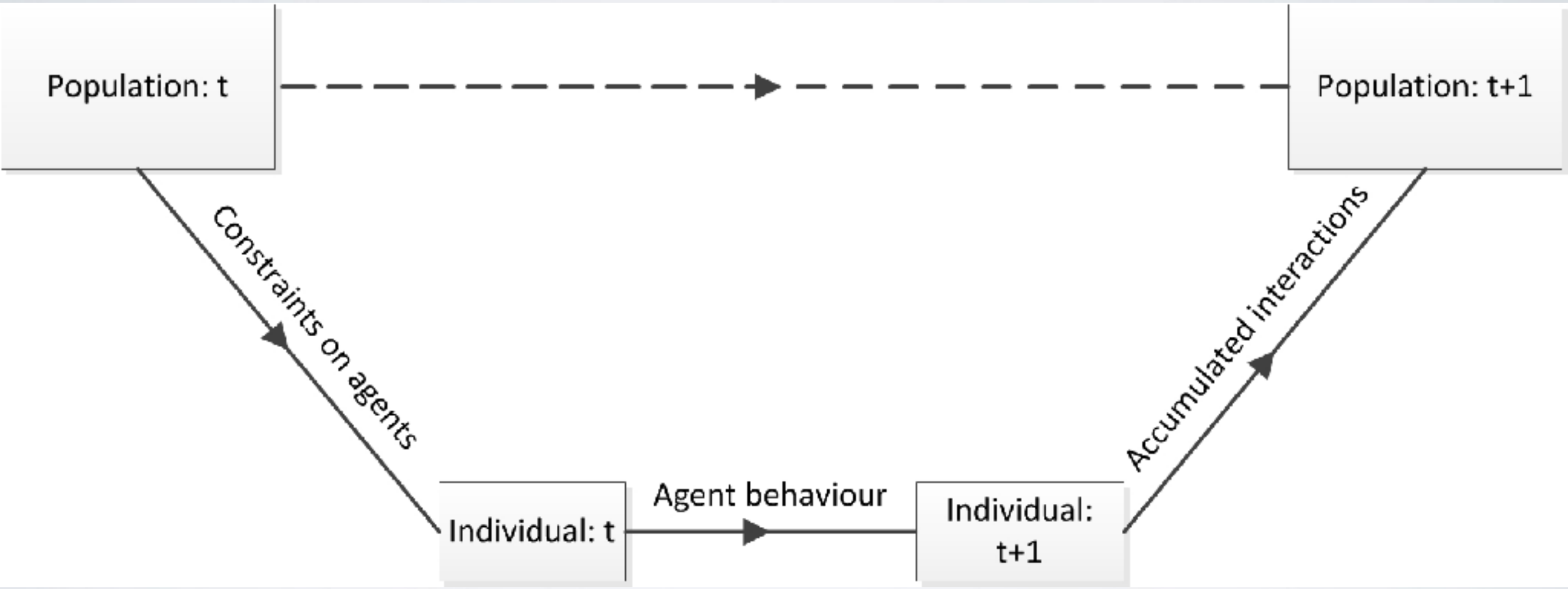
- *Mechanistic* models: hypothesised relationships between agents.
- Nature of the relationship is the data-generating process.
- Parameters often independent of data.
- Detailed microstructures
- Models validated by qualitative comparison, often to patterns in real world.

- *Statistical* models- Phenomenological, hypothesised relationship between data set variables.
- Relationship seeks 'best fit' to data. It is *Descriptive*.
- Stripped down microstructures
- Validated by quantitative comparison

QUASI-STATISTICAL PROCESSES IN ABM

- Estimation of parameters
- Testing of hypotheses (before and after)
- Covariation/ANOVA type modelling
- Prediction/Forecasting
- Model selection, models within models.

COLEMAN'S BOAT



COLEMAN'S BOAT (2)

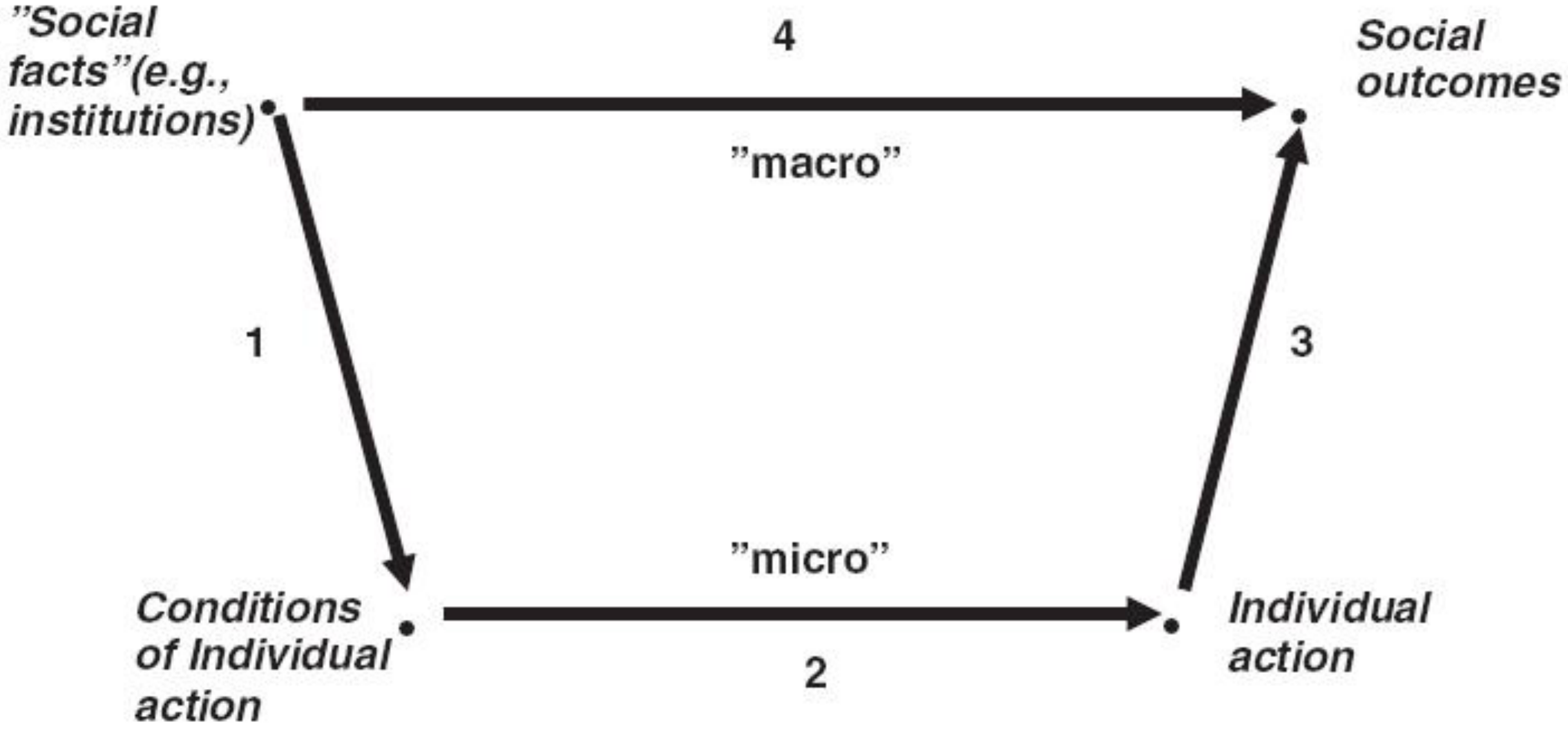
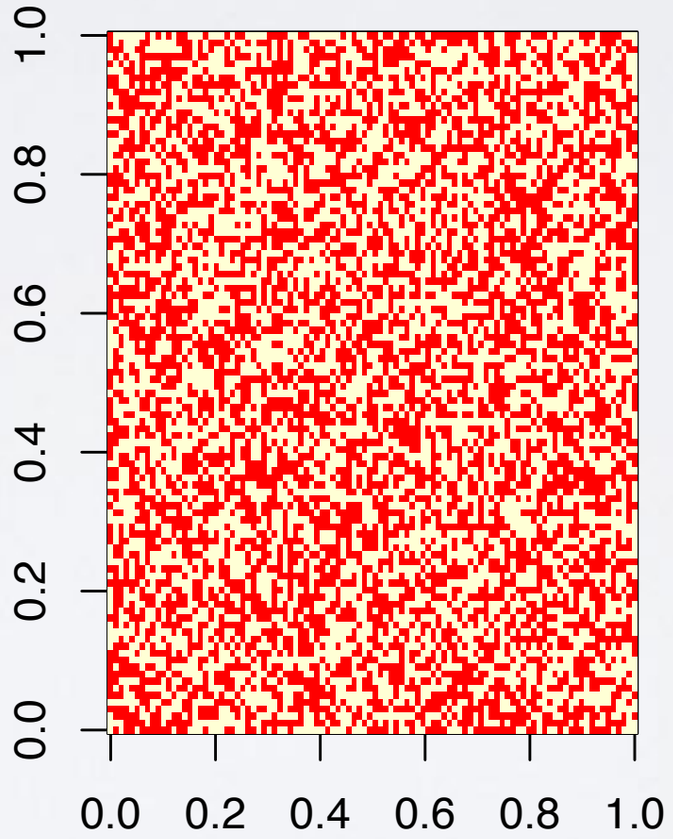


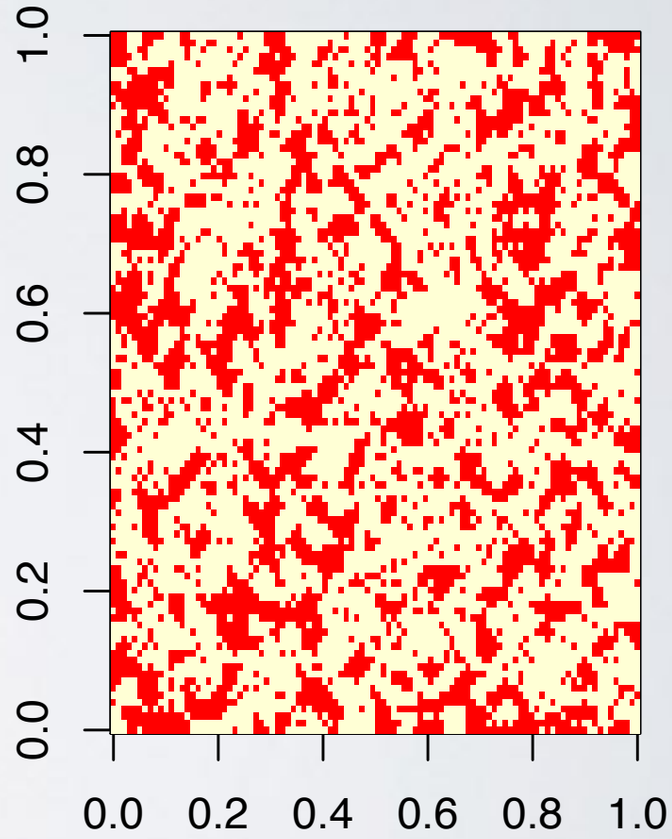
Figure 1. A general model of social science explanation.

ABMS IN ECONOMICS

- See Gallegati's *Paradigm Lost* (2012) for detailed history, focusing on macro ABMS.

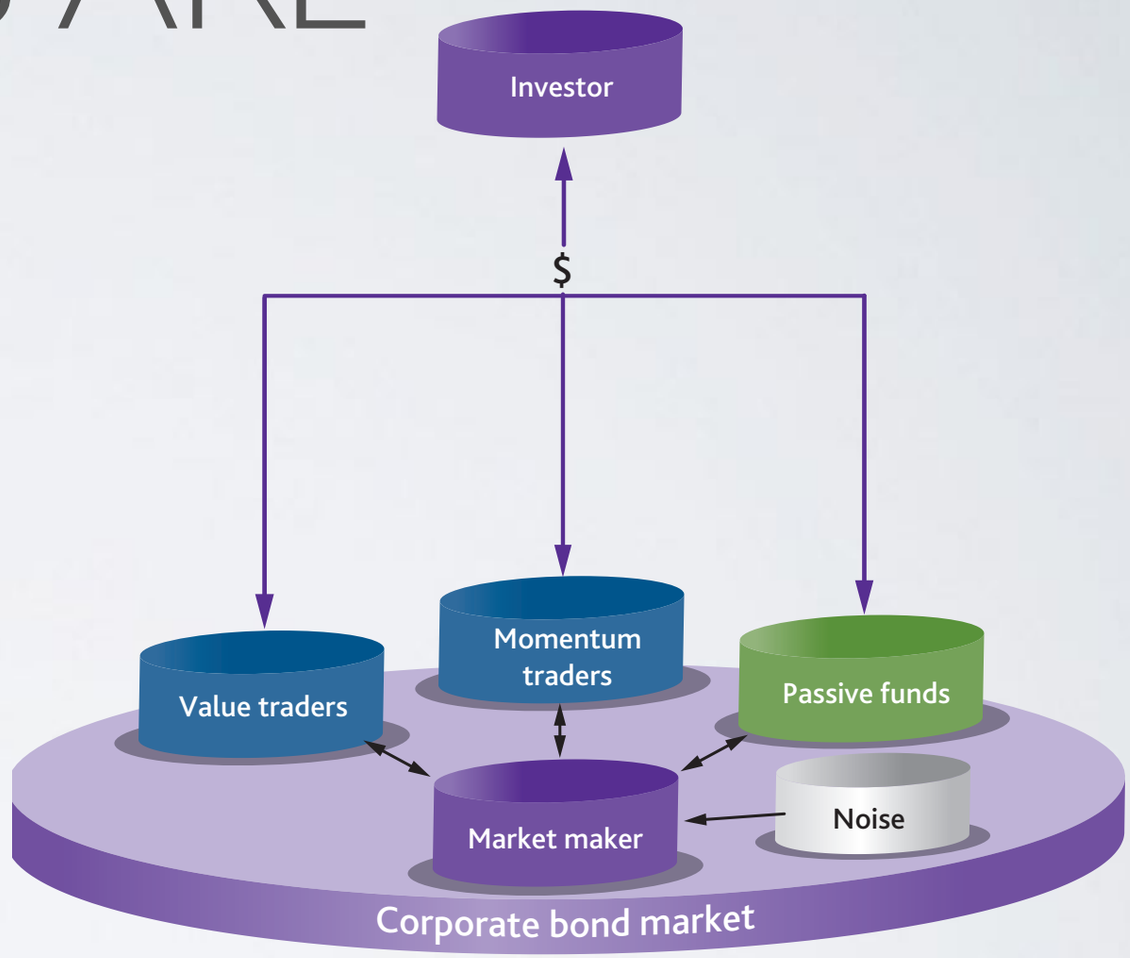
- Schelling's Model of Segregation —>





AT PROGRAMMATIC LEVEL, ABMS ARE

- Agents
- Rules
- Loops
- An example ABM using Rock, Paper, Scissors.

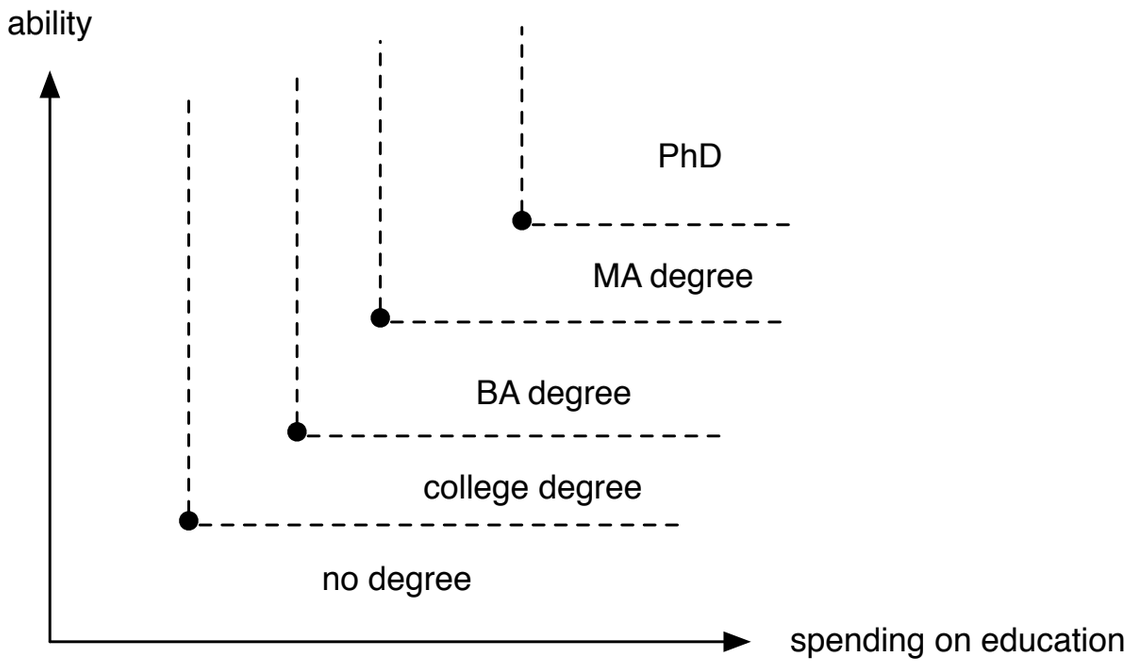


AB-SFC PAPERS TO CHECK OUT

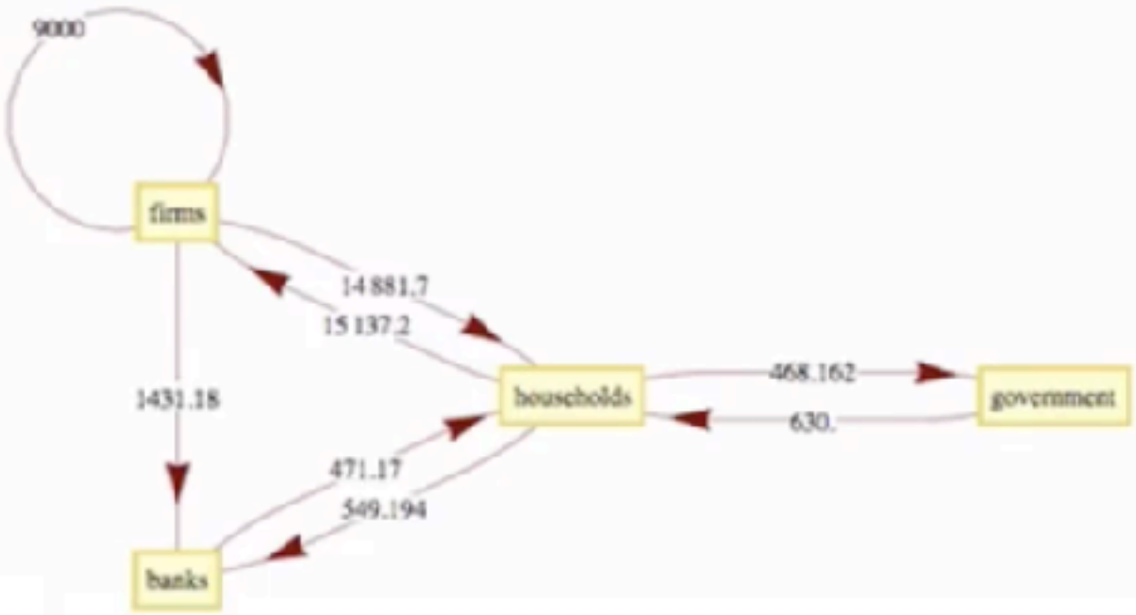
- Focus on credit and finance:
  - EURACE (Deisseberg et al. 2008, Raberto et al. 2012)
  - JMAB-Ancona (Caiani et al. 2016, 2017),
  - Russo et al., Pisa (Dosi et al. 2010, 2013, 2015, 2017)
- Explicit focus on PK economics:
  - Seppecher et al.(2016, 2017) on learning, etc
  - Caiani et al. (2016) on credit and endogenous money
  - Schasfoort et al. (2017) on monetary policy channels

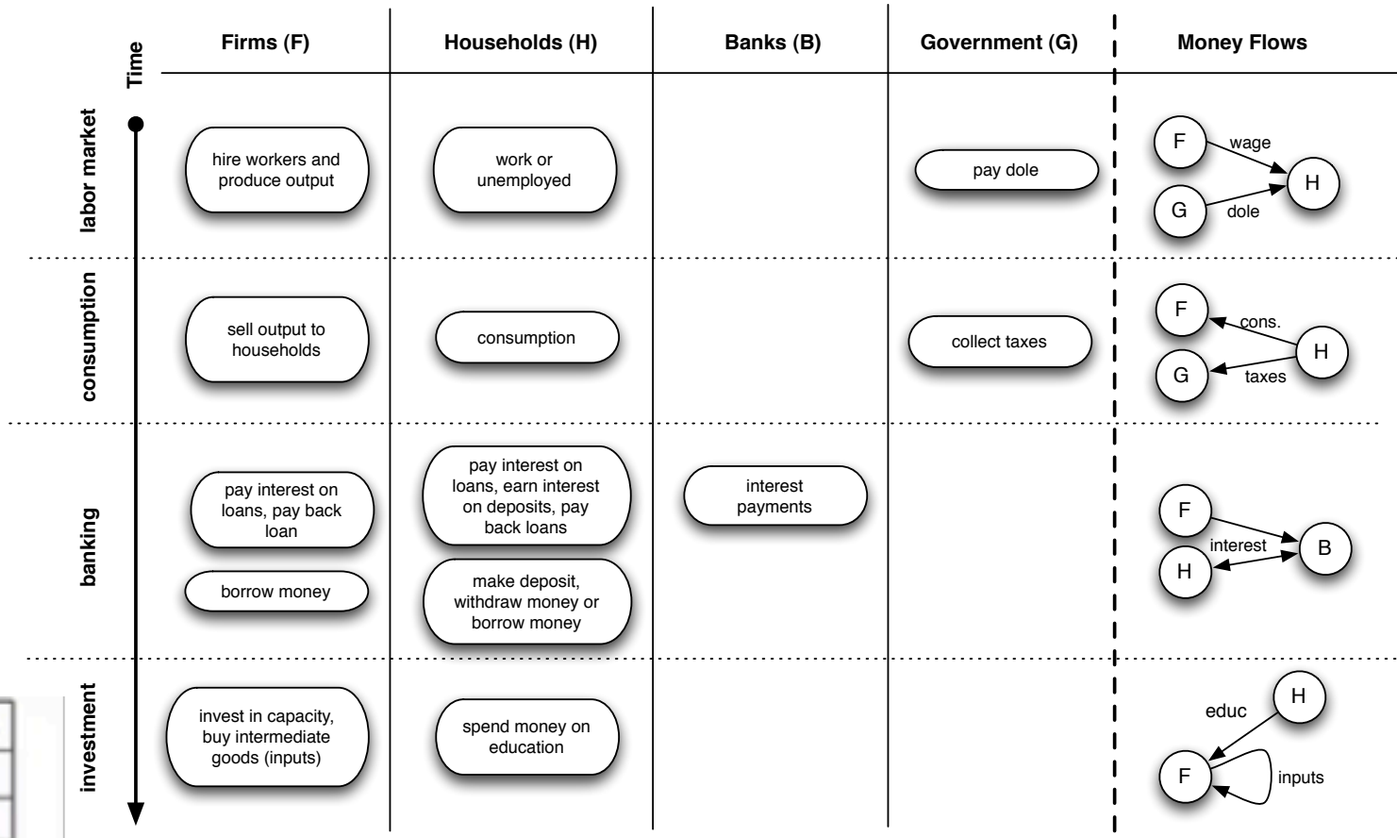
MORE EXAMPLES

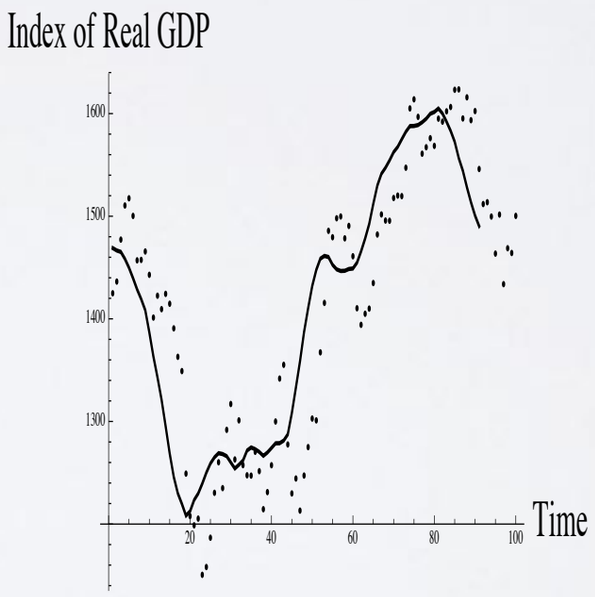
- Kinsella et al, *Income Distribution in a Stock-Flow-Consistent Model with Education and Technological Change* EEJ, 2011
- Caiani et al, Agent based-stock flow consistent macroeconomics: Towards a benchmark model JEDC, 2016
- Xiong et al, Peer Effects in the Diffusion of Innovation, JBEE, 2016



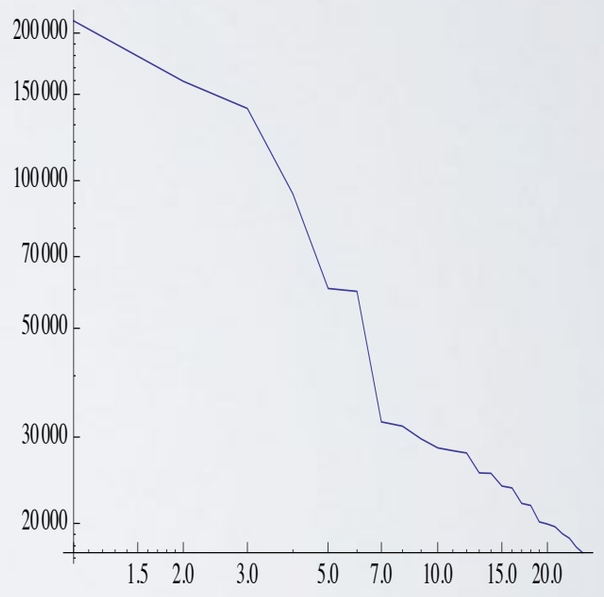
	Households	Firms	Banks	Government	SUM
Consumption	-15 605.4	15 137.2		468.162	0
Wages	14 881.7	-14 881.7			0
Dole	630.			-630.	0
terest on deposits	471.17		-471.17		0
Interest on loans	-549.194	-1431.18	1980.37		0
Bad debt	0	0	0		0
SUM	-171.702	-1175.66	1509.2	-161.838	0





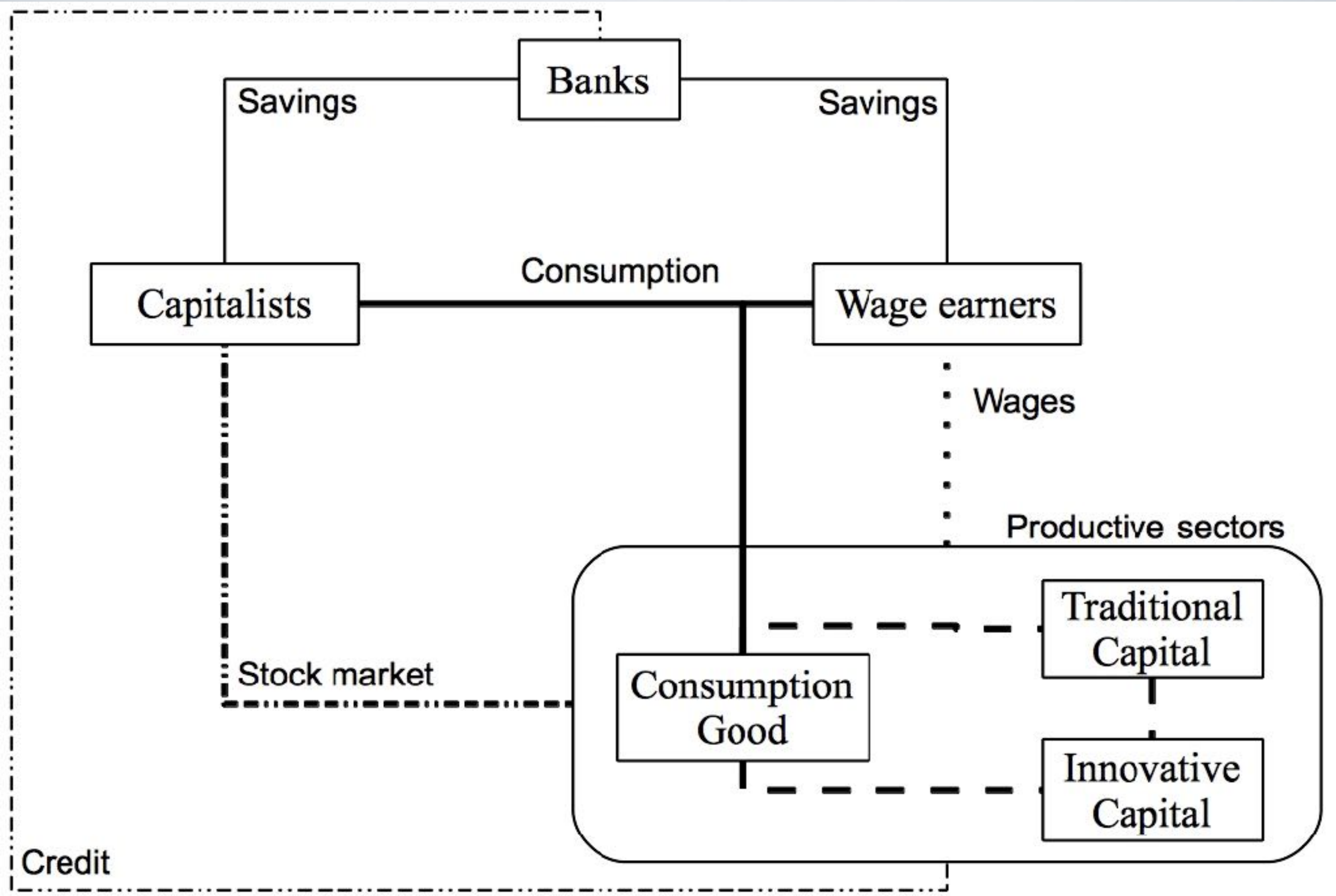


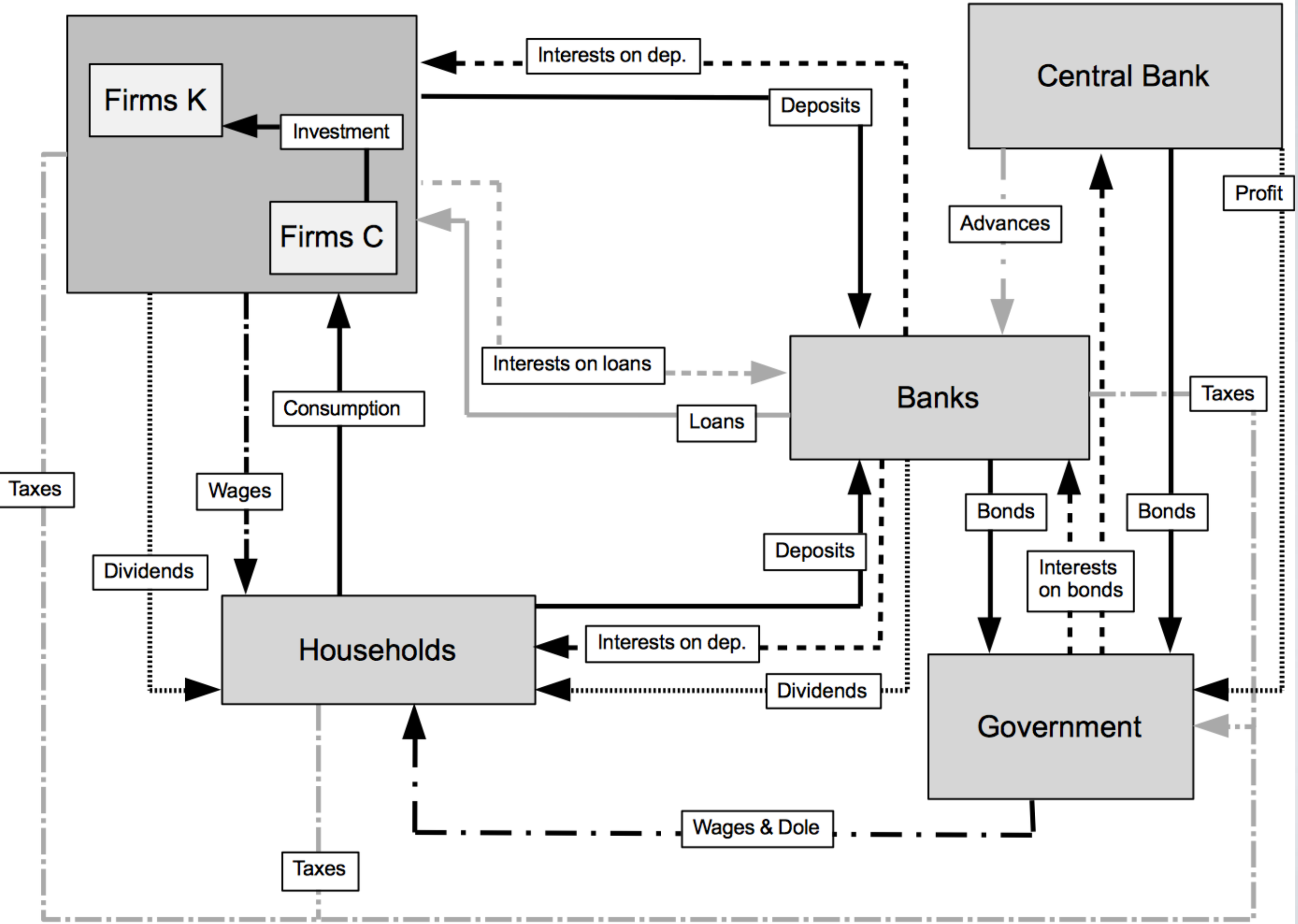
(a) Real GDP clearly shows business cycles, black line is a 5-period moving average.



(b) Top 5% of the income distribution, Pareto-distributed with $\alpha = 1.51$, tested with Kolmogorov-Smirnov tests in line with Clauset et al. (2009).

Caiani et al, JEDC, 2016.




Firms K
Investment
Firms C
Interests on dep.
Deposits
Central Bank
Profit
Advances
Interests on loans
Consumption
Loans
Banks
Taxes
Taxes
Wages
Bonds
Bonds
Deposits
Interests
on bonds
Dividends
Households
Interests on dep.
Dividends
Government
Wages & Dole
Taxes

planning:

labour & investment demand; prices, interest, regulation, wage demand

interaction 1:

capital, credit & labour market interaction

interaction II:

consumption, interest, bonds, loan repayment; wages, benefits, taxes, defaults

financial allocations:
deposits, bonds, interbank market, reserves

Simple Agent

History

Income

Unemployment

Strategies

Consumption Strategy.

Investment Strategy

Price setting Strategy

Expectations

Prices

Sales

StockMatrix

Assets

Bond 1 | Bond 2 | Bond 3 | Bond 4

Deposit 1 | Deposit 2

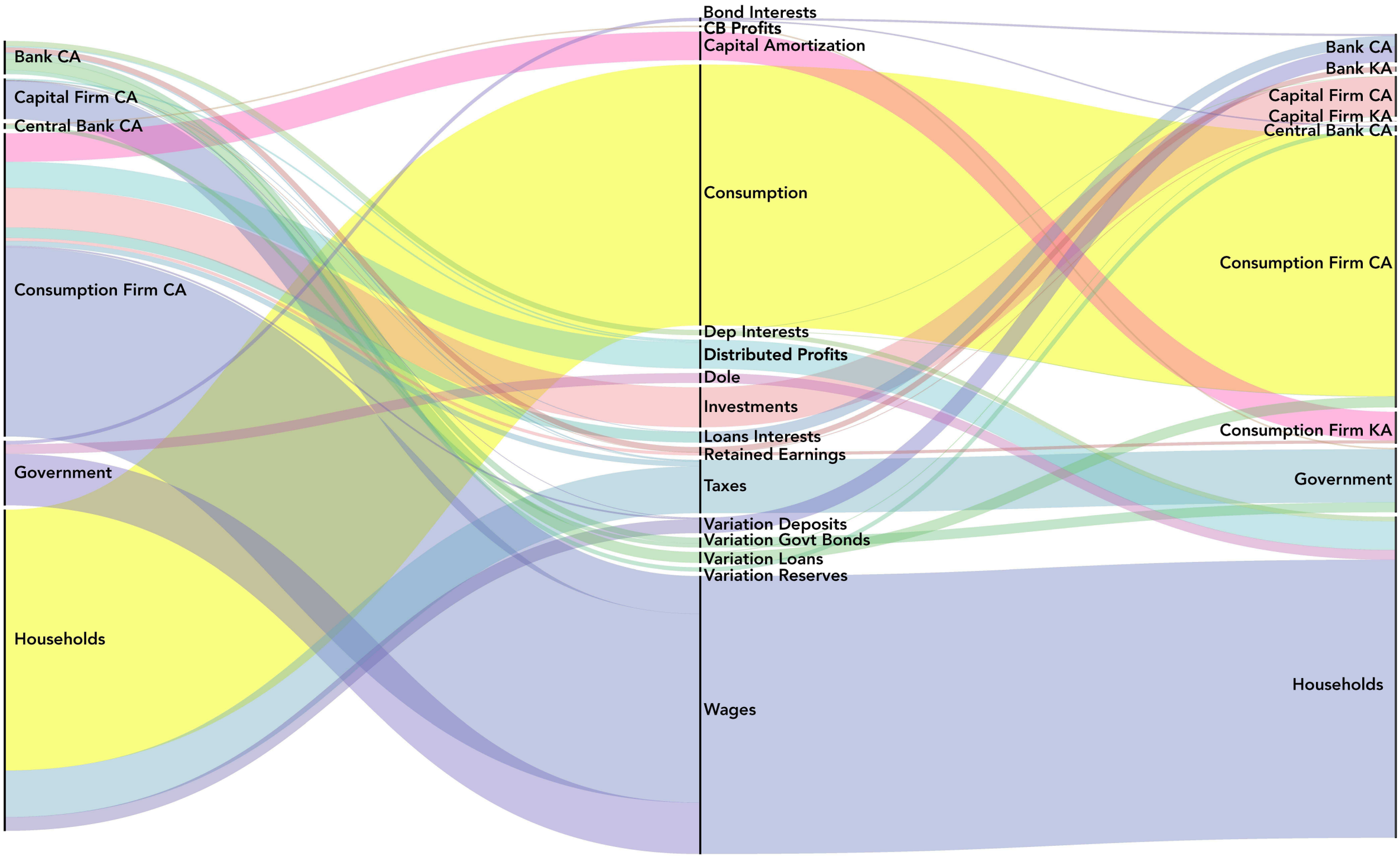
Capital good 1 | Capital good 2

Liabilities

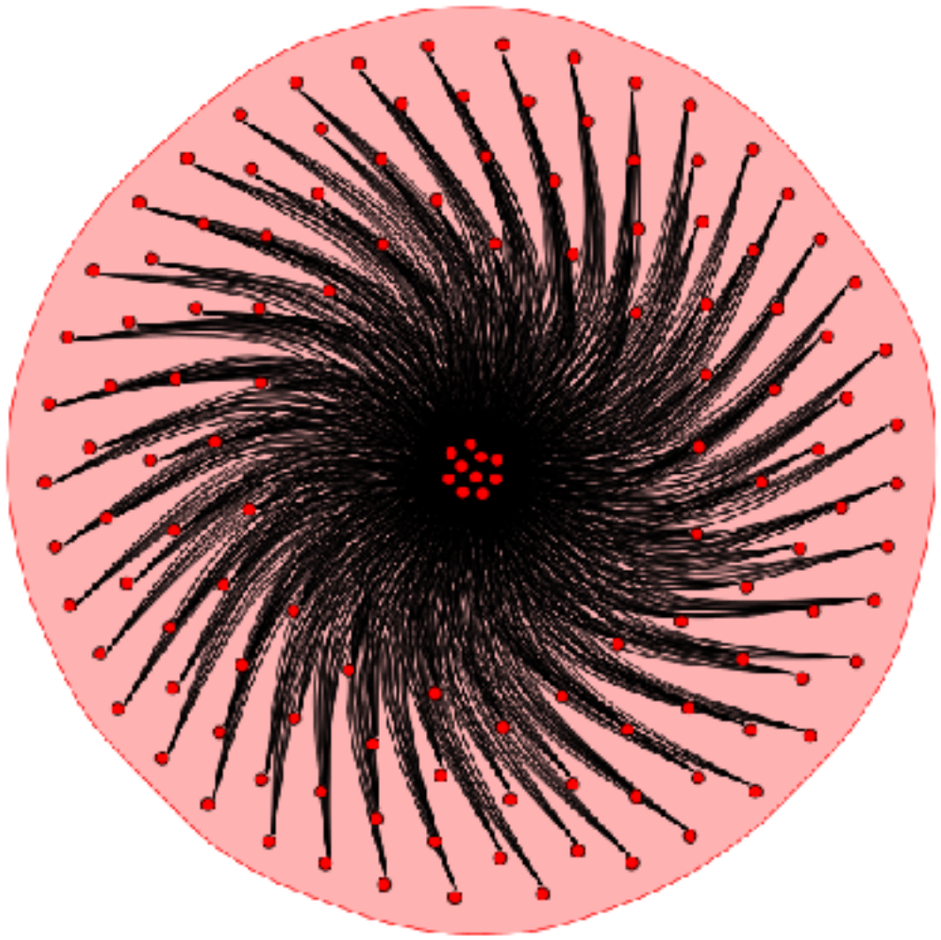
Loan 1 | Loan 2 | Loan 3 | Loan 4

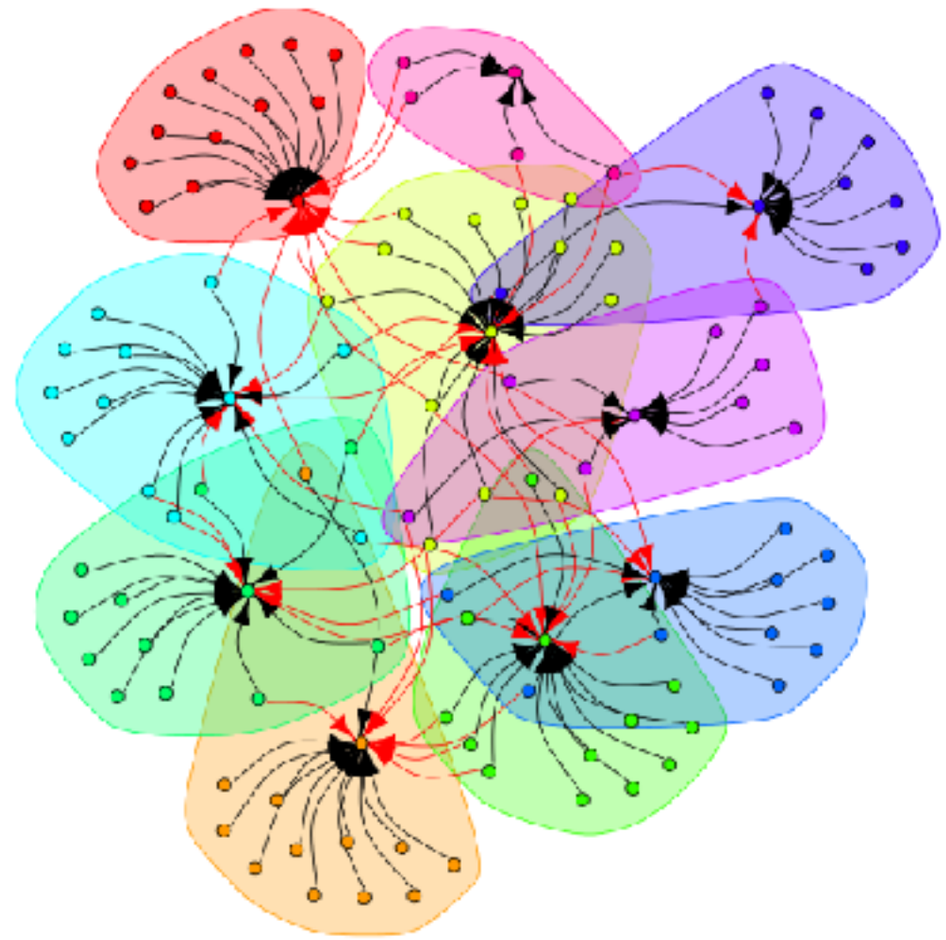
Deposit 1 | Deposit 2

Fund flows per period

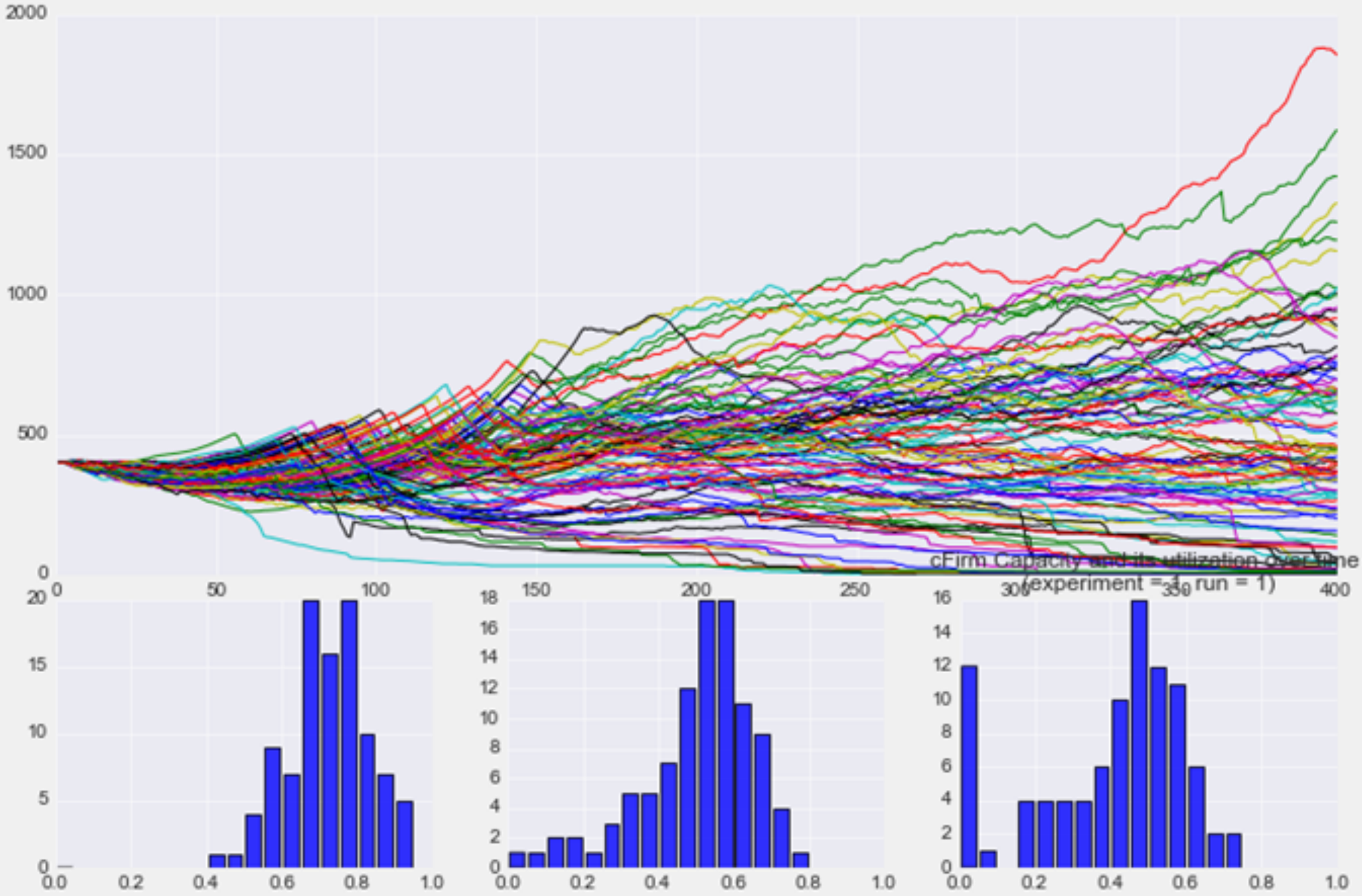


Evolution of Banking Network

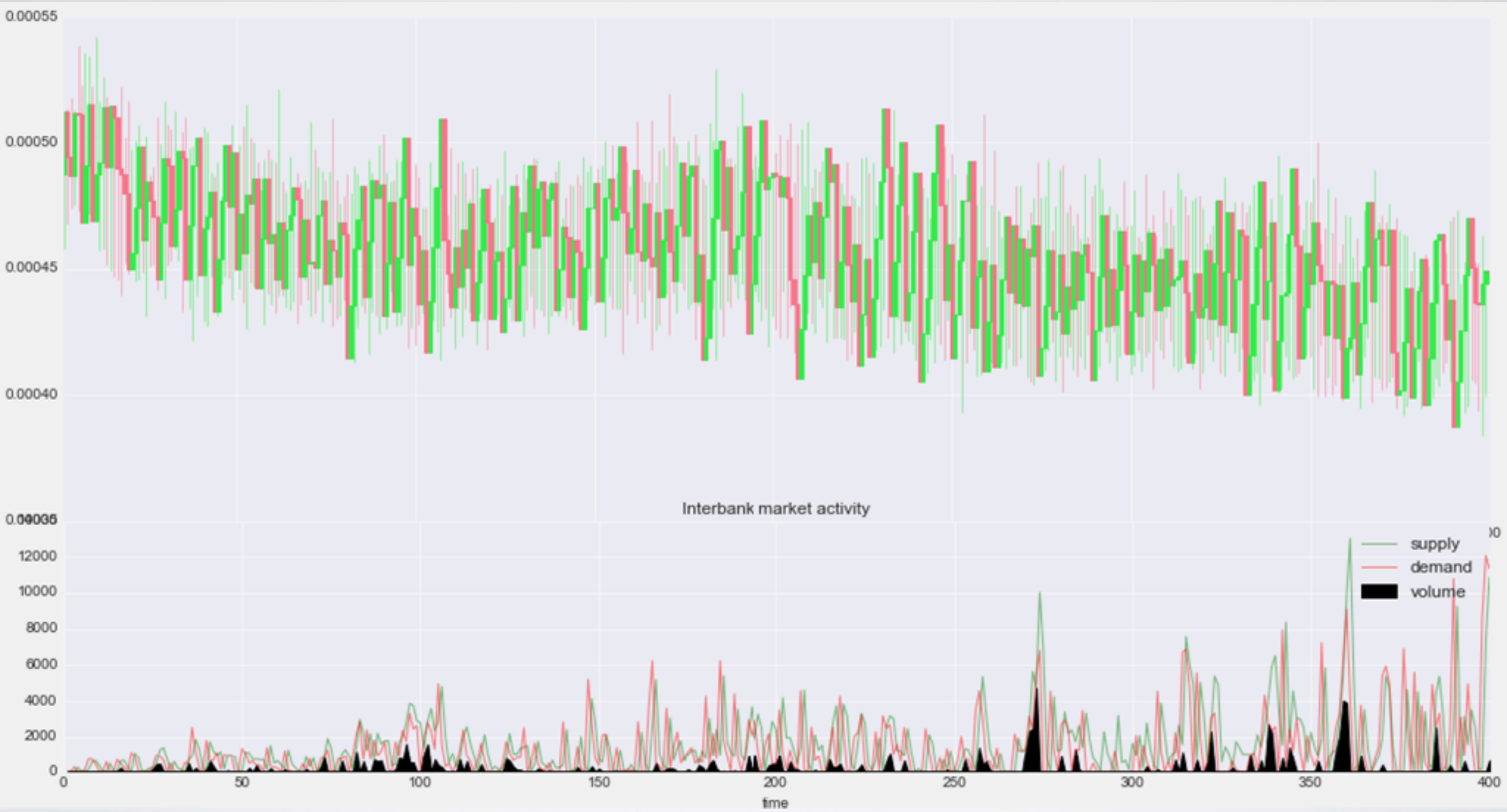




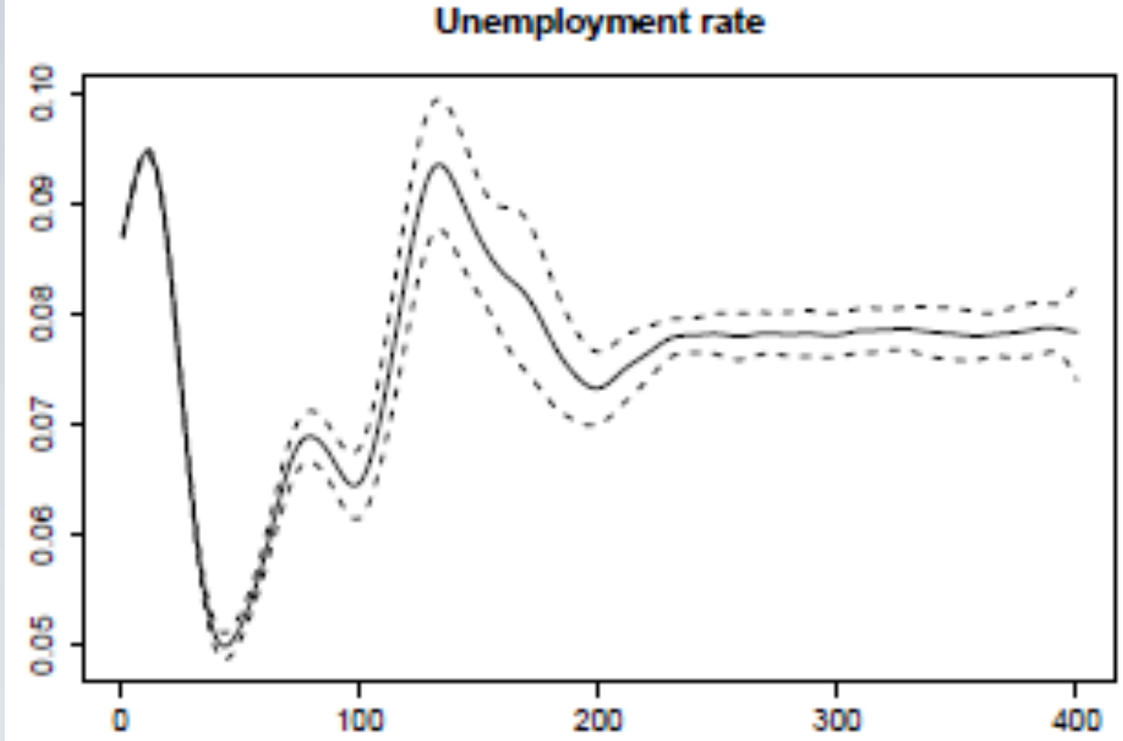
Evolution of firm size distribution

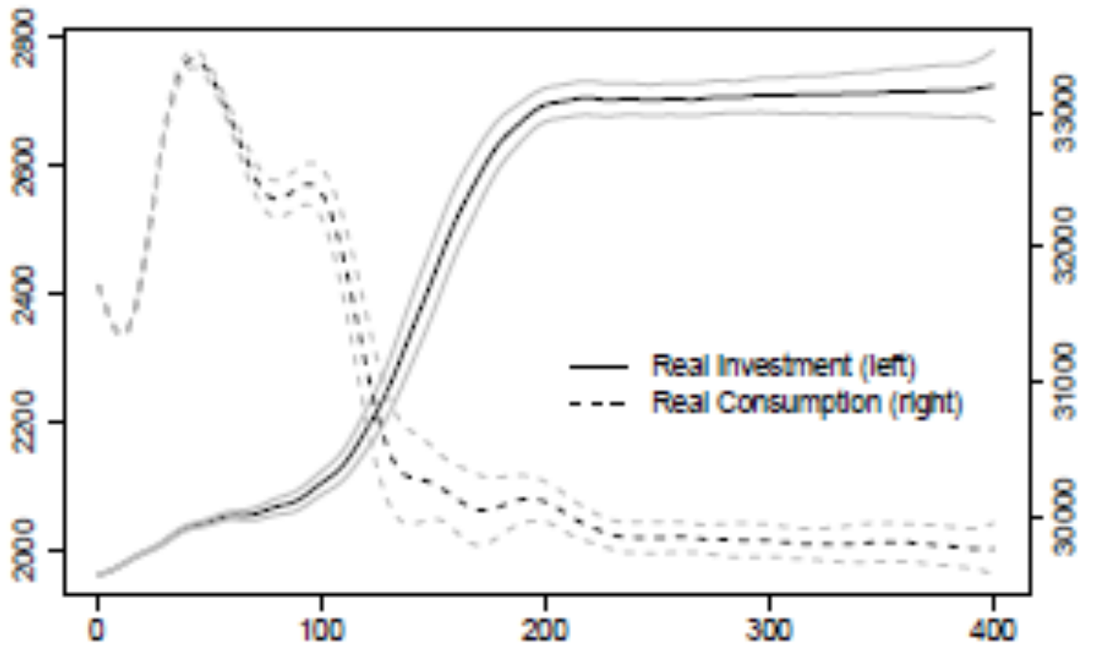


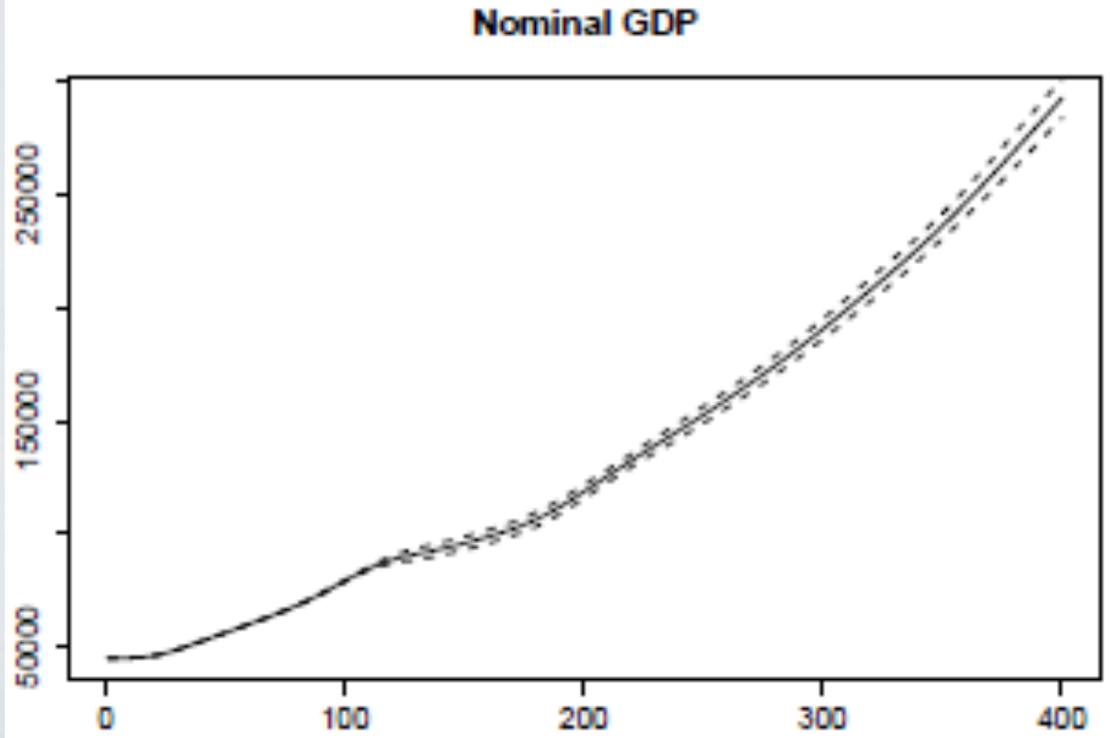
Schaasfort (2017): Interbank market

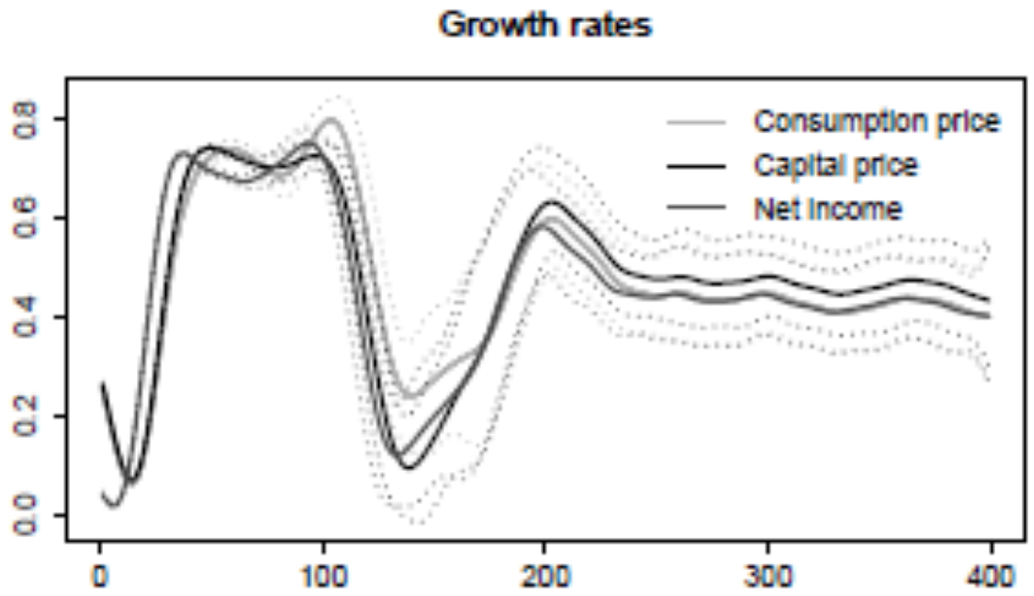


Long Term Dynamics









Xiong et al, 2016

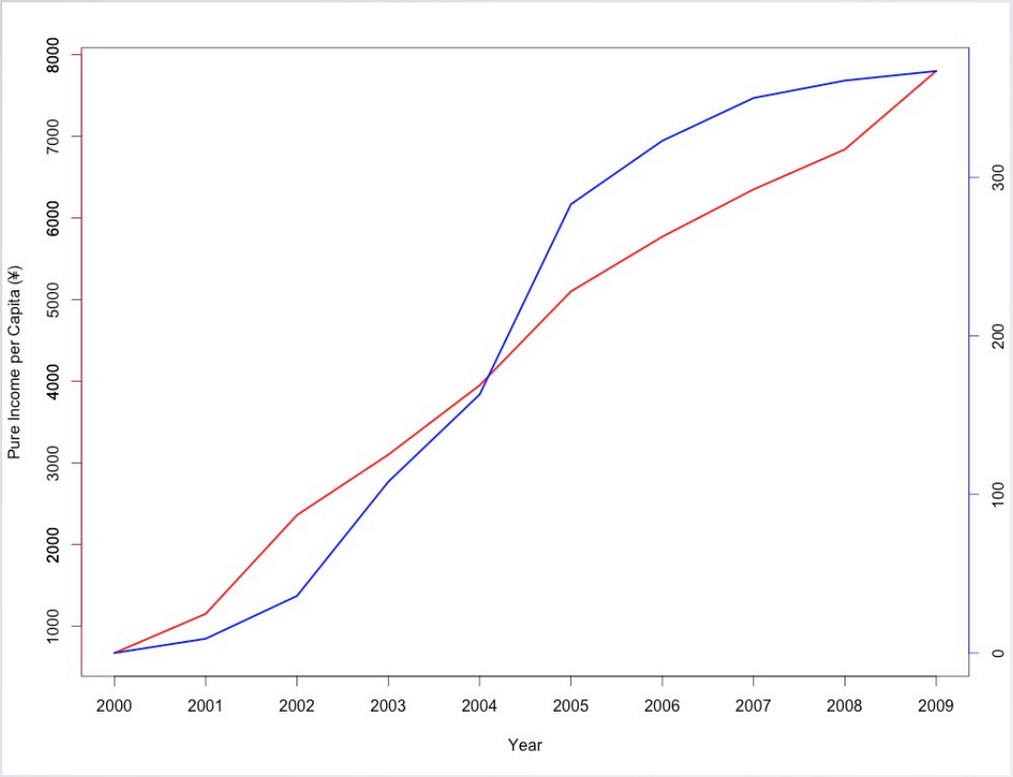


Fig. 1: Diffusion Curve and Income Growth

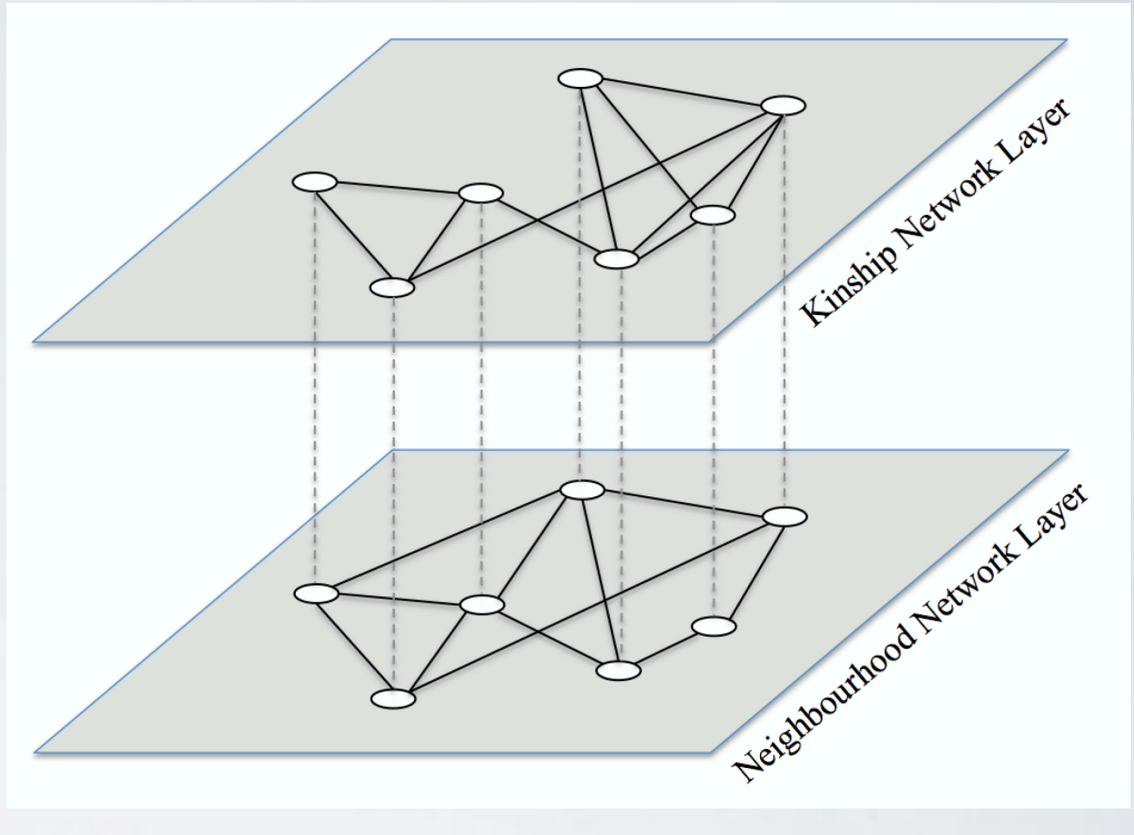


Fig. 2: Two-layer Multiplex Network

Tab. 4: Estimation Results

	γ (1)	η (2)	h (3)
Panel A: Experience Model			
Pure Experience Effect	4.10		
Standard Error	[0.2569]		
99% CI of Bootstrap Distribution	[3.84, 5.16]		
Close Relatives	3.32		
Standard Error	0.2425		
99% CI of Bootstrap Distribution	[2.73, 3.98]		
Proximity in Age	4.50	0.275	
Standard Error	[0.2964]	[0.1231]	
99% CI of Bootstrap Distribution	[3.72, 5.25]	$[-0.04, 0.60]^{\dagger}$	
Panel B: Experience-Externality Model			
All Years	3.60		0.30
Standard Error	[0.2929]		[0.2226]
99% CI of Bootstrap Distribution	[2.83, 4.34]		$[-0.20, 0.95]$
First 4 Years	4.80		0.42
Standard Error	[0.2979]		[0.2339]
99% CI of Bootstrap Distribution	[3.76, 5.30]		$[-0.13, 1.08]$
Last 4 years	3.10		0.48
Standard Error	[0.4477]		[0.0788]
99% CI of Bootstrap Distribution	[2.79, 4.88]		[0.13, 0.50]

† 95% CI of Bootstrap Distribution is $[0.04, 0.52]$.

30

20

5 Ideas

Pitfalls & Promise

Potential

Q&A

"We are surrounded by what looks like something we might need"

—@JohnMaeda

INTELLECTUAL ROI

- Econometrics: 50k person-years.
- DSGE, etc: 20k person-years.
- ABM models of all kinds, 500 person-years.
- AB-SFC: 10 person-years (being optimistic)

SUCCESS IS

- Doing useful, applied work that influences policy makers by answering important questions.
- How?
    - Reproduce correct stylized macro-economic facts
    - Exceed performance of DSGE and econometric models?
    - Reproduce past events (crises and bubbles)
    - Reproduce cross-sectional statistical measures
    - Reproduce key time series behaviours
    - Provide useful feedback to sub-domains e.g. eliminate some existing theories
    - Establish a community of users

SUMMARY: IDEAS

- Behaviour doesn't need explicit rules. It needs intention & Interaction.
- Behaviour often doesn't heed explicit rules, because of idea # 1
- Uncoordinated Behaviour can appear coordinated
- Coordinated Behaviour Can be Really, Really coordinated
- Micro behaviour can have macro-effects.

SUMMARY: IDEAS

- Behaviour doesn't need explicit rules. It needs intention & Interaction.
- Behaviour often doesn't heed explicit rules, because of idea # 1
- Uncoordinated Behaviour can appear coordinated
- Coordinated Behaviour Can be Really, Really coordinated
- Micro behaviour can have macro-effects.

TIPS FOR GETTING STARTED

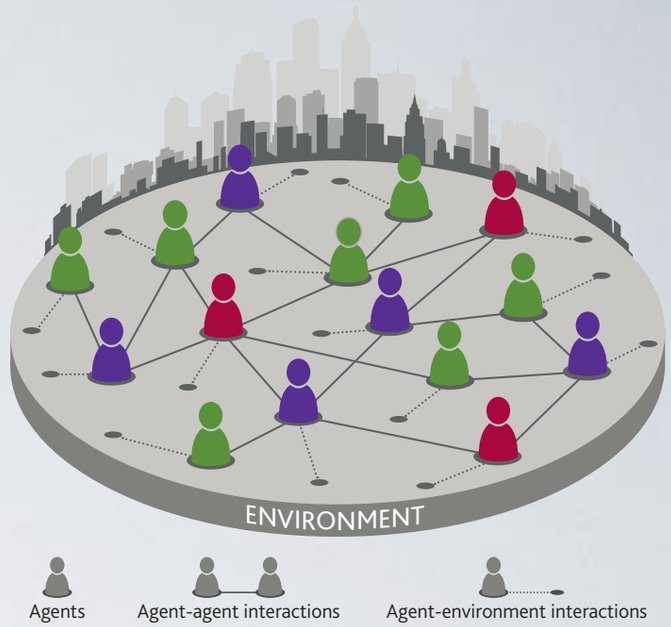
- Don't use computers. Use whiteboards.
- Start by thinking in terms of agents and behaviour, then build interactions.
- Do the accounting, carefully
- Then code it up.
- A highly non linear process: 20% of paper can take 90% of time

5 Ideas

Pitfalls & Promise

Potential

Q&A

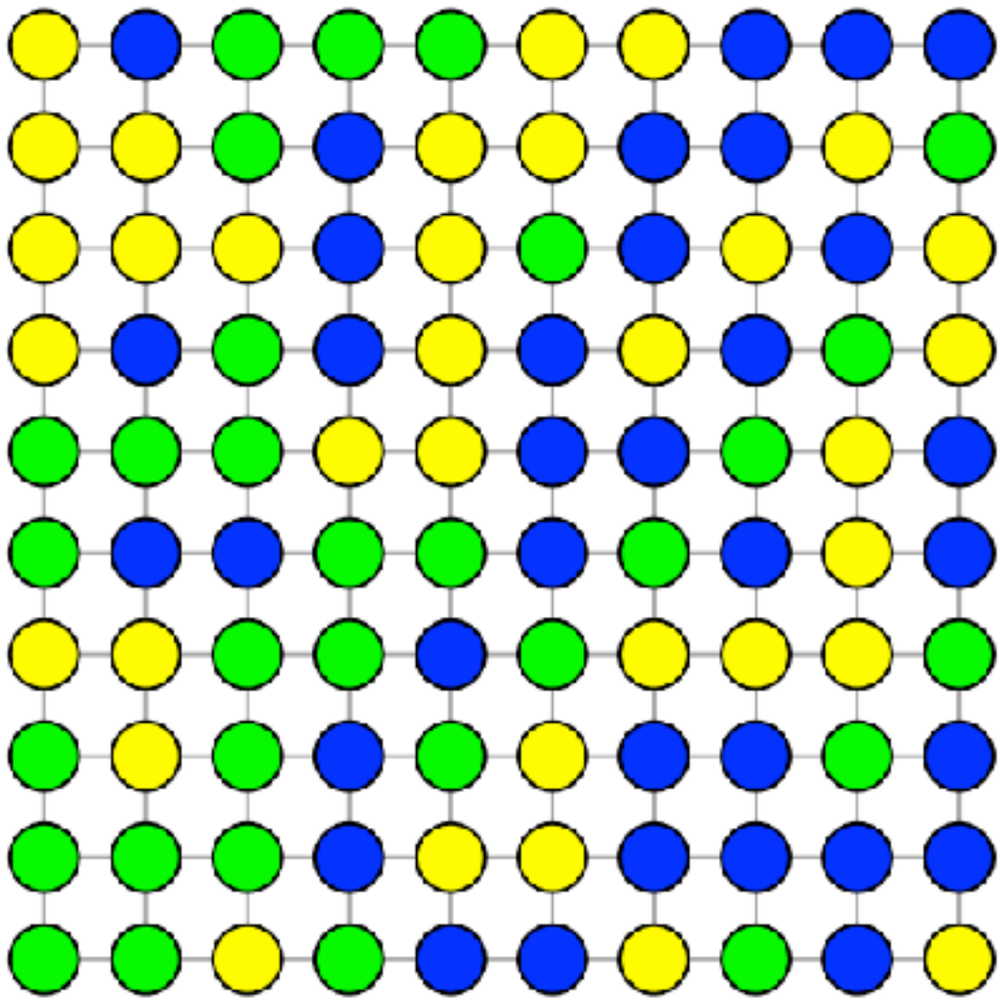


AGENT BASED MACROECONOMICS

Stephen Kinsella, University of Limerick and University of Melbourne

FMM Keynesian Summer School, 3 August 2017

LAB~ EXERCISES



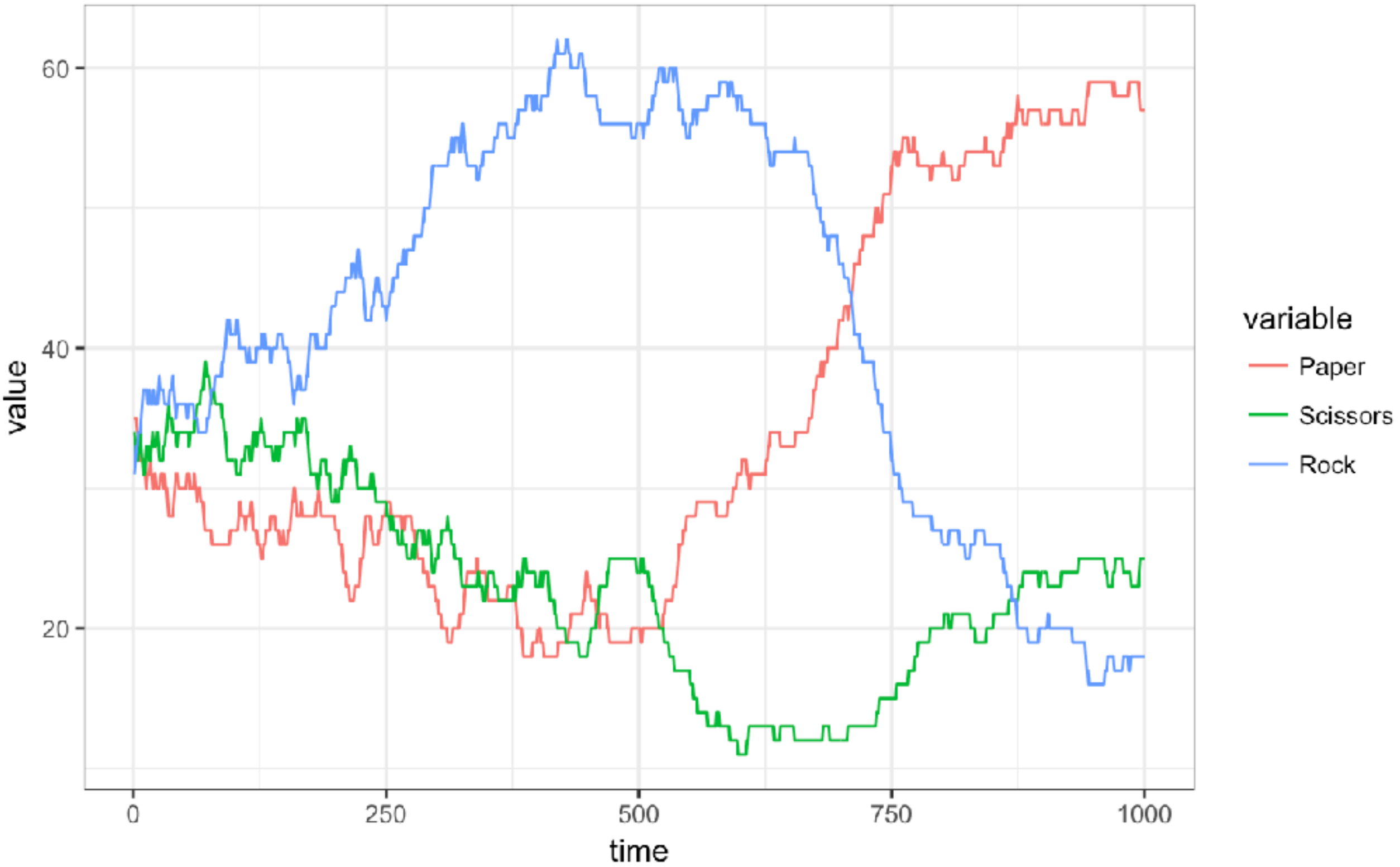
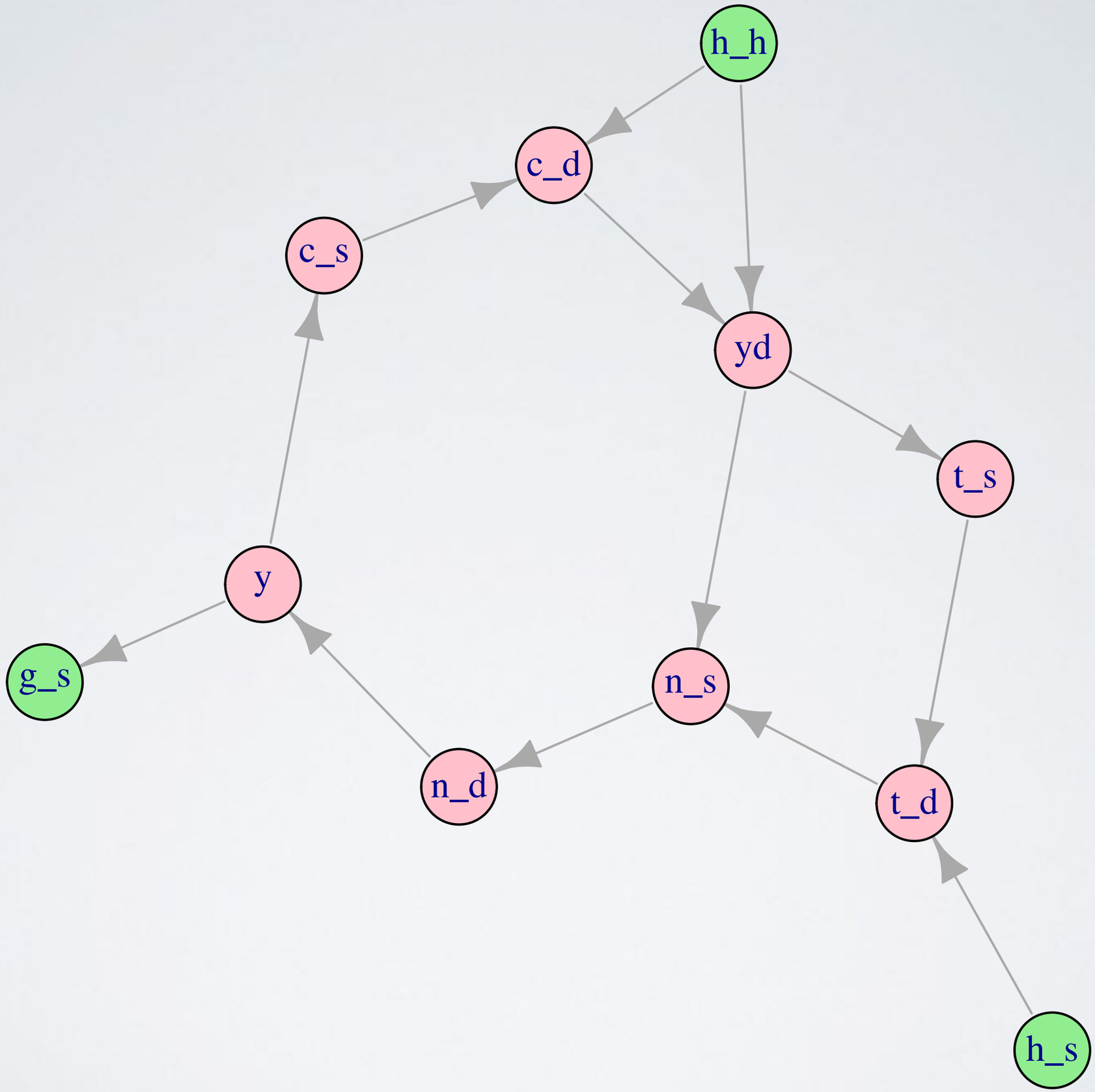

60
40
20
value
0
250
500
750
1000
time
variable
Paper
Scissors
Rock

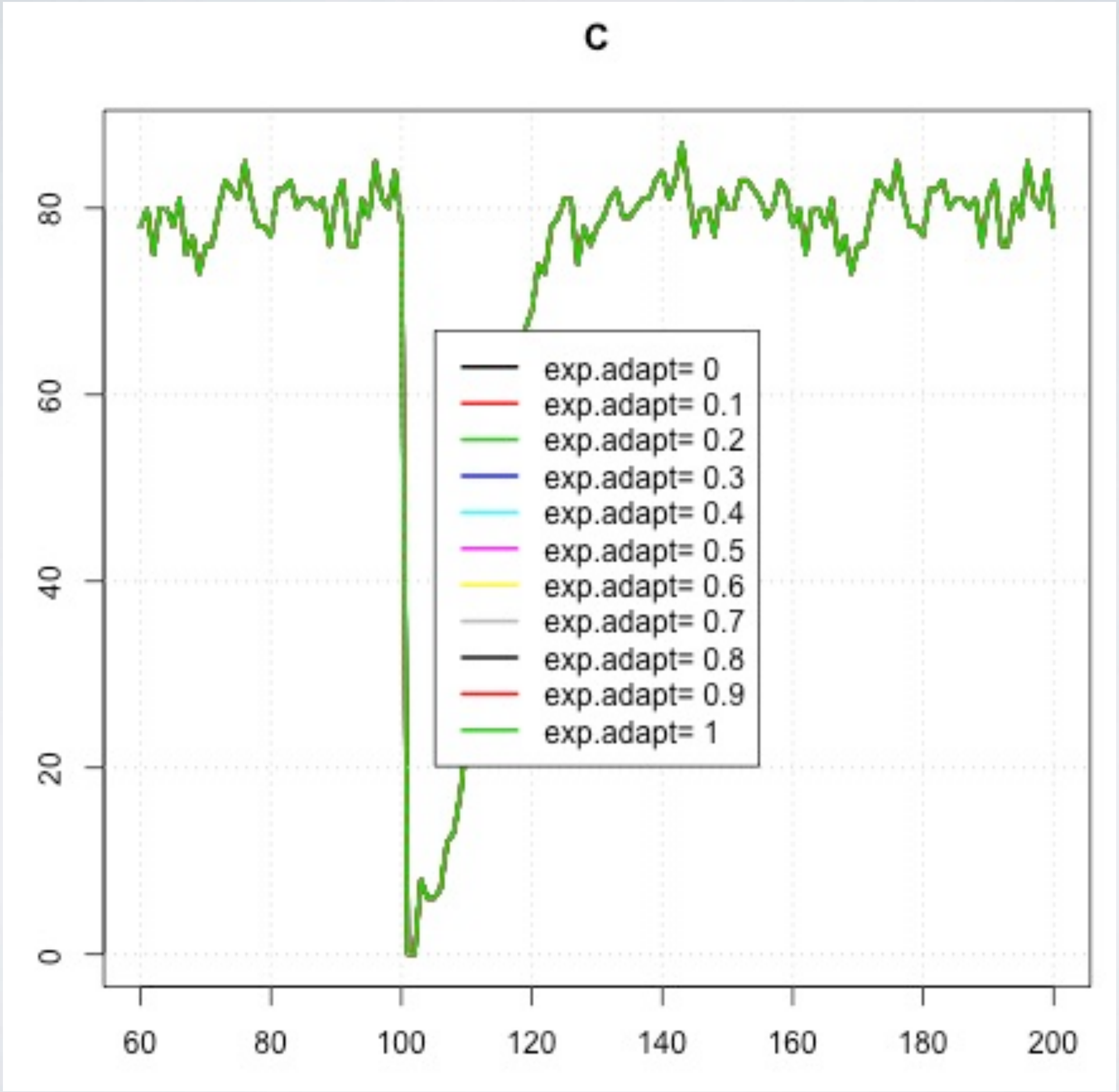
Table 3.1 Balance sheet of Model *SIM*

	1. Households	**2. Production**	**3. Government**	**Σ**
Money stock	$+H$	0	$-H$	0

Table 3.2 Accounting (transactions) matrix for Model *SIM*

	1. Households	**2. Production**	**3. Government**	**Σ**
1. Consumption	$-C$	$+C$		0
2. Govt. expenditures		$+G$	$-G$	0
3. [Output]		$[Y]$		
4. Factor income (wages)	$+WB$	$-WB$		0
5. Taxes	$-T$		$+T$	
6. Change in the stock of money	$-\Delta H$		$+\Delta H$	0
Σ	0	0	0	0


h_h
c_d
c_s
yd
t_s
y
g_s
n_s
n_d
t_d
h_s


C
80
60
40
20
0
60
80
100
120
140
160
180
200
exp.adapt= 0
exp.adapt= 0.1
exp.adapt= 0.2
exp.adapt= 0.3
exp.adapt= 0.4
exp.adapt= 0.5
exp.adapt= 0.6
exp.adapt= 0.7
exp.adapt= 0.8
exp.adapt= 0.9
exp.adapt= 1