

"Global systems as networks of networks"

May 2012 14th-16th, villa Finaly, Florence

Rationale

Analyzing the influence of networks on the behavior of agents and organizations has vastly improved, over the past decade, our understanding of the social dynamics at the source of a variety of phenomena such as the build-up of systemic risk in financial markets, the innovativeness of regions, the development of international trade, the formation of eco-industrial clusters or the spreading of information/influence/influenza. Accordingly networks have become paradigmatic examples of transdisciplinary concepts, laying at the core of research programs in economics, finance or environmental science.

The aim of this workshop is to build upon this common interest in order to identify questions and challenges raising at the interface of these disciplines and to approach them as problems posed by networks of networks. As networks have proved instrumental in the analysis of sub-systems such as the interbank market for loans or the life-cycle of products, networks of networks might be useful to approach socio-environmental issues from a global perspective, focusing on the meta-interactions which are at play between international trade, economic growth in China and climate change mitigation or between green growth and the recovery from the financial crisis.

The workshop will bring together economists, computer scientists, physicists, environmental scientists and stakeholders engaging those global issues. A first part of the event will be devoted to the discussion of network-based approaches within each of these disciplines with a particular emphasis on interfaces between models and disciplines. A second part will be devoted to the identification of challenges and questions posed by the integration of these different approaches in view of addressing global challenges at the interface between economic, financial and environmental issues. Special sessions will be devoted to contributions by junior participants.

Organizing Committee

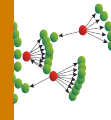
Guido Caldarelli, Institute for advanced Studies ,IMT Lucca
Jürgen Kurths, Potsdam Institute for Climate Impact Research
Antoine Mandel, University Paris 1 Panthéon-Sorbonne

GSDP

GSDP is an FP7 funded coordination action to develop a research program for the study of global systems in an ongoing dialogue wit decision makers, see <http://www.gsdp.eu/>

FOC

FOC is a Scientific Project Financed by FET OPEN Scheme in the field of Information and Communication Technology by the European Commission. The research topic is to understand and possibly forecast systemic risk and global financial instabilities



Program, Monday the 14th

09:45-10:00

Welcome

10:00 -11:00 :

John Ehrenfeld, *Sustainability: an emergent property of the web of life.*

coffee-break

11:15- 13:00 :

Denise Pumain, *City networks as adaptive networks for information and communication*

Mauro Gallegati and Lenardo Bargigli, *Diversification and communities in credit networks*

13 :00-14 :15

Lunch at villa Finaly

14:15-16 :00

Giorgio Fagiolo, *Post-Mortem Examination of the International Financial Network*

Jobst Heitzig, *Using networks in the game theoretic study of international climate policy*

coffee-break

16 :30-18 :15

He-Ling Shi, *Applying evolutionary game theory to model the division of labour and the dynamics of network*

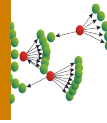
Herbert Gintis, *The Stability of General Equilibrium with Networked Traders*

18 :15-

Open discussion

20 :00 -

Diner at Villa Finaly



Program, Tuesday the 15th

9 :30 -10 :30 :

Fernando Vega-Redondo, *Social networks and the process of "globalization"*

coffee-break

11 :00-12 :45 :

Massimo Riccaboni, *A Probabilistic Framework for International Trade*

Luciano Pietronero, *A new metric for the economic complexity of countries and products*

12 :45-14 :00

Lunch at villa Finaly

14 :00- 15 :45

Peter Schmidt, *The political-economy challenges of the SuperSmart Grid*

Alexandra Penn and Frank Schiller, *Networks of networks and industrial ecology*

coffee-break

16 :15- 17 :15

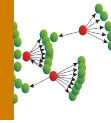
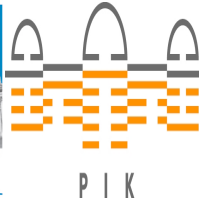
Gérard Weisbuch, *Spatial organisation of economic activity*

17 :15 –

Open discussion

20 :00 -

Diner at Villa Finaly



Program, Wednesday the 16th

9 :30 -11 :15 :

Thomas Lux and Mattia Montagna, *Systemic risk in scale-free InterBank networks.*

Steffano Battiston, *DebtRank: Too Central to Fail? Financial Networks, the FED and Systemic Risk.*

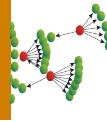
coffee-break

11 :30-12 :30

Jeff Johnson, *Hypernetworks in multilevel systems of systems of systems*

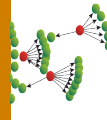
12 :30-

Light lunch and farewell



Participant list

Leonardo Bargigli, University of Florence
Steffano Battiston, ETH Zurich
Guido Caldarelli, IMT Lucca
Mathieu Cristelli, University of Roma La Sapienza
John Ehrenfeld, Marlboro College
Giorgio Fagiolo, Sant'Anna School of Advanced Studies
Mauro Gallegati, Università Politecnica delle Marche Ancona
Herbert Gintis, Central European University
Jobst Heitzig, Potsdam Institute for Climate Impact Research
Carlo Jaeger, Global Climate Forum
Patrik Jansson, Chalmers University of Technology
Jeffrey Johnson, Open University
Jürgen Kurths, Potsdam Institute for Climate Impact Research
Simone Landini, IRES Piemonte
Antoine Mandel, Université Paris 1 Panthéon-Sorbonne
Mattia Montagna, Kiel Institute for the world economy
Jean-Pierre Nadal, EHESS Paris
Fabio Pammolli, IMT Lucca
Alexandra Penn, University of Surrey
Luciano Pietronero, University of Roma La Sapienza
Denise Pumain, Université Paris 1 Panthéon-Sorbonne
Massimo Riccaboni, IMT Lucca
Luca Riccetti, Università Politecnica delle Marche Ancona
Frank Schiller, University of Surrey
Peter Schmidt, Smart Grid Initiative
He-Ling Shi, Monash University
Joan David Tabara, Universidad Autonoma de Barcelona
Andrea Tacchella, University of Roma La Sapienza
Gabriele Tedeschi, Università Politecnica delle Marche Ancona
Fernando Vega-Redondo, European University Institute
Gérard Weisbuch, Ecole normale supérieure Paris



Abstracts

Sustainability: An emergent property of the web of life, John R. Ehrenfeld

The growth in frequency and severity of instabilities in social, economic and environment systems signals a loss of resiliency. Sustainability is slowly gaining prominence as a societal norm that demands more attention. Most public debate about sustainability is mislabeled. The target is the reduction of unsustainability, not the creation of a new attractor in which flourishing or some other positive societal norm can emerge out of the complex socio/economic/environmental global system and persist. The cause of instabilities are cultural and cannot be countered by technology alone. I will discuss the causes and some potential routes toward sustainability. In particular, I will discuss the potential and limitations of industrial ecology.

City networks as adaptive networks for information and communication, Denise Pumain,

Diversification and communities in credit networks, Leonardo Bargigli and Mauro Gallegati.

*After the financial crisis, credit connections are recognized as a potential source of systemic risk. In this perspective, detecting communities in credit networks has become an important issue for policy, since communities are the most likely transmission channels of any shock that could affect the network. In particular, it's possible to show that the emergence of significant communities in a credit network is linked to (a lack of) diversification of the same network. We propose a comprehensive approach in order to solve the problem of community detection in credit networks. As a first step, we obtain ensembles of random networks endowed with a modular structure as specified by a community matrix MS . Then we test alternative community detection algorithms on samples of modular artificial networks, for both *strong* and *weak* communities, obtaining the best results with spectral decomposition. Finally, we apply the same algorithm to the Japanese credit dataset (2000 - 2005), finding that the connectivity of these networks are much higher of the one we could expect by taking into account only within-module (internal) connections. In other words, Japanese firms and banks entertain a high number of links which we could define as "weak" since they connect different communities. This result is consistent with the Japanese "main bank" system (De Masi, 2009). We also find evidence of a strengthening of the community structure over time, with an increasing number of internal links and a growing size of communities.*

Post-Mortem Examination of the International Financial Network, Giorgio Fagiolo.

As the recent crisis has forcefully suggested, understanding financial-market interconnectedness is of a paramount importance to explain systemic risk, stability and economic dynamics. In this paper, we address these issues along two related perspectives. First, we explore the statistical properties of the International Financial Network (IFN), defined as the weighted-directed multigraph where nodes are world countries and links represent debtor-creditor relationships in equities and short/long-run debt. We investigate whether the 2008 financial crisis has resulted in a significant change in the topological properties of the IFN. Our findings suggest that the crisis caused not only a reduction in the amount of securities traded, but also induced changes in the topology of the network and in the time evolution of its statistical properties. This has happened, however, without changing the disassortative, core-periphery structure of the IFN architecture. Second, we perform an econometric study to examine the ability of network-based measures to explain cross-country differences in crisis intensity. We investigate whether the conclusion of previous studies showing that international connectedness is not a relevant predictor of crisis intensity may be reversed, once one explicitly accounts for the position of each country within the IFN. We show that higher interconnectedness reduces the severity of the crisis, as it allows adverse shocks to dissipate quicker. However, the systemic risk hypothesis cannot be completely dismissed and being central in the network, if the node is not a member of a rich club, puts the country in an adverse and risky position in times of crises. Finally, we find strong evidence of nonlinear effects, once the high degree of heterogeneity that characterizes the IFN is taken into account.

Using networks in the game theoretic study of international climate policy, Jobst Heitzig.

Despite the broad consensus that CO₂ emissions must be reduced vastly, the international community has yet failed to cooperate on this issue. This conflict has been studied with various game-theoretic approaches. I will present an overview of the relevant literature, identify different points where network structures appear naturally in this context, and suggest related research questions.

Applying evolutionary game theory to model the division of labour and the dynamics of network, He-Ling Shi.

Inframarginal economics argues that with the improvement of transaction efficiency, the level of specialisation and the division of labour will be developed concurrently - which leads to the emergence of market and the establishment of a network. The continuous improvement of transaction efficiency, therefore, generates the dynamics on the size and the complexity of network. However, current models are based on comparative statics analysis which does not capture the whole dynamics of the emergence and the development of such a network. This paper attempts to incorporate the evolutionary game theory to model the coordinations among economic agents which collectively determine the optimal level and pattern of specialisation and the division of labour.

The Stability of General Equilibrium with Networked Traders, Herbert Gintis.

This paper investigates the out-of-equilibrium price and quantity adjustment process for a decentralized market economy. In place of the public prices and auctioneer of standard Walrasian general equilibrium theory, we assume each agent has his own set of private prices that he uses to maximize utility, determine the desired supply and demand of each good, and decide whether to enter into market trades. Each agent is connected to a set of other agents through a social network modeled as a random graph that is periodically randomly updated. Agents periodically learn the price system of those to whom they are linked in the network, and have useful but imperfect information concerning their trading success. Agents update their private prices periodically by assessing their performance relative to those to whom they are linked, and copy the price structure of an agent who is judged more successful.

The economy is modeled as a finite Markov process. With an initial random assignment of private price vectors to agents, this Markov market economy quickly moves to an ergodic subprocess with a set of quasi-public prices, in which the standard error of private prices across agents becomes very small. In the long run, over a wide range of parameters, the stationary distribution of this Markov process is a quasi-cyclical excursion from the market-clearing condition, with a period and amplitude that is a function of the degree of the network. The system nevertheless converges on long run average to the Walrasian equilibrium.

Social networks and the process of "globalization", Fernando Vega-Redondo.

We propose a stylised dynamic model to understand the role of social networks in the phenomenon we call "globalization." This term refers to the process by which even agents who are geographically far apart come to interact, thus overcoming what would otherwise be a fast saturation of local opportunities. A key feature of our model is that the social network is the main channel through which agents search and exploit new opportunities. Thus only if the social network becomes global (heuristically, "reaches far") can global interaction be steadily sustained. To shed light on the conditions under which such a transformation may, or may not, take place is the main objective of the paper.

One of our interesting insights is that in order for a local social network to turn global, the economy needs to display a degree of "geographical cohesion" that is neither too high (for then global opportunities simply do not arise) nor too low (in which case there is too little social structure for the process to take off). And if globalization does arise, we show that it often occurs abruptly and consolidates as a robust state of affairs. We also show how it is affected by improvements in the flow at which information travels in the network, or the range at which the social network helps to monitor behavior.

A Probabilistic Framework for International Trade, Massimo Riccaboni.

The paper develops a stochastic baseline model to describe the dynamics of international trade flows. We show that such a simple stochastic setup, similar to the one recently proposed by Chaney (2011), is able to simultaneously match a large number of empirical regularities, such as the fraction of zero trade flows across pairs of countries, the positive relationship between intensive and extensive margins, the high concentration of trade with respect to both products and destinations. Our model can thus be considered a useful stochastic benchmark for international trade theories. In particular, our stochastic approach is fully compatible with the Helpman, Melitz,

Rubinstein (2008) – HMR – model of international trade with heterogeneous agents. Our findings suggest that incorporating stochastic elements into more formal theoretical models can improve their ability to match relevant stylized facts of world trade.

**A new metric for the economic complexity of countries and products,
Luciano Pietronero.**

We discuss a recent new approach to the complexity of countries and products in the spirit of the recent approach by Hidalgo and Hausmann (PNAS 2009). The basic information is represented by the matrix of countries and exported products. The standard economic analysis is essentially based on the GDP but the diversification of this into a series of different products provides an additional element of fitness in the spirit of biodiversification in a fluctuating environment. According to the standard analysis the specialization of countries towards certain specific products should be optimal but this is valid only in a static situation. The strongly dynamical situation of the world market suggests that flexibility and adaptability are even more important. Our new metric has the following fundamental properties: 1. It defines a Fitness for countries and a Complexity for products which are improved by iteration but always keep their original meaning. 2. The iteration adds complexity to the distributions which become broad and Pareto like. 3. Test cases and real applications are strongly improved with respect to previous approaches.

The information provided by this new metric can be used in various ways. The direct comparison of the Fitness with the country GDP gives an assessment of the non expressed potential of the country. Also for each country it is possible to define the Complexity of the products exported and how competitive is this country with respect to the other countries which produce the same product. The behavior of the countries in this new space is rather heterogeneous for different groups of countries. This heterogeneity is crucial to identify a predictive power for the GDP or for the Stock indices. The method permits also a scientific test of the rating and the new variables are shown to be far superior to the standard rating in identifying risky situations long before the collapse.

**The political-economy challenges of the SuperSmart Grid,
Peter Schmidt.**

In light of rising concerns about energy security and climate change, Europe has started to decarbonizing its power sector. Concerted collective action in international electricity infrastructure policy and the construction of a fully integrated pan-European electricity network is necessary to further allow for a large-scale grid integration of electricity from renewable energy sources (RES-E). However, the expansion of cross-border electricity transmission infrastructure is a challenging undertaking and very little progress on the ground is being observed today.

The conventional approach to study cross-border electricity infrastructure policy is rather technical and almost only focusing on macroeconomic optimization. I argue that such an approach is not properly equipped to deal with the many political-economy factors that render cross-border electricity transmission policy such a challenging collective action task. I suggest using a bottom-up actor- and institution-oriented research perspective to better understand about the drivers of and barriers to cross-border electricity infrastructure policy. I will briefly describe key elements of a framework that can be used to study cross-border transmission policy in a more integrated manner and point to some research questions.

**Networks of networks and industrial ecology,
Alexandra Penn and Frank Schiller.**

The Evolution and Resilience of Industrial Ecosystems (ERIE) project is a “Complexity Science for the Real World” project, explicitly aimed at working with stakeholders from government and industry to produce applicable tools and provide useful insights from complexity science for real world development. Our area of concern is sustainability and resilience of “industrial ecosystems”, interconnected networks of firms exchanging material and energy and connected via economic and social networks and influenced by a variety of endogenous factors such as business models, spread of innovations and exogenous factors including policies exerting stress or crisis causing shocks. We are working with heavy carbon-intensive industrial networks in the Humber region of the UK as well as studying the global food security and bio-based economy challenges ahead.

We will present an overview of three specific domains which we have encountered in the course of our work in which network and network-of-network approaches are highly relevant to system dynamics, sustainability and resilience: 1. Levels of selection, network structure and relevant policy intervention, 2. Cascading risk in networks of networks and 3. Layered, interacting networks, the bi-directional feedback between physical, social and economic networks in industrial ecosystems.

**Spatial organisation of economic activity,
Gerard Weisbuch.**

How come certain regions have large economic activities while others are depleted ? These spatial inequalities were strongly increased during the Industrial Revolution which calls for a dynamical approach rather than standard equilibrium models. The purpose of the presentation is to assess the possibilities of inequality reduction in the future when economic development will slow down and transportation costs of energy will rise. The model is based on coupled map lattices which can display spatial patterns depending upon the choice of elementary processes and parameters.

**Systemic risk in scale-free InterBank networks,
Thomas Lux and Mattia Montagna.**

The paper proposes a scale-free network model for studying domino effects in financial networks with a realistic topological structure. In particular, a fitness model generating scale-free networks is combined with an internal representation of the balance-sheets of each node. In the resulting simulation engine, stress tests are performed in order to study how the network effects influence contagions in InterBank markets. The numerical results point out the presence of a singular shell-structure affecting the spread of an idiosyncratic shocks

**DebtRank: Too Central to Fail? Financial Networks, the FED and Systemic Risk,
Stefano Battiston, Michelangelo Puliga, Rahul Kaushik, Paolo Tasca, and Guido Caldarelli**

Systemic risk, here meant as the risk of collapse of a large portion of the financial system, depends on the network of financial exposures among institutions. However, there is no widely accepted methodology to determine the systemically important nodes in a network. Moreover, exposures are seldom disclosed. To fill this gap, we introduce, DebtRank, a novel measure of systemic impact inspired by feedback-centrality. As an application, we analyse a new and unique dataset on the USD 1.2 trillion FED emergency loans program to global financial institutions during 2008-2010. We find that a group of 22 institutions, which received most of the funds, form a strongly connected graph where each of the nodes becomes systemically important at the peak of the crisis. The system

is even vulnerable to small, dispersed shocks. The results suggest that the debate on too-big-to-fail institutions should include the even more serious issue of too-central-to-fail.

Hypertexts in multilevel systems of systems, Jeffrey Johnson.

Networks have been very important in understanding the dynamics of complex systems. Surprisingly the focus of network science is mainly on binary relations between pairs of entities and less attention is paid to relations between $n > 2$ things. For example, the dynamics of the structure \langle mother, father, daughter \rangle cannot be adequately described by the edges \langle mother, father \rangle , \langle mother, daughter \rangle and \langle father, daughter \rangle . Generalisations to n -ary relations have included hypergraphs in which edges are sets with any number of elements, and simplicial complexes which generalise oriented edges to simplices. Thus one-dimensional edges $\langle a, b \rangle$ in networks are generalised to p -dimensional simplices in simplicial complexes, $\langle a, b, c, d, e... \rangle$. Hypertexts offer a further generalisation by making explicit the relation that binds the n vertices together in relational simplices, such as \langle mother, father, daughter; R-family \rangle . This allows for the possibility that the vertices can be combined in different ways to form different emergent entities. For example, the letters $\{ a, p, t \}$ can be combined in different ways to form the relational simplices $\langle a, p, t; R\text{-pat} \rangle \neq \langle a, p, t; R\text{-tap} \rangle$. Relational simplices provide an algebraic way of representing parts and wholes in multilevel systems. By moving to higher dimensions, hypertexts have a richer connectivity structure than networks. Hypergraphs, simplicial complexes and hypertexts all have Galois lattice structure, which is very interesting but its applications are limited by an associated combinatorial explosion. A higher dimensional connectivity generalises connectivity in networks. Two simplices are q -near when they share a q -dimensional face. Simplices are q -connected by chains of pairwise q -near simplices. A Q -analysis finds q -connected components. These have interesting internal structure, including them being related to classes of connected Galois pairs – possibly opening up new computationally tractable ways of using Galois connections. As with networks, the connectivity structure of hypertexts can underlie the dynamics of systems. In networks these dynamics include changing values on links and nodes, the creation or destruction of vertices, and the creation or destruction of links. This generalises to hypertexts where the dynamics include the changing values on relational simplices and their faces including their vertices, the creation or destruction of new vertices, and the creation or destruction of new relational simplices. The creation or loss of a p -simplex is called a p -event, where these are related to system time. In hypertexts the dynamics can be multilevel bottom-up and top-down. Events occur at all levels, with sequences of events forming dynamic multilevel trajectories. Dynamic patterns of numbers are distributed over this dynamic topological structure. Hypertexts provide a rich way of representing the multilevel dynamics of systems of systems of systems which is necessary if not sufficient for a science of complex systems. The talk will be developed through examples in the planning, design, and management of complex socio-technical systems.