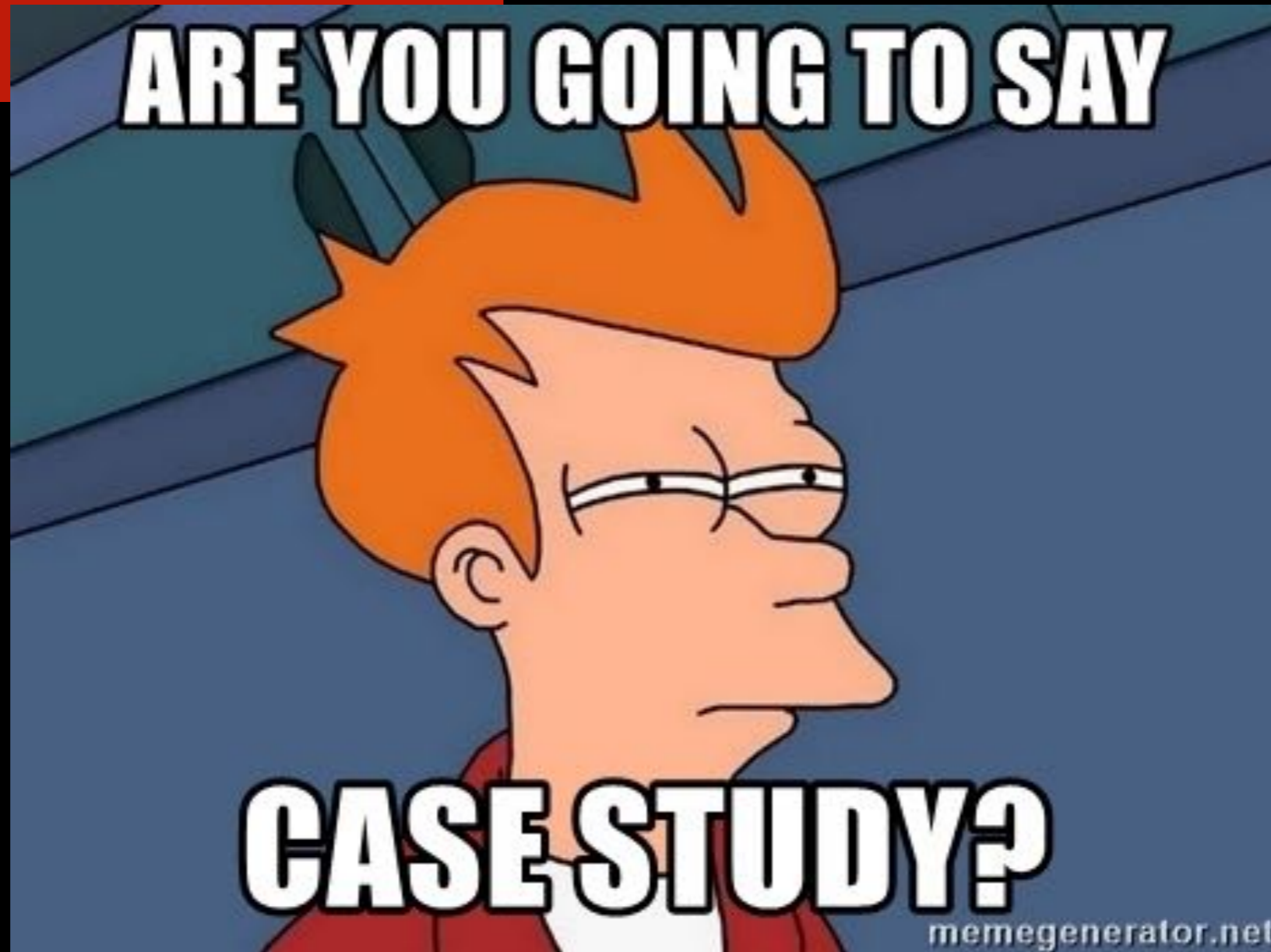


Examples of abms



Learning outcomes

See different examples of **ABMs in economics and finance**

Understand how professionals **define models**

Compare validation/calibration methods



Bonus Learning outcome

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Financial markets



Lux and Marchesi 1999

Considered one of the best early examples of ABM for financial markets

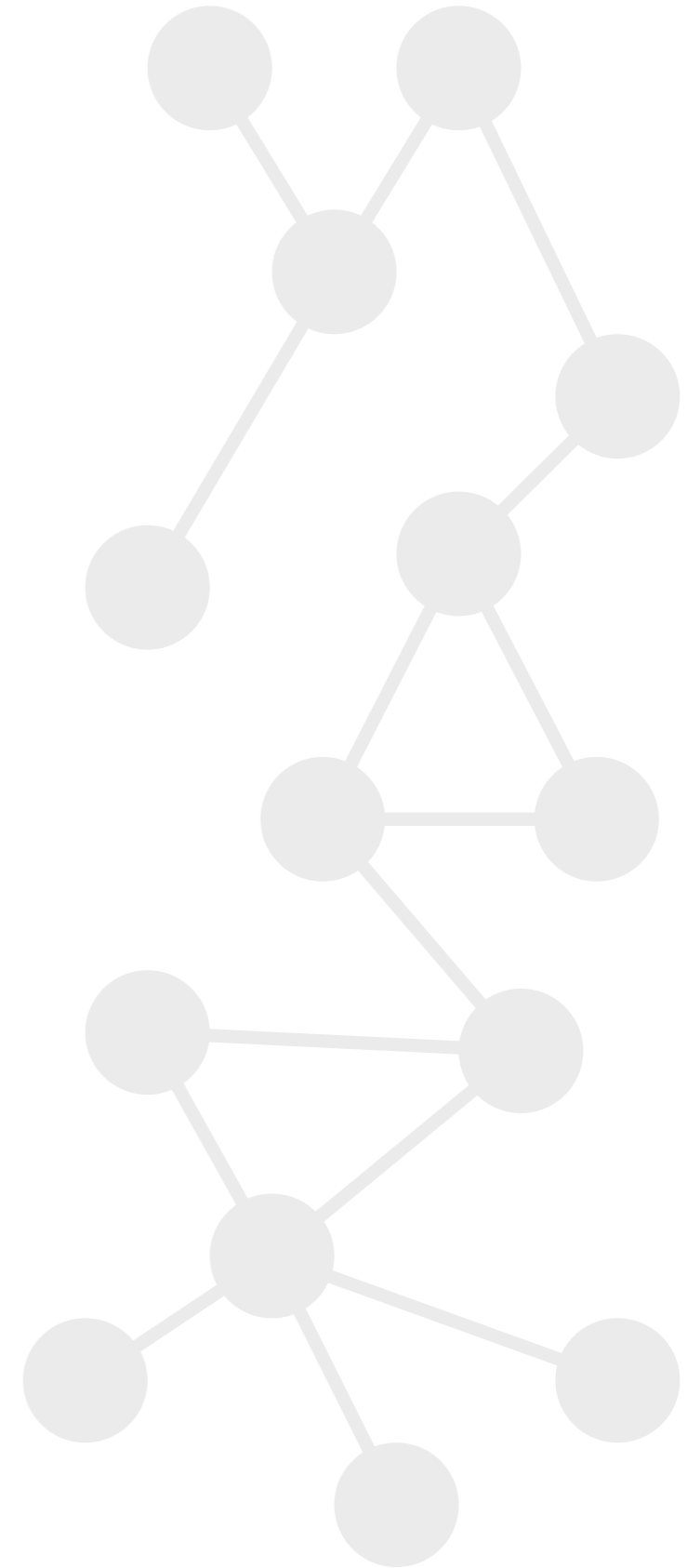
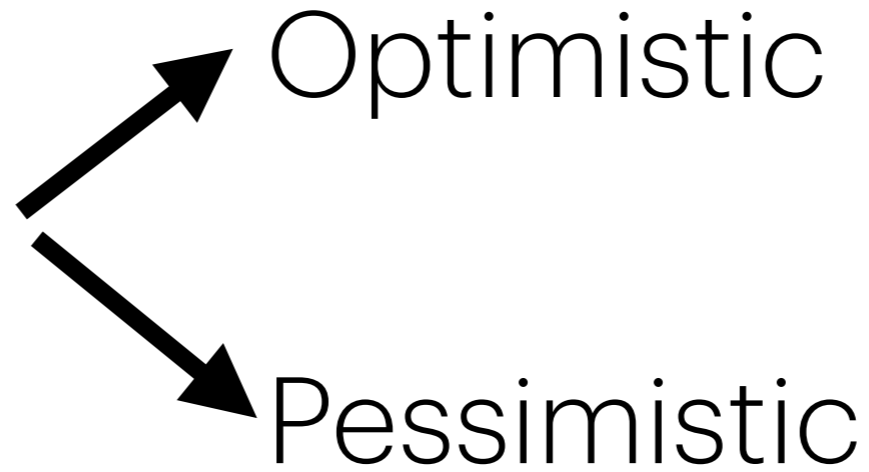
Two types of agents, switching behaviour

Many following abms were inspired by this one

Model

Fundamentalists
S

Noise traders
(chartists)

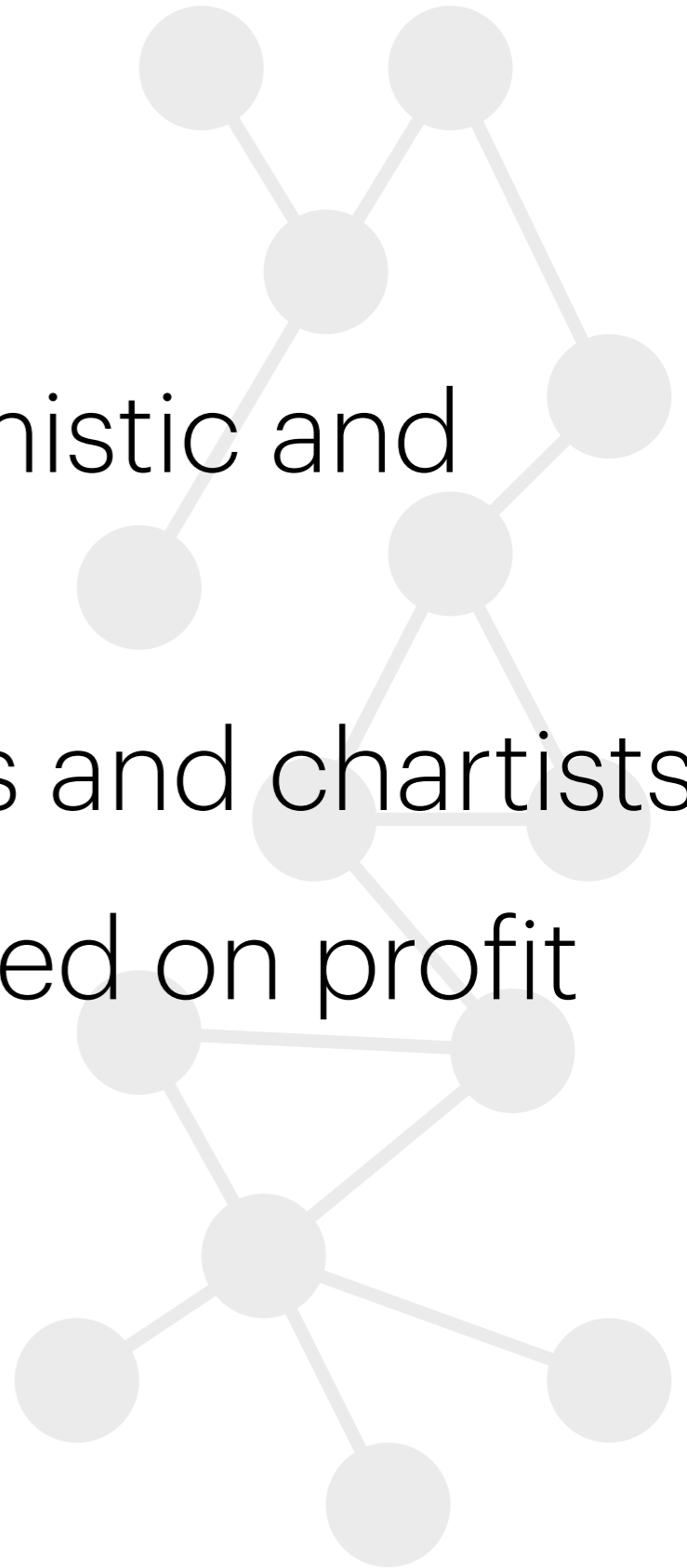


Model

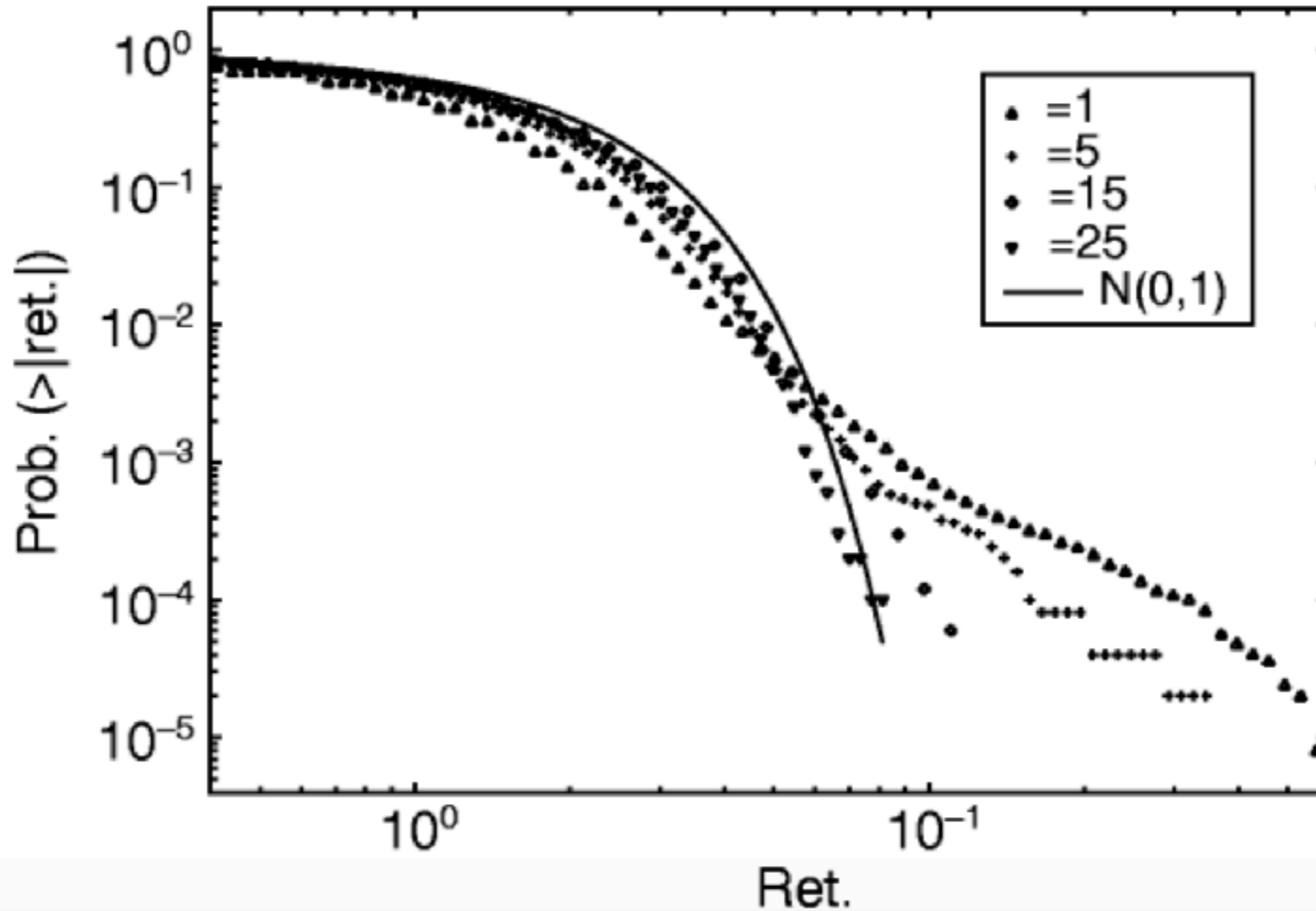
Switching behaviour between optimistic and pessimistic traders

Switching between fundamentalists and chartists

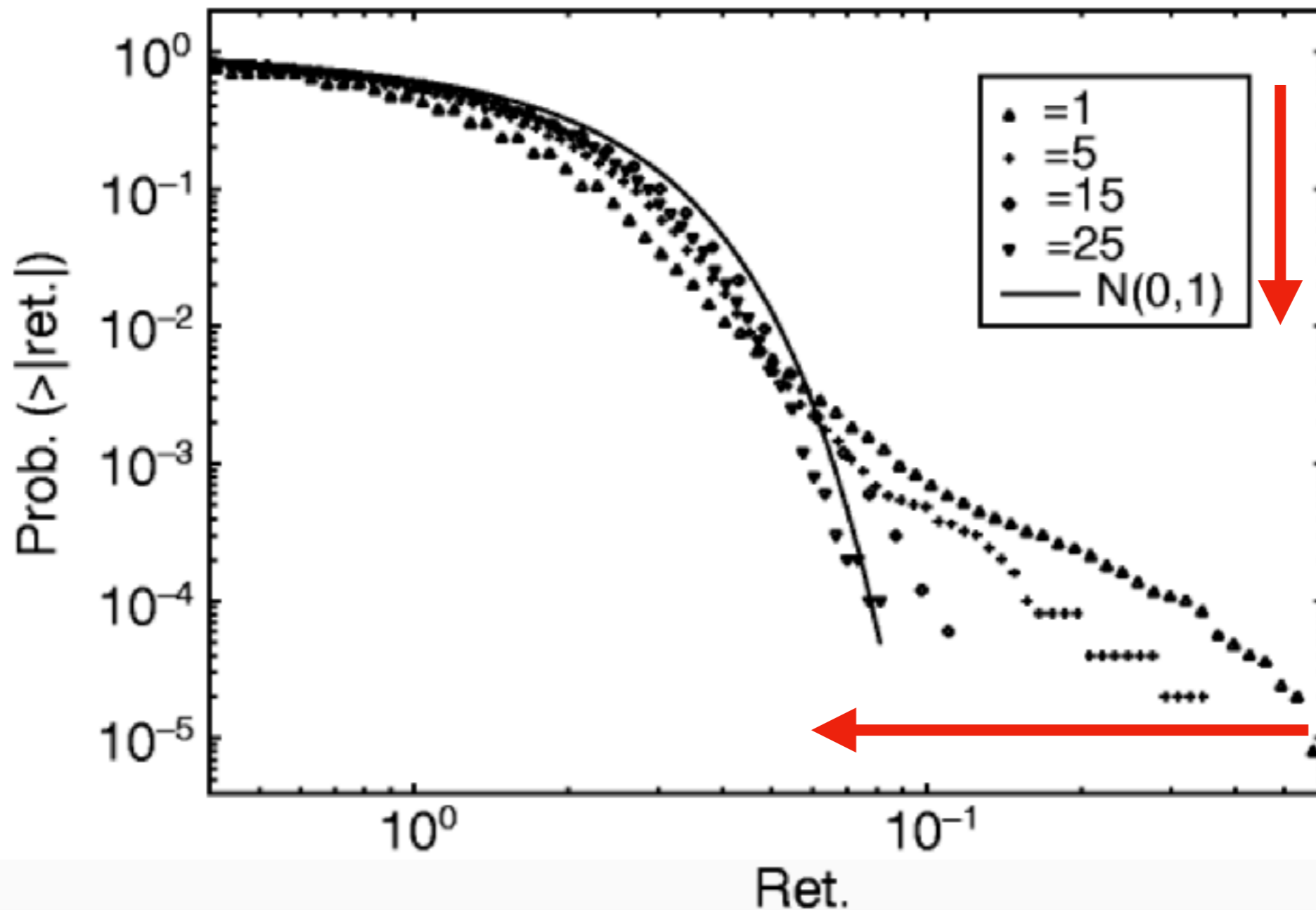
Probabilistic switching function based on profit differential

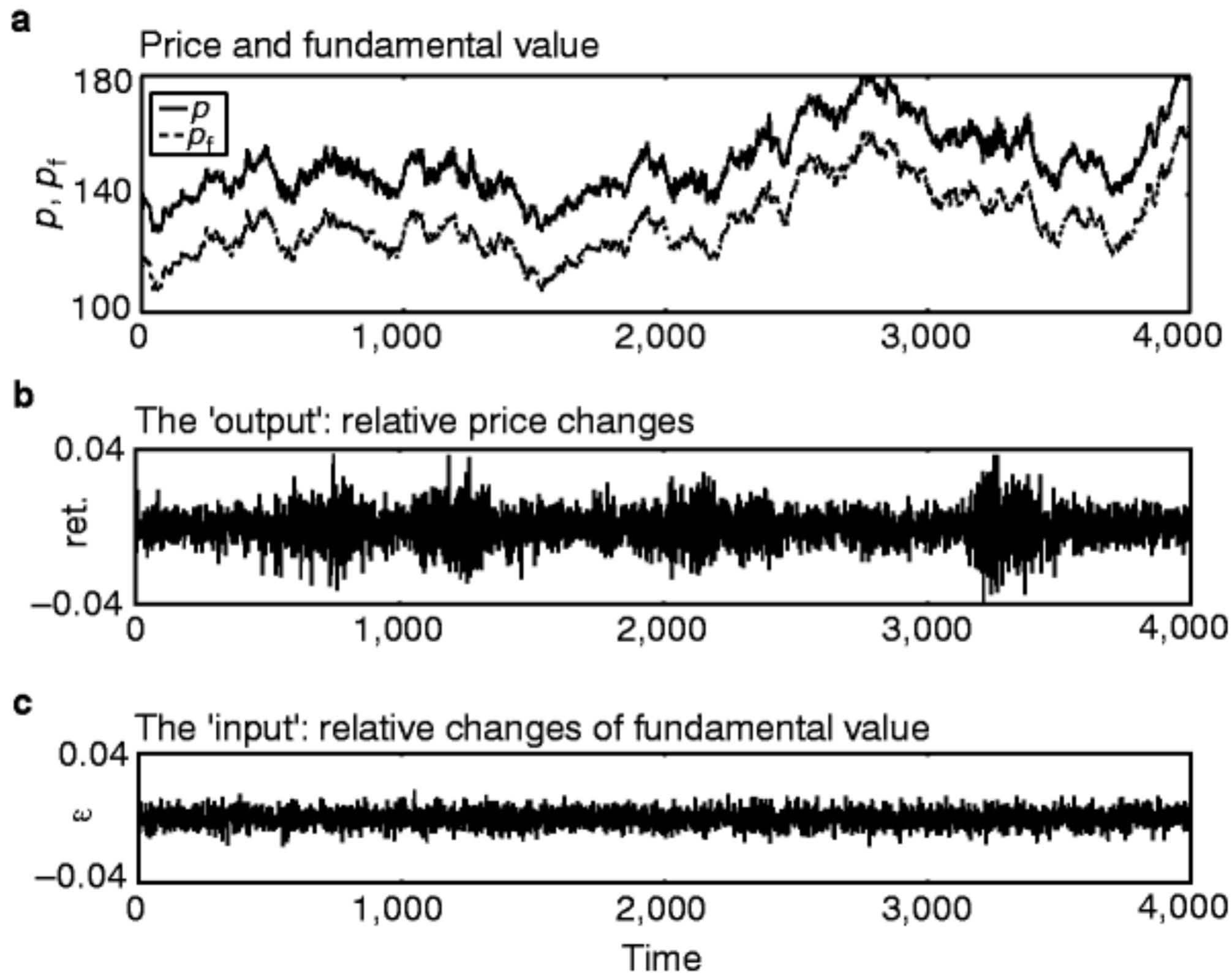


Results



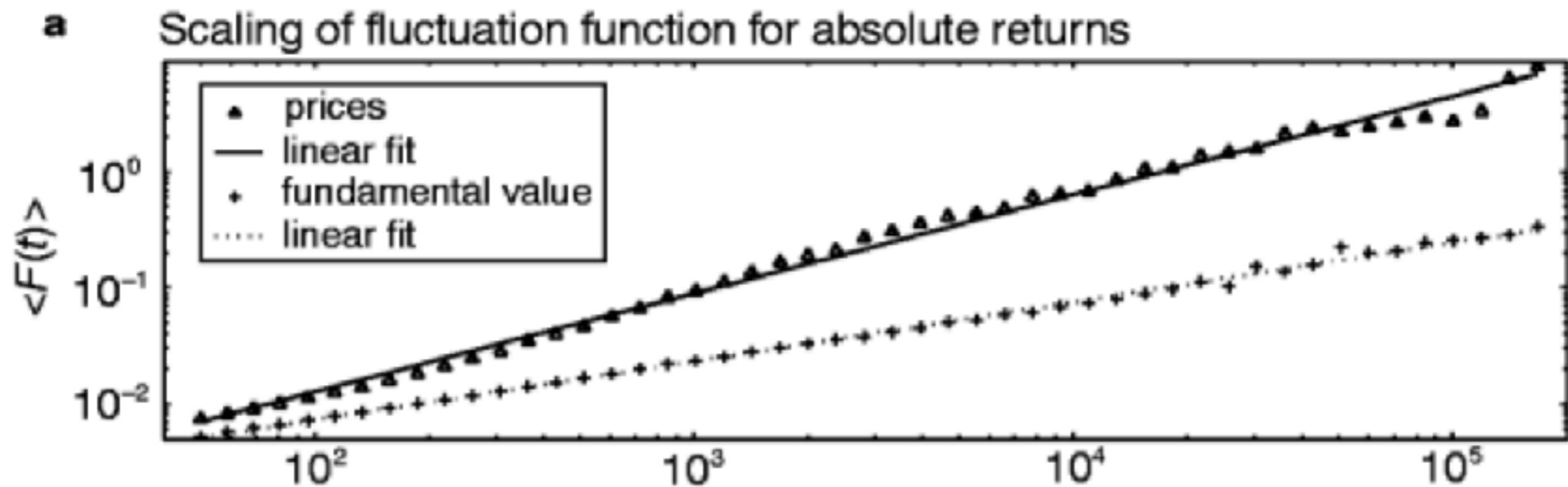
Results





Exogenous changes in **fundamental** price

Results



Slope is **hurst** exponent

$H=0.5$ for fundamental value (random)

$H=0.85$ for prices (long memory)

Robustness

For “many different parameter sets”, they find that the distribution of returns shows fat tails, and volatility exhibits long memory

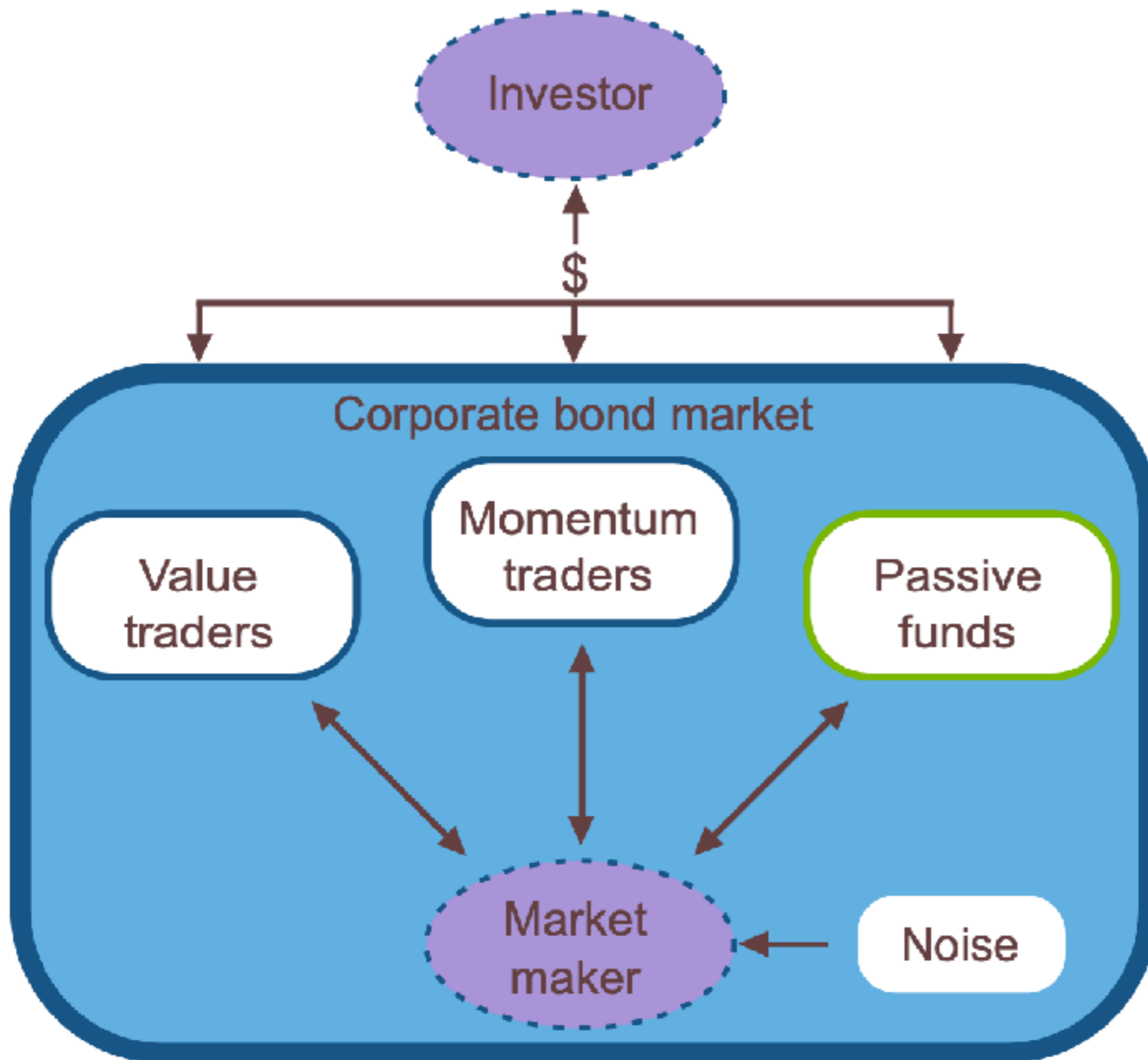
Bond trading

Model by **Bank of England**

Model to explore the **impact of shocks**

Findings to aid policy making





Fundamentalists

Chartists

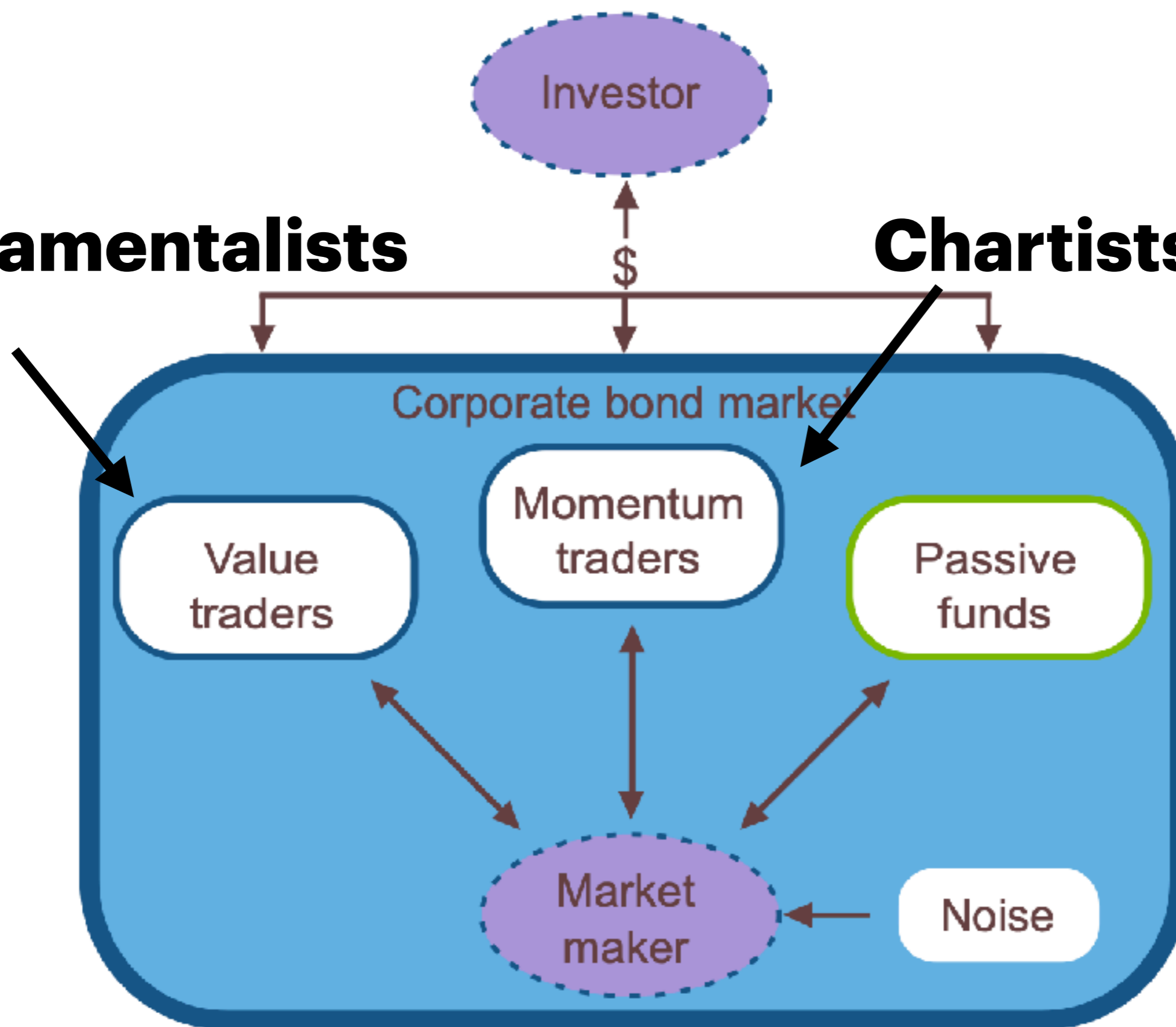
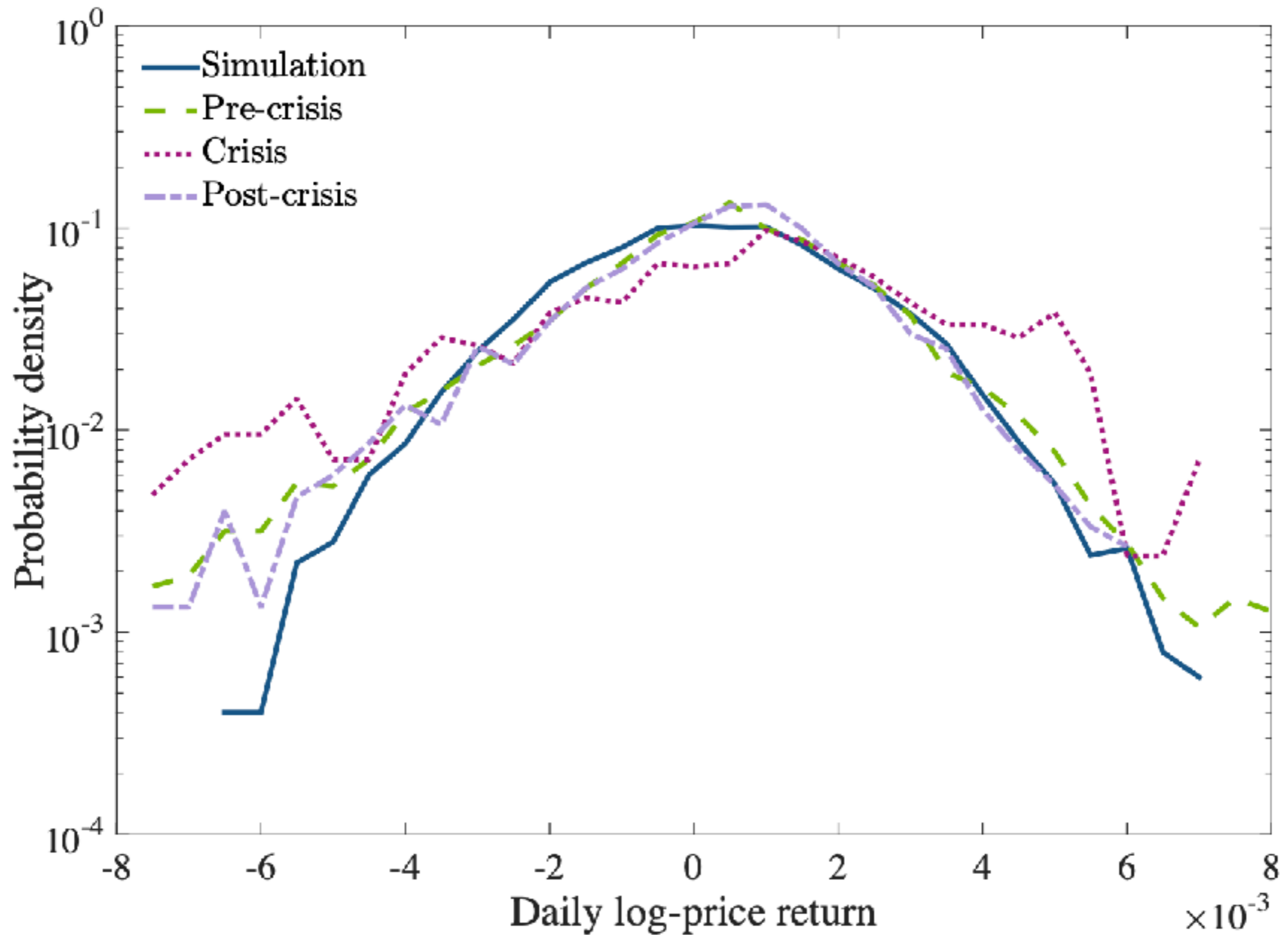


Table 1: Summary of parameters

Empirically Determined Parameters	Value	Imposed Parameters	Value
Number of agents	1000	Proportion of value traders	0.4
Size of agents	\$7.3 billion	Proportion of momentum traders	0.4
Proportion of index funds	0.2	Reaction strength lower bound, L_R	10
Systematic flow strength, s	0.25	Reaction strength upper bound, U_R	20
Fund-specific positive flow strength, I_+	0.621	Momentum trader long window, t_{lw}	100
Fund-specific negative flow strength, I_-	1.128		
Duration of risky asset, D	6.917	Calibrated Parameters	Value
Fundamental yield, Y^*	1.282%	Market maker sensitivity, λ	0.033
Expected loss rate, L	0.04%	Volatility component, v	20
		Value trader strength, α	0.008
		Momentum trader strength, β	1.65
		Noise level, N_{ns}	0.0266



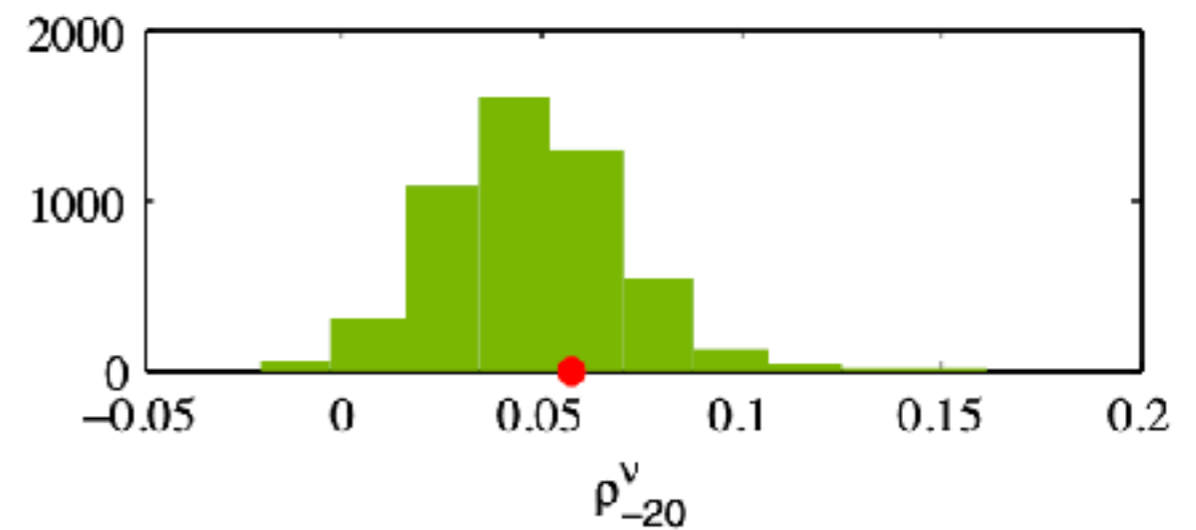
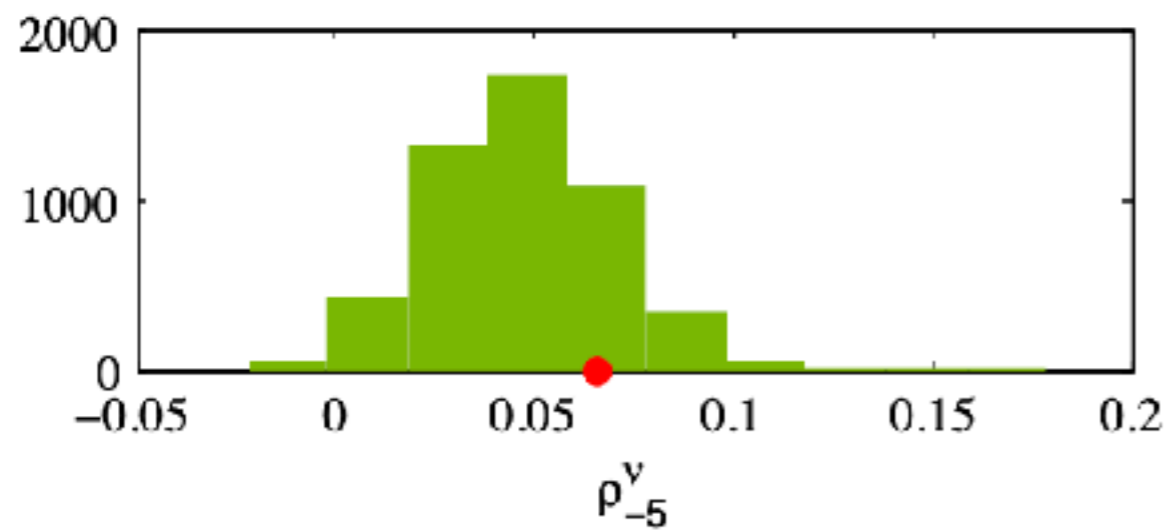
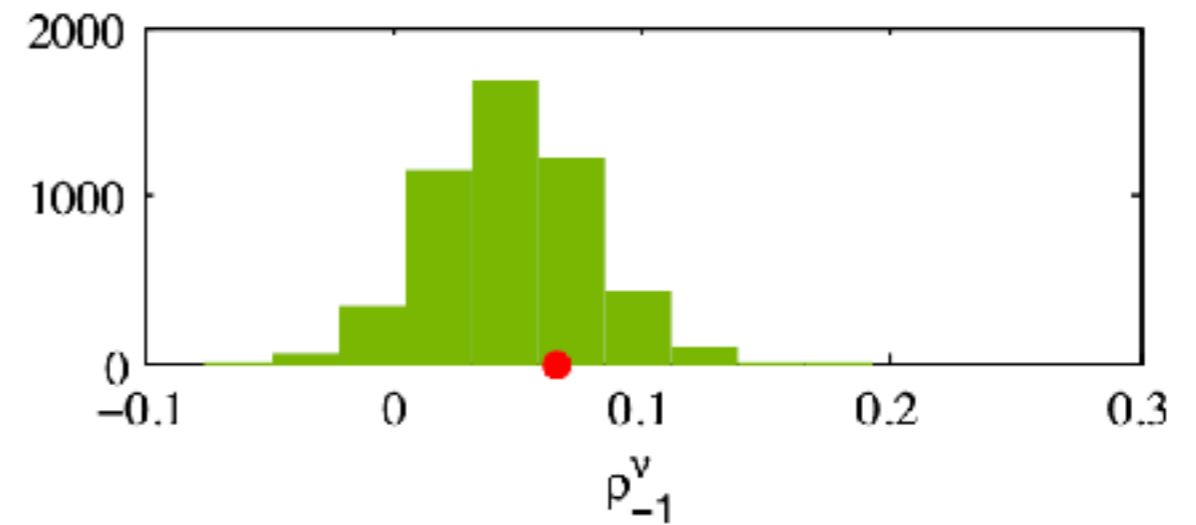
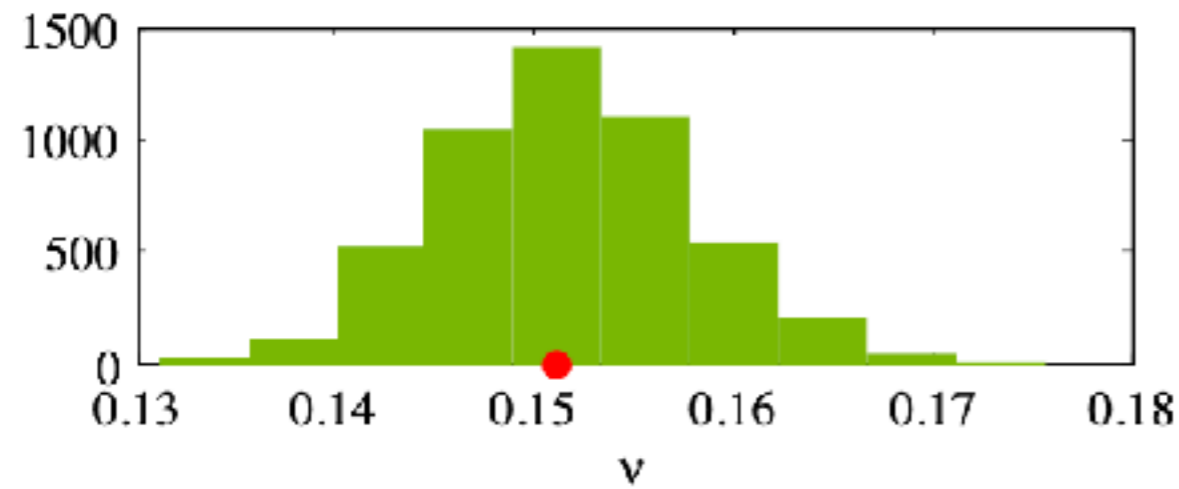
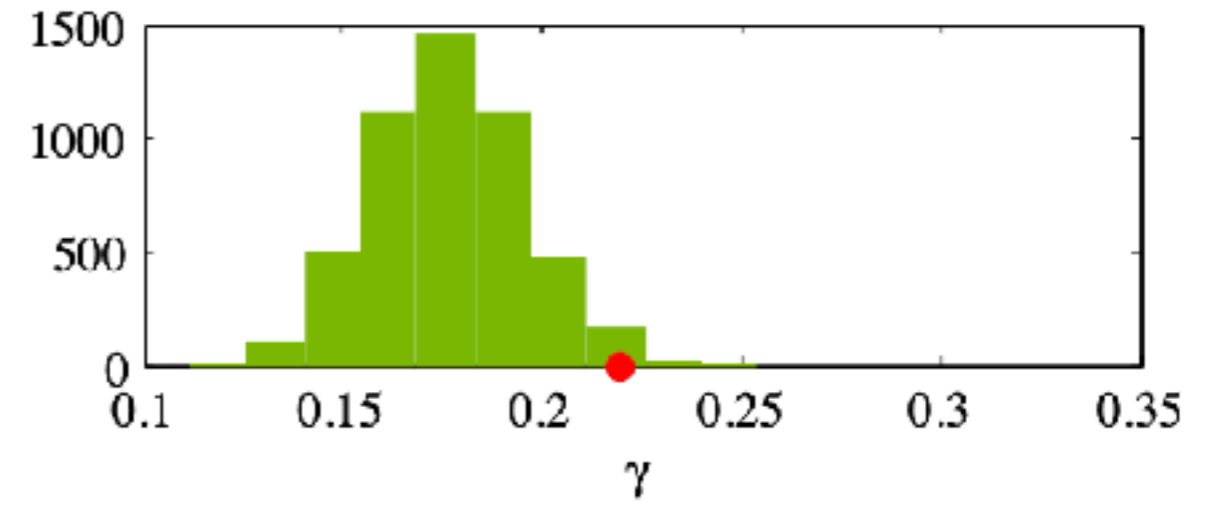
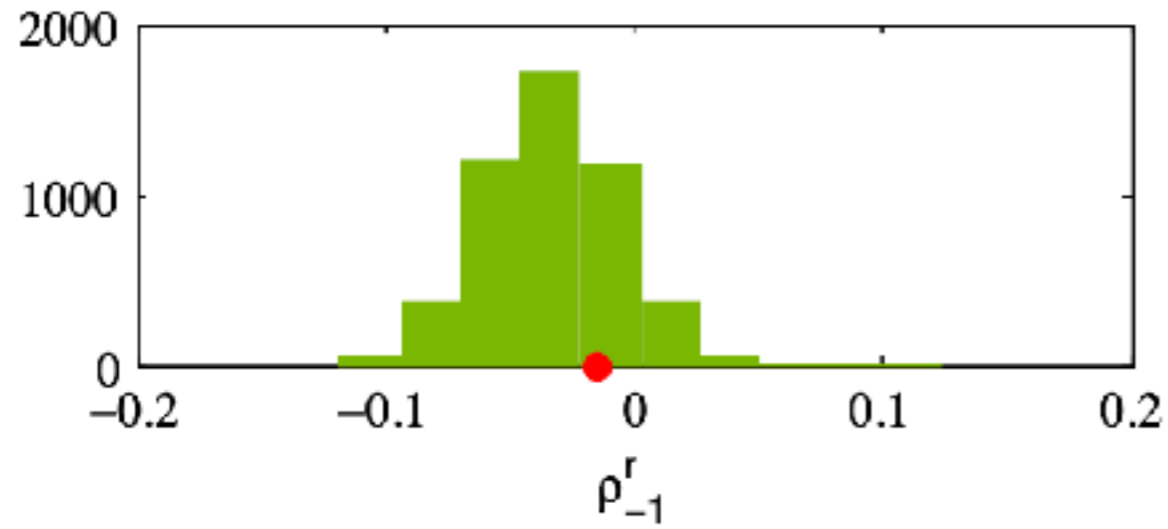


Table 3: Moment coverage ratios

**Autocorrelation
of returns**



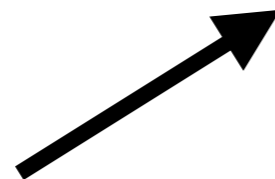
Moment	MCR (%)
ρ_{-1}^r	92.3
γ	62.4
ν	80.1
ρ_{-1}^ν	88.8
ρ_{-5}^ν	95.6
ρ_{-10}^ν	95.9
Joint	38.9

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**Autocorrelation
of returns**



**Mean of
absolute
returns**



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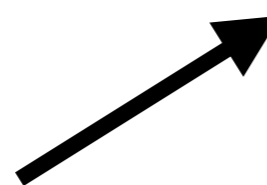
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**Autocorrelation
of returns**



**Mean of
absolute
returns**



**Autocorrelation
of absolute
returns (multiple
lags)**

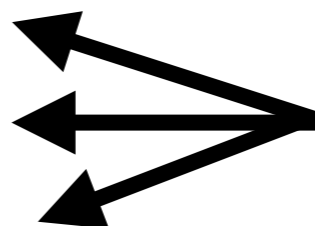


Table 3: Moment coverage ratios

**Autocorrelation
of returns**

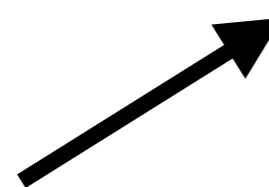


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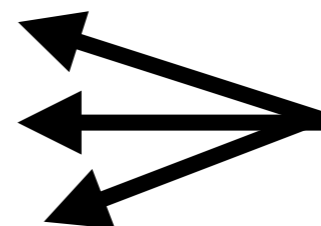
**Tail index
absolute
returns**



**Mean of
absolute
returns**



**Autocorrelation
of absolute
returns (multiple
lags)**



Based on observations, they **develop a policy** to reduce shock propagation, and test it by running a **new experiment** that includes this policy in their ABM



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They find that managing bond redemption by spreading payments over several days can significantly reduce shocks

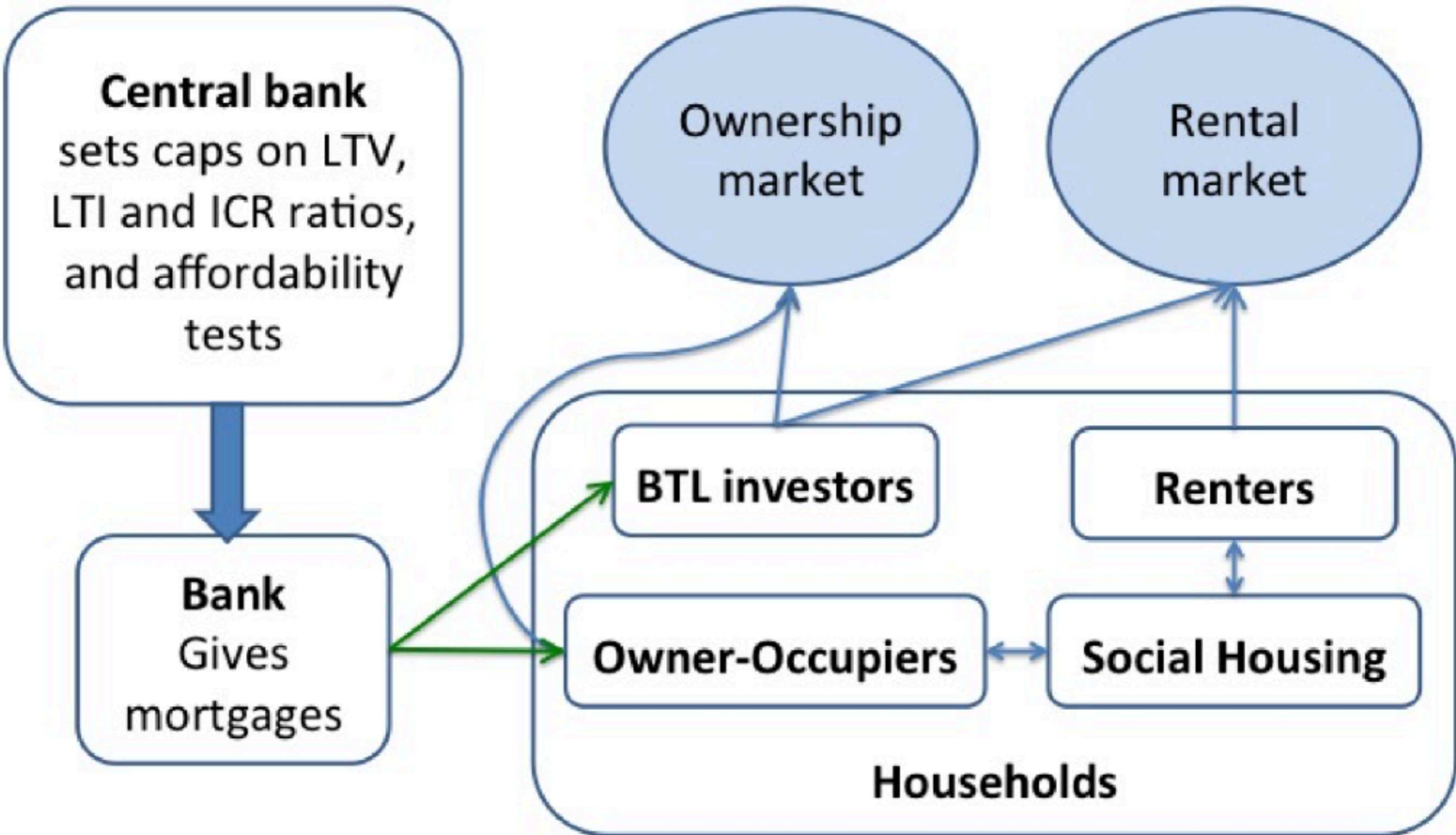
Credit risk - housing market



Model housing market with heterogeneous agents

They include lenders as well as households

They develop a policy to attenuate price cycles

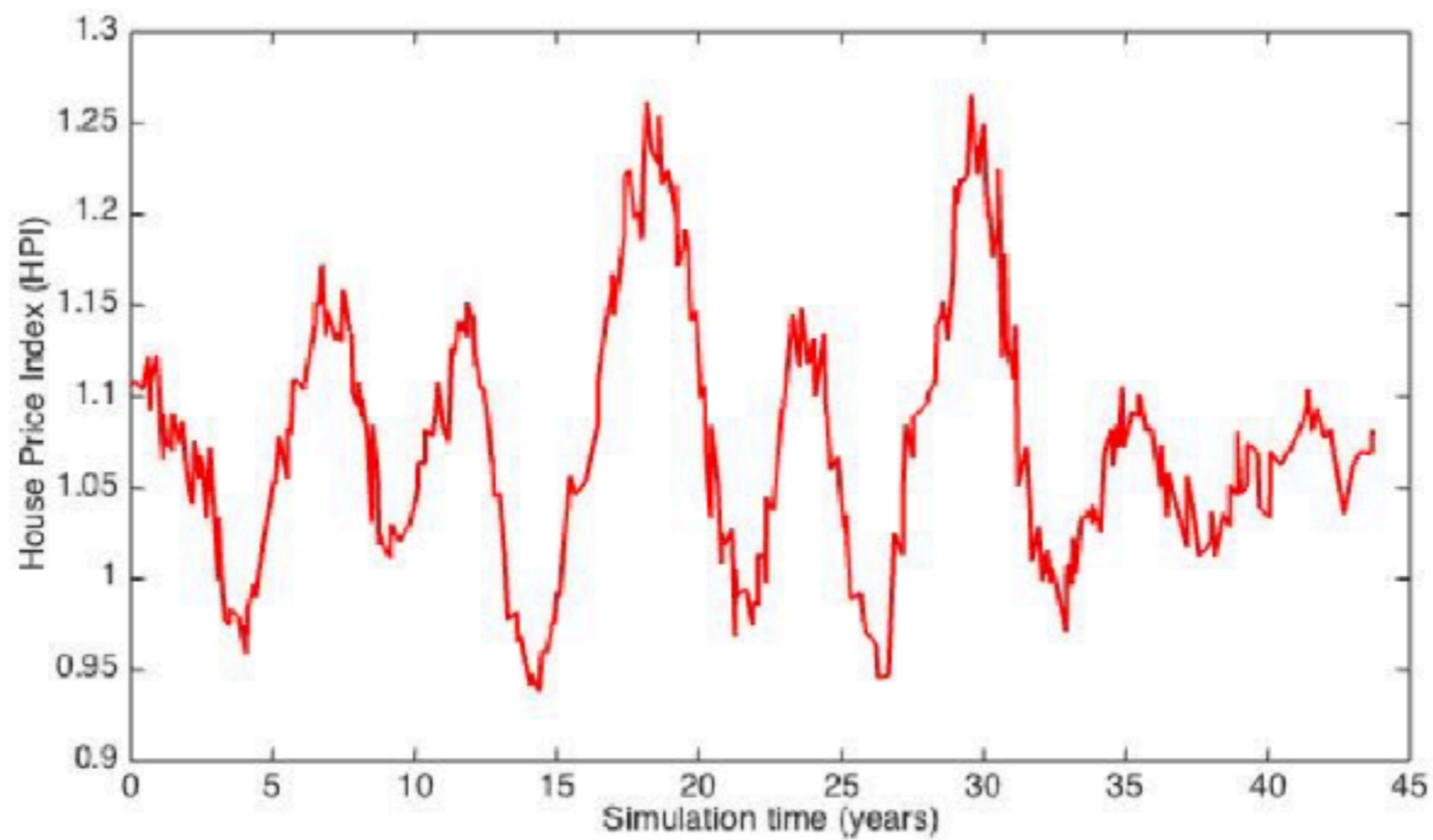


Parameters

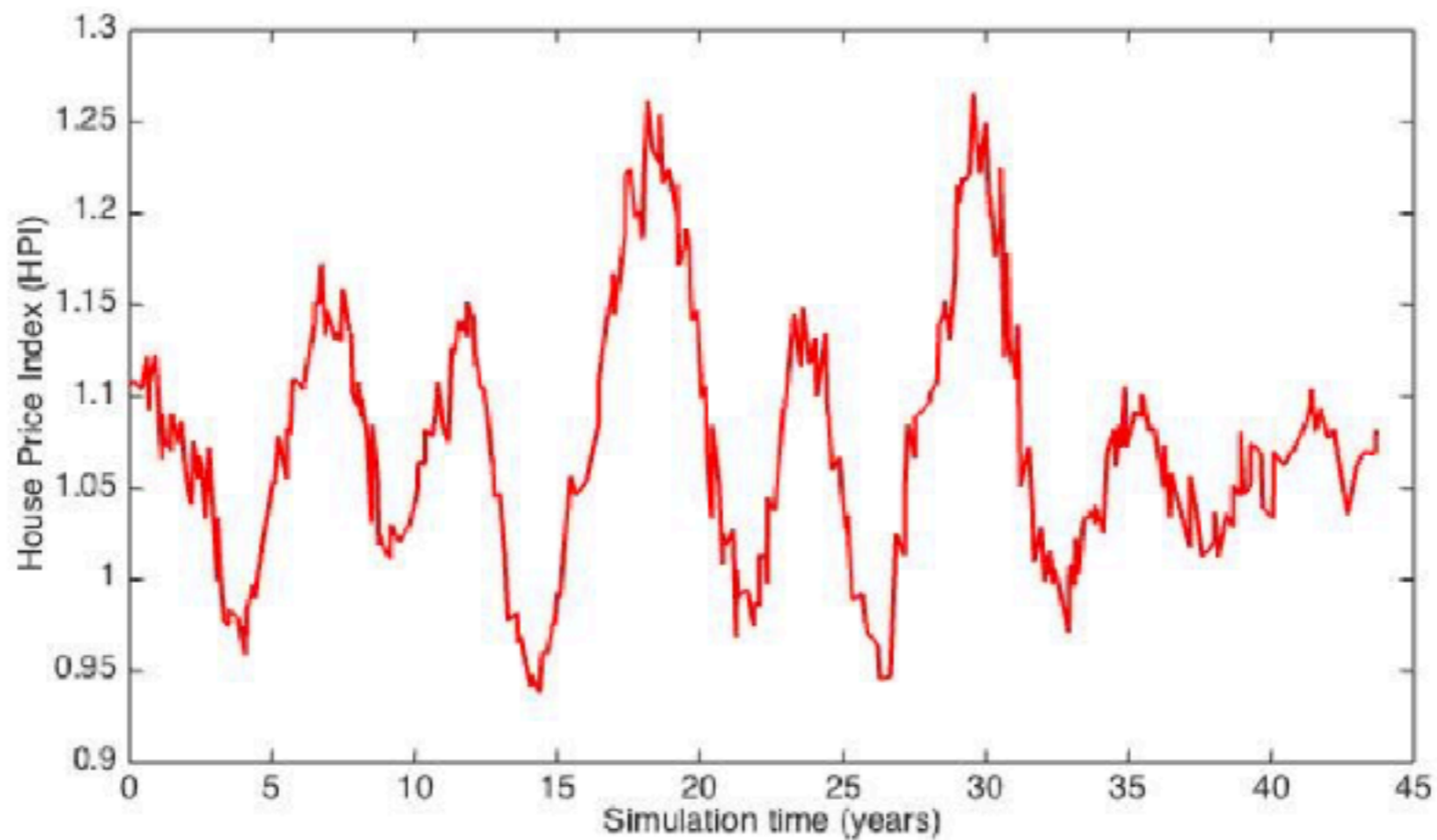
Model component or Equation	Parameter values	Sources	Notes
Demographics			
Number of Households	10,000	Model input	
Birth rate	1.02%	English Housing Survey (DCLG - Department for Communities and Local Government (2014))	
Mortality		ONS Statistical Bulletin: Historic and Projected Mortality. Data from the Period and Cohort, Life Tables, 2012- based, UK, 1981-2062.	The pdf was multiplied by a constant factor so that the overall death rate is set equal to the birth rate, in order to ensure a constant population in the model

Income and financial wealth

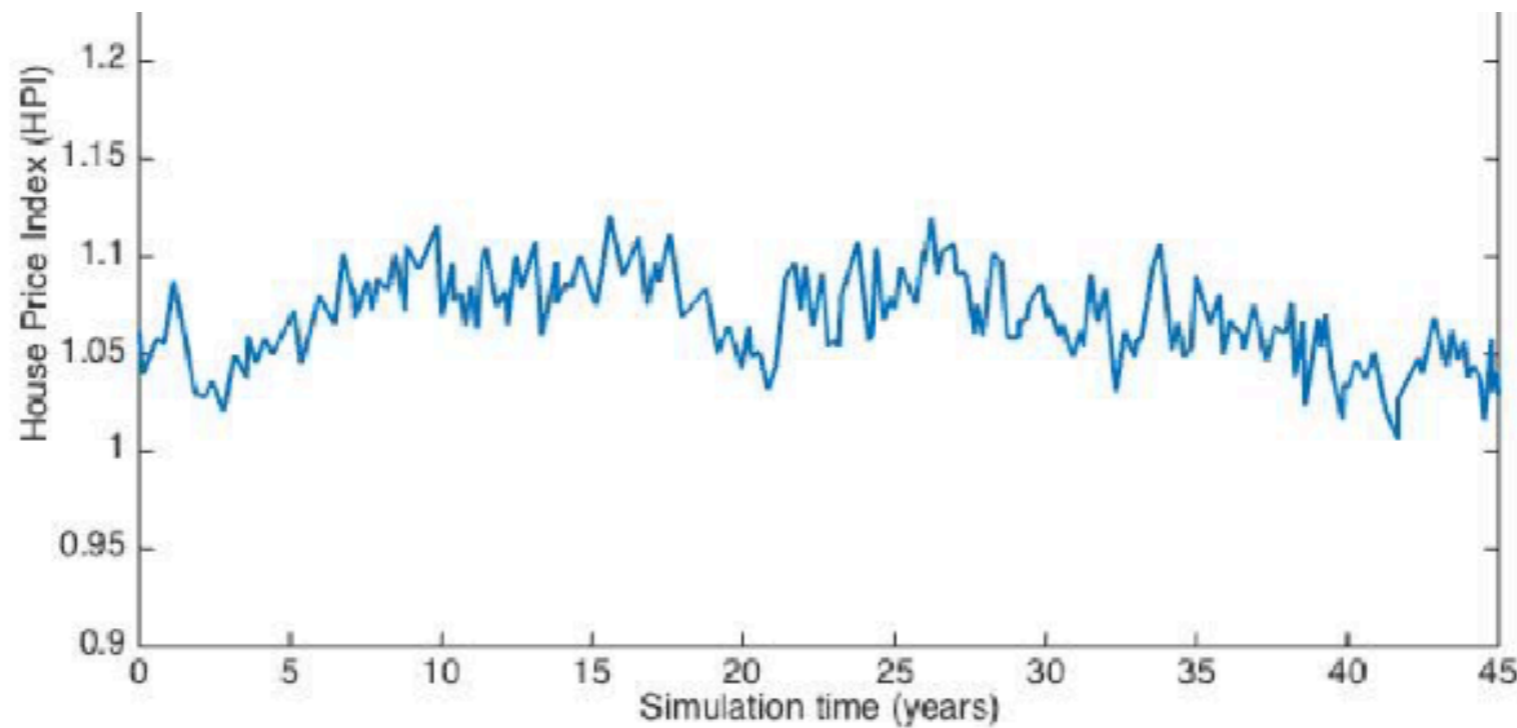
Income given age and income percentile		Living Costs and Food Survey (Office for National Statistics and Department for Environment, Food and Rural Affairs (2014))		
Minimum income	£5900	www.nidirect.gov.uk		Married couple's monthly lower earnings from income support
Essential consumption fraction	80%	Percentage of the minimum income spent by every household each month as "essential consumption"		
Equation (1) - Desired bank balance	$\alpha=-32.00, \beta=4.07, \epsilon=N(0,0.1)$	Wealth and Asset Survey (Office for National Statistics (2014))		ϵ is constant for each household and represents a "propensity to save"
Equation (2) - Consumption fraction	C=0.5	Fraction of the available monthly budget the household uses for non-essential consumption		
Return on financial wealth	0.20%	Interest rate for bank deposits		
National Insurance	NI bands (NI rates) = £7755 (12%), £41450 (2%)	Government figures for 2013/14		



(a) Benchmark case, displaying boom and bust cycles



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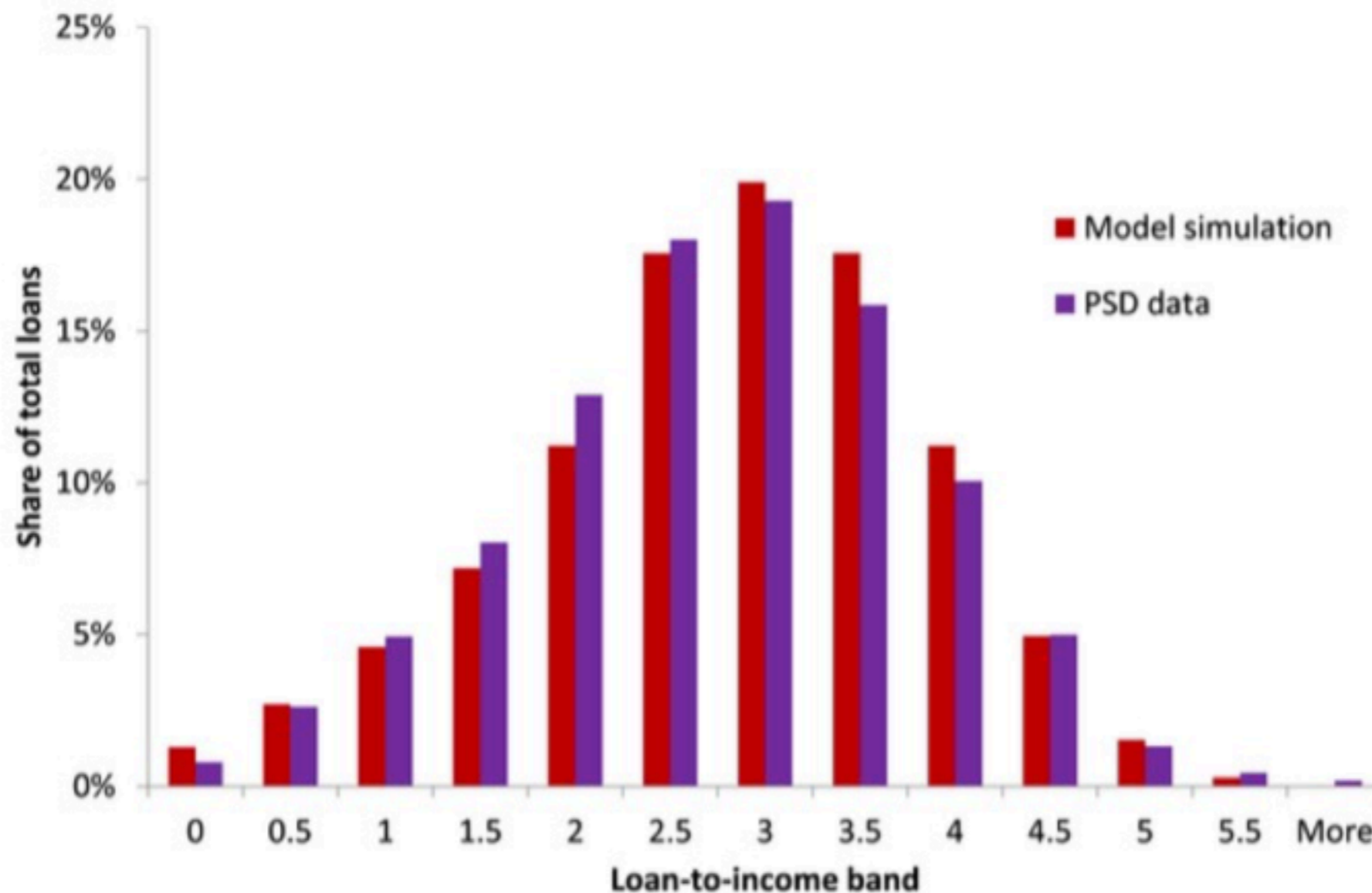


(b) Experiment with house price growth expectation g set to zero, no longer showing any boom and bust cycles

Validation

They show that **aggregate variables** are correlated as expected in every scenario —> the model is consistent and reproduces empirical observations

Validation



Experiments

They perform a number of experiments to study the effect of various policies on 9 different key housing market indicators

Results

Among other things, they find that an increase in the size of the buy-to-let markets leads to amplification of price cycles

Plunging profits

This example from broker John Charcol is based on a someone with earnings of £45,000 a year who has a £337,500 interest-only mortgage on a £450,000 house (ie, 75% loan-to-value). The 5.85% interest rate is fairly representative of what was on offer a few years ago. Pence rounded down and tax deductible costs £0 for simplicity.

	2016-17	2017-18	2018-19	2019-20	2020-21
Monthly income from rent	£2,300	£2,300	£2,300	£2,300	£2,300
Monthly mortgage interest	£1,645	£1,645	£1,645	£1,645	£1,645
Profit before tax	£655	£655	£655	£655	£655
Reduction in mortgage interest allowance	£0	£411	£822	£1,233	£1,645
Taxable profit	£655	£1,066	£1,477	£1,888	£2,300
Tax chargeable (40%)	£262	£426	£591	£755	£920
20% tax credit	£0	£82	£164	£246	£329
Tax owed	£262	£344	£426	£508	£591
Monthly net profit after tax	£393	£310	£228	£146	£64
Annual net profit after tax	£4,716	£3,729	£2,742	£1,755	£768

Source: John Charcol

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83% profit reduction

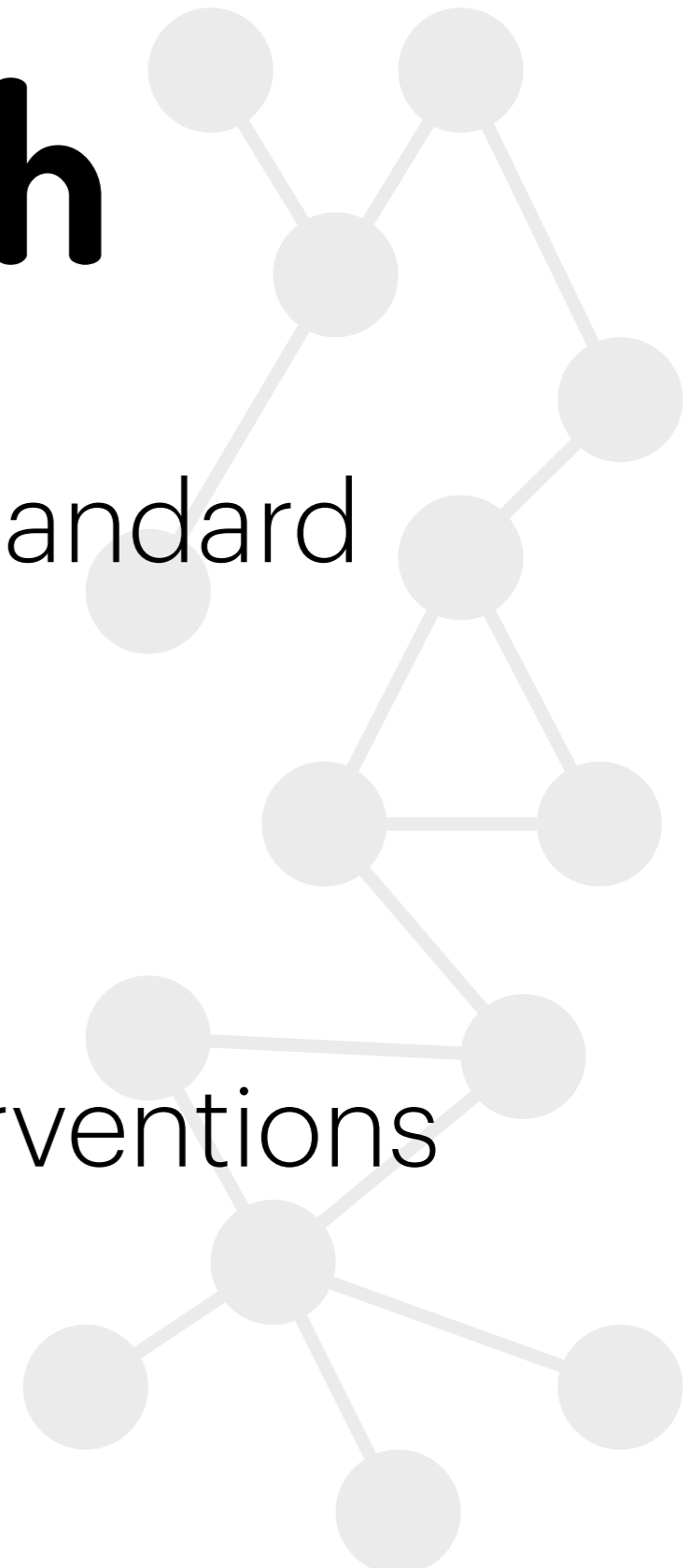
Source: John Charcol

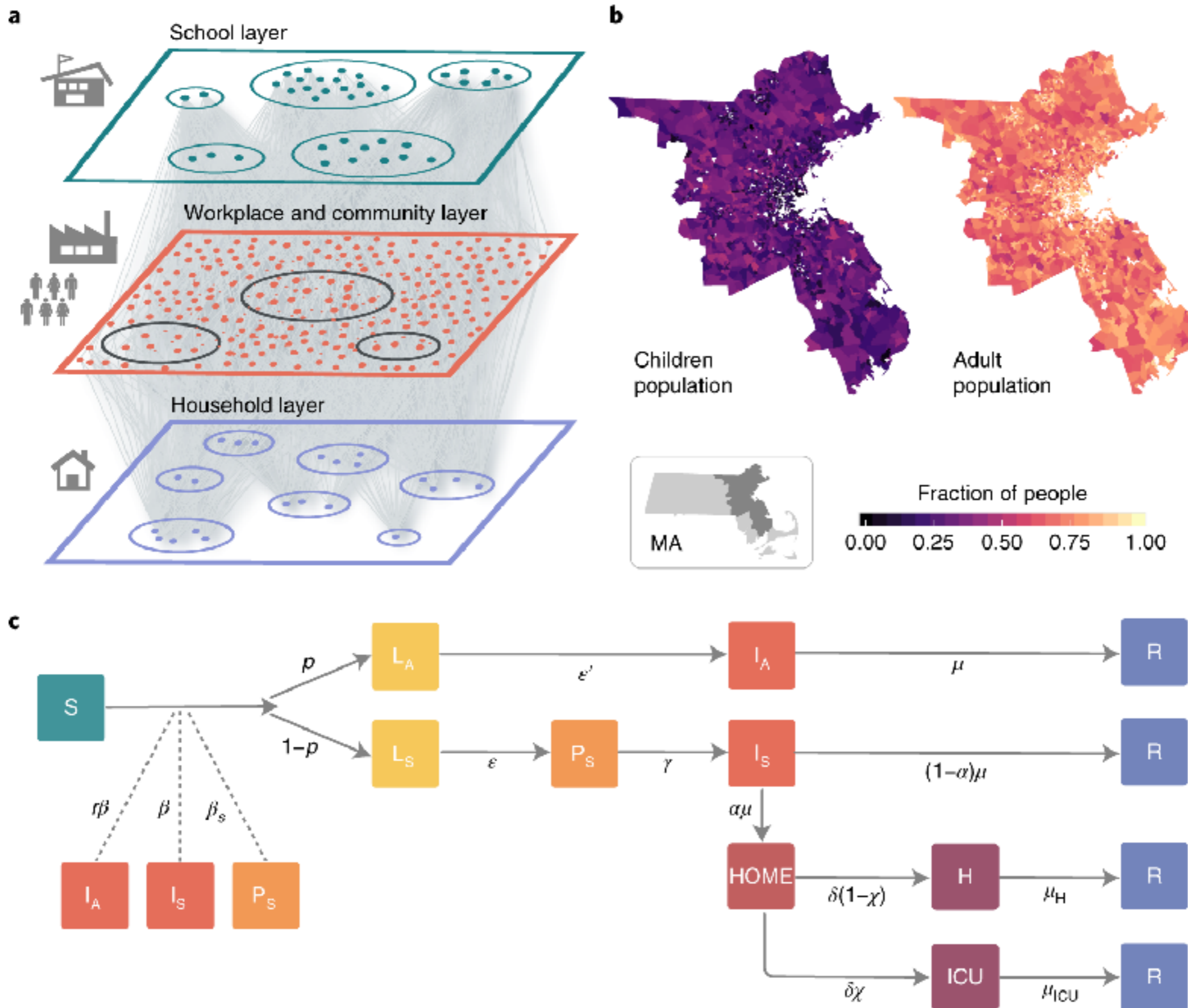
Public health

Contagion model (starting from standard sir)

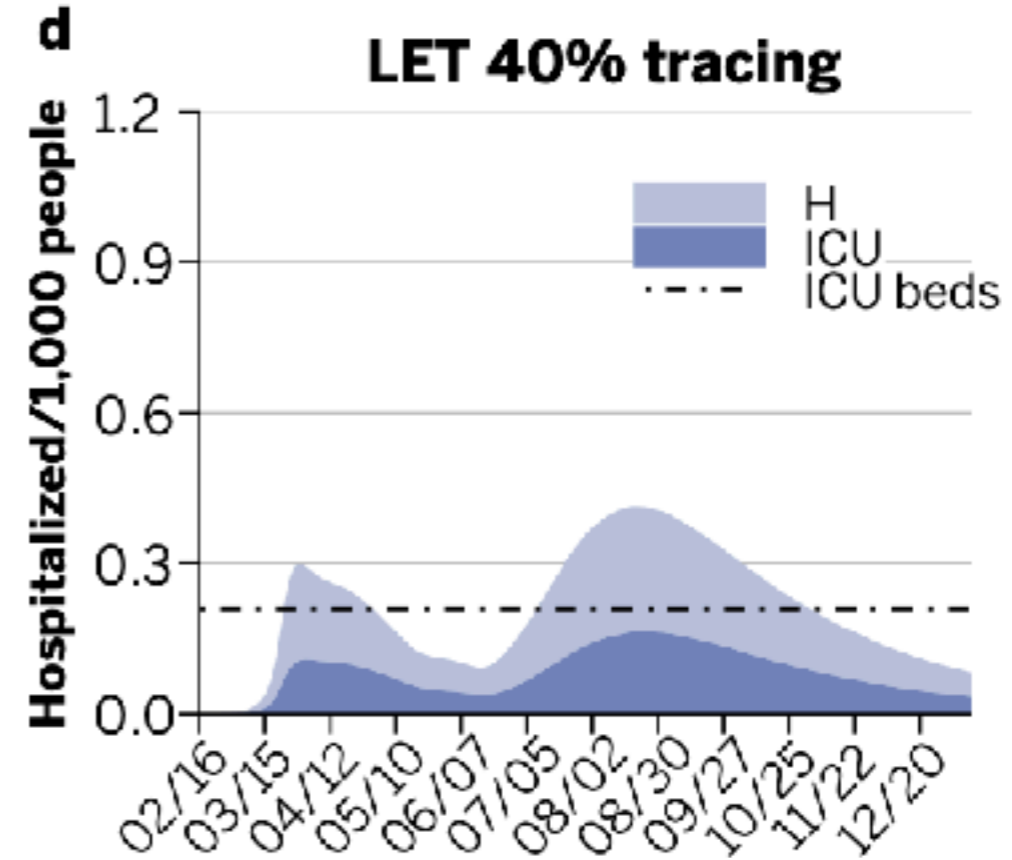
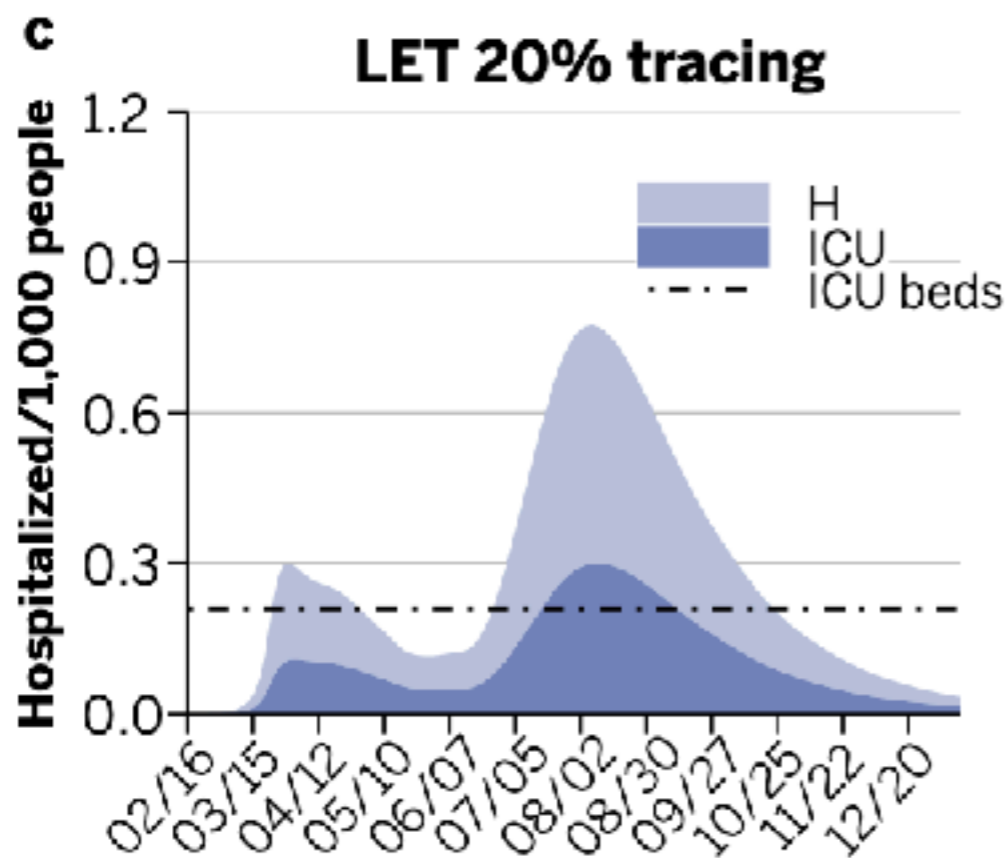
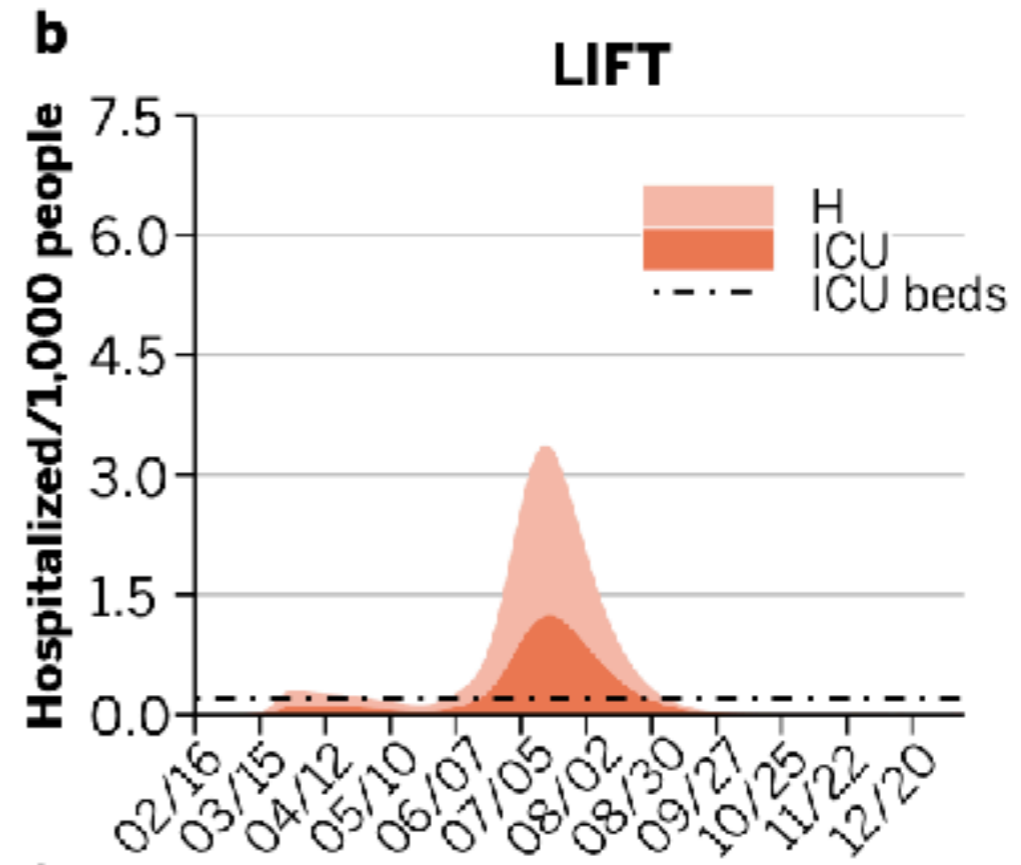
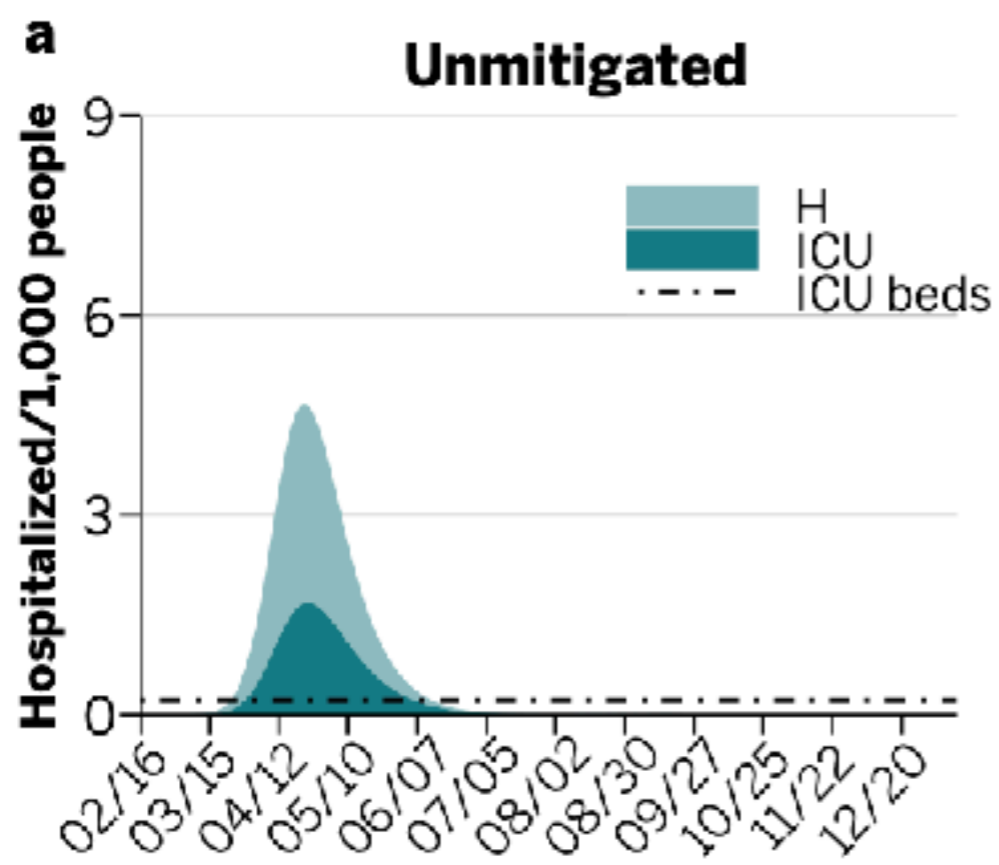
Use of multiplex networks

Develop non-pharmaceutical interventions





Parameters	Description	Age group	Value	Ref.
r	relative infectiousness of asymptomatic individuals	-	50%	†
ϵ^{-1}	latent period	-	3 days	[8]
ϵ'^{-1}	latent period	-	5 days	[8]
p	proportion of asymptomatic	-	25%	[9]
γ^{-1}	pre-symptomatic period	-	2 days	[8]
μ^{-1}	time to removed/home stay	-	2.5 days	*
α	symptomatic case hospitalization ratio (%)	0-4	0.0	[10]
		5-17	0.025	
		18-49	2.672	
		50-64	9.334	
		65+	15.465	
χ	ICU % among hospitalized	0-4	5.0	[11]
		5-17	5.0	
		18-49	5.38	
		50-64	17.10	
		65+	44.71	
δ^{-1}	days from home stay to hospital admission	-	2	[12]
μ_H^{-1}	days in hospital	-	8	[10]
μ_{ICU}^{-1}	days in ICU	-	13	[10]
k	proportion of presymptomatic transmission	-	15%	[13]
R_0	basic reproduction number	-	2.5	†
β	transmission for symptomatic and asymptomatic individuals	-	$\frac{R_0 \mu}{pr + (1-p)/(1-k)}$	
β_S	transmission for pre-symptomatic individuals	-	$\frac{\beta \gamma k}{\mu(1-k)}$	



Other references

Need for abms

<https://www.nature.com/articles/460685a>

Overview of ABM in economics and finance by BoE

https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2898740

Heterogeneous abms in finance

[https://doi.org/10.1016/S1574-0021\(05\)02023-X](https://doi.org/10.1016/S1574-0021(05)02023-X)

Simudyne - Overview from industry and academia

<https://simudyne.com/wp-content/uploads/2019/08/A4-Guide-to-ABM-FINAL-5.pdf>

Banking

<https://www.sciencedirect.com/science/article/pii/S0165188918300976>

ABM in marketing

<https://link.springer.com/article/10.1057/jos.2013.21>

