Editorial

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Biographical notes: Iván Castilla Rodríguez attended the University of La Laguna, Tenerife, where he obtained his Degree in Engineering Computer Science in 2004. He has been working since then as a Researcher with the Department of Systems Engineering and Automation at the same university. He has taken part in several national research projects related to simulation of hospitals and call centres. He has been actively involved in several collaborations with private companies and the local government regarding simulation projects. He has served as General Co-Chair of the MAS 2009 (*The International Workshop on Modelling and Applied Simulation*). His research interests include simulation techniques for representing social systems, parallel discrete event simulation and computer architecture.

Francesco Longo received his PhD in Mechanical Engineering from the University of Calabria; he is currently an Assistant Professor and Director of the Modelling & Simulation Center, Laboratory of Enterprise Solutions (MSC-LES). His research interests include modelling and simulation for training procedures in complex environments, supply chain management and security. He has published more than 80 papers in international journals and conferences. He is Associate Editor and Guest Editor of *Simulation: Transactions of the SCS*. He is Guest Editor of the *International Journal of Simulation and Process Modelling*. He is Editor-in-Chief of the SCS M&S Newsletter and he has extensively supported the organisation of international conferences as General co-Chair, Program Co-Chair and Track Chair (MAS, EMSS, I3M, SCSC, etc.).

The behaviour of real-world systems is usually affected by a wide range of factors. The ways in which such factors interact and the stochastic nature of their evolution over the time increase the complexity of many real-world systems up to critical levels, where the use of ad-hoc methodologies, techniques, applications and tools is the only way to tackle problems and succeed in identifying proper and optimal solutions. Modelling & Simulation (M&S) has been widely recognised as the best and most suitable methodology for investigation and problem-solving in real-world complex systems in order to choose correctly, understand why, explore possibilities, diagnose problems, find optimal solutions, train personnel and managers, and transfer R&D results to real systems (Banks, 1998). In addition, M&S, regardless of the application domain, usually provides innovative solutions and new user-friendly tools, with special attention to integration into business processes and management.

The identification of proper and optimal solutions in complex real-world systems often requires the solution of multi-objective optimisation problems involving multiple stochastic variables. As stated in Chen (2003), real world optimisation problems involve contrasting and competing objectives and require the definition of multiple performance measures. In such a context where the whole is greater than the sum of parts (Abbass, 2006), successful approaches require something more than simple mathematical or stochastic models; simulation capability to recreate (with high level of accuracy) the intrinsic complexity of real-world systems allows to find out and test alternative solutions under multiple constraints and to monitor, at the same time, multiple performance measures.

In fact, since the beginning of multi-objective optimisation problems, M&S has been widely used by researchers and scientists as the main methodology to face challenging problems in real-world systems. A complete review of the simulation-based optimisation literature reveals heterogeneity among the scientific approaches due to the different models, techniques and methods used for different problems in diverse domains of application. In the sequel some interesting review papers in the area of simulation optimisation are cited. Fu and Glover (2005) provide a descriptive review of the most important approaches for simulation optimisation, opportunely organised in a multi-categories classification framework. The authors also propose a survey on software and simulation languages available for simulation optimisation. Additional classifications and description can be found in Azadivar (1992), Fogel (1994), Merkuryev and Visipkov (1994), Alander (1997), Carson and Maria (1997), Andradóttir (1998), Andradóttir (2005) and Fulcher (2008). In addition, Piera et al. (2004) face the integration problem between simulation models and optimisation methods.

The literature review clearly shows that M&S is widely used in different application domains from supply chain and industry to business, service, health and wealth management, from complex systems design to decision support tool development. The following paragraph provides some helpful references in the application domains depicted above.

Ingalls (1998) reports a complete list of advantages and disadvantages in using simulation for supply chain modelling and optimisation. As stated by Lee et al. (2002), M&S is the most suitable approach for dealing with the stochastic nature existing in real supply chains, also for its capability to find local optimal solutions for those problems involving the whole supply chain. Problems investigation and solving in complex real world supply chains requires multi-measures based approaches. Viswanadham (1999) proposes a two-category classification framework for supply chain performance measures: quantitative and qualitative. Beamon (1998, 1999) proposes a review of the most important supply chain performance measures. Similarly, Chan and Chan (2005) provide a detailed description of both quantitative and qualitative supply chain performance measures (such as fill rates, costs, inventory levels, customer satisfaction, products quality, etc.). Additional supply chain performance measures descriptions, including innovative vulnerability and resilience measures, can be found in Longo and Oren (2008). M&S-based approaches allow to monitor multiple performance measures under the effect of different combinations of critical parameters. Supply chain critical parameters usually include inventory control policies, lead times, demand intensity and variability, information sharing, demand forecasting methods, etc. Examples of complex supply chain simulations involving multiple critical parameters and multiple performance measures can be found in the following papers. Axsäter (2003) select the optimal control policy to minimise the total holding cost under fill rates constraints. Moinzadeh (2002) compares inventory control policies behaviour in the case of information sharing and without information sharing. Fleisch and Tellkamp (2005) investigate the effect of inaccurate inventory information as critical issue for supply chain performance. Longo and Mirabelli (2008) and De Sensi et al. (2008) propose an advanced simulation framework for comparing different inventory control policies under demand intensity, demand variability and lead times constraints in real-world supply chains. Tiacci and Saetta (2009) investigate the interaction between demand forecasting methods and control policies on the inventory system performances. Additional useful references and research works on supply chain simulation can be found in Bruzzone (2002).

M&S is also widely used in industry: manufacturing systems (including internal logistics and warehouse management) always provide challenging problems and a large spectrum of applications for M&S researchers and practitioners. As stated in Rohrer (1998), the main reasons for using simulation include the need for industries and manufacturers to stay competitive, the need to test alternative production/management strategies and technologies, and the need to recreate and investigate the intrinsic complexity of a manufacturing system. Nowadays, owing to the recent financial crisis, the need to stay competitive has to be regarded as a need to survive in a completely changed reference scenario. In effect, the current models for industrial and logistics processes management are no longer able to keep up with economic developments and the globalisation of markets. The numerous cases of bankruptcies, production stops, and supply chain disruptions registered during 2008 and 2009 strongly underline the need to consider alternative production and management strategies (i.e., for the first time after many years Toyota is reconsidering the way to use its just-in-time based manufacturing, Ehsan, 2009a). As stated by several industry top managers and well-known academic researchers, the development and application of new production paradigms and strategies is the only way to face financial crisis effects (Burkitt, 2008; Ehsan, 2008, 2009b; Mussomeli, 2008; Hart, 2009). This will provide scientists with the opportunity to use M&S as cutting-edge technology for technical and economic sustainability of both industrial and logistics processes.

Needless to say, M&S is not only an enabling technology for investigating forefront problems; it is widely applied to tackle all those problems that are usually too complex for any other analytical approach/methodology. Innumerable research works have been proposed in the recent years in which M&S is used as problem solving methodology. To cite a few, the following references are some of papers dealing with different problems in industries and manufacturing systems. Bruzzone et al. (1999) use simulation combined with genetic algorithms for industrial plant lay-out re-engineering in the automotive sector. Groumpos and Merkuryev (2002) propose an

overview on discrete event simulation applied to manufacturing systems. Longo et al. (2006) face the shop orders scheduling problem in a real manufacturing system by proposing an advanced real-time simulator. Cimino et al. (2008) use the same simulator combined with artificial intelligence techniques (genetic algorithms) to optimise shop orders scheduling. Longo et al. (2009) propose an overview on simulation combined with swarm intelligence (ant colony optimisation) applied to production planning in manufacturing systems. Macro and Salmi (2002) investigate the storage capacity and rack efficiency in a real warehouse by using a ProModel-based simulation tool. Bocca et al. (2008) propose an approach for warehouse management based on M&S. Finally, M&S is also used as one of the most suitable approaches for recreating the high complexity of manufacturing systems in terms of interactions between humans and their industrial working environment: simulation models integrated with ergonomic standards and work measurement methodologies are used to achieve the ergonomic effective design of industrial workstations (Longo and Mirabelli, 2009).

The enhancement in quality of our life comes not only from supply chain and industry. Over the years, a continuous effort has been devoted to improve services systems and, to this end, M&S is widely applied to support design and decision making in numerous services systems: from healthcare to wealth management, from insurance and transportation to entertainment. An overview on simulation of service system can be found in Laughery et al. (1998); similarly, an overview on healthcare simulation can be found in Mcguire (1998). Simulation is also extensively used for wealth management: nowadays companies operate in a dynamically changing scenario (i.e., recent financial crisis) and scenarios planning and decision support based simulation (i.e., agents directed simulation) have proven to be effective as tools for process improvement in wealth management. Examples of research works and useful references in this area are Solomon (1999), Terano et al. (2005), Bossomaier et al. (2005), Trigaux (2005), Patriarca et al. (2006), Chen and Huang (2007).

This Special Issue provides evidence on the relevance of M&S as cutting-edge methodology in the application areas and domains depicted above and focuses on both theoretical and practical tools and cross methodological researches. The papers included in this special issue show that M&S is a growing research field capable of providing an invaluable support:

- in different optimisation problems involving different type of complex systems (Merkuryeva and Napalkova, Zouein and Diab, Affenzeller et al., Bossomaier et al., Krull et al.)
- in complex decisions and projects where engineers and managers are usually asked to quickly react without knowing in advance the effects of their actions (Boskers and Abourizk)
- in the effective design of complex systems in different domains (Schuddebeurs et al., Cimino and Mirabelli)
- and finally in training (and also recruiting) personnel and managers able to correctly work in complex systems (Bruzzone et al.).

The papers are based on the extended versions of the best papers selected in the 2008 International Mediterranean and Latin American Multi-conference, including the 2008 European Modelling & Simulation Symposium (EMSS 2008), the 2008 International Workshop on Modelling and Applied Simulation (MAS 2008), the International Workshop on Harbor, Maritime, Multimodal, Logistics Modelling & Simulation (HMS 2008). All the papers, after their extensions (to include latest results and scientific achievements) have undergone rigorous peer review and revision process. This special issue contains nine papers that cover a broad range of M&S methodologies, techniques and applications: a state of the art overview.

In 'Two-phase simulation optimisation algorithm with applications to multi-echelon cyclic planning', Merkuryeva and Napalkova present a two-phase simulation algorithm for optimising the cyclic plans in a multi-echelons supply chain. After the optimisation problem statement, the authors propose an application example in the chemical supply chain (integration of genetic algorithm and response surface-based linear search algorithm).

In 'A sequential heuristic programming approach for a corrugated box factory: trade-off between set-up cost and trim waste', Zouein and Diab combine simulation with a three steps procedure for optimising trim waste cost and setup cost in a corrugator trim problem. After introducing some practical and valuable considerations in jobs scheduling on corrugators, the authors describe the three-step optimisation procedure and propose, as application example, the minimisation of the cost corrugator schedule in a real industry facility.

In 'Effective allele preservation by offspring selection: an empirical study for the TSP', Affenzeller et al. face a challenging problem in the simulation optimisation area; the authors propose an enhanced selection model for genetic algorithms (based on alleles preservation). The approach proposed by authors is successfully tested on the basis of some instances of the Travelling Salesman Problem although the authors clearly state that the improvements of genetic algorithms and genetic programming do not depend on the application area considered.

In 'Simulation of trust in client-wealth management adviser relationships', Bossomaier et al. describe a model used for the simulation of trust in clients; the simulation model is essentially in two parts: the first part simulates the evolution of clients trust under various conditions, then the model is extended incorporating two real datasets to determine a baseline (supplied to the simulation model) in terms of investment profiles of millions of customers.

Fuzzy logic combined with a multi-objective evolutionary algorithm is used to model clients' behaviour. Finally the two-phase simulation model is used for optimising trust in financial advisor client relationships.

In 'Proxel-based simulation of queuing systems with attributed customers', Krull et al. extend a proxel-based queuing simulation method to include attributed customers. The main idea behind the approach proposed by authors is to increase the number of queuing problems that can be tackled by using proxel-based simulation (where no analytical solutions are available). Experimental results and statistics are also presented.

In 'SPS tools for capital project planning analysis', Boskers and AbouRizk present a Special Purpose Simulation (SPS) template devoted to support capital planning in large scale infrastructure construction projects. The developed SPS template has to be regarded as an advanced decision support tool capable of estimating projects durations and costs using the Box Jenkins method of forecasting. The authors also propose a real case study (based on the Yellowhead Trail and 156 Street Grade Separation project, in the City of Edmonton, Canada) to test the potentials of the SPS tool.

In 'A solution for improved simulation efficiency of a multi-domain marine power system model', Schuddebeurs et al. focus on marine power systems based on Integrated Full Electric Propulsion (IFEP). Simulation is used to achieve the effective design of the marine power system; the authors tackle two major challenging problems:

i the increase of the simulation models computational efficiency (the proposed simulation tool brings together different simulation models)

ii the optimal trade-off between computational efficiency and simulation results accuracy.

Case studies are finally presented to validate the IFEP simulation tool.

In 'Modelling and simulation and ergonomic standards as support tools for a workstation design in manufacturing system', Cimino and Mirabelli propose the integration of M&S with ergonomic standards to achieve the effective design of a complex industrial workstation. They recreate in a 3D virtual environment a simulation model of the industrial workstation (also including human models) and use the simulation model for evaluating (on the basis of multiple performance measures) the ergonomic risk level of the workstation. The achievement of the effective ergonomic design of the industrial workstation (in terms of ergonomic risk reduction) passes through different workstation modifications and changes tested and validated by using the simulation model.

In 'Virtual world and biometrics as strongholds for the development of innovative port interoperable simulators for supporting both training and R&D', Bruzzone et al. propose an innovative containerised architecture of distributed and interoperable port cranes simulators integrated with biomedical devices. According to authors the containerised architecture can be used simultaneously as research facility for assessing gantry crane operators' performances, for innovative operators training in immersive virtual environments and for measuring/monitoring a number of different operator's physiological and biomedical parameters.

We strong believe that the papers in this special issue will provide the reader with an interesting state-of-the-art overview on the most important M&S methodologies, techniques and applications in different but equally important domains. Our sincere gratitude goes to authors and reviewers for their invaluable effort in providing each other continuous feedbacks to improve the scholarly and scientific relevance of papers. Special thanks go to Nuno Melão, the Editor-in-Chief of the *International Journal of Simulation and Process Modelling*.

References

Abbass, H. (2006) 'Pareto-optimal approaches to neuro-ensemble learning', in Jin, Y. (Ed.): *Multi-Objective Machine Learning, Volume 16 of Studies in Computational Intelligence*, Chapter 18, Springer, Berlin, pp.407–427.

Alander, J.T. (1997) 'An indexed bibliography of genetic algorithms with fuzzy logic', in Pedrycz, W. (Ed.): *Fuzzy Evolutionary Computation*, Kluwer Academic, Boston, pp.299–318.

Andradóttir, S. (1998) 'Simulation optimization', in Banks, J. (Ed.): *Handbook of Simulation: Principles, Methodology, Advances, Applications, and Practice*, Chapter 9, John Wiley & Sons, New York, pp.273–333.

Andradóttir, S. (2005) 'An overview of simulation optimization via random search', in Henderson, S.G. and Nelson, B.L. (Eds.): *Handbooks in Operations Research and Management Science: Simulation*, Chapter 21, Elsevier.

Axsäter, S. (2003) 'Optimal policies for serial inventory systems under fill rate constraints', *Management Science*, Vol. 49, No. 2, pp.247–253.

Azadivar, F. (1992) 'A tutorial on simulation optimisation', *Proc. of the Winter Simulation Conference*, Arlington, Virginia, USA, pp.198–204.

Banks, J. (Ed.) (1998) 'Principles of simulation', *Handbook of Simulation: Principles, Methodology, Advances, Applications, and Practice*, Chapter 1, John Wiley & Sons, New York, pp.3–30.

Beamon, B.M. (1998) 'Supply chain design and analysis: models and methods', *International Journal of Production Economics*, Vol. 55, No. 3, pp.281–294.

Beamon, B.M. (1999) 'Measuring supply chain performance', *International Journal of Operations and Production Management*, Vol. 19, No. 3, pp.275–292.

Bocca, E., Curcio, D., Longo, F. and Tremori, A. (2008) 'Warehouse and internal logistics management based on modeling & simulation', *Proceedings of the International Workshop on Modelling & Applied Simulation*, Campora S. Giovanni (CS), 17–19 September, Italy, Vol. I, pp.41–48, ISBN/ISSN: 978-88-903724-1-4.

Bossomaier, T., Jarratt, D., Anver, M., Thompson, J. and Cooper, J. (2005) 'Optimisation of client trust by evolutionary learning of financial planning strategies in an agent based model', *Proceedings of the IEEE Conference on Evolutionary Computing*, pp.856–863.

Bruzzone, A.G. (2002) 'Supply chain management', *Simulation*, Vol. 78, No. 5, May, pp.283–337, ISSN 0037-5497.

Bruzzone, A.G., Giribone, P. and Vio, F. (1999) 'Genetic algorithms and simulation for supporting layout re-engineering of automotive component production facilities', *International Journal of Flexible Automation and Intelligent Manufacturing*, Vol. 7, Nos. 3–4, pp.379–391, ISSN 1064-3645.

Burkitt, F. (2008) *My Take*, available at http://www.deloitte.com/dtt/article/0%2C1002%2Csid%25253d205755%252526cid%25253d238378%2C00.html?wt.mc_id=pr

Carson, Y. and Maria, A. (1997) 'Simulation optimization: methods and applications', *Proc. of 1997 Winter Simulation Conference*, Atlanta, GA, USA, pp.118–126.

Chan, F.T.S. and Chan, H.K. (2005) 'Simulation modeling for comparative evaluation of supply chain management strategies', *Journal of Advanced Manufacturing Technology*, Vol. 25, pp.998–1006.

Chen, J.H. (2003) *Theoretical Analysis of Multi-Objective Genetic Algorithms – Convergence Time, Population Sizing an Disequilibrium*, Report for IEEE NNS Walter Karplus Research Grant, Taichung, Taiwan.

Chen, S. and Huang, Y. (2007) 'Relative risk aversion and wealth dynamics', *Information Sciences*, Vol. 177, pp.1222–1229.

Cimino, A., Longo, F., Mirabelli, G. and Papoff, E. (2008) 'Shop orders scheduling: dispatching rules and genetic algorithms based approaches', *Proceedings of the European Modeling & Simulation Symposium*, 17–19 September, Campora S. Giovanni (CS), Italy, Vol. I, pp.817–823, ISBN/ISSN: 978-88-903724-0-7.

De Sensi, G., Longo, F. and Mirabelli, G. (2008) 'Inventory policies analysis under demand patterns and lead times constraints in a real supply chain', *International Journal of Production Research*, Vol. 46, No. 24, pp.6997–7016.

Ehsan, E. (2008) *E&HT Supply Chain Model Needs to be Adapted to the Market Needs*, available at http://www.supplychainer.com/50226711/eht_supply_chain_model_needs_to_be_adapted_to_the_market_needs.php

Ehsan, E. (2009a) *Toyota and Honda Revising JIT Methods to Avoid Future Crisis Problems*, available at http://www.supplychainer.com/50226711/toyota_and_honda_revising_jit_methods_to_avoid_future_crisis_problems.php

Ehsan, E. (2009b) *There are Good Costs as Well as Bad Costs in the Supply Chain*, available at http://www.supplychainer.com/50226711/there_are_good_costs_as_well_as_bad_costs_in_the_supply_chain.php

Fleisch, E. and Tellkamp, C. (2005) 'Inventory inaccuracy and supply chain performance: a simulation study of a retail supply chain', *International Journal of Production Economics*, Vol. 95, pp.373–385.

Fogel, D. (1994) 'An introduction to simulated evolutionary optimization', *IEEE Trans. on Neural Network*, Vol. 5, No. 1, pp.3–14.

Fu, M.C., Glover, F. and April, J. (2005) 'Simulation optimization: a review, new developments, and applications', *Proc. of the Winter Simulation Conference*, Orlando, FL, USA, pp.83–95.

Fulcher, J. (2008) 'Computational intelligence: an introduction', *Studies in Computational Intelligence*, Vol. 115, p.1.

Groumpos, P.P. and Merkuryev, Y. (2002) 'A methodology of discrete-event simulation of manufacturing systems: an overview', *Studies in Informatics and Control*, Vol. 11, No. 1, pp.53–60.

Hart, B. (2009) *Top Nine Challenges for '09*, available at http://www.jpmorgan.com/cm/ContentServer?cid=1159369990891&pagename=jpmorgan%2Fts%2FTS_Content%2FGeneral&c=TS_Content

Ingalls, R.G. (1998) 'The value of simulation in modeling supply chain', *Proceedings of the 1998 Winter Simulation Conference*, Washington DC, USA, pp.1371–1375.

Lee, Y.H., Cho, M.K., Kim, S.J. and Kim, Y.B. (2002) 'Supply chain simulation with discrete continuous combined modeling', *Computer & Industrial Engineering*, Vol. 43, pp.375–392.

Laughery, R., Plott, B. and Scott-Nash, S. (1998) 'Simulation of service systems', in Banks, J. (Ed.): *Handbook of Simulation: Principles, Methodology, Advances, Applications, and Practice*, Chapter 18, John Wiley & Sons, New York, pp.629–644.

Longo, F. and Mirabelli, G. (2008) 'An advanced supply chain management tool based on modeling & simulation', *Computer and Industrial Engineering*, Vol. 54, No. 3, pp.570–588.

Longo, F. and Oren, T. (2008) 'Supply chain vulnerability and resilience: a state of the art overview', *Proceedings of the European Modeling & Simulation Symposium*, 17–19 September, Campora S. Giovanni (CS), Italy, Vol. I, pp.527–533, ISBN/ISSN: 978-88-903724-0-7.

Longo, F., Mirabelli, G. and Papoff, E. (2006) 'Modeling, analysis & simulation of tubes manufacturing process and industrial operations controls', *Proceedings of the Summer Computer Simulation Conference*, 30 July – 3 August, Calgary Canada, SAN DIEGO, CA: SCS, Vol. 38, pp.54–59, ISBN/ISSN: 1-565555-307-1.

Longo, F. and Mirabelli, G. (2009) 'Effective design of an assembly line using modeling & simulation', *International Journal of Simulation*, Vol. 3, pp.50–60.

Longo, F., Mirabelli, G. and Rondinelli, S. (2009) 'Ants systems, a state of the art overview: applications to industrial plants problems', *Proceedings of the European Conference on Modeling & Simulation*, 9–12 June, Madrid, Spain, pp.421–429.

Mcguire, F. (1998) 'Simulation in healthcare', in Banks, J. (Ed.): *Handbook of Simulation: Principles, Methodology, Advances, Applications, and Practice*, Chapter 17, John Wiley & Sons, New York, pp.615–328.

Macro, J.G. and Salmi, R.E. (2002) 'A simulation tool to determine warehouse efficiencies and storage allocations', *Proceedings of the 2002 Winter Simulation Conference*, San Diego, California, USA.

Merkuryev, Y. and Visipkov, V. (1994) 'A survey of optimization methods in discrete systems simulation', *Proc. of the First Joint Conference of International Simulation Societies*, Zurich, Switzerland, pp.104–110.

Moinzadeh, K. (2002) 'A multi-echelon inventory system with information exchange', *Management Science*, Vol. 48, No. 3, pp.414–426.

Mussomeli, A. (2008) *A View from the Consumer Packaged Goods Sector*, available at http://www.deloitte.com/dtt/article/0%2C1002%2Csid%25253d205755%252526cid%25253d238378%2C00.html?wt.mc_id=pr

Patriarca, M., Chakraborti, A. and Germano, G. (2006) 'Influence of saving propensity on the power-law tail of the wealth distribution', *Physica A*, Vol. 369, pp.723–736.

Piera, M.A., Narciso, M.,, Guasch, A. and Riera, D. (2004) 'Optimization of logistic and manufacturing systems through simulation: a colored petri net-based methodology', *Simulation*, Vol. 80, pp.121–129.

Rohrer, M.W. (1998) 'Simulation of manufacturing and material handling systems', in Banks, J. (Ed.): *Handbook of Simulation: Principles, Methodology, Advances, Applications, and Practice*, Chapter 14, John Wiley & Sons, New York, pp.519–545.

Solomon, S. (1999) 'Behaviourally realistic simulations of stock market traders with a soul', *Computer Physics Communications*, Vols. 121–122, pp.161–167.

Terano, T., Kita, H., Kaneda, T., Arai, K. and Deguchi, H. (2005) *Agent-based Simulation: From Modeling Methodologies to Real-World Applications*, Springer Series on Agent-Based Social Systems.

Tiacci, L. and Saetta, S. (2009) 'An approach to evaluate the impact of interaction between demand forecasting method and stock control policy on the inventory system performances', *International Journal of Production Economics (0925-5273)*, Vol. 118, No. 1, pp.63–71.

Trigaux, R. (2005) 'The wealth repartition law in an altruistic society', *Physica A*, Vol. 348, pp.453–464.

Viswanadham, N. (1999) *Analysis and Design of Manufacturing Enterprises*, Kluwer Academic Publishers, Norwell, MA, USA.