

Animal Spirits, Heterogeneous Expectations and the Amplification and Duration of Crises

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Animal Spirits (Keynes)

much of (macro)economic activity is governed by **animal spirits**

- ▶ people have **non-economic motives**
- ▶ they are **not always rational** in pursuit of economic interests

Keynes: animal spirits are the main source of economic fluctuations

... but animal spirits **disappeared** from the neoclassical, rational model

Animal Spirits (Akerlof and Shiller, 2009)

How human psychology drives the economy, and why it matters for global capitalism

5 animal spirits: confidence, fairness, corruption, money illusion and stories

- ▶ **cornerstone** animal spirit: **confidence**
- ▶ **behavioral economics**: how the economy really works, when people are human
- ▶ animal spirits **difficult** to conceptualize, model and measure

Goal of this paper: dynamic equilibrium model of agents' confidence

Main Result: sudden collapse of confidence **accelerates** and **amplifies** downturn or crisis and **slows down** recovery

Main hypothesis: heterogeneous expectations

Brock and Hommes, 1997

main tool for modeling confidence in market for loans

- ▶ lenders' **heterogeneous expectations** about the (exogenous) **probability of succes/failure** of borrowers

Main finding:

- ▶ In the presence of a (small) **fraction of pessimistic beliefs**, an unexpected **negative shock** to credit markets triggers these pessimistic beliefs to become **self-fulfilling**, **amplifying** a "crisis" and **slowing down** recovery

Model

- ▶ market for **loans**
- ▶ **overlapping generations** (OG) structure for households
- ▶ households **savings** into a riskless asset or a risky asset (productive investments)
- ▶ **no banks**, but **households can lend** to firms)
- ▶ firms **borrow capital** for productive investment and pay wages to households
- ▶ market clearing determines the “**contract rate**” for loans (i.e. the interest rate, downpayments, and other loan requirements)

Households: 2-period OG

maximize utility $u_t = \ln c_{t,t} + \ln c_{t,t+1}$

under the **budget constraints**

$$c_{t,t} \leq w_t - s_t,$$

$$c_{t,t+1} \leq \omega_o + s_t[(1 - \delta_t)\rho + \delta_t\lambda_{t+1}^e],$$

- ▶ $c_{t,t} / c_{t,t+1}$: **consumption** when young/old;
- ▶ $w_t = w_{p,t} + \omega_y$, real **wages** + labour endowment when young;
- ▶ s_t real **savings** when young;
- ▶ δ_t **fraction** invested in risky asset;
- ▶ $\lambda_{t+1}^e = p_{t+1}^e r_t$ expected **return on capital**
- ▶ p_{t+1}^e **expected probability of success**

Households Savings function

optimal **saving**

$$s_t = \frac{1}{2} \left(w_t - \frac{\omega_o}{\mu_{t,t+1}^e} \right).$$

with expected **average return on investment**

$$\mu_{t+1}^e =: (1 - \delta_t)\rho + \delta_t\lambda_{t+1}^e$$

Assuming zero endowment when old i.e., $\omega_o = 0$, savings is

$$s_t = \frac{w_t}{2}.$$

Firms demand for loanable funds

Firms borrow to finance productive investments

- ▶ p_t **probability of success**
- ▶ $1 - p_t$ probability of bankruptcy

Firms **choose capital** x_t to maximize

$$\max_{x_t} \{p_t g(x_t) - r_t x_t\},$$

where $r_t = 1 + r_{0,t}$ is **contract rate** for loans

(i.e. “*rental rate*” on capital + other conditions for loans)

optimal **demand for loans**:

$$x_t = x(r_t; p_t) = g'^{-1} \left(\frac{r_t}{p_t} \right).$$

wages from the productive sector (returns to other factor):

$$w_{p,t} := p_{t-1} g(x_{t-1}) - r_{t-1} x_{t-1}.$$

Market Equilibrium under Homogeneous Expectations

demand for loans \equiv total supply of loans

homogeneous expectations on probability of succes:

$$x(r_t; p_t) = S_t(r_t; p_{t+1}^e)$$

loan supply correspondence

$$S_t(r_t) := \frac{w_t}{2} \bar{v} [r_t > r_t^* = \frac{\rho}{p_{t+1}^e}]$$

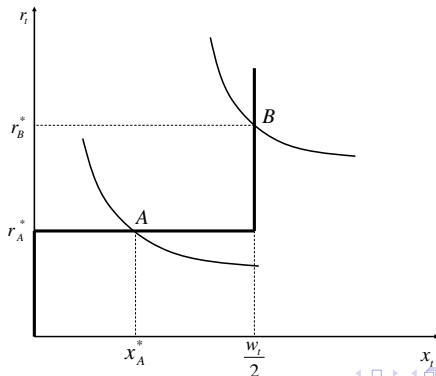
[no arbitrage; risk-neutrality; **expected loan return**]

$$\lambda_{t+1}^e(r_t) = p_{t+1}^e r_t = \rho \quad \implies \quad r_t^* = \frac{\rho}{p_{t+1}^e}.$$

Temporary Equilibria: Homogeneous Expectations

temporary equilibrium A or B depending on demand curve

$$r_A^* = \frac{\rho}{p_{t+1}^e}$$



Dynamics under Homogeneous Expectations

exogenous stochastic **probability process** AR(1)

$$p_{t+1} = \mu + a(p_t - \mu) + \epsilon_t,$$

▶ **naive expectations:**

$$p_{t+1}^e = p_t$$

▶ **average expectations**

$$p_{t+1}^e = \frac{1}{t+1} \sum_{i=0}^t p_i$$

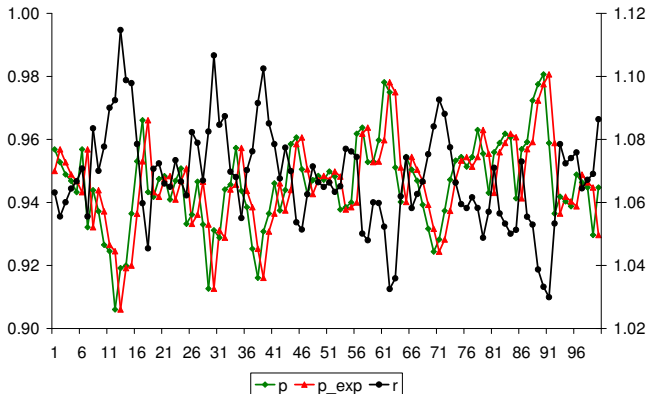
▶ **minimum expectations:**

$$p_{t+1}^e = \min\{p_{t+1-T}, p_{t-T}, \dots, p_{t-1}, p_t\}$$

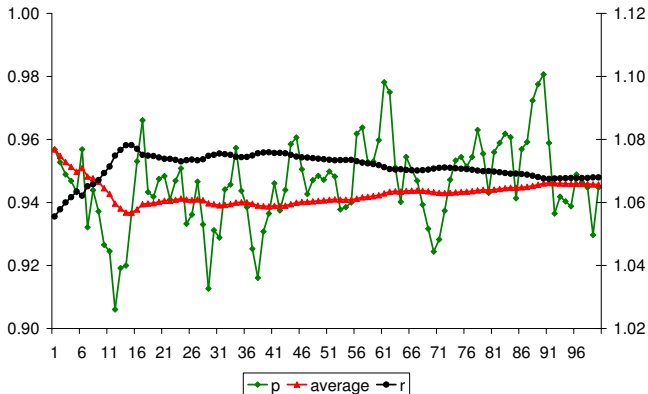
▶ **rational expectations:**

$$p_{t+1}^e = \mu + a(p_t - \mu)$$

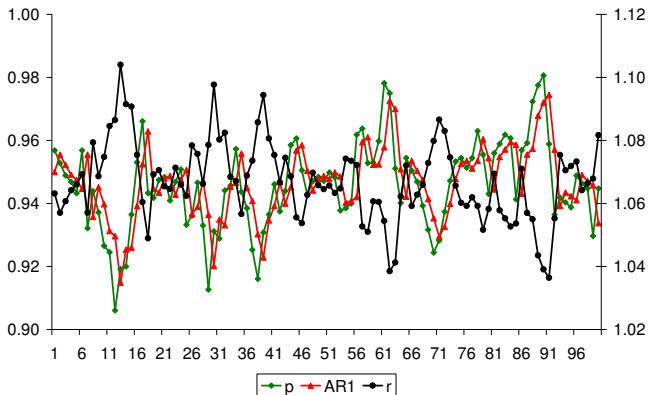
Dynamics under Homogeneous Naive Expectations



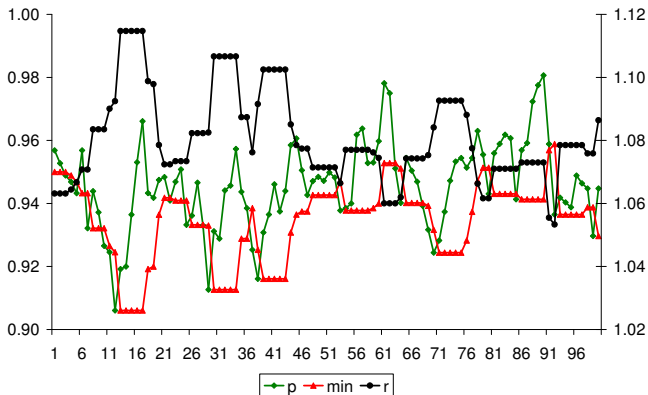
Dynamics under Homogeneous Expectations (average)



Rational Expectations



Pessimistic Expectations (minimum, 5 lags)



Dynamics under Homogeneous Expectations

- ▶ **average expectations** smoothes out aggregate behavior (no extremes)
- ▶ **minimum expectations** **amplifies** the crisis and **slows down** recovery

Heterogeneous Expectations (Brock and Hommes, 1997)

J types of lenders, with expectations on return of risky asset:

$$\lambda_{j,t+1}^e = p_{j,t+1}^e r_t$$

performance measure: relative past squared errors

η **memory parameter**

$$U_{j,t} = r_t^2 (p_t - p_{j,t}^e)^2 + \eta U_{j,t-1},$$

$$u_{j,t} = U_{j,t} / U_t^{tot}, \quad U_t^{tot} = \sum_{j=1}^J U_{j,t}.$$

fractions: discrete choice model with asynchronous updating

$$n_{h,t} = \delta n_{h,t-1} + (1 - \delta) \frac{e^{-\beta u_{h,t-1}}}{z_{t-1}},$$

where z_{t-1} is a normalization factor. The parameter $\delta \in [0, 1]$ – the **inertia** of the traders

Market Equilibrium under Heterogeneous Expectations

demand for loans \equiv total supply of loans

heterogeneous expectations on probability of success:

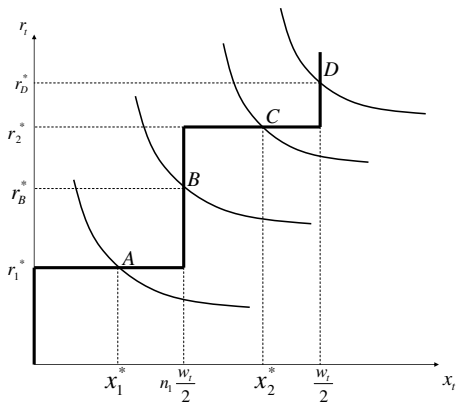
$$x(r_t; p_t) = S_t(r_t; p_{1,t+1}^e; \dots, p_{J,t+1}^e)$$

total supply of loans under heterogeneous expectations

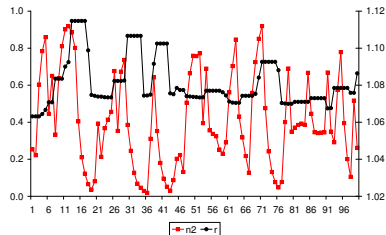
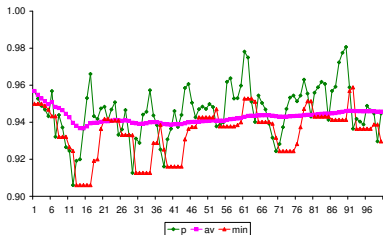
$$S_t(r_t) = \frac{w_t}{2} \sum_{j=1}^J n_{j,t} \bar{v}[p_{j,t+1}^e r_t > \rho],$$

Temporary Equilibria: Heterogeneous Expectations 2 Types

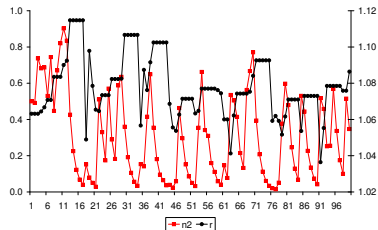
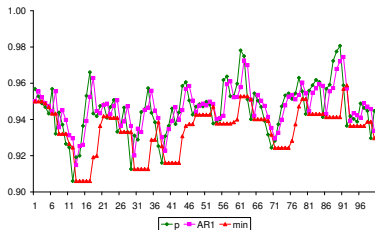
temporary equilibrium A, B, D or C depending on demand curve



Two type example: average versus minimum beliefs



Two type example: rational versus minimum beliefs



Conclusions

- ▶ **confidence** in economy can be modeled with lenders' **heterogeneous expectations** about the probability of success of firms (banks)
- ▶ a small fraction of **pessimistic**, minimum expectations **amplifies a crises** and **slows down recovery**;
- ▶ other types of human behaviour, such as **trend following** and **fear** makes these effects even stronger
- ▶ **policy makers** must take **boundedly rational heterogeneous expectations** into account to **manage** a complex economy

Thanks very much

- ▶ suggestions are more than welcome ...
- ▶ We need more research on **complexity in economics and finance**
and a **big science EU Flagship** such as **FuturICT**
- ▶ ... not only for **scientists**, but also for **policy makers**