Network Models in Economics and Finance Conference 2013

June 13th – June 15th, 2013

National Technical University of Athens

Center for Applied Optimization (CAO),
University of Florida, USA

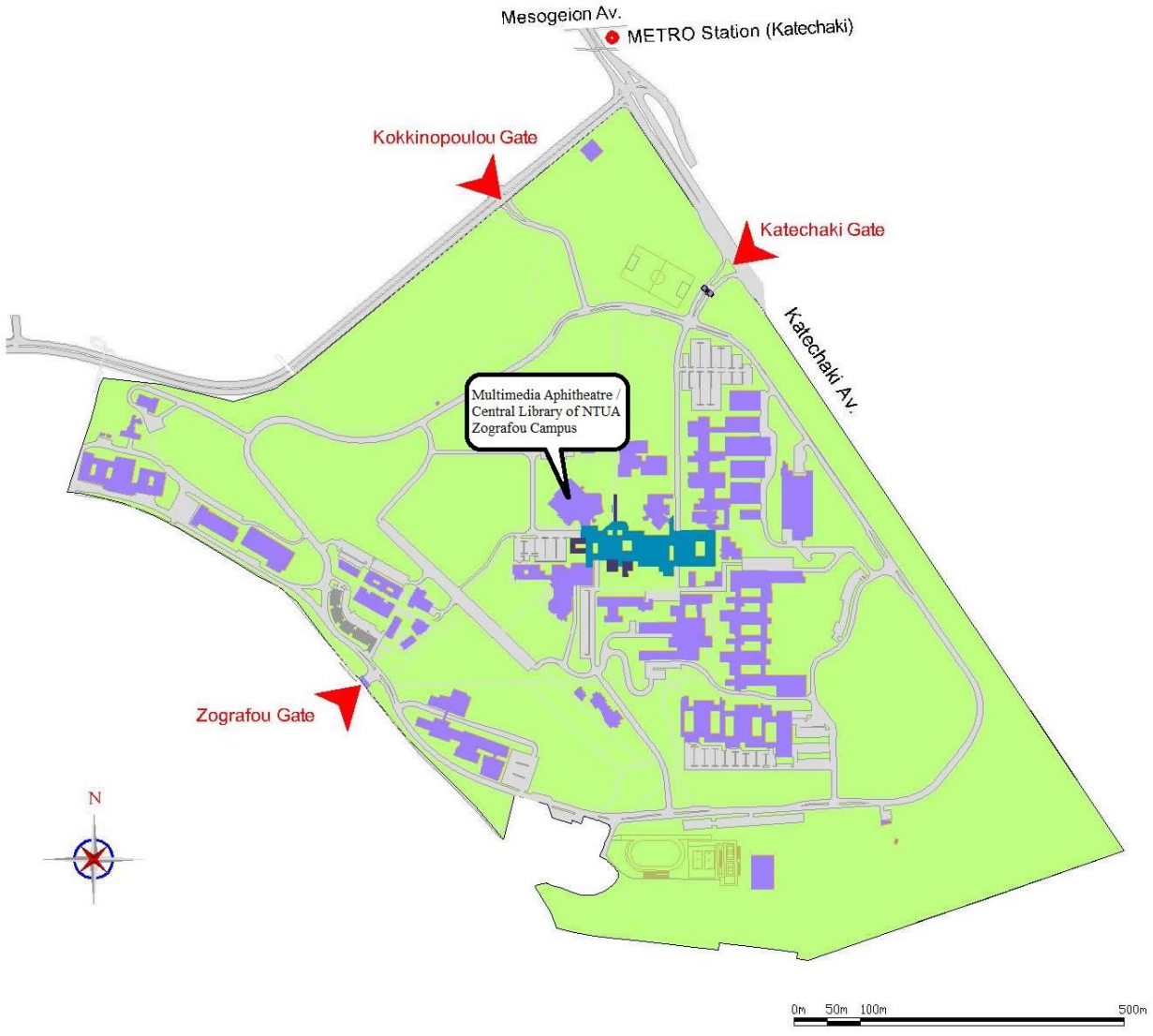
Laboratory of Algorithms and Technologies for Networks Analysis (LATNA), Higher School of Economics, Russia

Springer
science+business media

Conference venue

The conference will take place in the **Multimedia Amphitheatre** (Αμφιθέατρο ΠΟΛΥΜΕΣΩΝ / Amphitheatre Polymeson) located in the **Zografou Campus of the National Technical University of Athens**.

Multimedia Amphitheatre can be found in the basement of the Building of the Central Library of NTUA Zografou Campus.



- The Zografou Campus can be reached by buses **№608**, **№230** (“8th of Zografou” stop), **№242** (from Katehaki Metro station), **№140** (stops near the "lower" gate of the campus, needs a 15 minutes walk), **№245**, **№251**.
- In case of using taxi, please keep in mind that cars can enter the campus only through the entrance near Katehaki Avenue.
- For additional details, please refer to http://www.ntua.gr/map_en.html web page.

Thursday, June 13th

9:00 – 9:30 Registration

9:30 – 10:00 Welcome
- Simos E. Simopoulos, Rector of the National Technical University of Athens
- Themistocles M. Rassias, Professor of the National Technical University of Athens
- Panos M. Pardalos, Distinguished professor, Director of Center CAO, University of Florida and Scientific advisor of the Laboratory LATNA, HSE

10:00 – 11:00 Harilaos Mertzanis
A Network Model for Systemic Risk in Finance

11:00 – 11:20 Coffee Break

11:20 – 12:20 Session 1

Bhaskar DasGupta
Contagion in Financial Networks

Elia Daniele
A game theoretical model for experiment design optimization

12:20 – 14:00 Lunch Break

14:00 – 15:00 Valeriy Kalyagin
Network Models and Uncertainty in Market Analysis

15:00 – 15:20 Coffee Break

15:20 – 16:50 Session 2

Georgios Sarantitis
The Euro and GDP Growth Convergence in the E.U. using a Minimum Dominating Set

Grigory Bautin
Network characteristics of Russian stock market

Ioannis C. Demetriou
An Example of Nondecomposition in Data Fitting by Piecewise Monotonic Divided Differences of Order Higher than Two

Friday, June 14th

9:00 – 9:30 Registration

9:30 – 10:30 Anna Nagurney
Network Economics and the Internet

10:30 – 10:50 Coffee Break

10:50 – 12:20 Session 3

Egorova Liudmila
The agent-based simulation of the stock exchange behavior

Matteo Chinazzi
Defuse the Bomb: Rewiring Interbank Networks

Maria Matthaiou
A novel Banking Supervision Method using the Minimum Dominating Set

12:20 – 14:00 Lunch Break

14:00 – 15:00 Antonino Maugeri
Variational approach for a general financial equilibrium problem: the Deficit formula, the Balance law and the Liability formula

15:00 – 15:20 Coffee Break

15:20 – 16:20 Session 4

Taewon Kim
Contagion in Financial Networks

Alexander Belenky
An approach to quantitatively estimating the expediency of incorporating new sources of energy into electric grid

16:20 – 17:20 Michael Doumpos
A Multiple Criteria Decision Paradigm for Financial Decision Support

Saturday, June 15th

Cultural program

A Network Model for Systemic Risk in Finance

Harilaos Mertzanis
Director of Research, Certification and Market Regulation,
Hellenic Capital Market Commission, Greece

Modem financial systems are characterized by a high degree of interdependence. Connections among financial institutions stem from both the asset and the liability sides of their balance sheets. Connections among financial markets stem from contagion, securities offering, herding behavior, etc. Networks, understood as a collection of nodes and links between nodes, provide a useful representation of financial systems. Network analysis can therefore provide an explanation of some economic phenomena and enhance the understanding of financial systems and their behavior. The analysis addresses several important issues, such as systemic risk, by examining the following questions. First, the extent of financial network resilience to contagion and the formation of connections by financial institutions when exposed to contagion risk. Second, the role of network theory in explaining freezes in the interbank market. Third, the role of social networks in improving investment decisions and corporate governance. Fourth, the role of networks in allocating initial public offerings of securities. Finally, they consider the role of networks as a form of market monitoring.

Contagion in Financial Networks

Bhaskar DasGupta
Associate Professor in the Computer Science department
at University of Illinois at Chicago, USA

The recent financial crisis have generated renewed interests in fragilities of global financial networks among economists and regulatory authorities. In particular, a potential vulnerability of the financial networks is the "financial contagion" process in which insolvencies of individual entities propagate through the "web of dependencies" to affect the entire system. We formalize an extension of a financial network model originally proposed by Nier et al. for scenarios such as the OTC derivatives market, define a suitable global stability measure for this model, and perform a comprehensive evaluation of this stability measure. Based on our evaluations, we discover many interesting implications of our evaluations of this stability measure, and derive topological properties and parameters combinations that may be used to flag the network as a possible fragile network.

A game theoretical model for experiment design optimization

Elia Daniele
University of Naples Federico II, Italy

In this paper we present a non-cooperative game theoretical model for the well known problem of experimental design. A virtual player decides the design variables of an experiment and all the players solve a Nash equilibrium problem by optimizing suitable payoff functions. The resulting game has nice properties, so that a computational procedure is performed by using different algorithmic approaches. We consider the case where the design variables are the coordinates of n points in a region of the plane and we look for the optimal configuration of the points under some constrained. The problem arises from a concrete situation: find the optimal location of n receivers able to pick up particles of cosmic ray in a given platform (some experiment to measure the quantities of gamma rays are ongoing in Nepal thanks to the altitude of the region). Theoretical and computational results are presented for this location problem.

Network Models and Uncertainty in Market Analysis

Valeriy Kalyagin
National Research University Higher School of Economics, Russia

Network analysis is a popular and powerful tool of modern analysis of complex systems. A nodes (vertices) of the network correspond to the elements of the complex system and links (edges) of the network correspond to the interaction between elements. A measure of interaction between nodes give the weights of the links. Resulting weighted graph represents the network model of the complex system. Financial market is known to be a complex system. Nodes of the associated network correspond to the stocks and interaction between every pair of stocks can be measured by correlation between observations. The correlations provide a similarity measure for the joint behavior of different elements in the system. The complexity of the system is reflected in the associated complete weighted graph. The minimum spanning tree (MST) was studied in [1] to extract the most valuable information from this complex network. This information can be extended with the use of planar maximally filtered graph (PMFG) as suggested in [2]. The application of this method to financial market allows to observe an hierarchical and cluster structures in the market. Both procedures (MST and PMFG) can be considered as a filtering of a complex graph into a simpler relevant sub graph.

Another filtering procedure was proposed in [3]. As a result of this procedure a market graph (MG) is constructed. It is shown that this graph has a power law property. Maximum cliques (MC) and maximum independent sets (MIS) of the market graph give interesting information about financial market structure [4]-[5].

In the present paper we develop a general approach proposed in [6] to the design of different models of the market network and to the construction of statistical procedures for network and FC identification from the observations. This approach allows us to introduce a control of uncertainty of the model and of the FC. We study the statistical uncertainty of the MST, PMFG, MG, MC and MIS. In our investigation we estimate the statistical uncertainty by the number of observations needed to reach the prescribed conditional risk (confidence) of the particular method of market network analysis. We show that statistical uncertainty of the MC and MIS is essentially lower than the statistical uncertainty of MG which is essentially lower than statistical uncertainty of MST and PMFG.

[1] Mantegna R.N. (1999). Hierarchical structure in financial market. European Physical Journal, series B, 11, 193-197.

[2] Tumminello M., Aste T., Matteo T.D., Mantegna R.N. (2005), A tool for filtering information in complex systems, Proceeding of National Academy of Scince, 102, pp. 10421-10426

[3] Boginsky V., Butenko S., Pardalos P.M. (2003). On structural properties of the market graph. In: Nagurney A. (Editor) Innovations in financial and economic networks. Northampton: Edward Elgar Publishing Inc., 29-45.

[4] Boginsky V., Butenko S., Pardalos P.M. (2005). Statistical analysis of financial networks,

Computational statistics and data analysis, 48, 431-443.

[5] Boginsky V., Butenko S., Pardalos P.M. (2006). Mining market data:A network approach, Computers & Operation Research, 33, 3171-3184.

[6] Koldanov A.P. Koldanov P.A. Kalyagin V.A. Pardalos P.M. Statistical Procedures for the Market Graph Construction, Computational Statistics and Data Analysis, to appear.

The Euro and GDP Growth Convergence in the E.U. using a Minimum Dominating Set

Georgios Sarantitis
Department of Economics, Democritus University of Thrace, Greece

The convergence of GDP growth rates is an important ingredient for the efficient implementation of a common monetary policy within a currency union. The European economic and monetary union is a reality since 1999, when eleven of the fifteen members of the European Union adopted the euro as a common currency. In this paper, we propose the use of the Minimum Dominating Set (MDS) methodology for the study and empirical evaluation of E.U. convergence. We employ the MDS concept and reveal the network properties of 22 European countries that are now members of the European Union and are used as the network's nodes with the cross-country real Gross Domestic Product growth rate correlations as the weight factor of each edge. We use an arbitrary correlation threshold to remove every edge of the network that corresponds to an "uncorrelated" couple of countries and then we identify the MDS and the isolated nodes. To identify possible changes of the GDP growth network after the adoption of the euro and thus evaluate the degree of convergence, we estimate the MDS in two sub-samples: a) for the period before the introduction of the common currency, 1986-1998 and b) for the common currency era of 1999-2011. A smaller MDS size and more dense network in the second sub-sample could be interpreted as significant evidence of increased convergence of the 22 E.U. countries after the introduction of the euro. Increased convergence is important as monetary policy implementation becomes efficient and the costs associated with the participation in a monetary union are reduced and net benefits are maximized.

Network characteristics of Russian stock market

Grigory Bautin
National Research University Higher School of Economics, Russia

Network approach for the stock market analysis has gained a lot of attention recently. By analyzing network properties one can study structure and dynamics of the market, and get some valuable information for financial decisions.

In this work we study some characteristics from social network analysis and graph theory applied to Russian stock market. For our analysis we use the data for two periods before and after the financial crisis of 2008 for a set of the most traded companies.

An Example of Nondecomposition in Data Fitting by Piecewise Monotonic Divided Differences of Order Higher than Two

Ioannis C. Demetriou
Department of Economics, University of Athens, Greece

A counter-example is provided on a conjecture that might be useful to least squares data smoothing calculations that allow q sign changes in the sequence of the divided differences of order m of the smoothed values. The main difficulty in these calculations is that there are about $O(n^q)$ combinations of positions of sign changes, where n is the number of data, so that it is impossible to test each one separately. In addition a general optimization algorithm can stop at a local minimum that need not be a global one. It has been proved that the calculations when $m=1$ (piecewise monotonicity) and $m=2$ (piecewise convexity / concavity) reduce to separating the data into disjoint sets of adjacent data and solving structured quadratic programming problems for each set. Specifically, separation allowed the development of some dynamic programming techniques that solve the particular problems in $n^2 + O(qn \log n)$ and about $n^3 + O(qn^2)$ computer operations respectively. We present an example which shows that the separation property is no longer true if we consider similar smoothing calculations with order of divided differences higher than two. Therefore a question of practical importance is whether there exists an efficient algorithm that can provide a global solution to this problem. The problem has many applications in finance and economics.

Network Economics and the Internet

Anna Nagurney
John F. Smith Memorial Professor,
Director - Virtual Center for Supernetworks, USA

The Internet is the critical infrastructure for businesses, the government, the military, and personal communications and has transformed the manner in which we conduct many of our daily economic, financial, and social activities. Several recent trends in technology and network use have pushed the capabilities required of the Internet beyond what can be provided by the currently deployed infrastructure. To address these limitations, the network community has developed a variety of technologies to adapt the functionality of network protocols and services. A critical question that remains unanswered is how to integrate these technologies into an ecosystem, supported by an Economy Plane, that involves users, service providers, and developers in such a way that new ideas can be deployed and used in practice and that innovations can be supported.

In this talk, I will first discuss our recent multidisciplinary, multi-institutional research, funded by the National Science Foundation (NSF), on an enhanced Internet, known as ChoiceNet. Our ChoiceNet system is based on three tightly coupled principles in that it aims to (1) encourage alternatives to allow users to choose among a range of services, (2) let users vote with their wallets to reward superior and innovative services, and (3) provide the mechanisms to stay informed on available alternatives and their performance. This approach ensures that innovative technical solutions can be deployed and rewarded through a comprehensive system where solutions can be incorporated and compete to allow the network to adapt to current and future challenges. I will then describe several game theory models, based on network economics, that capture the complexity and the dynamics of the various interacting actors/agents.

The agent-based simulation of the stock exchange behavior

Egorova Liudmila
National Research University Higher School of Economics, Russia

We represent a stock exchange as a flow of events of two types – "regular" and "crisis" events. Player does not know in advance the type of coming event and must identify it. Player's welfare depends on the success of its recognition. It was shown that successful identification of regular events in more than half of the time allows the player to have a non-negative average gain. Also we analyze the problem of the threshold separating the events on the stock exchange, and other parameters depending on this threshold and introduce a simulation model based on such framework and its results.

Defuse the Bomb: Rewiring Interbank Networks

Matteo Chinazzi
Sant'Anna School of Advanced Studies, Italy

Aims and Goals. The topology of the financial sector has fundamental implications for the state and dynamics of systemic risk. In this contribution, we examine how network topology, banks' heterogeneity and prudential regulation alter the probability of observing a systemic meltdown.

First, we examine how different network configurations affect the probability of contagion. In particular, we show how the Erdos-Renyi (1960) random graph, the Watts and Strogatz (1998) small-world network and the Barabasi and Albert (1999) scale-free system display different resilience to attacks.

Second, we study how we can alter systemic risk by fixing higher order network statistics, extending the traditional frameworks that are used in the literature to model interbank networks. In particular, we observe how frequency and extent of contagion vary when we fix the node clustering sequence of the graph.

Third, we explore what happens when banks are not homogeneous. In particular, we introduce heterogeneity in the composition of their portfolio, in the size of their balance sheets and in their creditworthiness.

Lastly, we study how different measures of prudential regulation alter the probability of observing default cascades under different stress testing scenarios. In particular, we analyze how liquidity and capital requirements interact with connectivity in determining the stability of the system in the presence of random and targeted attacks. Furthermore, cases in which also liquidity risk is introduced are examined. Our ultimate goal is to further clarify the role of network topology in the spreading of contagion and to provide additional policy insights for the regulation of the financial system by also addressing whether it is more important to regulate "too-big-to-fail" or "too-connected-to-fail" institutions.

Methodology. We develop a computational model to test the resilience of the financial system under different assumptions regarding network topology, banks' heterogeneity and prudential regulation. Our analytical framework is developed upon the existing literature on financial networks and it is close in spirit to the contributions of: Gai and Kapadia (2010), Amini, Cont and Minca (2010, 2012), Iori, Jafarey and Padilla (2006), Nier et al. (2007), Caccioli, Thomas and Farmer (2012) and Battiston et al. (2012a, 2012b).

The financial system is represented as a directed and weighted network of credit exposures between N banks. The directed weighted graph is fully described by the weighted adjacency matrix P, also called exposure matrix. Each entry p_{ij} represents an interbank lending relationship between bank i (i.e. the creditor) and bank j (i.e. the debtor). Furthermore, we assume no netting off of reciprocal exposures so that both entries p_{ij} and p_{ji} can be positive. Banks' balance sheets are explicitly modeled and they include: interbank assets and liabilities that constitute

the edges of the directed graph, and other non-network external resources such as deposits, external assets and external liabilities. Exogenous shocks are modeled as a loss to the external assets of the targeted bank such that its solvency condition is violated and the node is forced to default.

Preliminary Results. System's fragility is non-monotonic in connectivity with the financial system displaying the so called "robust-yet-fragile" property: i.e. contagion is very unlikely, but when it happens it hits the entire network. In the benchmark scenario of no liquidity risk and random attack, small-world networks display a higher frequency of contagion than random graphs, while the extent of contagion does not differ significantly. Scale-free networks, instead, have a much wider contagion window than random graphs, but are far more resilient for low level of connectivity and they provide a good insurance against random attack, as the frequency of contagion never reaches such high peaks as it does for random graphs. By adding a "liquidity risk", contagion windows are widened, but -- compared to the previous case -- no striking difference is found. Interestingly, the resilience of small-world networks is not particularly affected by the presence neither of fire-sales nor of mark-to-market pricing of assets. This suggests that -- when node clustering is high -- connectivity is the major factor explaining contagion. The same consideration can be made when the exogenously defaulted bank is not selected completely randomly, but with "probability proportional to its degree". The results change considerably when the exogenous default is "targeted" to hit the most connected bank. The scale-free networks become the most fragile, displaying a contagion window much wider than the other two configurations, with both frequency and extent of contagion close to hundred percent for a wide range of connectivity levels. Small world networks, instead, are not affected at all in this scenario.

Concluding Remarks. With this paper we aim to further clarify the role of network topology in the spreading of contagion. We prove that the random graphs which are often assumed in theoretical literature tend to overestimate the severity of contagion in case of random attacks; while it is typically underestimated in case of targeted attacks.

A novel Banking Supervision Method using the Minimum Dominating Set

Maria Matthaiou
Department of Economics, Democritus University of Thrace, Greece

The financial crisis of 2008 demonstrated that effective and continuous supervision of economic systems is necessary. More specifically, close monitoring of banking institutions and their interrelations is of outmost importance in the effort to reduce and control systemic risk in the specific industry and the economy as a whole. This interconnectedness can be described and examined through Complex Network models. In this context, every node corresponds to one bank, every link describes the interconnections between two nodes and the weight of every link shows the correlation level between the connected nodes. In this work, we propose the use of Complex Networks for the monitoring of the whole banking system through a smaller subset of it, the Minimum Dominating Set (MDS). Our approach has two steps: a) eliminate every link with a weight (correlation) below a threshold and b) indentify the MDS in the updated network. We show that the MDS nodes can be used as "gauges" for the monitoring of the whole network. In this paper we apply the MDS methodology on the 200 largest US banks, in terms of their total deposits and use this variable to calculate the respective cross-correlation that reveals their interconnectedness. Results show that we can effectively monitor the whole 200 bank system through just 27 institutions (10 banks of the MDS and 17 isolated ones). The proposed method can be proven useful to Central Banks as a warning system that can swiftly identify incidents of bank distress and their paths of contagion for prompt intervention and regulation.

Variational approach for a general financial equilibrium problem: the Deficit formula, the Balance law and the Liability formula

Antonino Maugeri
Professor, Dipartimento di Matematica, Universita di Catania, Italy

Without using a technical language, but using the universal language of mathematics, we provide simple but significant laws, as deficit formula, balance law and liability formula, for the management of the world economy. Decisions, under these laws, for the recovery of the economy and for the good governance clearly appear. Further a simple but useful economical indicator *E(t)* is provided and the results are illustrated with a significant example.

Contagion in Financial Networks

Taewon Kim
California State University, Los Angeles, USA

Our paper analyzes contagion in financial markets and the cascades of crises that can ensue from financial interdependences, as well as offering an alternative view toward modeling this phenomenon, so prominent in the crises of recent years. Notable among them is the 1997 Asian financial crisis which started in Thailand but had an enormous contagion effect throughout Asia, the effect of which is still being felt. The most recent such crisis is the one originated in the U.S. through subprime mortgage problems along with the demise of Lehman Brothers. It is currently wreaking havoc in the country, the entire Euro-zone as well as the rest of the world to some extent. These two events have in common one fact; that is, a loss in asset prices accompanied by the dramatic failure of super-indebted borrowers, be they financial institutions, companies, or even countries themselves. Throughout these processes, one cannot ignore the role played by the networks of financial systems and their global interdependences in reinforcing the intensity of each problem at every stage of the crises. The emphasis of the paper is on the nature of the interdependent financial structures permitting such events. In particular, we analyze the following financial mechanisms: the role played by deficits, exchange rate regimes, capital flow and the international institutions. Finally, we suggest prudent policy improvements in financing mechanisms for growth. Our study contains implications for future common-currency zones, such as ones being considered for parts of Asia.

A Multiple Criteria Decision Paradigm for Financial Decision Support

Michael Doumpos
Assistant Professor, Co-Director of Research in Financial Engineering & Operational Research, Technical University of Crete, Greece

Financial decision making is involved with a plethora of important issues for individual and institutional investors, managers of firms and organizations, as well as policy makers. The finance theory has adopted the wealth maximization principle, focusing on normative and descriptive approaches often highlighting multiple factors that drive this single goal. Multicriteria decision systems add important practical contributions in this context, supporting financial decision makers in modeling, analyzing, and evaluating multiple ways of action, under all decision criteria pertinent in a specific decision instance. This paper analyzes the relevance of multicriteria decision systems for financial decisions. A detailed discussion and up-to-date review on two important areas of financial decision support, namely portfolio selection and corporate performance evaluation, are also given to highlight how different multicriteria modeling approaches complement and enhance exiting techniques from the areas of finance and operations research.

An Approach to Quantitatively Analyzing the Expediency of Incorporating New Sources of Energy in an Electric Grid

Alexander S. Belenky
Department of Mathematics for Economics and Decision Choice and Analysis Laboratory, National Research University Higher School of Economics, Moscow, Russia, and Center for Engineering Systems Fundamentals, Massachusetts Institute of Technology, Cambridge, U.S.A.

A fragment of a country's electric grid which includes a company (or a group of companies) generating electricity (generator), transmission lines and distribution networks, and three groups of customers a) industrial companies and government organizations working with the generator under long-term contracts, b) utility companies supplying customers in residential and industrial areas via distribution networks, and c) organized groups of customers that are licensed to operate a distribution network is considered. The problem of determining the optimal level of electricity production by the generator that minimizes its overall expenses, including those associated with the uncertainty of the electricity demand in the fragment of the grid is discussed. Each group of customers can use solar power and wind power (as well as other natural sources of energy) to cover a part of its electricity demand, especially during peak hours, and the expenses associated with the acquisition, installation, and operation of the corresponding equipment, are known. Taking into account a) the dynamics of the electricity demand of each group of the customers and the dynamics of the solar activity and that of the wind in every twenty-four hours, b) the maximum generator capacity, and c) the volumes of energy losses both in transmitting and in storing electricity, one needs to determine the above optimal level of generating electricity and competitive electricity prices for each group of customers for every time segment within twenty-four hours. A game-theoretic approach to quantitatively evaluating this optimal level is proposed, and sufficient conditions for equilibriums in a game describing the behavior of both the generator and the customers are established. The conditions underlie a technique to evaluate whether the incorporation of new sources of energy into the grid makes the grid more efficient.