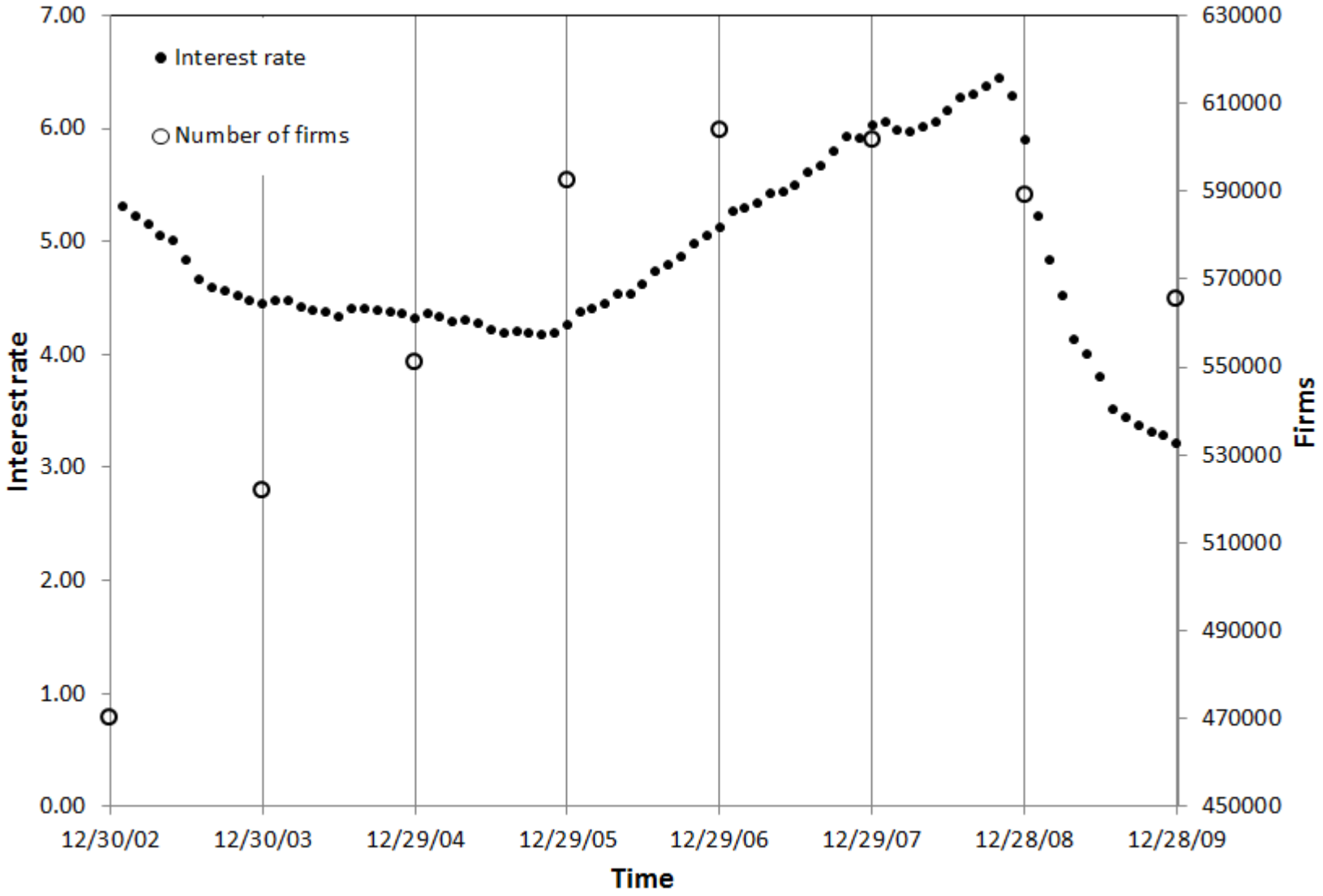
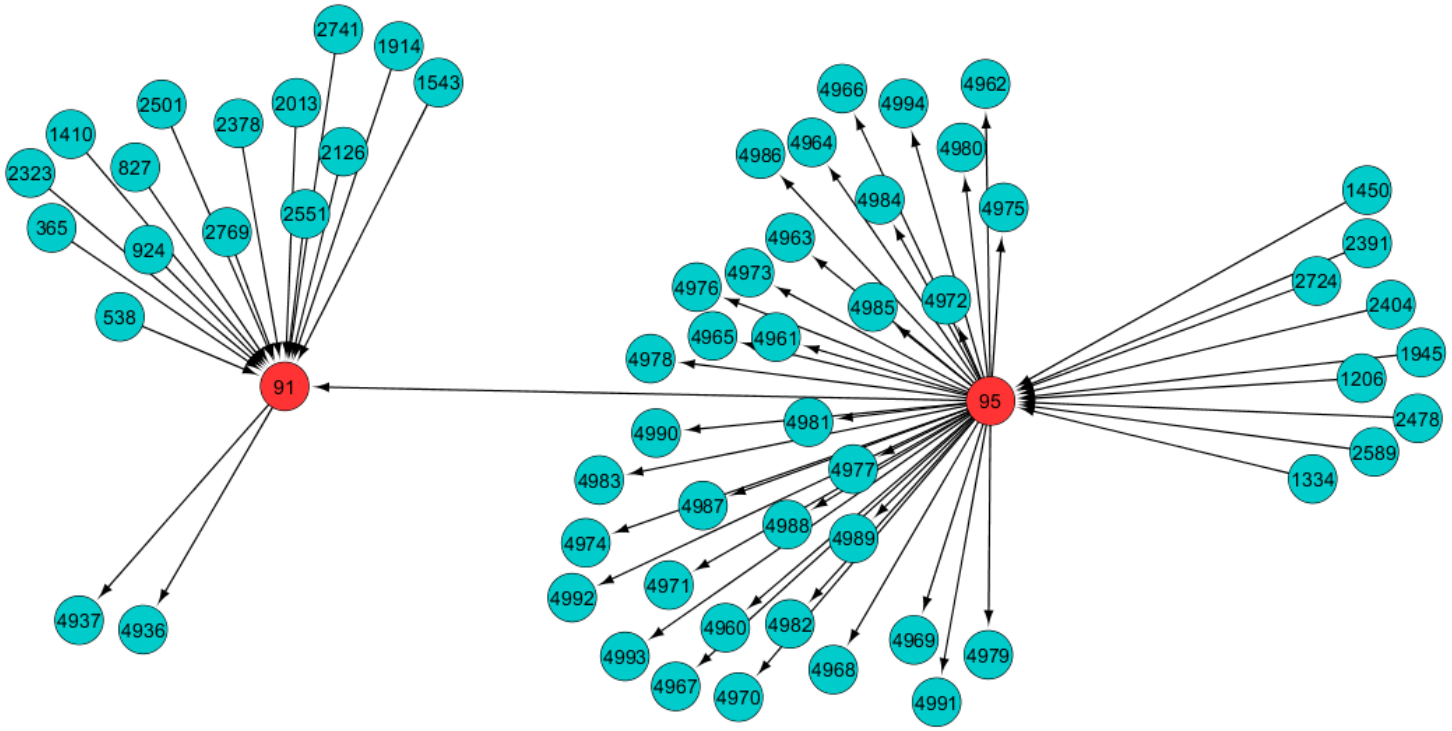
Too dynamic to fail. Empirical support for an autocatalytic model of Minsky's financial instability hypothesis.

Golo, Ussher, Kelman, Lamieri, Breé, Solomon

Empirical setting – interest rate



Empirical setting – firms network and individual firms balance sheets



Network: 2007

Balance sheets: 2002-2009

Network: Trade credit links

(in how far is the trade credit network appropriate for the model validation? … The lander of the last resort … more about TC in talks Leanne Ussher)

In general, trade creditors don't charge interest unless payment is delayed well beyond the settlement date. By delaying payment to a trade creditor, a business holds onto its cash balances for longer. Trade creditors are seen (wrongly) as a "free" source of capital. Some firms habitually delay payment to creditors in order to enhance their cash flow - a short sighted policy leading to "Ponzi scheme".

The period allowed before the invoice must be settled will vary from industry to industry. In the building trade, it is common for trade creditors to require settlement of invoices after 30 days. For businesses in some industries to extend the time taken to up to 90 days (3 months).

The importance of credit markets: More than just Demand/Supply of money

-> not sufficient understanding of the channels through which monetary macroeconomic policies are applied: IS/LM model, liquidity trap, crowding out, quantitative easing…

Steve Keen [Debunking macroeconomics]:
in addition to income earned by selling goods and services (which primarily finances consumption of goods and services and thus conserves money), the money is supplied by banks :

- in the context of entrepreneurial debt (**which primarily finances investment**) and
- in the context of rising ponzi debt (**which primarily finances the purchase at increasing prices of existing assets**).

The Financial Instability Hypothesis by Hyman P. Minsky WP No.74 May 1992

The FIH is a theory of the impact of debt on system behavior.

3 distinct income-debt relations:

HEDGE, SPECULATIVE and PONZI finance

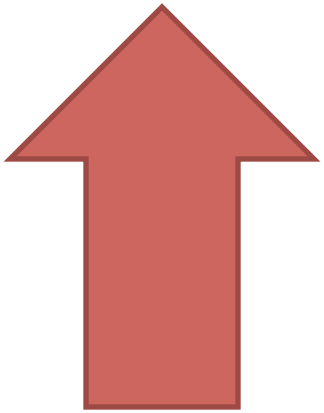
extent to which a firm is expected to be able to cover the cost of external borrowings that it requires in order to operate.

The greater the weight of speculative and Ponzi finance, the greater the likelihood that the economy is a deviation amplifying system.

The FIH

1. The economy has financing regimes under which it is stable, and financing regimes in which it is unstable.
2. Over a protracted period of good times, capitalist economies tend to move hedge finance units to a structure in which there is large weight of Ponzi units.

>Triggering of a downturn (crisis)
>> Many firms become Ponzi
>>> Minsky moment
>>>> Irrational exuberance
>>>>>Amount of loans increases
>>>>>> Business cycle upswing

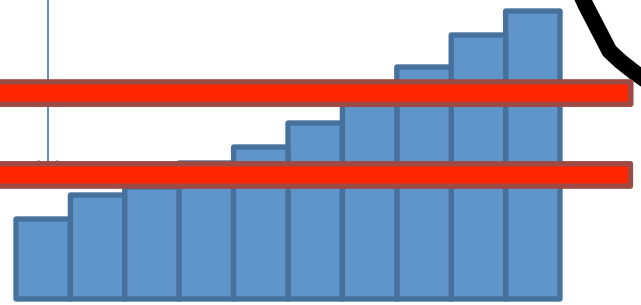


Solomon S, Golo N. "How Does IT Happen? A Marshall-Walras view of the Minsky Financial Instability ", Accounting, Economics and Law: A Convivium

Marshall-like supply/demand diagram for interest rates and loans

i is a measure of the credit availability

REGIME 1: Neo-classical 'Money is conserved" reasoning: the larger the interest the smaller credit demand .



Macro State
Interest rate i

$N=(i/k)^{\mu}$, $\mu<0$
top-down

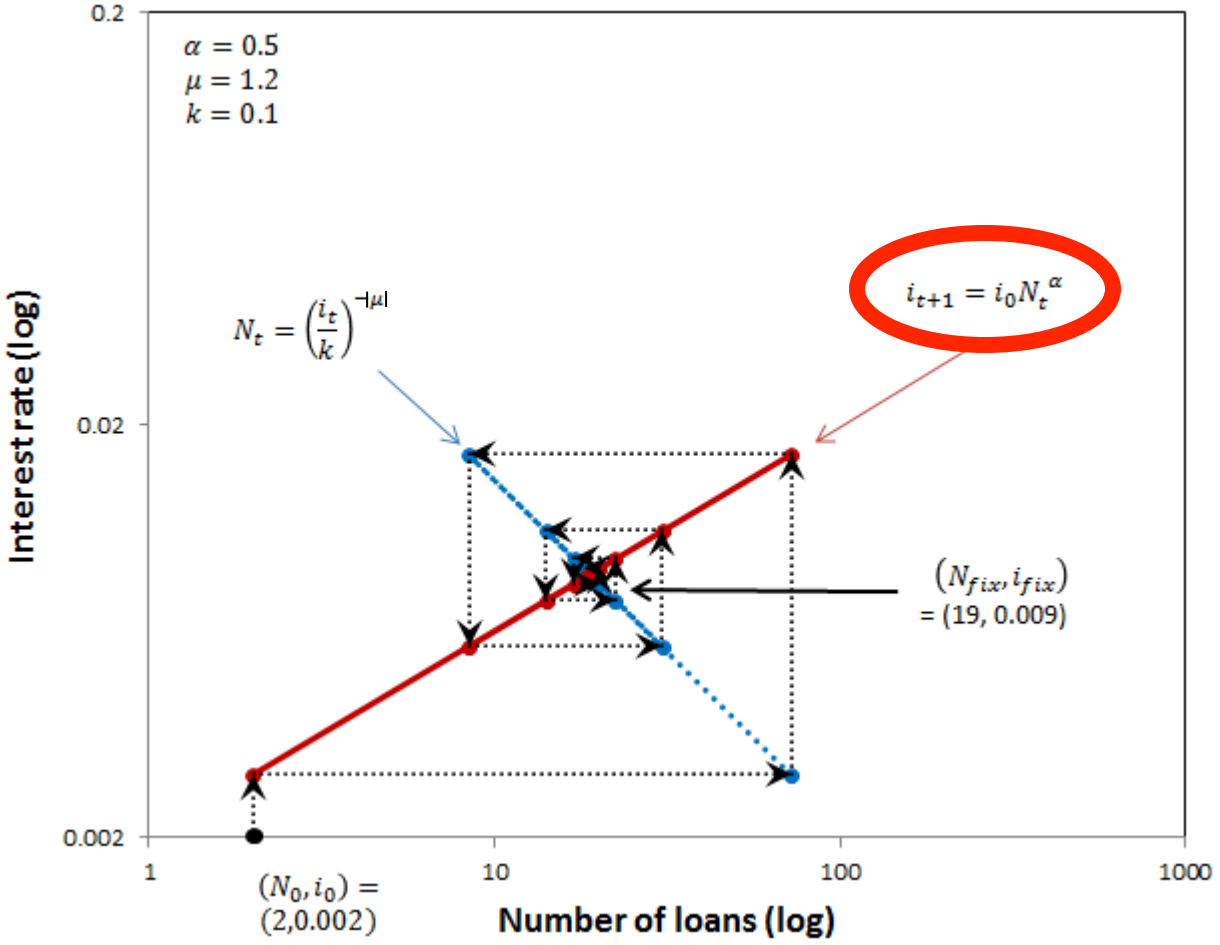
$i=i_0 N^{\alpha}$, $\alpha>0$
bottom-up

Micro States
quantity N of loans

Firms have a power law (μ~1-2) distribution of their earnings/debt ratio = which is a measure of their "capacity" to borrow more money.

Regime 1: Walrasian loan market equilibrium

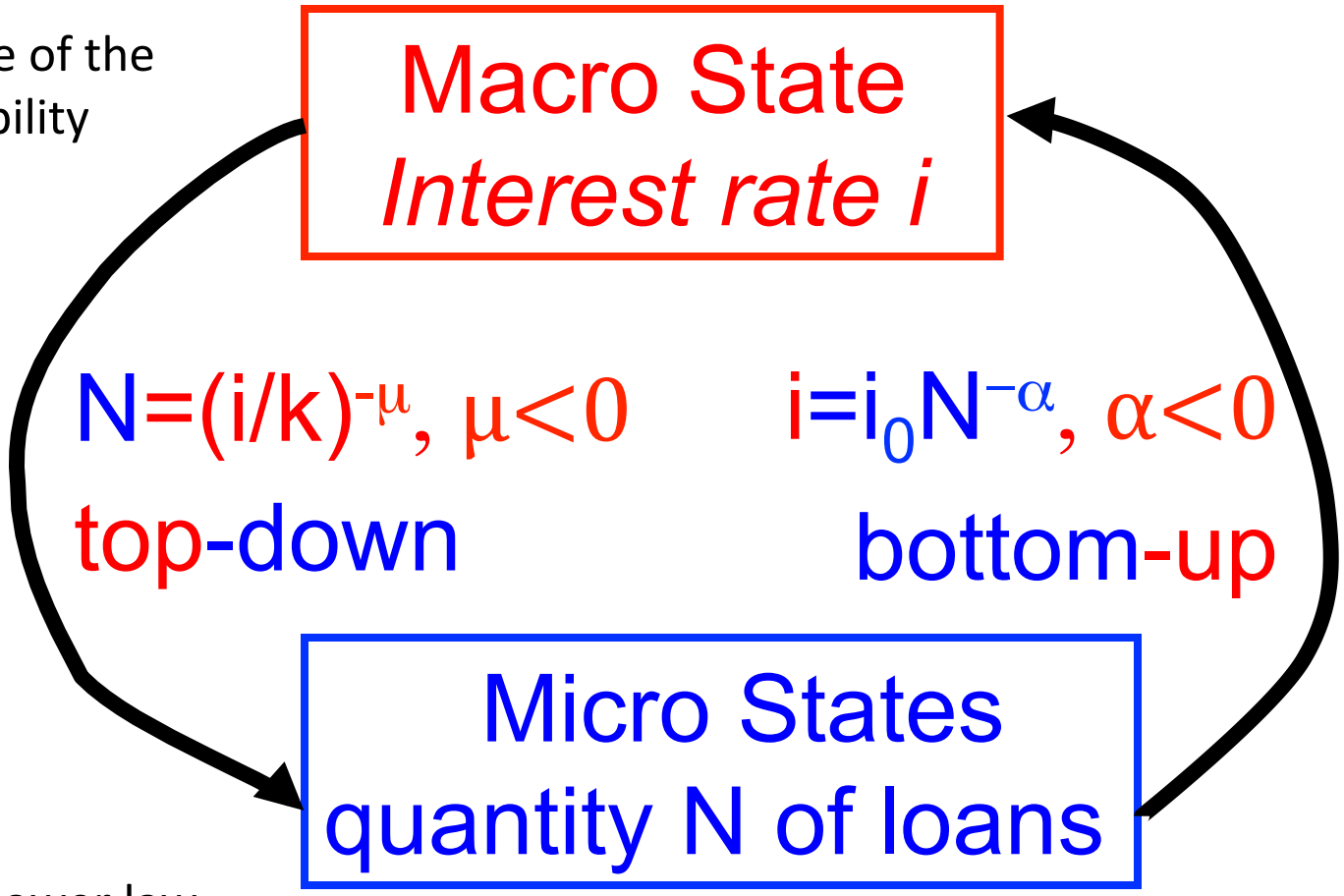
"Rational" loan demand and "rational" interest rate charging lead to an equilibrium in the loans market: oscillating in the number of loans and the interest rate the system would move towards an equilibrium of loans demand and supply.



A change in macro-behavior leads to regime 2

i is a measure of the credit availability

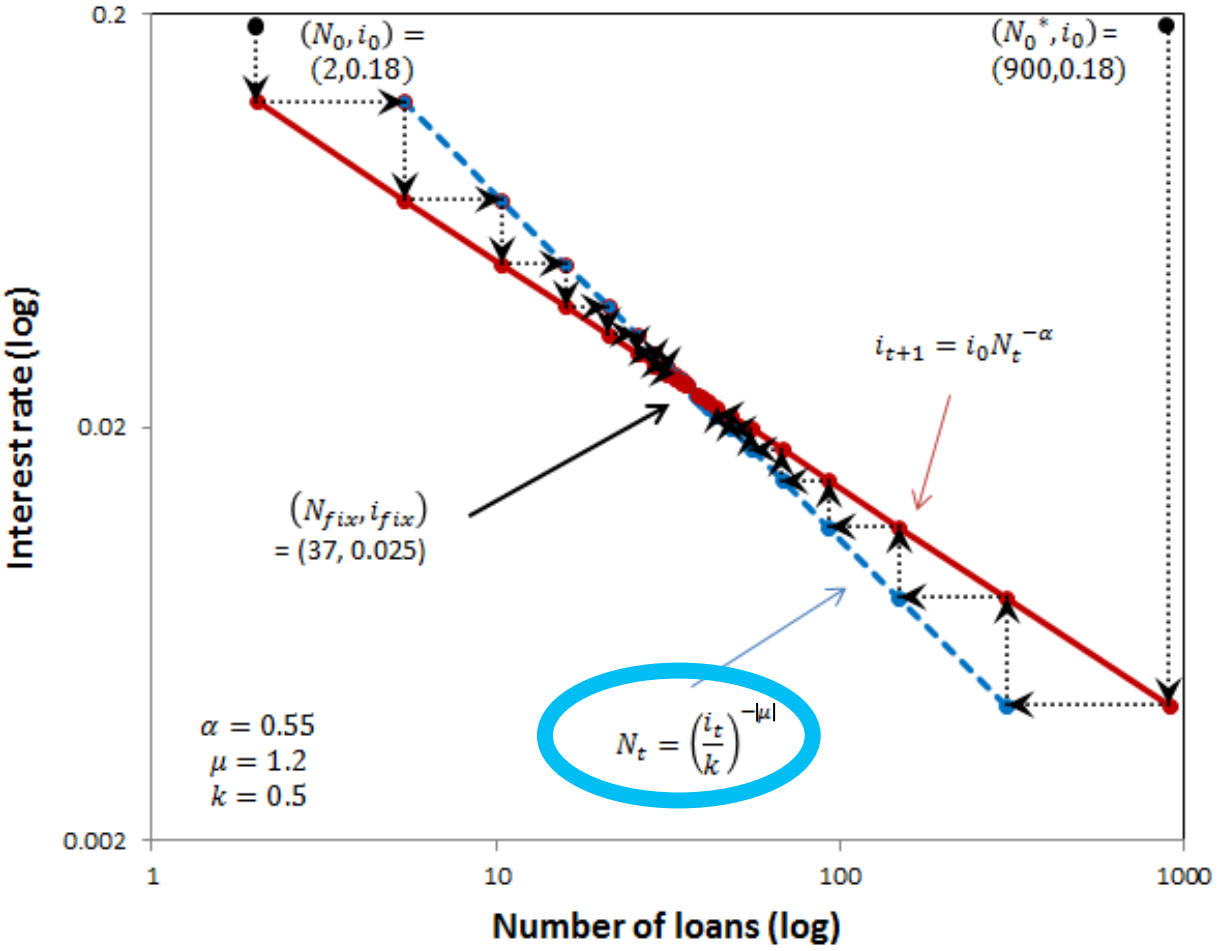
REGIME 2: The "increasing returns" regime: because loans given by banks are recognized as their assets: the more "assets" the lower interest rate (capital/asset requirement).



Firms have a power law ($\mu \sim 1$-2) distribution of their earnings = which is a measure of their "capacity" to borrow more money.

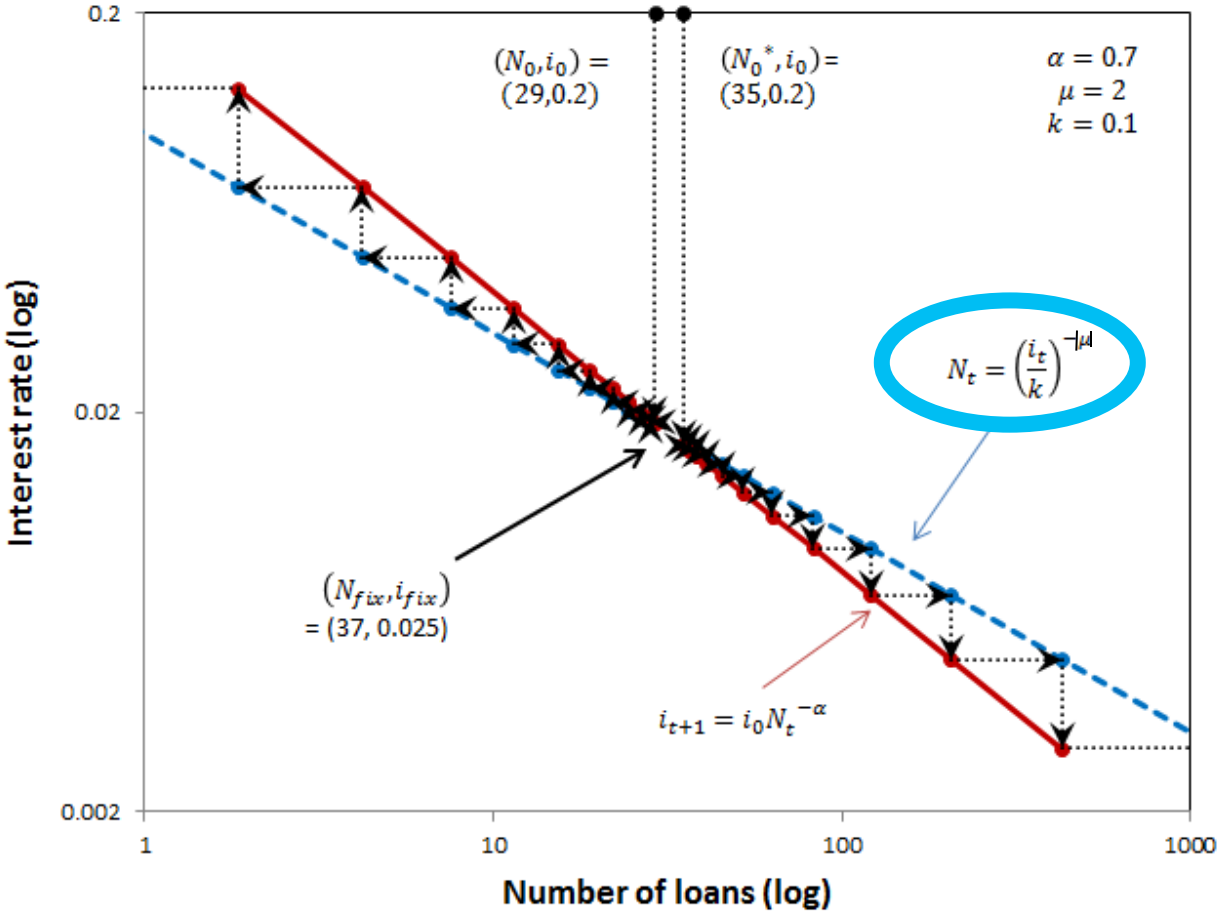
Regime 2: Loan accelerator

If the interest rate charging is a decreasing function of the number of loans, this can easily lead to disequilibrium in the loans market: lowering the interest rate the number of loans increases: loans accelerator.



Regime 2': Fast Loan accelerator

If the interest rate charging is a decreasing function of the number of loans, this can easily lead to disequilibrium in the loans market: lowering the interest rate the number of loans increases: loans accelerator.



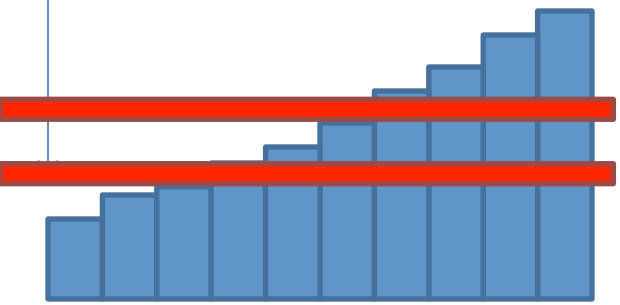
FIH:

the prolonged period of economic growth leads to an increased of number companies close to the Ponzi status. Exogenous shock – slight increase *i* and … ??

An exogenous shock leads to regime 3

i is a measure of the credit availability

Firms have distribution of resilience= earnings/debt that follows power law with power β.



Macro State
Interest rate i

$N=(i/k)^{\beta}$

top-down

$i=i_0N^{\alpha}$

bottom-up

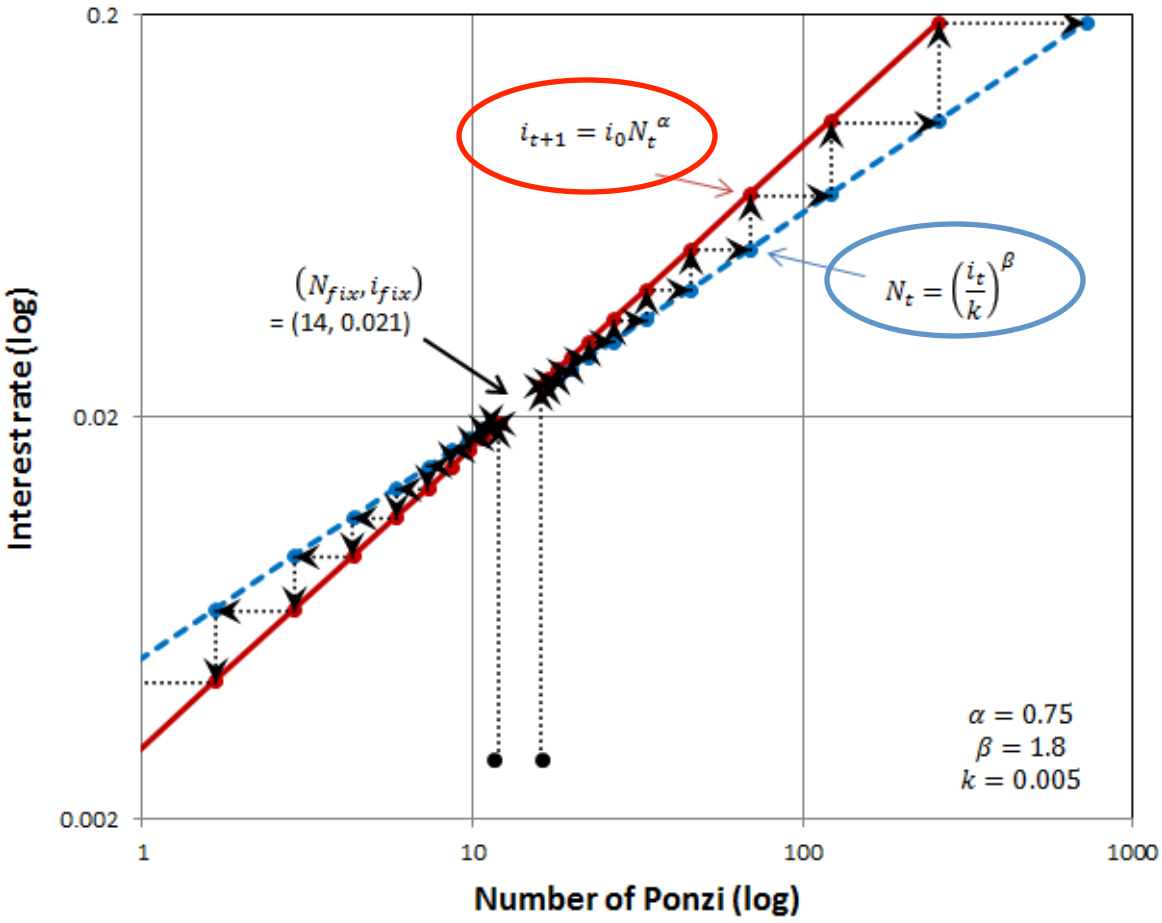
Micro states
number N of Ponzi

resilience=earnings/debt

Regime 3: Minsky crisis accelerator

An initial increase in the interest rate over the business cycle can make firms more speculative and become Ponzi.

Then, banks will react to an increased number of financially fragile firms by increasing further the interest rate.



Implementation of the proposed model (submitted paper)

Translating Minsky's ideas into an exact model is very difficult as the variables that he has defined in a descriptive way are difficult to be tracked back in firm's balance sheets. We make an attempt to classify these categories using performance data that is closely aligned with Minsky's descriptions.

HEDGE: EBIT(t) > BL(t)

SPECULATIVE: EBTDA(t) >FC(t), EBIT(t) < BL(t)

PONZI: EBTDA(t) < FC(t).

- EBIT(t) is Earnings Before Interest and Taxes due in year t,
- FC(t) is Financial Costs, i.e. interest on loans and costs associated with financial transactions, incurred in year t.
- EBITDA(t) is Earnings Before Taxes due and Depreciation Allowance in year t.

Autocatalitic Minsky model adapted for TC data

In the adapted model, the number of Ponzi companies $N\downarrow t$ at a certain moment t is a positive function of the interest rate is $i\downarrow t$.

$$N_{loans}(t) = \left(\frac{i(t)}{i_{min}}\right)^{\mu} \times N_{tot}(t) \qquad N_{ponzi}(t) = \left(\frac{i(t)}{i_{max}}\right)^{\beta} \times N_{tot}(t)$$

β *and* μ are heterogeneity coefficients extracted from the power law distribution of the companies resilience to the interest rate changes. This generates an iterative process which may either converge towards an equilibrium price $i\downarrow fixed$ and an equilibrium level of production $N\downarrow fixed$, or, after an exogenous shock, a one-time injection of a number of ponzi / failures in the system, it may develop into a divergent dynamical process in which the number of ponzis and the interest rate react iteratively to one another.

(when a ponzi firm is blocked from further borrowing and it fails)

Autocatalitic Minsky model adapted for TC data

The mechanism that the bank apply when adjusting interest rate is:

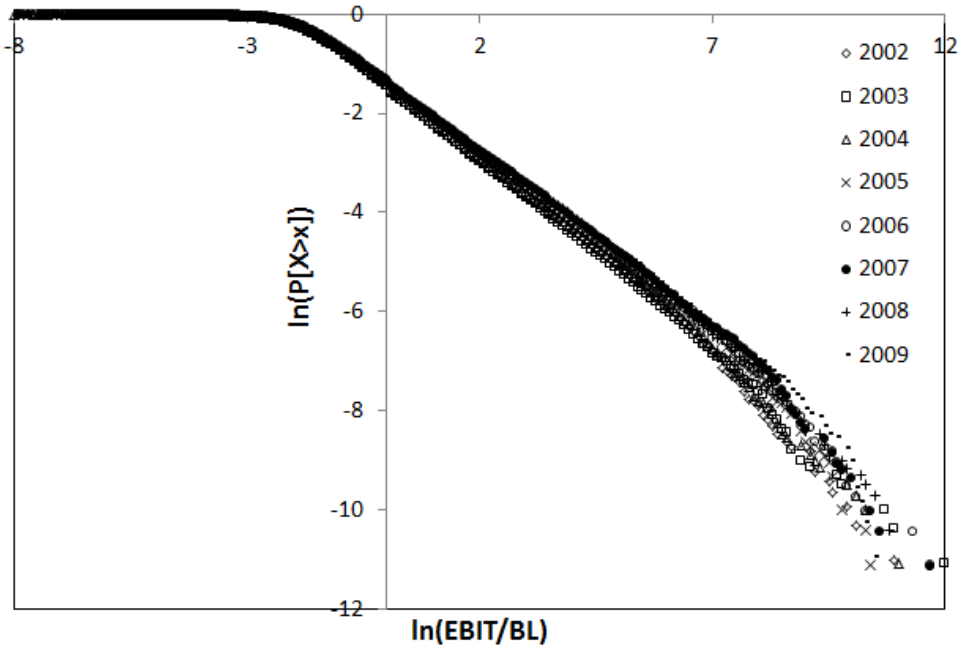
$$i_{t+1} = i_{min} \times (N_{loans}(t)/N_{tot}(t))^{\alpha},$$

$$i_{t+1} = i_{max} \times (N_{ponzi}(t)/N_{tot}(t))^{\alpha}$$

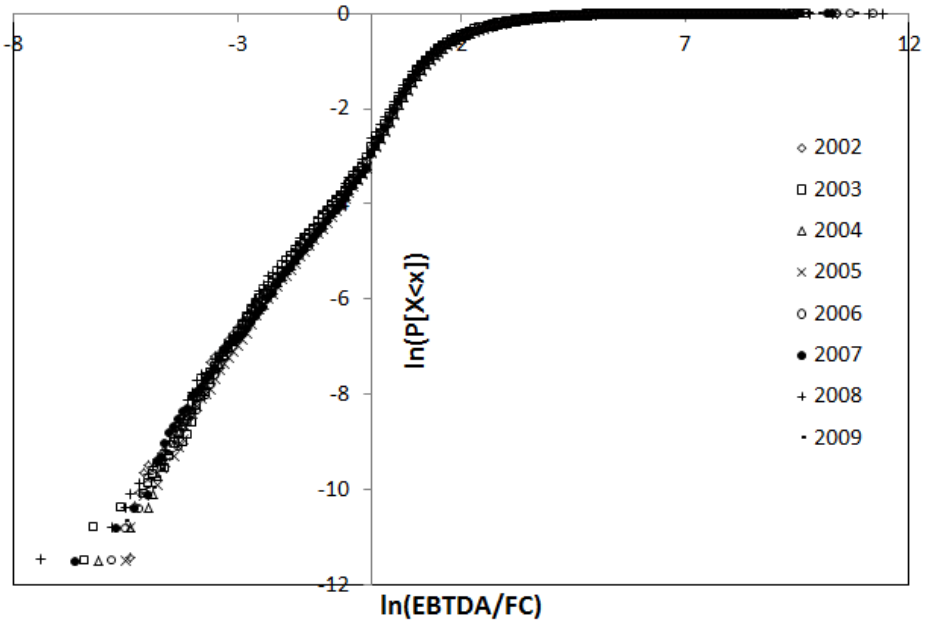
where $i\downarrow max$ is a constant (the max resilience), and the $N\downarrow tot\ (t)$ is the total number of companies at time t. Similar for i_{min}.

α is the inter-scale coefficient that is expressing the strength of the autocatalytic loop between the entire system and the individual companies.

Heterogeneity of ‘hedgeness’



Heterogeneity of ‘ponziness’

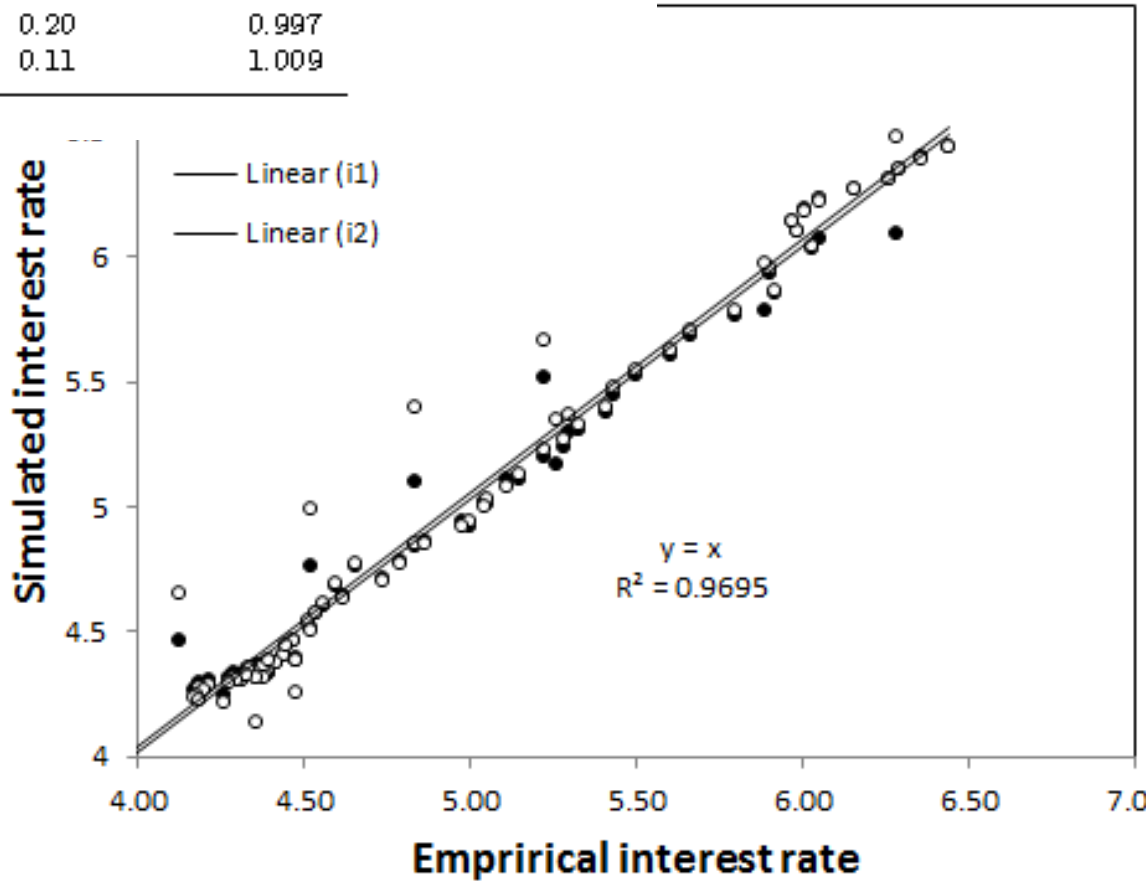


Year	μ	i_{min}	β	i_{max}
2002	-0.83	2.42	1.29	49
2003	-0.79	2.42	1.29	49
2004	-0.79	2.42	1.30	49
2005	-0.77	2.42	1.32	49
2006	-0.76	2.42	1.30	49
2007	-0.76	2.42	1.28	49
2008	-0.76	2.42	1.27	49
2009	-0.73	2.42	1.27	49

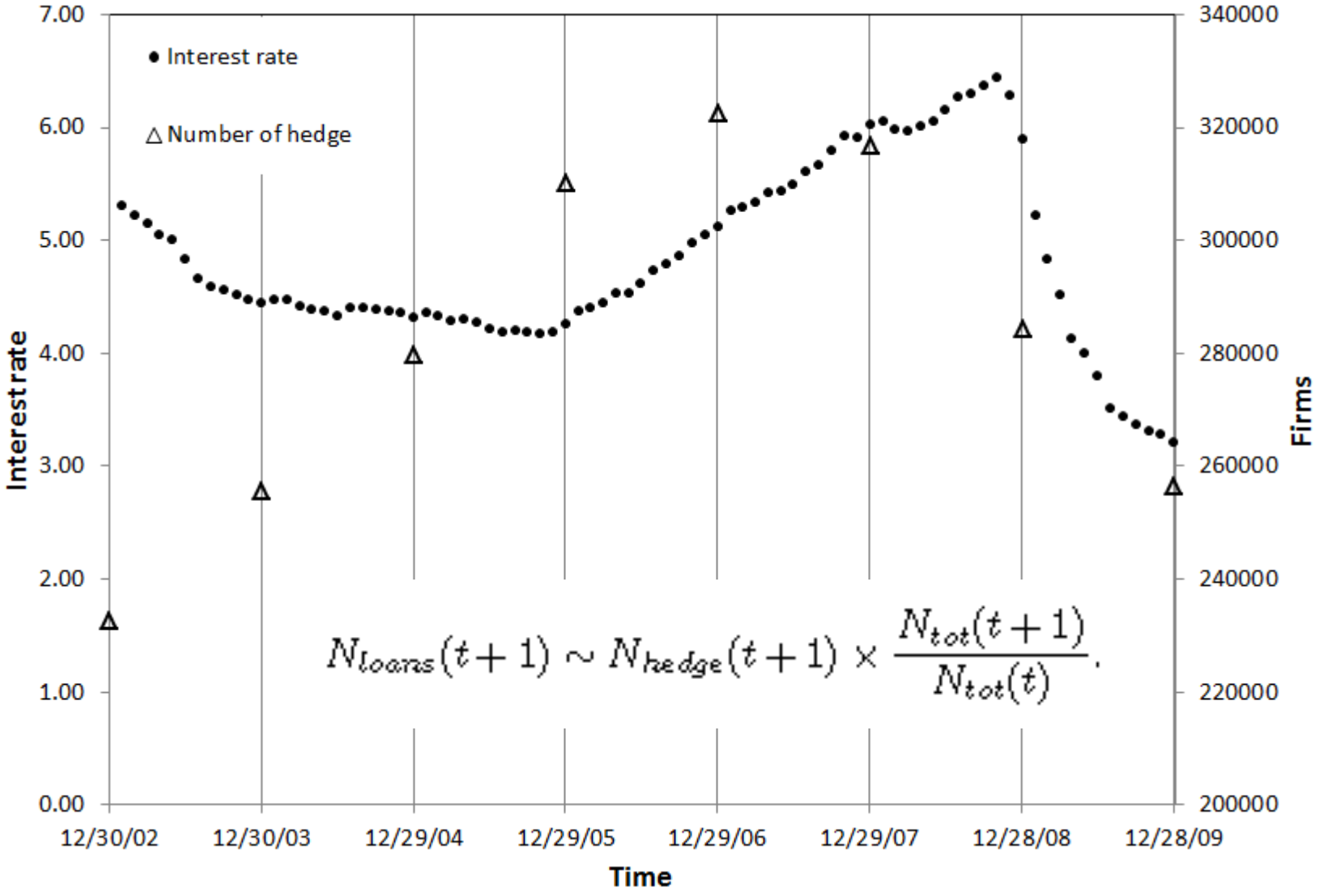
Table 1 Estimation of the parameters μ from the distribution of $EBIT/BL$, β from the distribution of $EBTDA/FC$ and i_{min}, i_{max} fitting paratemers.

Table 3 Simulation results, using the previously estimated / fitted parameters β, μ, i_{max}, i_{min} and the models of Loans accelerator, Eqs. 2 and 5 and Crisis accelerator, Eqs. 4 and 6. The results are: the estimation of the parameter α for each year, starting from January until December, leading to the N_{loans}/N_{tot} and N_{ponzi}/N_{tot} ratios in December of each given year. This was necessary because of the yearly basis on which the coefficients β and μ are measured.

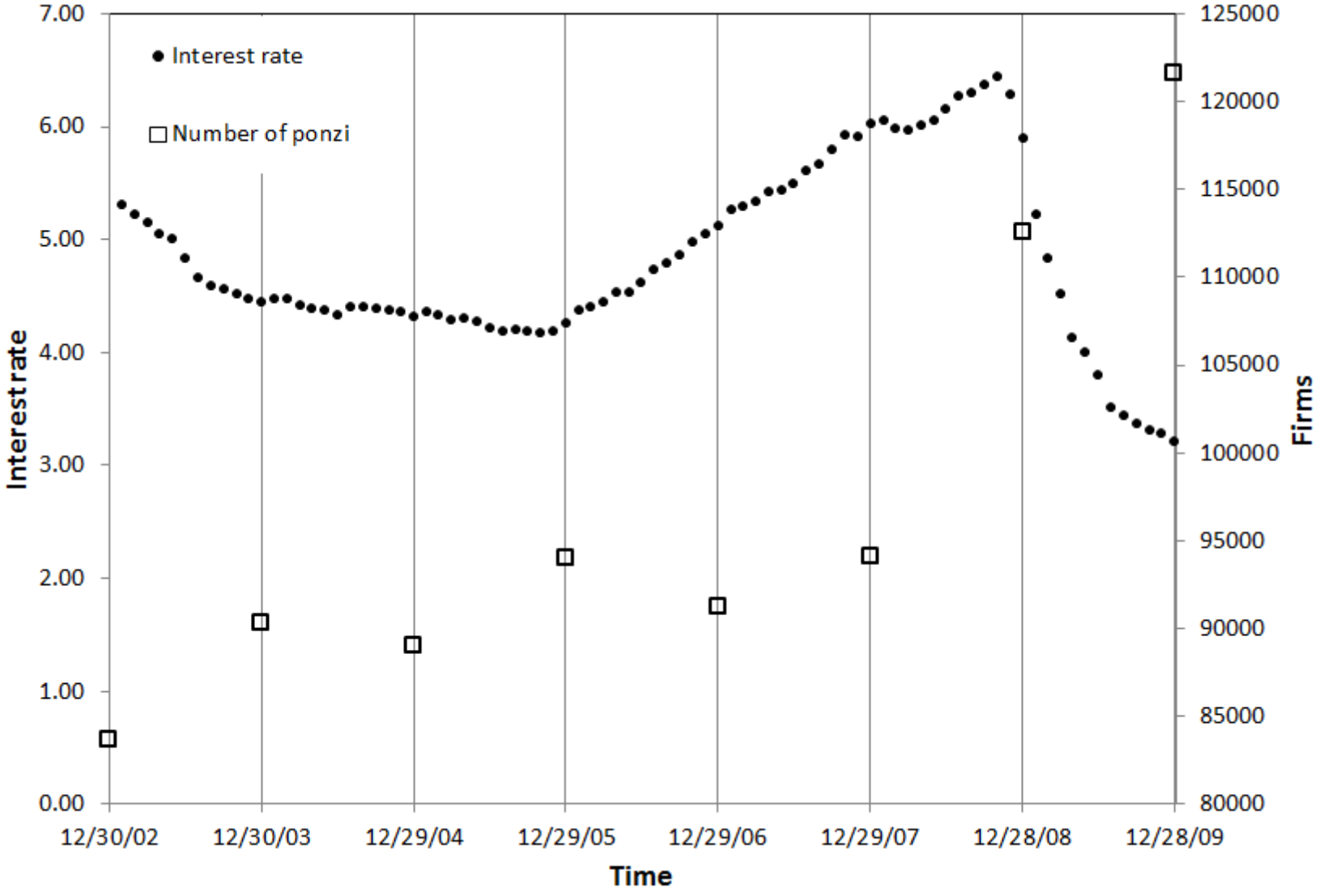
Year	α_1	N_{loans}/N_{tot}	$\alpha_1\mu$	α_2	N_{ponzi}/N_{tot}	$\alpha_2\beta$
2003	-	0.53	-	-	0.18	-
2003	-1.235	0.62	0.976	0.78	0.15	1.006
2004	-1.262	0.63	0.997	0.77	0.15	1.001
2005	-1.293	0.65	0.995	0.76	0.16	1.003
2006	-1.346	0.57	1.023	0.765	0.18	0.994
2007	-1.338	0.50	1.017	0.775	0.20	0.992
2008	-1.325	0.47	1.007	0.85	0.20	0.997
2009	-1.242	0.81	0.907	0.795	0.11	1.009



Evolution of loans

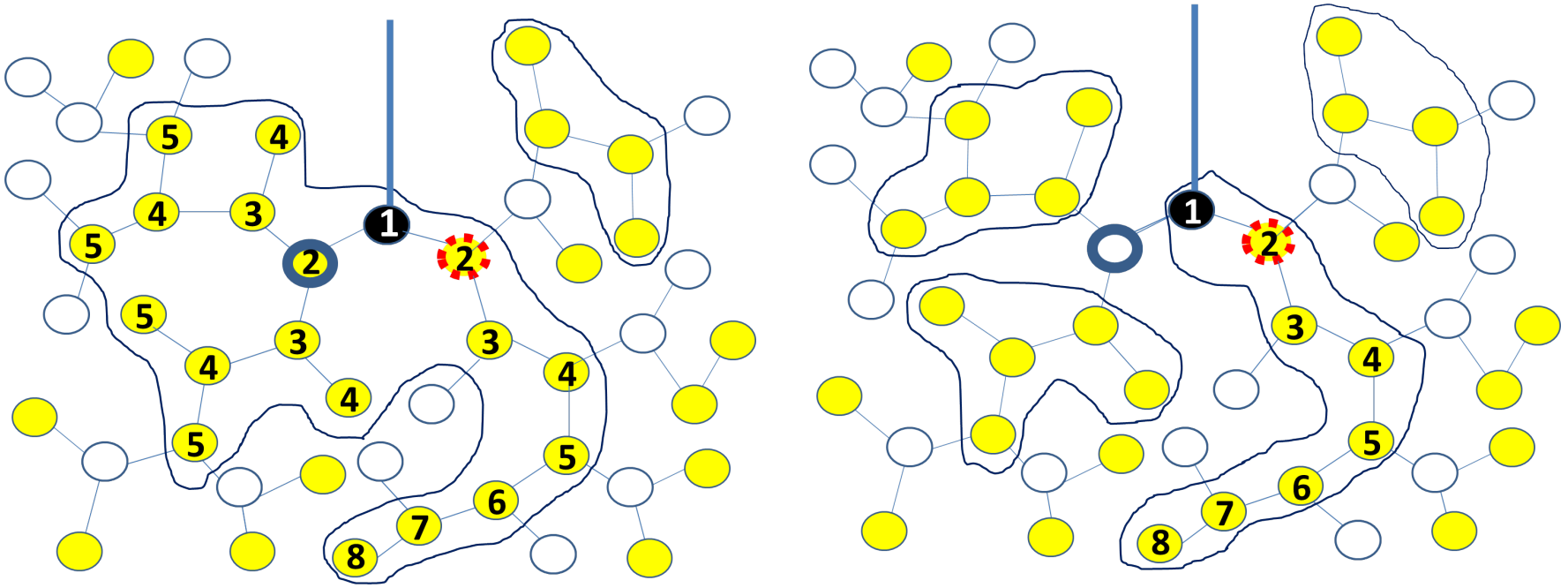


Evolution of ponzi firms



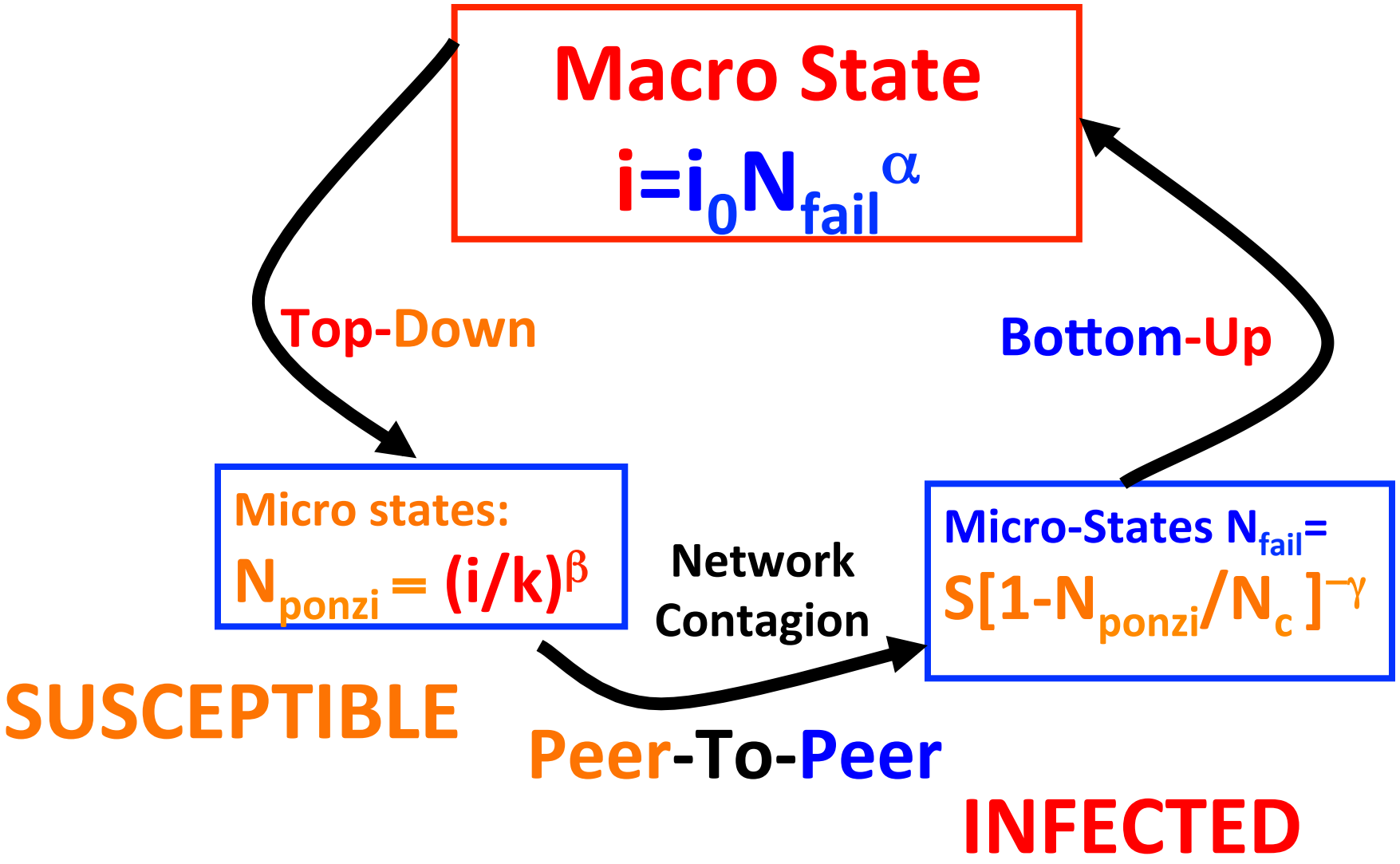
Contagion on a network

Network is introducing non-linearity in the model by applying the rule that a firm can fail only if at least one of its first neighbors has been ponzi and already failed.



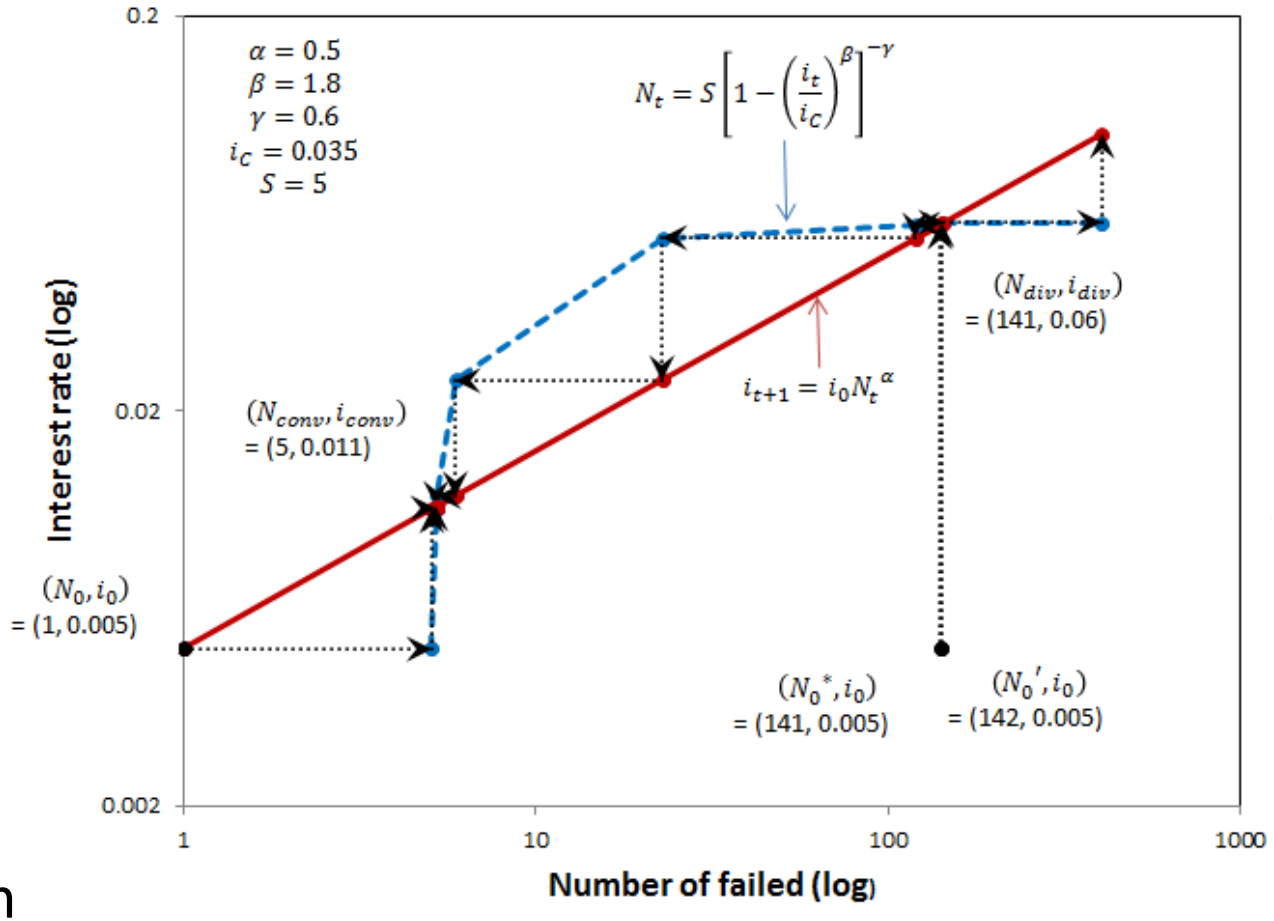
Stauffer, Dietrich. "Scaling theory of percolation clusters." *Physics Reports* 54, no. 1 (1979).

Susceptible-Infected-Macro loop



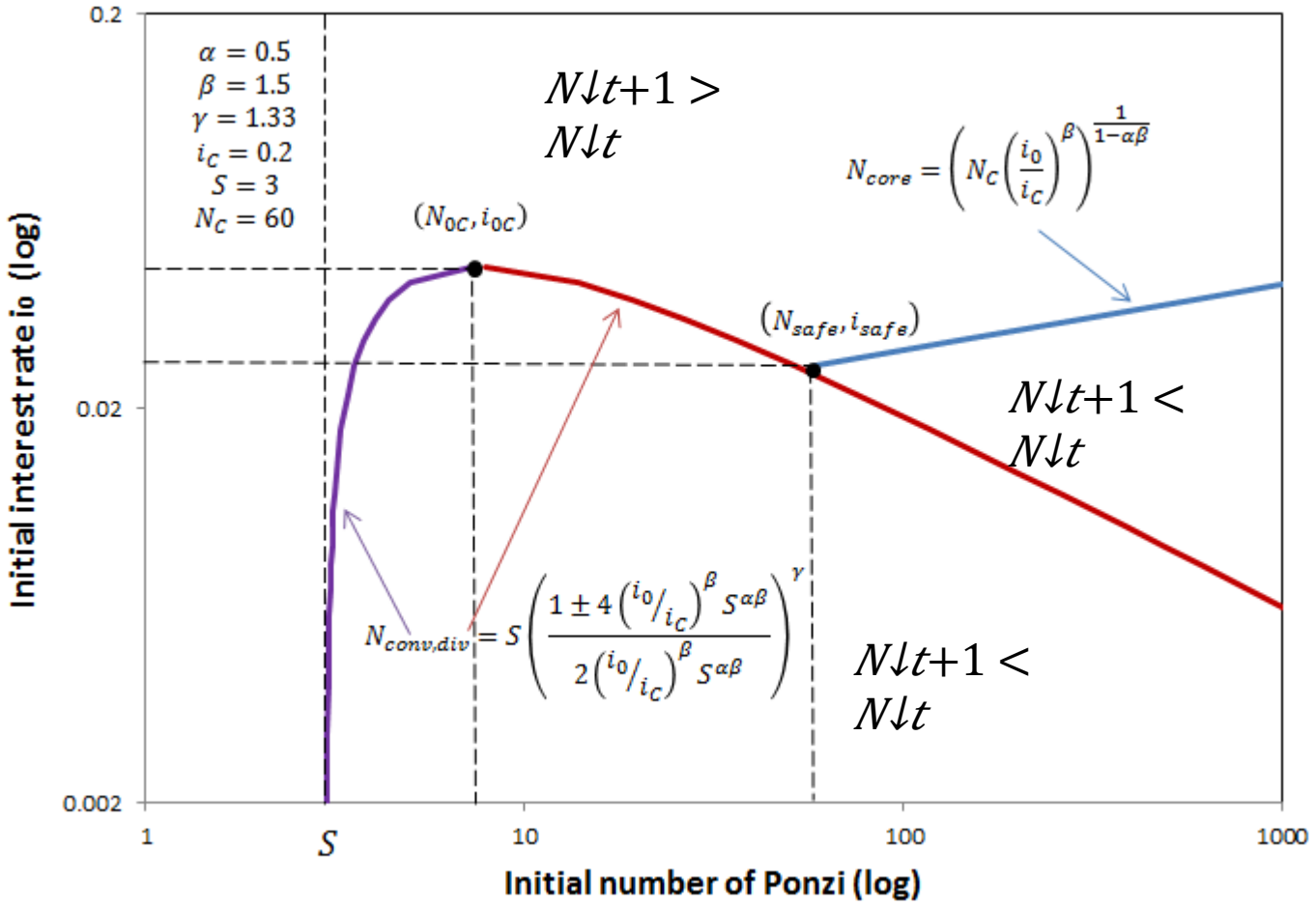
Minsky FIH model on a network

On the graph, the effect of the network reflects in to the non-linearity of the blue line. The two intersections of the red and the blue line define the fixed points of such system: one of them is convergent and the other divergent.



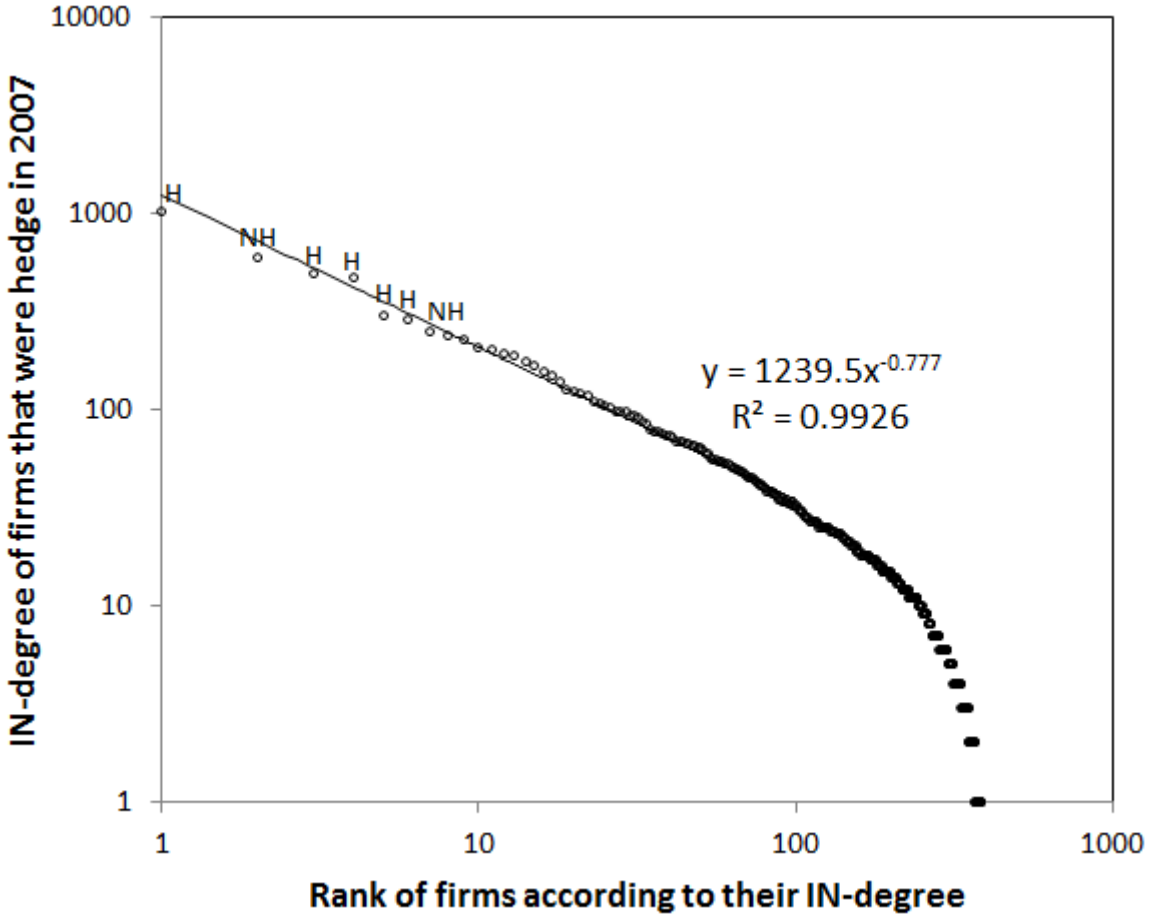
For the math: Galor, Oded. *Discrete dynamical systems*. Springer, 2007.

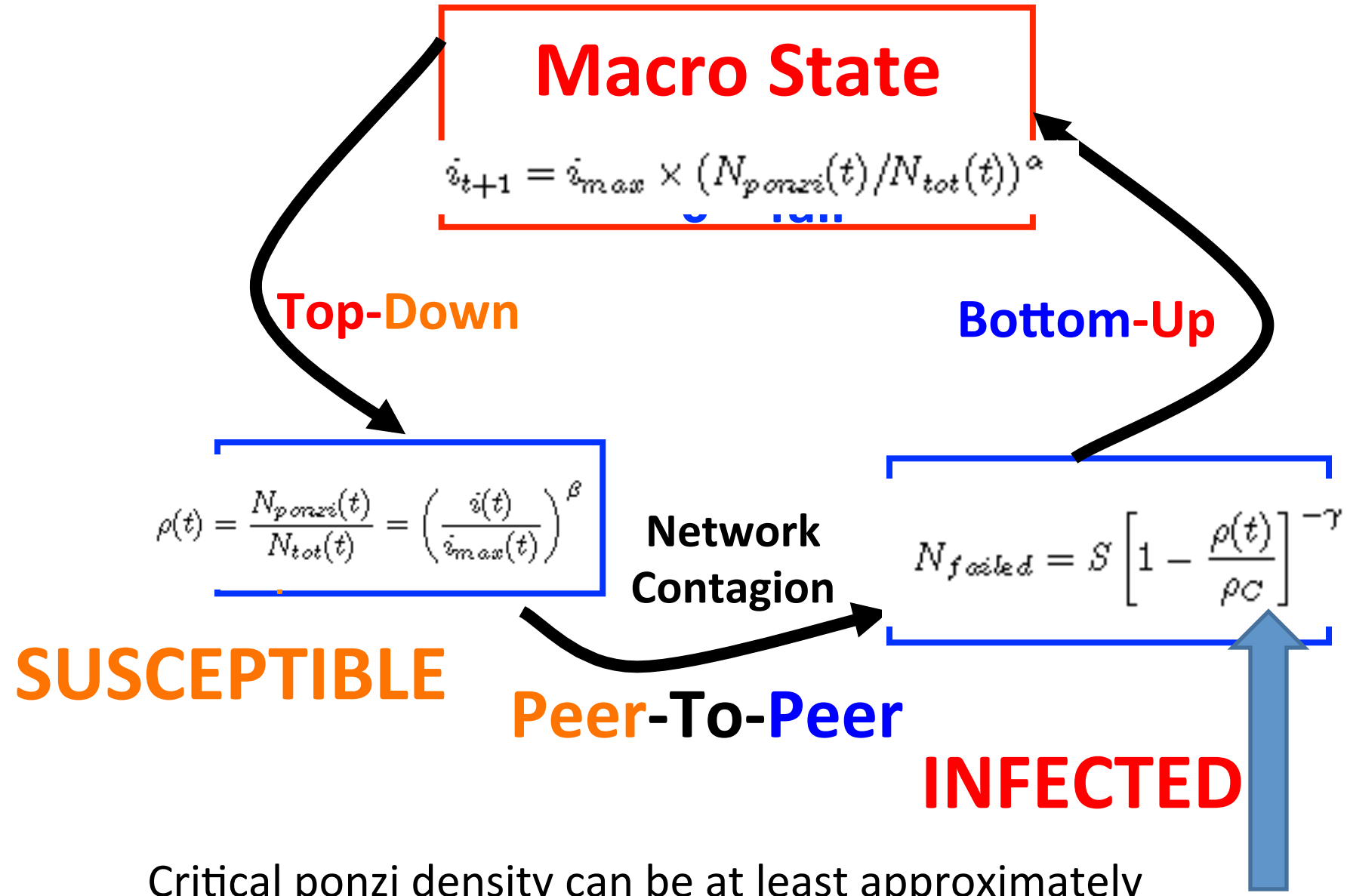
Model predictions



Derivation of the (innovation) model: Cantono, S., and S. Solomon. "When the collective acts on its components: economic crisis autocatalytic percolation." *New Journal of Physics* 12, no. 7 (2010): 075038.

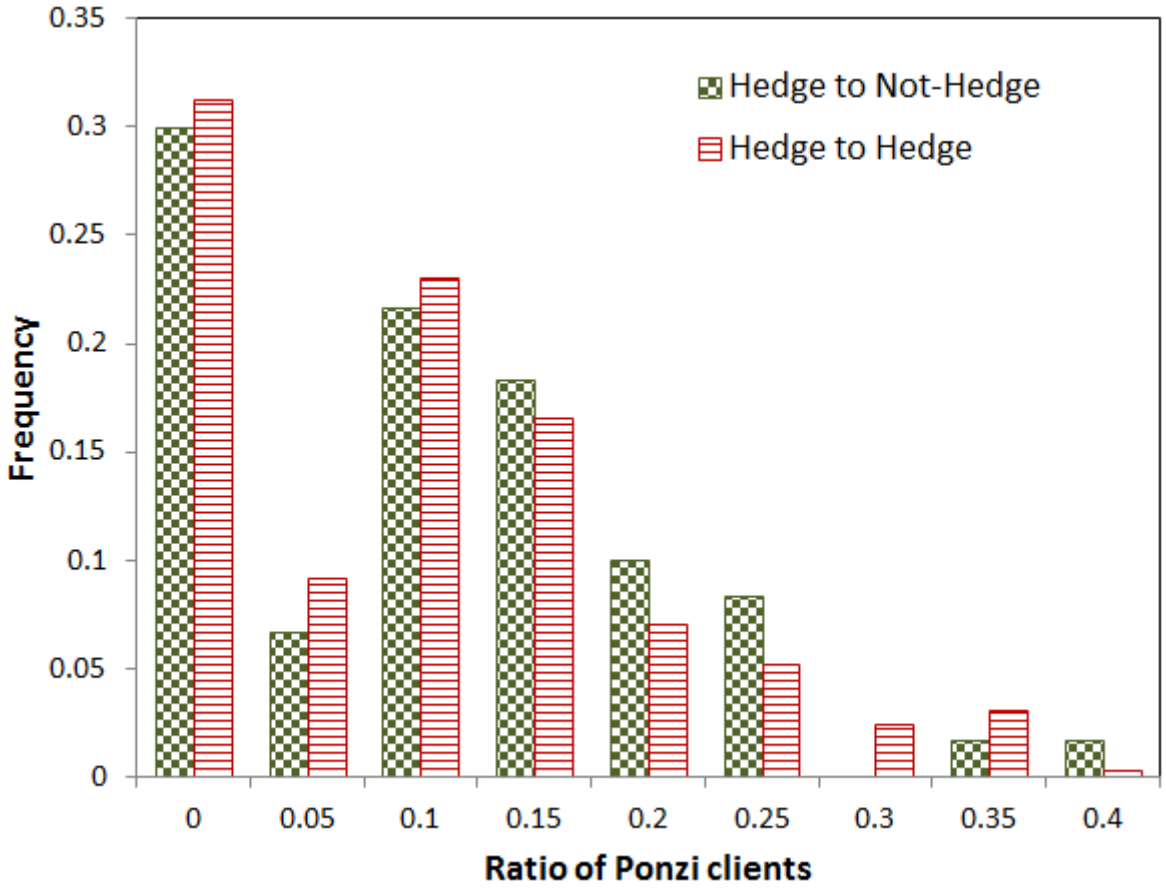
IN-degree and the hedge/nonhedge status of firms





Critical ponzi density can be at least approximately estimated from the system behavior: ρ_C<0.20

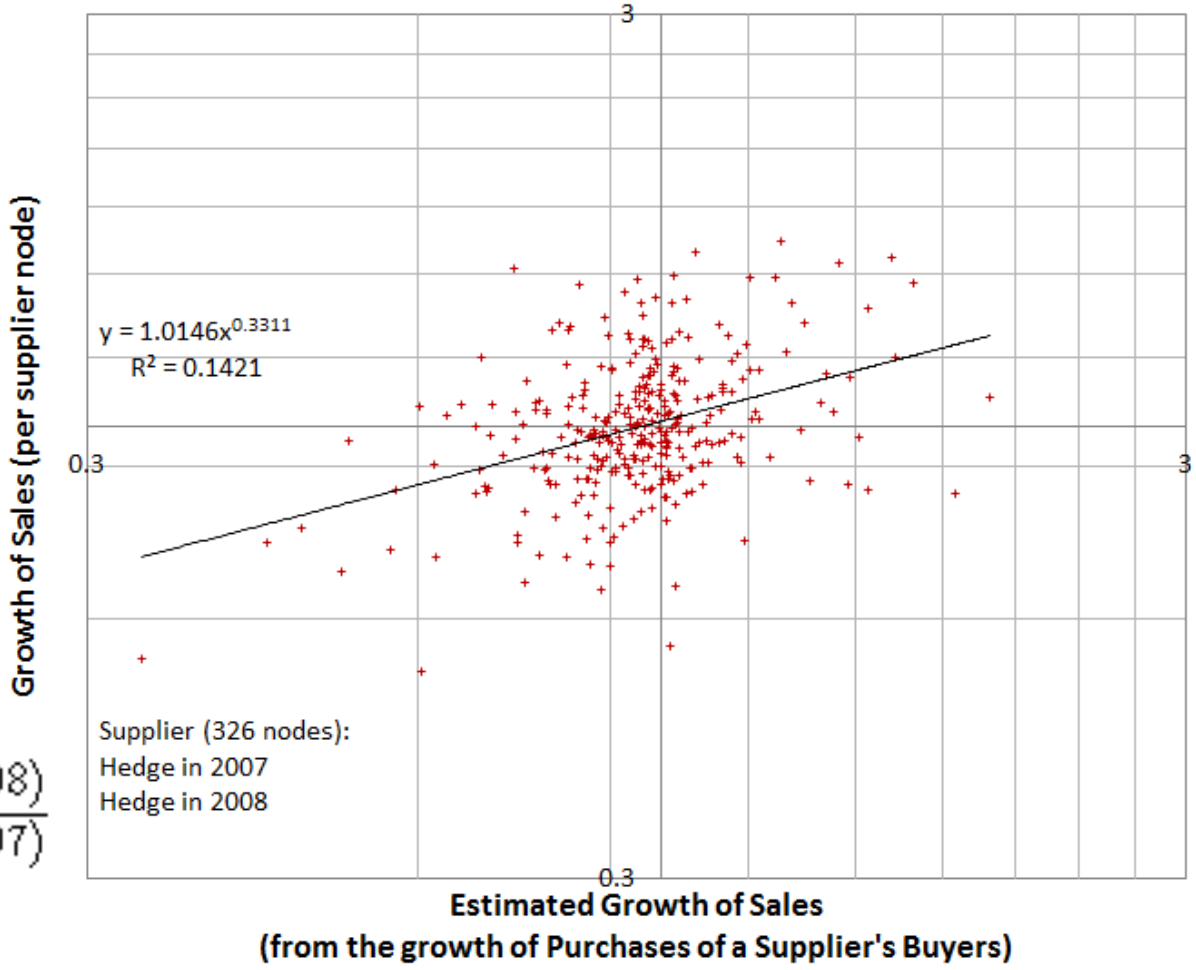
How to estimate gamma? How to measure network effect? How to quantify the effect of ponzi-clients?



Significance of the given network for defaults is difficult to estimate.

Growth/shrinkage contagion

The scatter plot shows that the significance of correlation is very low; this is because the companies did not stay dependent only on their initial clients.



$$\text{Growth}_i = \frac{Sales_i(2008)}{Sales_i(2007)}$$

$$\text{Estimated Growth}_i = \sum_j TC_{ji} * \frac{Purchases_j(2008)}{Purchases_j(2007)}$$

Not dynamic enough to remain hedge:

In the group of firms which degraded from their hedge status, this correlation is better; it might indicate that those firms have been less dynamic in finding the new clients.