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XXX Cycle - I year presentation

A complex network approach to the analysis of artificial markets

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My background

- I received the M.Sc. Degree in Ingegneria Gestionale from University of Naples «Federico II» with the thesis «Agent behaviours in an artificial financial market».
- I work with the SINCRO group
- My fellowship is «Fondo Sociale Europeo, P.O. Campania 2007/2013-2014/2020»

The problem

*"In the face of the crisis, we felt abandoned by conventional tools... we need to develop **complementary tools** to improve robustness of our overall framework... I would very much welcome inspiration from other disciplines: **physics, engineering, biology**. Bringing experts form these fields together with economist and central bankers is potentially very creative and valuable. Scientists have developed sophisticated tools for analysing **complex dynamic systems** in rigorous way."*

Jean-Claude Trichet

former European Central Bank Governor

ECBs flagship annual Central Banking Conference, 2010

The idea

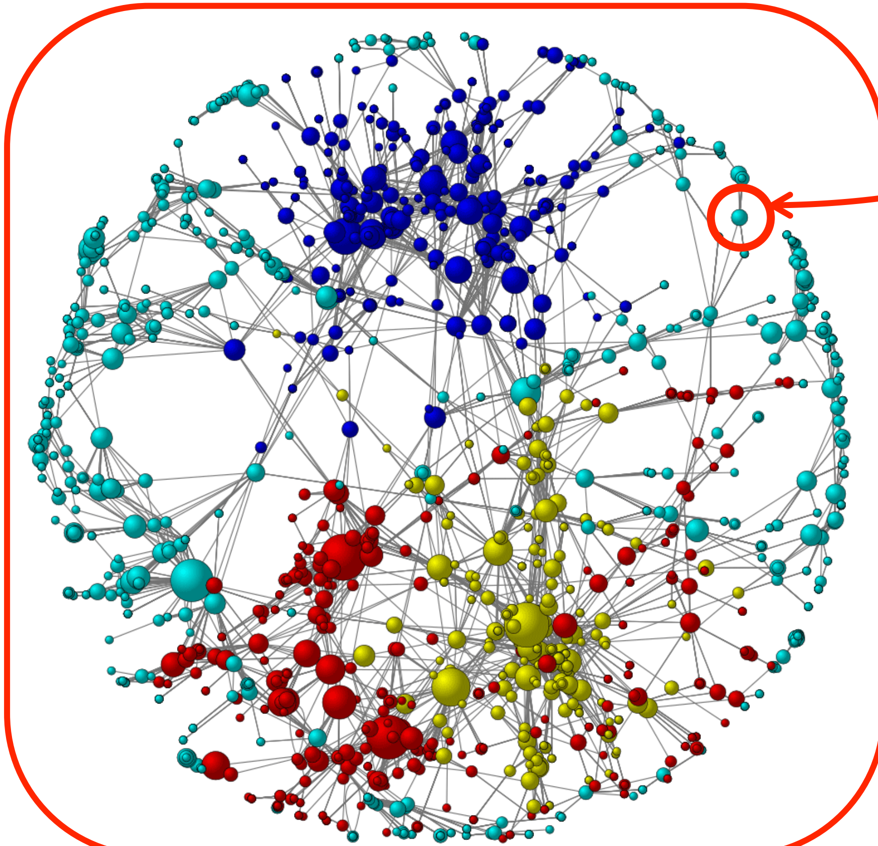
- A limit of the classical approach is that of neglecting the interactions amongst the market agents. To overcome this limitation, physicists consider the market agents as gas particles and mainly rely on the mean field approach or on regular lattices to model their interactions.

- Unfortunately, the interaction schemes amongst market agents are far more sophisticated than those captured by these regular structures.

My contribution consists in leveraging the tools from complex networks of dynamical systems to model these interactions. An agent-based approach will be used to in order to reproduce and predict emerging features of the market.

Complex Networks

- A network can be represented by a graph $\mathcal{G} = (\mathcal{N}, \mathcal{E})$, where $\mathcal{N}$ is the set of nodes and $\mathcal{E}$ is the set of edges.



Agent: dynamical system

Classical dynamical system theory

Topology of the connections: interactions among the agents

Graph Theory

The Model

- Agent behaviours:

$$E\Big[U_j\big(x_j(k),\, i\big)\Big] = 0.5\Big[\big(a_i\delta x_j(k)\big)^{\alpha_j(k)} + \big(b_i\delta x_j(k)\big)^{\alpha_j(k)}\Big],\ i = 1,\ \ldots,\ m$$

- Agent dynamics:

$$\begin{cases} x_j(k) = x_j(k-1) + \beta\delta x_j(k)\big(a_i - 1\big) - (1-\beta)\delta x_j(k)\big(1 - b_i\big) \\ x_j(0) = x_{j0}. \end{cases}$$

- Agent interactions:

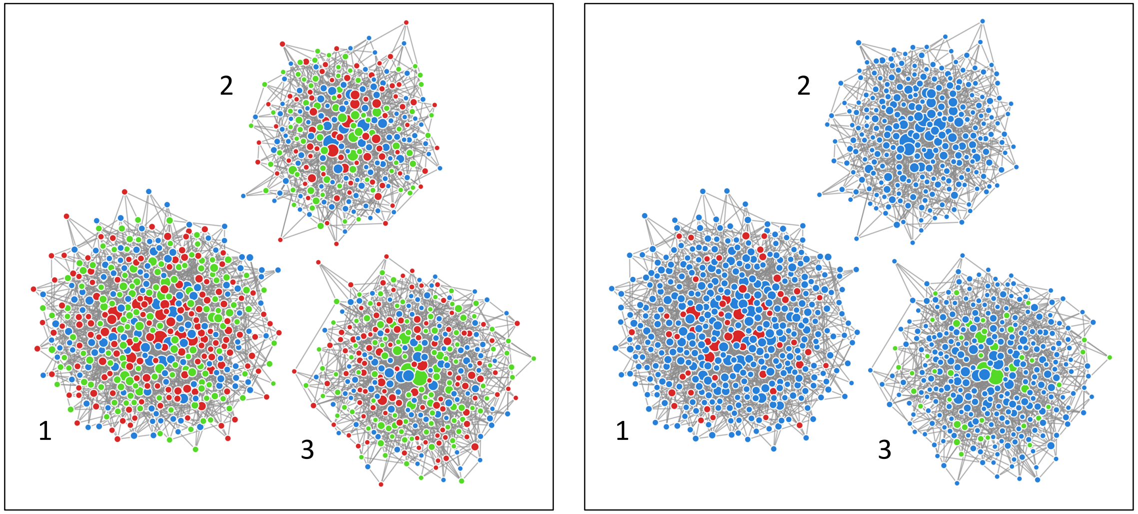
$$\begin{cases} \alpha_j(k) = (1-w)\alpha_j(0) + \dfrac{w}{|\mathcal{N}_j|}\displaystyle\sum_{h\in\mathcal{N}_j}\alpha_h(k-1) \\ \alpha_j(0) = \alpha_{j0} \end{cases}$$

The interactions amongst market agents tend to evolve in time. The need of modelling evolutionary networks spurred us to develop a new abstract network model based on proximity metrics which we have tested on Kuramoto oscillators.

Results

Up to now, we have been able to model:

- The emergence of community structures among the agents
- The effect of external inputs on the market dynamics, such as taxation schemes
- The adaptation of agent behavior due to interaction phenomena
- The main emerging features of the market, such as wealth distribution and trading volumes.



Communities composition before and after interaction

My products

- Already published: DeLellis, P., Garofalo, F., Iudice, F. L., & Napoletano, E. (2015). “Wealth distribution across communities of adaptive financial agents”. *New Journal of Physics*, *17*(8), 083003. (Impact factor: 3.558)

- In preparation: DeLellis, P., Garofalo, F., Iudice, F. L., & Napoletano, E. “The topologies of entrainment in an ensemble of proximity Kuramoto oscillators”.

Next year

- Continue the study of artificial markets, implementing new scenarios with the introduction of other phenomena (i.e. herding), by using new tools, such as evolutionary networks.
- Summary of the first year activity and outlook on the second year:

	Credits year 1							Credits year 2
	1	2	3	4	5	6		
	bimonth	bimonth	bimonth	bimonth	Bimonth	bimonth	**Summary**	**Estimated**
Modules			3	4	7	6	**20**	**9**
Seminars		0,8	1,6	0,4		0,2	**3**	**6**
Research	10	9	5	7	6	5	**42**	**42**
	10	9,8	9,6	11	13	11	**65**	**57**