



14<sup>th</sup> International Conference on Industrial Logistics  
15-17 May, Beer-Sheva, Israel

# ICIL 2018

## Conference Program and Abstracts

With support:



# ICIL 2018

International Conference on Industrial Logistics

15-17 May 2018, Beer-Sheva, Israel

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Dear participants welcome to Israel to the International Conference of Industrial Logistics (ICIL) of 2018. ICIL 2018 is hosted by the Department of Industrial Engineering and Management at Ben-Gurion University (BGU) of the Negev in Beer-Sheva, (Israel), International Centre for Innovation and Industrial Logistics (ICIL), and Operations Research Society of Israel (ORSIS).

ICIL has been developing an integrated view of Industrial Logistics, sharing and exchanging ideas and research results among students, researchers, academics and industrialists. The biannual International Conference on Industrial Logistics (ICIL) is the main means of attaining these objectives worldwide. Starting in 1993, ICIL took place in France, Brazil, USA, Russia, Okinawa, Finland, Uruguay, Lithuania, Israel, Brazil, Croatia, and Poland.

In our scientific program we have a total of 66 submissions, including 6 keynote speakers, and over 80 participants from Europe, North and South America, and Asia. The conference program includes original research results and contributions to the fields of logistics and supply chain management, as well as related fields, such as: transportation, production and inventory planning. We have 22 sessions, 16 sessions of which are in 2 parallel halls (A and B). Twenty (20) minutes are allocated for each lecture in the parallel sessions (including 5 min. for questions).

To optimize logistic maneuvering between the two lecture halls, registration area, and coffee and lunch areas we had to move the scientific programs from the BGU campus to the Leonardo hotel.

Our social program spreads over the three days of the conference. On the first evening we plan a short guided tour of the city of Beer-Sheva, followed by a visit of Abraham's Well, and a reception by the city officials. On the second evening, a gala dinner is planned at the main campus of BGU, accompanied by a virtual tour, presented by the vice president of BGU, of the archeological digs of the ancient ruins of the city. The last day will be devoted to a visit at the logistics center of Soda-Stream, near Beer-Sheva, and a tour of Jerusalem.

The Organizing Committee gladly invites professionals, academics, students and industrialists to enjoy our rich scientific and social programs.

# ▶▶▶ Tuesday - May 15, 2018 ◀◀◀

Venue: Leonardo Hotel Beer-Sheva

All lectures are in: A-Negev Hall and B-Timna Hall

▶ 08:00 Registration Opens

▶ 08:30 - 09:00 *Gathering & Coffee*

▶ 09:00 - 10:00 **T1.A - Opening**

*Chair: Zilla Sinuany-Stern*

Welcome by **Zvi HaCohen, BGU Rector & Alberto canen, ICIL President**

**Keynote, Nicholas Hall**

**Research and Teaching Opportunities in Project Management**

▶ 10:00 - 11:20 **T2.A - Inventory Logistics – Yuval Cohen**

25. **Nethanel Drezner, Michael Dreyfuss and Tal Grinshpoun**, Optimization Model for Procurement, Inventory, and Logistics Management.

59. **Ilias Keork**, Benefits of Vendor Managed Inventory Programs in Two-Stage Supply Chains.

1. **Yuval Cohen, Dalia Fishlov and Yehudit Aperstein**, Retailer's Optimal Purchase Mix of Bundles and Separate Products in a Supply – Chain of Single Period Items.

13. **Marina Tošić, Dragutin Lisjak, Davor Kolar and Silvestar Špehar**, Determining Critical Aircraft Pare Parts Using Text Mining an Association Rule Mining Techniques.

▶ 10:00 - 11:20 **T2.B - Logistical Policies & Decision-making – Shraga Shoval**

30. **Gur Mosheiov, Assaf Sarig and Vitaly Strusevich**, Minmax Scheduling and Due-Window Assignment with Position-Dependent Processing Times and Job Rejection.

4. **Franco Basso, Leonardo J. Basso, Mikael Rönnqvist and Andrés Weintraub**, Coalition Formation Models for Collaborative Transportation among Multiple Productive Companies under Cournot.

33. **Shraga Shoval**, A Model for Vacation Queuing Policy Considering Deterioration and Recovery of the Service.

40. **Nicole Adler, Eran Hanany and Stef Proost**, Introducing Competition in Air Traffic Control Provision in Europe.

▶ 11:20 - 11:30 *Coffee break*

► 11:30 - 12:10 **T3.A - Keynote, Elise Miller-Hooks**

*Chair: Hillel Bar-Gera*

**Optimal Investment for a Resilient Global Port Network**

► 12:10 - 12:50 **T5.A - Keynote, Retsef Levi**

*Chair: Alberto Canen*

**Systematic Risk Management of Economically Motivated Adulteration in Food Supply Chains**

► 12:50 - 13:40 **Lunch**

► 13:40 - 15:00 **T4.A - Operational Logistics – Leonardo Epstein**

8. **Wanja Wellbrock, Nadine Brehm and Oguzhan Aksoy**, Disruption Management – Development and Evaluation of a Maturity Mode.

39. **Raymond Marie**, The Impact of the Unavailability of Line Replaceable Units on the Operational Availability of the System.

60. **Gabriel De Araujo and Maria Cristina Fogliatti de Sinay**, Research Trends of Industrial Logistics.

57. **Leonardo Epstein and Ignacio Inostroza-Quezada**, Joint Evaluation of the Effects of a Store Promotion on Traffic, Conversion, and Customer Expenditures.

► 13:40 - 15:00 **T4.B - Transportation Net Design-1 – Nicole Adler**

32. **Aakash Kamble, Amir Elalouf and Dmitry Tsadikovich**, Location, Routing and Scheduling of Emergency Vehicles for Maternal Services in Rural Areas of India.

46. **Josip Mesaric, Davor Dujak and Dario Šebalj**, Mapping of Natural Gas Supply Chain in Croatia Aimed at Creation Simulation Model for System Imbalance Removal.

44. **Nicole Adler and Amir Brudner**, Estimating High Speed Rail and Airport Catchment Areas.

► 15:00 - 16:20 **T6.A - Queueing Systems – Baruch Keren**

3. **Hila Hindi Ling and Hillel Bar-Gera**, Interaction Delay in M/M/C/N and the Impact of Buffers on Harbor Quay-crane Operations.

31. **Baruch Mor**, Minmax Common Due-Window Assignment and Scheduling on a Single Machine With Two Competing Agents.

36. **Baruch Keren and Yossi Hadad**, Setting the Right Parking Price via Queueing Model.

63. **Guy Wachtel, Amir Elalouf, Yael Perlman and Uri Yechiali**, Resource Allocation in Emergency & Hospitalization Departments to Reduce Costs & Waiting Times.

► 15:00 - 16:20 **T6.B - General Logistic – Yael Perlman**

21. **Paolo Bisogni, Franca Cantoni and Marco Giannini**, A Comparison Between The Italian University Curricula in Logistics & SCM and the Professionals' Needs.

38. **Ramon Narcizo, Alberto G. Canen and Iara Tammela**, A Framework for Innovation Capability Performance Assessment in Brazilian Low – Tech Small Business.

43. **Arik Sadeh**, Factors and Methodologies Affecting Vendor Evaluation with Respect to Organizational Satisfaction.

17. **Magdalena Daszkiewicz**, Sustainable Logistics as a Direction of Counteracting Development Problems of Small Tourist Centers.

► 16:20 - 16:40 *Coffee break*

► 16:40 - 18:00 **T7.A - Healthcare & Emergency – Celia Glass**

53. **C.T. Daniel Ng, T.C. Edwin Cheng, Dmitry Tsadikovich, Eugene Levner, Amir Elalouf and Sharon Hovav**, Optimal Immunization Strategies for Groups at Risk in Vaccine Supply Chain Management.

67. **Simona Cohen Kadosh, Zilla Sinuany-Stern and Yuval Bitan**, Preparedness for Earthquake Disaster: Optimal Deployment of Emergency Treatment Site.

72. **Celia A. Glass, Roger A. Knight and Hugo R. Mills**, Ergonomic Rostering: Optimization for Less Tired Doctors and Safer Patients.

► 16:40 - 18:00 **T7.B - Logistics of Sustainable Housing – Justyna Kobylarczyk**

11. **Karolina Bielecka**, Design and Implementation of Cracow Housing Estates during the Transformation Period in the Context of Sustainable Development.

14. **Krystyna Paprzyca**, Sustainable Management of The Space as a Condition for The Development of The Medium-Sized Cities.

15. **Karolina Wieja**, Principles of Sustainable Development in Multi-Family Housing Estates.

12. **Justyna Kobylarczyk**, Green Logistics and its Tools Supporting the Main Assumptions of Green Architecture.

► 18:00 - 21:00

*Tour of Beer-Sheva &  
Abraham's Well Reception*





# Wednesdays - May 16, 2018

Venue: Leonardo Hotel Beer-Sheva  
All lectures are in: A-Negev Hall and B-Timna Hall

▶ 08:30 - 09:00 *Gathering & Coffee*

▶ 09:00 - 10:00 **W1.A – Plenary**

*Chair: Zilla Sinuany-Stern*

Welcome by **Tal Oron-Gilad, IE&M Head & Ehud Menipaz, Ira Center**

**Keynote, Yale Herer**

**News vendor: You have More Time than Before**

▶ 10:00 - 11:20 **W2.A - Production Logistics-1 – Liron Yedidsion**

22. **Yaar Harari, Avital Bechar and Raziel Riemer**, Optimization Framework for Workplace Design Using Simulation and Considering Productivity and Ergonomics.

29. **Ran Etgar, Yuval Cohen and Roy Gelbard**, Scheduling on-going Research and Development Projects.

51. **Guy Kashi, Gad Rabinowitz and Gavriel David Pinto**, Economic Investigation in Variable Transfer Batch Size, in CONWIP Controlled Transfer Line.

71. **Alon Dourban and Liron Yedidsion**, Numerical Threshold Policy for the Multi-Period Inventory Problem with Mean Reverting Price.

▶ 10:00 - 11:20 **W2.B - Transportation Routing – Erel Avineri**

2. **Katarzyna Gdowska**, How to Assess Balancing Public Transportation?

23. **Edison Avraham and Tal Raviv**, Time-dependent and Stochastic Field Service Routing and Scheduling.

10. **Benjamin Baran, Fabio López-Pires and Haiko Eitzen**, A Government Perspective for Two-Echelon Vehicle Routing: A Multi-Objective Evolutionary Approach.

▶ 11:20 - 11:30 *Coffee break*

▶ 11:30 - 12:10 **W3.A - Keynote, Andres Weintraub**

*Chair: Ehud Menipaz*

**Operations Research Systems Support Logistic Decisions**

▶ 12:10 - 12:50 **W5.A - Keynote, Tadeusz Sawik**

*Chair: Goran Dukic*

**Supply Chain Disruption Management Using a Multi-Portfolio Approach**

▶ 12:50 - 13:40 *Lunch*

► 13:40 - 15:00 **W4.A - Traffic Planning – Mali Sher**

47. **Baohua Mao, Cunrui Ma and Yao Chen**, A Simulation-Based Analysis of Train Design Speed for Urban Rail Transit Systems.
55. **Erel Avineri and Yuval Cohen**, Optimal Road Project Portfolio Selection under Limited Local Authorities Budgets in Polynomial Time.
73. **Svetlana Mihic and Danijela Daisic**, Backbone of Water Transport in Europe-Promotion, Protection and Sustainability.
48. **Mali Sher**, Supply Chain Management in the Traffic Enforcement Cameras System.

► 13:40 - 15:00 **W4.B - Production Logistics-2 – Moshe Eben Chaime**

34. **Marko Mladineo, Ivica Veza, Nikola Gjeldum and Marina Crnjac**, Web Information System for Sustainability Optimization of Production Networks.
58. **Stefan Schmidt and Benjamin S. G. Schmidt**, Food Safety in Logistics Processes & Sustainable Logistics.
49. **Moshe Eben Chaime**, The Bill of Materials and Operations Process Chart for Facilities Design.
9. **Maciej Bielecki**, Standardization Impact on the Design of Logistically Efficient Products – Preliminary Study.

► 15:00 - 16:20 **W6.A - Supply Chain Management (SCM)-1 – Katarzyna Gdowska**

45. **Roberta Pellegrino, Nunzia Carbonara and Nicola Costantino**, Quantity Flexibility Contract for Coordinating Supply Chain in Presence of Uncertainty.
62. **Livia Viana Rangel, Tammela Iara, Ramon Baptista Narcizo and Alberto G. Canen**, Supplier Performance Indicators Applied to Micro and Small Enterprises Operating in Açú Port Complex in Brazil.
74. **Ittai Kenet**, Supply Chain Planning Using any Logistix™ Dynamic Simulation – Case Study.

► 15:00 - 16:20 **W6.B - Transportation for the Elderly – Tal Grinshpoun**

- Greetings:* **Dr. Andrey Borisman**, The Israeli Ministry of Science and Technology
35. **Elad Shufan, Hagai Ilani, Tal Grinshpoun, Vadim Levit and Haya Brama**, The Fixed Route Dial-a-Ride Problem: An Optimal Algorithm by Graph Reduction.
26. **Svetlana Daichman, Hillel Bar-Gera and Tal Grinshpoun**, Mobility Habits and Transportation Needs of Inhabitants of Elderly Homes in Israel.
41. **Oksana Sabinik, Hillel Bar-Gera and Hagai Ilani**, Fixed Route Dial-A-Ride Service, An Integer Programming Approach.
28. **Haya Brama and Tal Grinshpoun**, Solving the Fixed Route Dial-a-Ride Problem Using a Recurrent Neural Network.

► 16:20 - 16:40 **Coffee break**

▶ 16:40 - 18:00 **W7.A - Warehousing Logistics – Raymond Marie**

20. **Goran Dukic, Lukas Rose, Brigita Gajsek, Tihomir Opetuk and Hrvoje Cajner**, Space, Time and Ergonomic Assessment of Order-Picking Using Vertical Lift Modules.

42. **Tone Lerher, Bojan Rosi, Iztok Potrč, Boris Jerman and Tomaž Kramberger**, Performance Analysis of Shuttle-Based Storage and Retrieval Systems Versus Mini-Load Automated Storage and Retrieval Systems.

50. **Gavriel David Pinto, Amit Nir, Avi Mizrahi and Guy Kashi**, A Logistics Center Order Picking Method.

64. **Gorazd Hren and Andrej Predin**, Evaluation of a Warehouse with Virtual Technologies.

▶ 16:40 - 18:00 **W7.B - Supply Chain Management-2 – Penina Orenstein**

75. **Tal Avinadav and Tatyana Chernonog**, Inventory and Marketing Policy in a Supply chain of a Perishable Product Under a Revenue Sharing Contract.

37. **Itai Levy, Yale Herer and Avraham Shtub**, Integrating The Simulation-Based Training Approach with Teaching Supply-Chain Management.

7. **Penina Orenstein**, Mining Financial Relationship Data to Construct Visual Supply Chain Network Maps used to Characterize Network Structure, Evolution, and Performance.

▶ 18:00 - 21:00 ***Gala Dinner at BGU & Virtual Tour of Ancient Beer-Sheva, Steve Rosen, BGU VP***

▶▶▶ **Thursday - May 17, 2018** ◀◀◀

▶ 8:30 - 20:00

***Full day Tour***



**T1.A – Keynote Lecture 1**

**RESEARCH AND TEACHING OPPORTUNITIES  
IN PROJECT MANAGEMENT**

**Nicholas G. HALL**

Dept. of Management Science, Ohio State University  
Columbus, OH 43210, USA

Almost one-quarter of the world's economic activity, with an annual value of \$15 trillion, is organized using the business process of project management. This process has exhibited dramatic growth in business interest in recent years, with a greater than 1000% increase in Project Management Institute membership since 1996. Contributing to this growth are many new applications of project management. These include IT implementations, research and development, software development, corporate change management and new product and service development. However, the very different characteristics of these modern projects present new challenges. The partial resolution of these challenges within project management practice over the last 20 years defines numerous interesting opportunities for academic researchers. These research opportunities make use of a remarkably broad range of methodologies, including robust optimization, cooperative and non-cooperative game theory, nonlinear optimization, predictive analytics, empirical studies and behavioral modeling. Furthermore, the \$4.5 trillion that is annually at risk from a shortage of skilled project managers, and the 15.7 million new jobs in project management expected by 2020, provide great opportunities for contributions to project management education. These educational opportunities include the integration of case studies, analytics challenges, online simulations, in-class games, self-assessment exercises, videos and guest speaker presentations, which together form an appealing course for both business and engineering schools.

## **T3.A – Keynote Lecture 2**

# **OPTIMAL INVESTMENT FOR A RESILIENT GLOBAL PORT NETWORK**

**Elise MILLER-HOOKS**

George Mason University  
Fairfax, VA 22030, USA

Ports are critical components of the global supply chain, providing key connections between land- and maritime-based transport modes. They operate in cooperative, but competitive, co-opetitive, environments wherein the throughput of individual ports is linked through an underlying transshipment network. The ports, as well as supporting rail and roadway system infrastructures, however, are by the nature of their designs and locations inherently vulnerable to rising sea levels, significant precipitation events, storm surges and consequent coastal flooding. They are also subject to worker strikes as well as other disruptive events of natural or anthropogenic causes. Investments, thus, are needed to protect this intermodal (IM) system from such disruptive forces. This presentation proposes optimization and equilibrium techniques for developing multi-stakeholder, protective investment strategies aimed at enhancing resilience of this marine-based IM system to disruption while protecting the market share of individual ports. These techniques account for the existence of differing stakeholders, varying governing principles and variations in investment sources.

## **T5.A – Keynote Lecture 3**

# **SYSTEMATIC RISK MANAGEMENT OF ECONOMICALLY MOTIVATED ADULTERATION IN FOOD SUPPLY CHAINS**

**Retsef LEVI**

Sloan School of Management

MIT – Massachusetts Institute of Technology

Cambridge, MA 02139, USA

Economically motivated adulteration (EMA) is a serious threat to public health. In this paper, we develop a comprehensive modeling framework to examine farms' strategic adulteration behavior and the resulting EMA risk in farming supply chains. We study both “preemptive EMA,” where farms engage in adulteration to decrease the likelihood of producing low-quality output, and “reactive EMA,” where adulteration is done to increase the perceived quality of the output. We fully characterize the farms' equilibrium adulteration behavior in both types of EMA and analyze how quality uncertainty, supply chain dispersion, traceability and testing sensitivity (in detecting adulteration) jointly impact the equilibrium adulteration behavior. We show that greater supply chain dispersion almost always leads to a higher risk of EMA. Furthermore, we caution that investing in quality improvement without also enhancing testing capabilities may inadvertently increase EMA risk. Our results offer tangible insights that can help companies and regulators to more proactively address EMA risk in food products.

## **W1.A – Keynote Lecture 4**

### **NEWSVENDOR: YOU HAVE MORE TIME THAN BEFORE**

**Yale HERER**

Dept. of Industrial Engineering  
Technion (IIT), Haifa, Israel

The world is being transformed by technology. The Newsvendor Problem, one of the cornerstones of Supply Chain Management (inventory management really), is no exception. Though there are many ways that technology is affecting the Newsvendor Problem, we will concentrate on exploring two such ways: inventory accuracy and slowing down time. Though we will mention the new technologies, our talk will focus on new newsvendor type models that have come about due to the new technology. In particular, we will examine our new newsvendor models and associated case studies.

## **W3.A – Keynote Lecture 5**

# **OPERATIONS RESEARCH SYSTEMS SUPPORT LOGISTIC DECISIONS**

**Andres WEINTRAUB**

Dep. of Industrial Engineering, University of Chile  
Santiago, Chile

Our group has a stated objective: to develop innovative, high impact projects for Chilean firms and public institutions. Systems, based on Operations Research methodologies, that should change the way firms operate. This talk presents several of the projects we have developed in the area of logistics. I discuss the problems the firms had, the methodology we developed and the impact of the implementation. The cases are in the areas of forest timber transport, scheduling movement of empty containers for a large shipping company, transportation in the salmon production chain, and how fire trucks are scheduled to arrive faster to contain fires. These systems have led to important savings and improvements in operations in each case.



## **W5.A – Keynote Lecture 6**

# **SUPPLY CHAIN DISRUPTION MANAGEMENT USING A MULTI-PORTFOLIO APPROACH**

**Tadeusz SAWIK**

Industrial Engineering and Operations Research, AGH University of Science  
and Technology Kraków, Poland

A new portfolio approach is presented to support decision-making in the presence of supply chain disruption risks. Unlike most of reported research on supply chain disruption management, a disruptive event is assumed to impact both a primary supplier of parts and the buyer firm's primary assembly plant. Then the firm may choose alternate (recovery) suppliers and move production to alternate (recovery) plants along with transshipment of parts from the impacted primary plant to the recovery plants. For the impacted suppliers and assembly plants, both time and cost of recovery from disruption is considered. The resulting allocation of unfulfilled demand for parts among recovery suppliers and unfulfilled demand for products among recovery assembly plants determines recovery supply and demand portfolio, respectively. Scenario-based stochastic mixed integer programming formulations with an embedded network flow problem are developed for selection of primary suppliers; the decision to be implemented before a disruption and for selection of recovery suppliers and recovery assembly plants; and the decision to be implemented during and after the disruption. Local and regional, two- and multi-level disruptions of suppliers and assembly plants are considered. The selection of supply, transshipment and demand portfolios is determined simultaneously with production scheduling in assembly plants. The two decision-making approaches will be considered: an integrated approach with the information about the future disruption scenarios, and a hierarchical approach with no such information available ahead of time. In the integrated approach a two-stage stochastic model is applied, in which the first stage decision considers disruption scenarios to happen in the second stage, so that the impact of disruption risks is mitigated. The second stage decision optimizes the supply chain recovery process. The integrated approach accounts for all potential disruption scenarios. The primary supply portfolio that will hedge against all scenarios is determined along with the recovery supply and demand portfolios and production schedule of finished products for each scenario. In the hierarchical approach, first the primary supply portfolio is selected to optimize supplies and production in deterministic conditions (without a disruption), and

then, when a primary supplier or primary assembly plant is hit by a disruption, the recovery supply and demand portfolios are determined along with transshipment of parts and production schedule at recovery plants to optimize the process of recovery from the disruption, given the unfulfilled demand for products and the inventory of parts at the primary assembly plant. The integrated decision-making selects a more diversified primary supply portfolio to hedge against all potential disruption scenarios. When all primary suppliers are completely shut down, a single sourcing recovery supply portfolio is usually selected. If all assembly plants are shut down, the integrated approach may select the primary plant as a single recovery plant, whereas the hierarchical approach may choose multiple recovery plants. The scenario analysis indicates that for the hierarchical approach the best-case and worst-case disruption scenarios are, respectively, subsets and supersets of the corresponding scenarios for the integrated approach. In addition to risk-neutral decision-making based on expected cost or expected service level optimization, an integrated risk-averse approach is developed using Conditional Value-at-Risk as a risk measure. Several modifications of the proposed portfolio approach will be discussed, including selection of a resilient supply portfolio with fortified suppliers and prepositioning of emergency inventory of parts and selection of a dynamic supply portfolio under delay and disruption risks. A multi-period stochastic formulation will be compared with a simplified two-period model, where the multi-period production decisions are replaced by a simplified two-period decision: production before and production after a disruptive event. Computational results will be presented and discussed. The findings indicate that the developed multi-portfolio approach leads to computationally efficient mixed integer programming models with a very strong LP relaxation.

# Abstracts of Parallel Sessions' Submissions\*

## T2.A – Submission – 25

### OPTIMIZATION MODEL FOR PROCUREMENT, INVENTORY AND LOGISTICS MANAGEMENT

**Nethanel DREZNER<sup>1,2</sup>, Michael DREYFUSS<sup>2</sup>, Tal GRINSHPOUN<sup>1</sup>**

<sup>1</sup> Ariel University, Department of Industrial Engineering & Management  
65 Golan Heights St., Ariel 4070000, Israel

<sup>2</sup> Jerusalem College of Technology, Department of Industrial Engineering & Management  
21 Ha'vaad Haleumi St., Jerusalem 93721, Israel

In this study, we consider a periodic review inventory model using ABC and ORG classification methods, when the demand follows a Poisson process and the lead time for delivery is constant. The model optimizes the operational cost, consisting of order, inventory and discount cost subject to a service level constraint. In this study we use the window of fill rate, which is the probability to be served within a given tolerable time window as the service level. Two models are analyzed: In the first model all items are purchased simultaneously, whereas in the second model all items of the same group are purchased together. We present a methodology using the ARENA simulation package to demonstrate the model. We apply this model to an educational institution's procurement and logistics system and portray the model factors sensitivity analysis. In this application, the first model reduces the total cost by ten percent and the second model by fifteen percent.

**Keywords:** *purchasing and procurement, inventory management, smart logistics, customer service*

\* Submissions' numbering is according to EasyChair system's numbering

## BENEFITS OF VENDOR MANAGED INVENTORY PROGRAMS IN TWO-STAGE SUPPLY CHAINS

Ilias S. KEVORK<sup>1</sup>

<sup>1</sup> University of Thessaly, Department of Economics  
28<sup>th</sup> Octovriou 78, Volos 38333, Greece

This paper investigates potential benefits of an Information Sharing (IS) scenario in a two-stage supply chain where demand for an item is generated by the AR(1) process and inventory replacements are made according to an order-up-to level (OUT) policy. To quantify such benefits, the changes in the bullwhip ratio and the average on-hand inventory level are calculated. The analysis reveals that the choice of IS scenario depends simultaneously on three factors: (a) autocorrelation level, (b) relative length of lead times, (c) the size of probability for each member to face lead time demand at most equal to his OUT level.

**Keywords:** *supply chain management, inventory management, forecasting, customer service, bullwhip effect*

## T2.A – Submission – 1

# RETAILER'S OPTIMAL PURCHASE MIX OF BUNDLES AND PRODUCTS IN A SINGLE PERIOD SUPPLY-CHAIN

**Yuval COHEN<sup>1</sup>, Dalia FISHLOV<sup>1</sup>, Yehudit APERTSIN<sup>1</sup>**

<sup>1</sup> Tel-Aviv Afeka College of Engineering, Department of Industrial Engineering  
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38 Mivtsa Kadesh, Tel Aviv 69988, Israel

Bundling two or more different products as a discount bundle is a common practice that could be frequently seen in various businesses (e.g. convenient convenience stores and fast-food restaurants). In this paper, the demand for each product is assumed to be stochastic, and the manufacturer offers the retailers discounted bundles. The retailer buys the discounted bundle, separates its content, and sells its separate products at their full price. In that way the retailer increases profits while keeping the end-user demand distribution unchanged. The retailer's purchase policy is analytically analyzed, and the optimal solution is derived. A numerical example and a solution are provided for a mix of Uniform and Normal demand distributions to illustrate the solution methodology.

**Keywords:** *inventory, bundles, newsvendor, bundling, supply-chain, purchasing*

**DETERMINING CRITICAL AIRCRAFT SPARE PARTS  
USING TEXT MINING AND ASSOCIATION RULE  
MINING TECHNIQUES**

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Determination of critical spare parts is a crucial task in aviation during the process of forecasting spare parts demand. It is also an extremely challenging task due to the fact that demand in the aviation industry is intermittent, i.e. it is small and highly variable in size. The aim of this paper is not to predict exact spare parts inventory levels by using traditional forecasting methods (e.g. Chroston's), but rather to discover critical spare parts during the low and high season. In order to succeed in that aim, text mining (TM) and association rule mining (ARM) techniques will be applied on a real-life dataset obtained from one European air carrier. Typical data mining steps; data familiarization, data pre-processing and transformation, model development and result interpretation, will be presented. Based on the insights obtained from the results, conclusions and guidelines for further research will be presented.

**Keywords:** *spare parts, aircraft, text mining, association rule mining*

**MINMAX SCHEDULING AND DUE-WINDOW  
ASSIGNMENT WITH POSITION-DEPENDENT  
PROCESSING TIMES AND JOB REJECTION**

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We study a single machine scheduling and due-window assignment problem. The objective function is of a minmax type, i.e., the goal is to minimize the largest cost among all scheduled jobs. We assume position-dependent job processing times in the most general way. A polynomial time solution procedure is introduced. We further allow job rejection, where the scheduler may decide not to process certain jobs, which are penalized accordingly. For this setting, a polynomial time solution is presented, provided that the processing times deteriorate, i.e., the (generally position-dependent) processing times are non-decreasing functions of the job position.

**Keywords:** *scheduling, sequencing, due-window assignment, position-dependent processing times, Job-rejection*

**COALITION FORMATION MODELS FOR  
COLLABORATIVE TRANSPORTATION AMONG MULTIPLE  
PRODUCTIVE COMPANIES UNDER COURNOT**

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Horizontal collaboration in logistics is defined as the coordination of some operational activities among firms which are at the same level of the supply chain, i.e., they are competitors. Because of its importance in logistics costs, transportation is usually seen as the primal activity for which collaboration may be reached. Indeed, some successful cases have been reported in the forestry and energy areas, but have occurred over limited ranges of time, and far from the breadth that would be consistent with the alleged benefits that it would bring. We attempt to explain this discrepancy. The rationale we pursue in this paper is the following: until now, the OR models used to study the horizontal collaboration in transportation have not included competition between firms: contracts are signed, and both quantities and prices are fixed. Without competition, agreements always save on costs and it is then a matter of allocating costs savings wisely. In our model we consider a coalition formation game, but prior to market equilibrium; that is, we propose a collaborative model in which, after the agreements are signed, the different firms and coalitions compete in multiple markets in Cournot fashion. When this happens, the formation of one set of coalitions affect prices and production levels of all other competitors, something that did not occur in the previous literature. Possible partnership among these firms is allowed and studied. One main result is that, as opposed to findings in the literature to date, forming coalitions that are beneficial to firms in the agreement is actually quite hard, which would explain why collaboration has not been observed as much as expected. Moreover, when such coalitions emerge, it is likely that they will attract opposition from antitrust authorities. We propose two models to respond to the question of which coalitions will be formed in this setting, including at times the restriction that the agreement should be cleared by antitrust authorities.

**Keywords:** *collaborative transportation, cooperative game theory, Cournot Model*



**A MODEL FOR VACATION QUEUING POLICY  
CONSIDERING DETERIORATION AND RECOVERY OF  
THE SERVICE**

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In queuing theory, a vacation queue is one where the server (human or machine) suspends the service for a certain period of time due to system constraints and priorities, or due to a failure of the service system. The vacation period, as well as the vacation schedule, can be planned ahead or can be determined according to the status of the system. In existing models of vacation queuing, the server's capacity before and after the vacation period is identical. In this work, we present a different type of vacation queue, where the capacity of the server deteriorates during the service period (e.g. due to fatigue of a human server or wear and ageing of machinery) and improves after the vacation period (e.g. following a recovery period for a human server or servicing of machinery). Considering the various costs associated with the vacation queue, we analyze the effects of different vacation policies on the total cost. In particular, we consider the scheduling of vacation periods and their length as a function of the deterioration and improvement rates. The model proposed in this paper has a wide variety of applications in real-world queuing services as well as in other types of applications. As an example, we illustrate an application of the model in sport, where a skilled player (the server) needs to be temporarily replaced by a less skilled player to facilitate recovery for optimum performance later in the game. Such a model can assist coaches in planning the game's strategies.

**Keywords:** *queuing theory, vacation queue, deterioration, recovery*

## COMPETITION IN AIR TRAFFIC CONTROL PROVISION IN EUROPE USING GAME THEORETIC PRINCIPLES

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In this research, we focus on whether it is possible to introduce competition for the market in air traffic control in Europe and the likely outcomes. We develop a two-stage, network, congestion game in which multiple air navigation service providers bid to serve airspace. Airlines subsequently choose their optimal flight paths such that they minimize their operating costs. The individual governments set up an auction in which they specify minimum service levels and the rules of the auction, such as the right to increase charges as a function of air service levels. The winners of the auctions are the service providers that bid the lowest charge. We test the likely equilibria outcome if the companies are for-profit or non-profit air navigation service providers. The results suggest that introducing competition for the market via outsourcing service provision may reduce charges by up to half the current levels. It would also appear that auctioning the service is likely to lead to defragmentation of the European system as companies win more than one auction. Finally, it would appear that for-profit companies are highly likely to invest in SESAR technologies, thus encouraging technology adoption faster than appears to be occurring today. We note that it is important to ensure a sufficient number of competitors for the auction process to be successful over time. Without an auction process, non-profit companies would be strictly preferable to both the current state agency and to a government corporation.

**Keywords:** *transportation management, transportation modes: aviation, financial and economic modelling/aspects of logistics, route optimization*

**DISRUPTION MANAGEMENT – DEVELOPMENT AND  
EVALUTATION OF A MATURITY MODEL**

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High complexity in organization and technology together with the reduction of time and inventory buffers in the context of lean production increase the susceptibility of operational processes. As a result, process stability can no longer be guaranteed under economic aspects. The developed maturity model presents an analytical toolkit, which reflects the success factors of disruption management from the perspective of science and practice. Based on the maturity model, the status quo of disruption management is analyzed by a large-scale empirical study among German speaking companies.

**Keywords:** *disruption management, risk management, maturity model, supply chain management*

**THE IMPACT OF THE UNAVAILABILITY OF LINE  
REPLACEABLE UNITS ON THE OPERATIONAL  
AVAILABILITY OF SYSTEMS**

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The evaluation of the operational availability of a fleet of systems on an operational site is far from trivial when the size of the state space of a faithful Markovian model makes this issue unrealistic for many large fleets of systems. The main difficulty comes from the existence on the site of line replaceable units that may be unavailable from time to time when a breakdown occurs. In this paper, we present a simpler but approximate method which has given a quite good accuracy when tested on small cases. The main idea is to consider a non product form queuing network and to aggregate subsets of it as if they were parts of a product form queuing network. Nevertheless, the generalization to systems with multiple types of line replaceable units needs to be investigated further and tested with respect to the accuracy of the new approximate method.

**Keywords:** *integrated logistic system, stock shortage, line replaceable unit, operational availability, intrinsic availability, Markovian model, approximate method, non product form queuing network*

**RESEARCH TRENDS ON INDUSTRIAL LOGISTICS**

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The purpose of this article is to verify the trends and interrelations between the various subtopics of the Logistics area of knowledge. In order to do so, an analysis of the co-occurrences of keywords in academic articles was performed. Data from the Web of Science database were divided by decade (from 1951 until 2017) and treated with Vosviewer software. An exponential growth of the field from the year 2000, with a tendency to stagnation by 2017 was observed. Themes that were relevant in the past have been replaced by new themes of interest and increasingly new themes are addressed.

**Keywords:** *industrial logistics, science development, trends*

**JOINT EVALUATION OF THE EFFECTS  
OF A STORE PROMOTION ON TRAFFIC, CONVERSION  
AND CUSTOMER EXPENDITURES**

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The talk presents a novel approach to evaluate the joint effects of retail promotions on arrival traffic, conversion probabilities – and customer expenditures – key measures of promotions’ effectiveness. Retail researchers say that a store visitor converts if he/she makes a purchase before leaving the store. The conditional stages visit-conversion-expenditure is common in sales operations settings beyond sales in brick and mortar stores, for instance sales via call centers. More formally, the approach evaluates the effect of an intervention on three-dimensional time series with dependent components: counts of visitors, counts of converting visitors and expenditures. Assuming that the promotion did not occur, the approach uses the data outside the intervention interval to build counterfactual baselines for each of the three processes during the intervention. To evaluate the effects of the intervention, the approach compares the observations during the intervention to the corresponding baseline series. To compute the prediction distribution associated with the baseline, the approach uses a simple implementation of the bootstrap. This approach has at least three strengths: first, it does not require building a statistical model for the promotion effect. Second, it controls for covariate effects, such as time of the day, day of the week, etc. Third, it measures the effects of the promotion directly on the quantities of interest, arrival counts, conversion probabilities and expenditures. An illustration with data from an actual store combines arrival data from video images and sales recorded at sales registers.

**Keywords:** *store traffic, conversion, sales promotions, promotion effectiveness, prediction*

**LOCATION, ROUTING AND SCHEDULING  
OF EMERGENCY VEHICLES FOR MATERNAL  
SERVICES IN RURAL AREAS OF INDIA**

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India is the second most populated country in the world, with nearly a fifth of the world's population. For many individuals living in India—and particularly those living in rural areas, who make up a majority of the country's population—obtaining access to basic healthcare services is challenging. In particular, healthcare provisions for pregnant women in rural areas are based in centralized Rural Hospitals (RH) and in Primary Health Centers (PHC), and ambulances are used to transport individuals to these locations. However, a lack of ambulances, coupled with the fact that healthcare centers are highly dispersed and isolated, forces pregnant women to deliver their babies at home. This situation, in which women give birth under poor hygienic and sanitation conditions, and without access to medicine and necessary medical staff (i.e., doctors and nurses), results in high rates of infant and maternal mortality. To reduce these rates, it is necessary to substantially improve the operations of the process of transporting pregnant women to medical facilities. Accordingly, herein we seek to optimize: (a) the number and locations of the ambulances, as well as (b) their scheduling and routing.

In our study, we focus on Mulshi Taluka in Pune District of Maharashtra, India, which is located in the hilly terrain of Western Ghats. To find a solution for the considered problem, we develop a new mathematical approach based on a combination of dynamic routing and scheduling rules with an optimal allocation algorithm.

**Keywords:** *transportation management, customer service, operations management and scheduling*

**MAPPING OF NATURAL GAS SUPPLY CHAIN  
IN CROATIA AIMED AT CREATING A SIMULATION  
MODEL FOR SYSTEM IMBALANCE REMOVAL**

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With the growing importance of natural gas as the third most important fuel and fastest growing component of world primary energy consumption, its supply chains are becoming more complex in seeking ways for simultaneous optimization and further expansion. To gain clearer insight into situations and relations between members of the natural gas supply chain; to explore possibilities for optimization of its processes; to avoid multiplication of activities; and to prevent the occurrence of failures or catastrophes in the system, practitioners and scientist use supply chain mapping techniques. The paper aims to present existing types of supply chain maps, their benefits, limitations and methods for natural gas supply chain mapping through the case study method of mapping a Croatian natural gas supply chain. Mapping a natural gas supply chain serves the second objective of the paper, which is to develop a conceptual simulation model of physical and trading processes of natural gas in Croatia. Due to the mismatch of ordering (nominations) and withdrawal of gas made by balance groups, imbalances in the transportation system occur, which needs “balancing energy”. Consequently, balance groups that have a mismatch over the permitted limits are penalized. Exploring the reserves of transportation and distribution systems, the model aims to minimize or eliminate the inefficiencies resulting from the mismatch between the order (nomination) and the withdrawal of gas from the transportation system made by the balance groups under regulated market conditions. The initial version of the model was developed using Arena Simulation Software.

**Keywords:** *supply chain mapping, natural gas, simulation modelling*



**ESTIMATING HIGH SPEED RAIL AND AIRPORT  
CATCHMENT AREAS USING BIG DATA**

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One of the goals declared in the EU white paper “European transport policy for 2010: Time to decide” is to reduce car travel by encouraging passengers to switch to more sustainable modes of transport. For medium to long distance trips of around 300 to 700 km, the target mode is high speed rail, and the network has been expanding over the last two decades. A crucial element that enhances high speed rail and air travel choice is reasonable accessibility to residential centers. Estimating catchment areas is problematic, generally relying on simplistic assumptions with respect to spatial GIS data or sparse, inaccurate survey data. In this research, we estimate catchment areas based on the analysis of data generated from personal mobile devices. Anonymized mobile phone records are combined with data from the Google Maps Directions API and other sources to reconstruct trips and estimate the modal share between the Madrid and Catalonia regions in Spain. Based on a multinomial logit analysis, we are able to identify the impact of the length of access and egress times to the high-speed rail station or airport on the probability that passengers choose to drive between Madrid and Catalonia, which amounts to 50% of all trips. We note that passengers are less willing to accept longer travel times to airports than to high-speed rail stations, and proximity to high-speed rail stations has a slightly more negative affect on the aviation market share than vice versa. Finally, proximity to high-speed rail stations attracts more passengers from the road mode than does access to airports.

**Keywords:** *transportation*

## T6.A – Submission – 3

# INTERACTION DELAY IN M/M/C/N AND THE IMPACT OF BUFFERS ON HARBOR QUAY-CRANE OPERATIONS

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Reducing the average processing time (APT) of loading and unloading operations is one of the most important objectives in a container terminal. One of the factors influencing APT is the interaction between quay crane operation and the yard trucks operation. When buffer operations involve no further delay, the system can be represented by the analytic M/M/C/N queueing model. Otherwise, an event-based simulation model is used. The main measure used in the analysis is the relative interaction delay (RID), defined as the difference between the APT per unit and its lower bound, divided by the lower bound.

RID values range from 0 to 0.5. Buffers can reduce RID considerably, e.g. the RID of 0.5 reduces to 0.25 when using a buffer of size two. For given buffer size and number of servers, the RID reaches its peak when the ratio of supply to demand ( $\theta$ ) is one, and approaches zero when  $\theta$  gets away from one. In practice systems are likely to operate near the balanced point between supply and demand ( $\theta=1$ ), and therefore the consideration of interaction effects is important. Other properties of RID are examined analytically and numerically.

Simulation results for minor buffer slowdown (10%) are similar to the ideal case. Increasing the number of buffer spaces is helpful only until a specific value of  $\theta$ , above which a reverse impact occurs, as the harm of buffer slowdown becomes higher than the benefit of the buffer. The specific  $\theta$  threshold value decreases as the number of servers increases.

**Keywords:** *logistics Modelling and Simulation, operations management and scheduling, queueing model, OR in Maritime Industry*

**MINMAX COMMON DUE-WINDOW ASSIGNMENT  
AND SCHEDULING ON A SINGLE MACHINE  
WITH TWO COMPETING AGENTS**

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We study the classical method of common due-date assignment and focus on minmax objective functions. In due-date assignment problems, the objective is to find the optimal due-date and job sequence that minimize the total earliness, tardiness and due-date related costs. We extend the single agent problem to a setting involving two competing agents and a setting of multi-agent. In the two agents setting (herein agents A and B), the scheduler needs to minimize the maximum cost of agent A, subject to an upper bound on the maximal cost of agent B. In the general model of multi-agent scheduling, the scheduler needs to minimize the cost of each of the A-type agents, subject to an agent-dependent upper bound on the maximal cost of the B-type agents. We further generalize the problems to the method of common due-window assignment. For all studied problems, we introduce efficient polynomial time solutions.

**Keywords:** *multi-agent scheduling, Single machine, Common due-date, Minmax*

## SETTING THE RIGHT PARKING PRICE VIA QUEUING MODELS

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In economics, a shortage is a situation in which the demand for a product or service exceeds its supply in the market. It is clear that parking slots, especially in the big cities, are in shortage. Given a choice, drivers prefer free parking, but free parking has substantial costs. The local populations bear the parking costs through higher taxes and retail prices. The trade-off is actually between paying for parking directly or indirectly. Paying directly for parking is more efficient and fair. This research proposes a model for managing parking demands by setting the right parking price. The right parking price is defined as the price for maximizing the revenue or for setting a given level of occupancy of the parking slots. The research uses a queuing model and the concept of price elasticity to calculate the optimal parking price. The proposed model can be used by practitioners who want to set the right price for parking.

**Keywords:** *transportation management, queuing model, parking policy, parking pricing, occupancy*

**RESOURCE ALLOCATION IN EMERGENCY  
& HOSPITALIZATION DEPARTMENTS  
TO REDUCE COSTS & WAITING TIMES**

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Overcrowding remains a common problem in hospitals' emergency and hospitalization departments all around the globe. Many departments face lack of resources and inability to add more space to the existing treatment areas. With fixed available space and limitation of the available budget there is a need to find the best allocation for the existing hospital's resources, such as beds and treatment chairs. In our research we address two streams of patients: The first stream can be served only by beds, while the second stream can be served by either armchairs or beds. Both streams have Poisson arrivals rate. We further assume different costs for transportation and renting of the resources. We programed the general description of this problem, then compared different strategies under various conditions in order to evaluate them and gain insights for better decision making. We used two "extreme" strategies: (i) a fully flexible system that changes resources for every change in the demand and (ii) a solid system, where the resources are fixed or can be changed in intervals of days or shifts. In addition, we gave as an input to the program a few "in-between" strategies for scenarios observed in two hospitals in Israel and gave insights about their potential for improvement. To conclude we discuss further options to extend this method to the entire hospital, the benefits and possibilities for actual application, and the barriers that are facing it.

**Keywords:** *operations management and scheduling, financial and economic modeling, aspects of logistics*

**A COMPARISON BETWEEN THE ITALIAN UNIVERSITY CURRICULA IN LOGISTICS & SCM AND THE PROFESSIONALS' NEEDS**

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The evolution and interdisciplinarity of Logistics and SCM presume inevitable changes in professionalism demands. A dialogue between enterprises, universities and research aimed at aligning the required skills is therefore necessary. In that regard, the authors felt the need to reflect on the content and methodologies offered by universities to provide graduates with the technical and management tools necessary to effectively operate in logistics and SCM. Thus this research aims to identify and activate possible tools to encourage the creation a “bridge” between the University world and the logistics environment. The methodology adopted by the authors is summarized it verified the presence of standards of competence. After establishing which standards to include and having justified selection criteria, the authors have prepared a matrix containing the main jobs associated with the main technical competences to these job descriptions. These competences were then aggregated and produced by matrix where the technical macro competences necessary to effectively work on the Logistics and SCM have been combined with the target of competences that can be developed by the programs of Italian universities. Considering what we explained regarding business requirements in terms of jobs, competence areas and the training offer provided by universities, it becomes clear that there is a major gap between the requested competence system and topics being taught. Assuming that one of the causes behind such a gap is a reduced information exchange between academy and the business, the authors foster a systematic re-engineering of the contents of university curricula.

**Keywords:** *supply chain risk management, global logistics, distribution management*

**A FRAMEWORK FOR INNOVATION CAPABILITY  
PERFORMANCE ASSESSMENT IN BRAZILIAN  
LOW-TECH SMALL BUSINESS**

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This article presents a proposal for a framework for the evaluation of innovation performance resulting from innovation capability of Brazilian low-tech small companies. It was built as a reference model and is based on three increasing levels of granularity: performance perspectives, performance parameters and evaluation parameters. This framework has several potential applications, generating benefits from the provision of conceptual guidelines that can increase the competitiveness and innovation performance of small Brazilian companies through differentiations and innovations based on management mechanisms that are independent of formal research and development.

**Keywords:** *operations management, economic aspects of logistics, customer service*

## FACTORS AND METHODOLOGIES AFFECTING VENDOR EVALUATION WITH RESPECT TO ORGANIZATIONAL SATISFACTION

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Organizations have realized that an efficient supply chain will enable the organization to succeed and attain a competitive advantage, and that the most important factor in an efficient supply chain is the selection of vendors to suit this purpose and the needs of the organization.

There are various methodologies that enable decision makers in the organization to make the optimal choice of vendors to suit their requirements. The process of selecting vendors is complicated by the fact that there are a large number of criteria involved in the examination and determination of who is the most suitable supplier to be in contact with. This study examines the methodology of evaluation of vendors in various organizations, which is composed of several factors. The objective was to identify the factors that affect the accuracy of the evaluation result against the satisfaction with the organization from the performance of the vendors. Mapping the factors with the critical mass will enable decision makers to invest efforts and place an emphasis on the influencing factors in order to obtain a more accurate evaluation result that best reflects the satisfaction of the various departments in the organization.

The result of the evaluation is a score that can be provided according to a methodology chosen by the organization, and is supposed to reflect the level of satisfaction of the stakeholders in the organization with the contract with the supplier and to rank its performance to their satisfaction.

The research methodology is based on survey data that includes 105 procurement managers, suppliers and project managers. A structural model is defined using a Structural Equation Modeling (SEM) approach with integration of explanatory and confirmatory factor analyses.

The results of the research show that there is actual realization and expression between the results of an assessment depending on the methodology used, the score obtained and changes in actual activity with the vendor.

**Keywords:** *vendors' evaluation, structural equation modeling, supply chain management*



**SUSTAINABLE LOGISTICS AS A DIRECTION OF  
COUNTERACTING DEVELOPMENT PROBLEMS  
OF SMALL TOURIST CENTRES**

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Urban systems are central in logistics. It concerns economy, communication, human resource management and goods. Apart from the negative impact of transport on the environment, it is necessary to apply such tools as legal or environmental regulations, and activities related to so-called “Green” or “sustainable” Logistics. These include the use of standards specifying the permissible emission of pollutants, the use of hybrid engines, the use of ecological consumables such as eco-fuels and others. Particular attention should be paid to the availability, the possibility of providing supply, efficient mass communication, transfer of tourists and unloading of transit traffic. The article aims to highlight the spatial and social consequences of improperly pursued logistics policy, the need to update infrastructure solutions connected with investment plans and to stress the importance of striving to preserve or improve the quality of life in the city as the main objective of its functioning.

**Keywords:** *sustainable logistics, green logistics, small city, tourist centre, transportation*

## OPTIMAL IMMUNIZATION STRATEGIES FOR GROUPS AT RISK IN VACCINE SUPPLY CHAIN MANAGEMENT

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Annual influenza epidemics cause great losses in human and financial terms. Vaccination is the most effective way of protecting people from being infected. However, the impact of vaccination on the disease spread is dependent on the chosen immunization strategy and on functional, end-to-end vaccine supply chains and logistics systems. This paper aims to determine the optimal combination of the various immunization strategies that lead to decrease of the disease burden. A supply-chain based model is proposed to address this problem. Computational results show that targeted vaccination significantly outperforms other strategies and prevails over them in terms of cost and efficacy.

**Keywords:** *supply chain risk management, disaster logistics, operations management and scheduling*

**PREPAREDNESS FOR EARTHQUAKE DISASTER:  
OPTIMAL DEPLOYMENT OF EMERGENCY TREATMENT**

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The official framework of the earthquake preparation policy in Israel presumes that care for all casualties is the main concern and as so defined the necessity of deploying Emergency Treatment Sites (ETS) as part of disaster logistics. These treatment sites will provide medical first aid during the first 72 hours to moderate and lightly injured casualties. While authorities define only one kind of ETS, equipped and positioned in advance, defined here as static ETS, our optimization model suggests adding new mobile ETS that participate under command of the static ETS. These mobile ETS will be equipped and positioned only after an event occurs.

The model is based on minimizing distance on network hierarchical location problems with “soft” constraints, where a set of destruction locations, including casualties and sets of candidate static and mobile ETS are given. The destruction sites and number of casualties are based on Hazus software prediction for a specific area and damage scenario, while the candidate ETS locations are suggested according to emergency safety instructions. The research scenario assumes that a mobile ETS will be connected only to one destruction site and one static ETS within defined maximal distance. A static ETS can serve several sites.

The model we developed will provide the best recommended locations for both static and mobile ETS, that can handle the maximum casualties at minimum duration under given restrictions. Those planned facilities can help minimize uncertainty of policy makers at disaster logistics during the first hours, saving more lives.

**Keywords:** *network location, disaster logistic, deployment, earthquake, healthcare preparedness, goal programming*

## A ERGONOMIC ROSTERING: FOR LESS TIRED DOCTORS AND SAFER PATIENTS

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Scheduling staff to cover work duties is an NP-hard problem. We, in addition, take account of staff fatigue and autonomy, which is made possible through measures of fatigue and of priorities on leave requests. This work bridges academia and practice, and hopefully provides a demonstrator of a valuable contribution of mathematics/OR to the world. We in the UK have developed our ergonomic optimization rostering tool for use in 24/7 emergency departments in our highly pressurized National Health Service (NHS). I will explain the difference between the current NHS rota system and a roster, and present some very satisfactory results and feedback on the improvement in doctors' well-being. On the practical side, the mathematical program requires the formulation of a complex set of legislative and contractual rules, following legal advice. For completeness I should also mention barriers to use in the form of change management and commercialization issues. The rostering service is offered under Nightglass Medical Rostering Ltd..

**Keywords:** *optimization, hospital rostering, ergonomics*

**DESIGN AND IMPLEMENTATION OF CRACOW HOUSING  
ESTATES DURING THE TRANSFORMATION PERIOD  
IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT**

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The concept of „green architecture”, closely related to sustainable development, design and ecology is not only a reference to the technical issues in construction, but also, in a wider scope about shaping pro-health spatial conditions that would serve present and future generations, with care for human relations with the environment. The challenge of the modern generations is to achieve a balance between natural environment and man-made spaces. This article presents the development of the new housing estate implementing the assumptions of the sustainable design, including green architecture. It will be characterized by large, open green areas, playgrounds, local services and a provision of collective transport.

**Keywords:** *green architecture, sustainable design, living environment*

**SUSTAINABLE MANAGEMENT OF THE SPACE  
AS A CONDITION FOR THE DEVELOPMENT  
OF THE MEDIUM-SIZED CITIES**

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Medium-sized cities like Oświęcim are shrinking. They face many problems: the ageing inhabitants, the outflow of young people, a high level of migration, insufficient development of entrepreneurship, the polluted environment and the decrease of resources. Oświęcim had the largest number of residents in 1992 – 44,874. In 2016 there were 40,292 inhabitants in, Oświęcim: the number of inhabitants is decreasing year by year.

Currently, the attention of local governments of small and medium-sized cities is directed at undertakings that increase their attractiveness and minimalise the environmental damage. These activities are focused on improving the quality of the environment, spatial arrangement and the quality of life [2]. The author analyses the city of Oświęcim with regard to the aspects mentioned above, trying to prove that the town of Oświęcim follows the path of sustainable development.

There are many issues included in the principles of sustainable development:

- architectural and spatial aspects: improvement of the quality of public space, revitalization and modernization of buildings and technical infrastructure, reduction of their environmental impact, increase in the number of safe and friendly green spaces
- social aspects: activities aimed at maintaining social balance in a given area, logistics of the investment process, including forecasting market needs and satisfying customer expectations
- economic and ecological aspects: green logistics as optimization of the potential of a given place and its use in a proper manner

**Keywords:** *sustainable management, medium-sized cities, quality of the living environment, green logistics in sustainable development*

**PRINCIPLES OF SUSTAINABLE DEVELOPMENT  
IN MULTI-FAMILY HOUSING ESTATES**

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In 1989 in Poland, a political transformation, followed by great social and economic changes, took place. With the restoration of property rights and the introduction of free market rules, the construction of multi-family housing estates intensified, chaotically coinciding with the existing urban structure. In Cracow, the landscape of the historic city with an amazing development potential has begun to deteriorate due to the formation of architecturally inconsistent housing estates. In order to improve the quality of the space, the principles of sustainable development have been applied. However, theoretical assumptions were not always reflected in practice. The article raises the question whether housing estates created in the authoritarian system were more friendly to man and the environment, closer to the principles of sustainable development than multi-family housing units that are being created nowadays. The analysis of multi-family housing buildings created in two selected time intervals provides the opportunity to examine whether the “old” housing estates may have features worth imitating and whether new objects of this type should be further implemented in accordance with the developers’ vision.

On the basis of the analyses, it can be stated that under the guise of shaping friendly spaces, we obtain objects that have been removed from the environment and isolate the inhabitants from the rest of the society. The article aims to compare two ways of creating architecture: before and after the period of political transformation in Poland, in order to determine patterns of building multi-family housing estates in accordance with the principles of sustainable development, which will be useful in the future.

**Keywords:** *sustainable development, sustainable housing estates, sustainable urban planning, political transformation, urban fabric degradation*

**GREEN LOGISTICS AND ITS TOOLS SUPPORTING  
THE MAIN ASSUMPTIONS OF GREEN ARCHITECTURE**

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The article discusses the purpose of Green Logistics and its importance in implementing the primary objectives of Green Architecture as one of the determinants of sustainable development. The reduction of costs and energy inputs in the construction business has a direct impact on the economic sector and contributes to the environmental protection. The article aims to indicate the possible benefits resulting from the implementation of the Green Architecture principles based on the assumptions of Green Logistics favouring the pro-environmental attitude. As we witness numerous environmental threats and energy crises, sustainable development and favorable Green Logistics become a priority for economic growth, including construction, a sector that receives a large part of the capital. Therefore issues such as cost control, control of energy indicators of the facilities, use of the climate specificities, appropriate technology or local, but improved building materials-biomaterials are not without significance.

**Keywords:** *green logistics, green Architecture, sustainable development, energy-saving, low-energy objects*



## OPTIMIZATION FRAMEWORK FOR WORKPLACE DESIGN USING SIMULATION AND CONSIDERING PRODUCTIVITY AND ERGONOMICS

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This study offers a new optimization tool for workplace design using digital human modeling software (Jack™). The optimization aims to design a workplace that maximizes the workers' productivity while maintaining their injury risk under ergonomic constraints. The optimization was solved using Genetic Algorithm. To demonstrate this approach, a case study of a box-conveying process was examined. This process required the worker to lift a box from a conveyor, carry it for 3 m, and lower it onto a platform before returning to the starting point. The design parameters were the conveyor's and platform's heights and the box's mass. The optimization algorithm maximized the production rate without exceeding three ergonomic thresholds: 1) a compression force of 3400 N on the L5/S1 vertebra joint; 2) a Rapid Upper Limb Assessment (RULA) score of 4; and 3) a metabolic rate ( $\text{Vo}_2$ ) of 1000 ml/min.

The optimal design obtained for maximizing productivity with the ergonomic constraints was compared to solving the optimization problem with a multi-objective function that was used in previous studies, and was found to increase the productivity by 105%. Also, the performance of the Genetic Algorithm was compared to that of a two-step grid search that was used in previous studies, and was found to reduce computational time by 91% and increase productivity by 69%.

We believe that the new design approach presented here can enhance the capabilities of ergonomists and industrial engineers by enabling them to produce better designs that maximize productivity while maintaining the workers' injury risk below ergonomic thresholds.

**Keywords:** *manual handling, ergonomics in logistics, logistics modelling and simulation, plant layout*

**SCHEDULING ON-GOING RESEARCH  
AND DEVELOPMENT PROJECTS**

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Projects are often described as one-time efforts to achieve a specific goal. However, many typical R&D projects are often not originally planned to end at a specific date or event, but (if successful) continue to the next version release and the one after, for the foreseeable future.

The current scheduling methods developed for project scheduling do not provide the required tool for on-going project managers. A novel application of clustering methods was developed to tackle this problem and provide (near) optimal scheduling and allocation of features to releases, based on precedence, values, resource demands and durations.

**Keywords:** *combinatorial optimization, scheduling, cluster analysis, release, continuous projects, version release*

**ECONOMIC INVESTIGATION IN VARIABLE TRANSFER  
BATCH SIZE, IN CONWIP CONTROLLED TRANSFER LINE**

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Production shop is a complex task that impacts the ability of an organization to integrate economic and production performance measurements. The CONWIP (CONstant Work In Process) approach is the simplest pull system to implement. Two-machine transfer lines with the exponentially distributed duration of process, break and repair were formulated and solved as a Markovian-chain. Decomposition was used to iteratively employ this solution in solving K-machine transfer line. These models assume that batch size is fixed. In this study we extend the existing transfer line solution to deal with 1 unit process batch and t units transfer batch along the line.

**Keywords:** *financial and economic modelling/aspects of logistics, inventory management, logistics modeling and simulation*

**NUMERICAL THRESHOLD POLICY FOR  
THE MULTI PERIOD INVENTORY PROBLEM  
WITH MEAN REVERTING PRICE**

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In this research, we study a finite multi-period lot sizing problem for items with stochastic mean reverting price that follows the Ornstein-Uhlenbeck (OU) process. The model considers periodic setup cost that captures the fixed cost added to orders. The setup cost is associated with items' transportation fee, order-commission fee, etc. We used the free boundary method to construct a simple threshold based algorithm for minimizing the expected total cost. The algorithm constructs a set of threshold functions that define the respective price level over time in which it is optimal to purchase an item. The characteristics of the thresholds are analyzed with respect to time, inventory level, and setup cost for their dynamics and trends. The set of thresholds that were obtained exhibit interesting and sometimes counter-intuitive dynamics. We found that the multi-period thresholds obtain a quite different structure than the single period threshold. Some straight forward properties such as the monotonous structure of the threshold as time increases, were found not to hold for the multi-period setting. Other properties of the multi-period threshold regarding its dynamics in a different number of remaining items to be bought, and the effect of the setup cost were analyzed and meaningful insights were derived.

**Keywords:** *lot sizing, inventory, mean reverting prices, commodities*

## HOW TO ASSESS BALANCING PUBLIC TRANSPORTATION

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This paper is devoted to assessing equalization of urban public transport (UPT) timetable with commonly used statistic measures. In order to provide passengers with reliable collective transportation service in networks with long overlapping route segments, attention should be paid to interval synchronization at radial network segments. The purpose of balancing UPT timetables is explained, and evenly-spaced timetables are discussed. Problems with assessing balanced timetables are illustrated with four cases of possible timetables at a congestion node served by two lines of different headways.

This work was supported by AGH University of Science and Technology statutory fund – grant no. 15/11.200.357.

**Keywords:** *public transportation, interval synchronization, bus timetabling*

**TIME DEPENDENT AND STOCHASTIC FIELD  
SERVICE ROUTING AND SCHEDULING**

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The schedule and route for the field service personel are constructed, before the actual working day, based on estimations regarding the service and travel times. However, these estimations are often inaccurate. Furthermore, the estimations of travel times often do not account for their time dependent nature.

We present a model of a travelling salesperson problem (TSP) with soft time windows and time dependent and stochastic travel times, as well as stochastic service times. This model can be used to route a single technician or as a component of a multivehicle scheduling and route optimization process. We introduce several exact and heuristic solution methods and test them on a real life dataset. Our numerical experiments show that we can obtain optimal or near optimal solutions in a few seconds for real life instances.

We devised a specialized branch and bound procedure that can be used to produce an optimal solution. However, if one needs to solve the problem many times (possibly as a subroutine of a larger problem), it is possible to use an effective Tabu search algorithm. Alternatively, a heuristic solution can be obtained by solving a simplified version of the problem that ignores the stochasticity of the travel times or even their time dependency. In an extensive case study, we show that it is possible to save a significant share of the working day duration and delays by using our model and solution methods even under a tight solution time limit.

**Keywords:** *route optimization, operations management and scheduling*

**A GOVERNMENT PERSPECTIVE FOR TWO-ECHELON  
VEHICLE ROUTING A MULTI-OBJECTIVE  
EVOLUTIONARY APPROACH**

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Urbanization trends bring with them new challenges for city governments. Multi-level distribution is an already-known strategy employed by businesses, and the classic formulation of the Two-Echelon Vehicle Routing Problem (2E-VRP) reflects the perspective of single providers, without regarding the routing decisions of other parties. Various stakeholders (government, businesses, residents) may have conflicting objectives. This work presents a multi-objective formulation of a multi-provider heterogeneous vehicle 2E-VRP, from a city government perspective. To solve the considered problem formulation, a Multi-Objective Evolutionary Algorithm (MOEA) is proposed. An experimental evaluation is presented, demonstrating that the proposed algorithm is capable of finding good quality solutions.

**Keywords:** *vehicle routing, city government, multi-objective optimization, evolutionary algorithm*

## A SIMULATION-BASED ANALYSIS OF TRAIN DESIGN SPEED FOR URBAN RAIL TRANSIT SYSTEMS

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This paper analyzes the factors related to train operational speed. An analytical framework to evaluate the consequences of different design speeds is proposed to determine the rational speed. Based on the train simulator developed by the authors, the paper presents the concrete results of two urban rail lines. From the viewpoint of train operation and passenger journey efficiency, the paper concludes that increasing train design speed in central areas, where the distance between stations is not long enough, is not necessary as energy consumption may boost much rapidly.

**Keywords:** *transportation, transportation management, logistics modelling and simulation, design speed*



**OPTIMAL ROAD PROJECT PORTFOLIO SELECTION  
UNDER LIMITED LOCAL AUTHORITIES' BUDGETS  
IN POLYNOMIAL TIME**

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In most cases of road project portfolio selection, a limited budget is spent to build the best subset of a large set of possible road links. This paper tackles a special case where budgets of local entities located in the same geographical area of an authority that tries to optimize the selection of a road projects' subset. The non-polynomial complexity of existing formulations is prohibitive and dictates the use of search techniques for solutions. The technique uses a transfiguration of the problem into a minimum cost network flow problem which ensures optimal solution in polynomial time.

**Keywords:** *transportation, binary variable optimization, maximal flow optimization, transportation management, project selection*

**BACKBONE OF WATER TRANSPORT IN EUROPE:  
PROMOTION, PROTECTION AND SUSTAINABILITY**

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The River Danube is considered to be the backbone of water transport in Europe. It connects, via Rhine – Main Canal, Western Europe and Rotterdam harbor with the Black Sea. In this paper the authors analyze the data on the use of the Danube waterway for transport of goods and people. This research presents a short description of the Danube, an analysis of the Danube fleet, an analysis of the amount of transported goods and number of transported people, as well as an analysis of load and unload of goods in Danube harbors. The research covers these points in the period starting from 1950. Based on the resulting analysis, the authors reached the conclusion that the use of the River Danube for waterway transport purposes is unsatisfactory and that as such cannot be sustained in long term. Also, the research points to the basic European initiatives and investment projects in the field of river transport which is in the implementation stage. Considering the basic regulation documents and research results, the authors present an overview of measures and suggestions for efficient management conducted so far, development of a unique information system and promotion of the Danube waterway.

**Keywords:** *transportation, promotion, Danube, heavy load transport, passenger transport*

**SUPPLY CHAIN MANAGEMENT IN THE TRAFFIC  
ENFORCEMENT CAMERAS SYSTEM**

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The Traffic Enforcement Cameras (TEC) system is a manufacturing system that produces traffic tickets as a service system for road user deterrence and prevention of traffic offences, which will lead to a reduction in the number and severity of road accidents. The TEC system consists of several working stations as a supply chain, therefore inventory and bottlenecks are part of the process. This paper presents an inventory management model based on a linear programming formulation. The results lead to a more efficient and effective system with higher and better quality production, low inventory levels and short lead time.

**Keywords:** *supply chain management, inventory management, customer service, operations management*

## WEB INFORMATION SYSTEM FOR SUSTAINABILITY OPTIMIZATION OF PRODUCTION NETWORKS

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Industry 4.0 brought the introduction of Information and Communication Technology (ICT) and Internet of Things (IoT) into production systems. It led to the definition of Cyber-Physical Production Systems that enabled the definition of new production network concepts like Cyber-Physical Production Networks or, simply, Social Manufacturing. In this research, focus has been put on selection of the partners (enterprises) for the manufacturing process based on a multi-criteria approach that focuses on the three P's of sustainable development: People (society), Planet (environment), and Profit (economy). A specialized algorithm with a priori approach to multi-objective optimization has been applied on the Partner Selection Problem instance with 7 criteria (objectives). Furthermore, a concept of a Web information system for practical application of sustainable management of production networks is also presented.

**Keywords:** *information systems in logistics, operations management and scheduling, global logistics*

## FOOD SAFETY IN LOGISTICS PROCESSES & SUSTAINABLE LOGISTICS

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Packaging is one of the main factors of logistics. The primary functions of packaging are protection, preservation, economy, convenience and presentation, while its secondary functions are handling, containment, identification, labelling and suitability. Food safety, from farm to fork, is of vital importance and is dependent on packaging and logistics processes, for example. A wide range of regulatory measures, high standards and the correct handling of food in logistics processes ensure that food is delivered safely from farm to fork. The essential roles of packaging in logistics are providing necessary protection to the products during storage and transport and reducing costs. Packaging has a positive effect on product distribution and safety, especially in the case of foods. It facilitates transportation and helps to reduce costs, because the arrangement and packing of products in appropriate packaging allows optimal use to be made of the available space.

This contribution presents the current legislation and standards relating to the packaging of foods, examples of food safety considerations in logistic processes, such as transport and storage, loading and packaging of foods, traceability solutions and quality management methods. A case study presents, by way of example, a packaging plant and the overseas logistics chain of a superfood with its release of CO<sub>2</sub> and consumption of water. Packaging represents a short-lived good against all political discussion. Decisive is not the packaging itself, but rather the treatment of packaging in a sustainable logistics chain: reduce, reuse, and recycle. For reasons of sustainability, economy, society and environment, it is essential that companies are encouraged to focus their attention on the reduction of all types of waste, including packaging, which represents approximately 6% of the product costs.

**Keywords:** *food safety, logistics processes, sustainable, packaging, protection, farm to fork, packaging plant, waste reduction*

**THE BILL OF MATERIALS AND OPERATIONS PROCESS  
CHART FOR FACILITIES DESIGN**

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A major breakthrough in the management of industrial logistics is the development of material requirements planning (MRP) for production management of assembly products in the 1960s. Central building blocks of MRP are the product-structure, in which the product is hierarchically decomposed into its components, and the bill-of-materials (BOM), which lists the quantity of each component in the succeeding (sub)assembly. However, the BOM is presented at the item level while production is practically managed at a more detailed level – the operations level. Further, production systems are required for production to be managed. The design of production systems precedes any application of MRP and includes facility design and plant layout, during which the types of work stations and the number of stations of each type that are required are estimated. This capacity planning requires the quantitative relationships of the BOM. Consequently, it is proposed to replace the product-structure with an older tool – the operations process chart (OPC). “The OPC is one of the most useful techniques in manufacturing planning. Actually, it is a “diagram” of the manufacturing process.” With the addition of the quantitative relationships of the BOM and a few other elements, the OPC becomes a very effective capacity planning tool. It enables a more realistic estimation of the required volumes that need to be processed in each work station, thereby enabling a more adequate capacity planning. These volumes also flow between stations and are a key input in the design of the material handling systems and the plant layout.

**Keywords:** *in-plant logistics, material handling, plant layout*

**STANDARDIZATION IMPACT ON THE DESIGN  
OF LOGISTICALLY EFFICIENT  
PRODUCTS – PRELIMINARY STUDY**

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The need for a manufacturing company to operate in the global market in more and more cases makes it necessary to take into account a variety of aspects in product design processes. Product Design for Manufacturing or Product Design for Assembly have been adopted in industrial practice for many years. In business practice the idea of Product Design for Logistics, closely related to product logistic efficiency, has also come into focus. The article presents the results of the study on the standardization impact on the product logistic efficiency which was based on the example of a global furniture manufacturing company.

**Keywords:** *design, efficiency, logistics, product, standardization*

**QUANTITY FLEXIBILITY CONTRACT FOR  
COORDINATING SUPPLY CHAIN IN PRESENCE  
OF UNCERTAINTY**

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The purpose of this paper is to analyze the effectiveness of Quantity Flexibility Contract (QFC) as Supply Chain (SC) coordination mechanism under market demand and spot market uncertainty, by measuring such effectiveness in terms of the profits gained by each actor under QFC with respect to the profits obtained under traditional contract. In so doing and by varying the contract terms and implementation conditions, we ensure that the QFC is chosen only when it ensures a win-win condition, namely it improves the profits of both parties. A simulation-based research has been carried out in order to address this issue. In particular, a real options-based model has been developed to model and quantify the benefits granted by flexibility incorporated into the QFC, for both SC actors. A series of experiments consisting of different experimental settings was designed in order to investigate the effect that contract terms and implementation conditions have on the benefits of both actors and on the entire system. The proposed model's application and the experiments have been illustrated by considering an SC coordination problem handled by an example company operating as retailer in a European country through QFC.

**Keywords:** *supply chain coordination, uncertainty, flexible supply contract, simulation*



**SUPPLIER PERFORMANCE INDICATORS APPLIED  
TO MICRO AND SMALL ENTERPRISES OPERATING  
IN AÇU PORT COMPLEX IN BRAZIL**

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This paper aims to present suppliers' performance indicators for micro and small enterprises participating in the Local Suppliers Development Project promoted by SEBRAE in Rio de Janeiro, Brazil. Through a bibliographical research based on select authors and models a set of 17 theoretical indicators was proposed. The indicators can benefit the companies participating in the project of Açú Port Complex in meeting expectations and demand of the large companies in the industrial area. The indicators presented in this paper intend to be a response to the difficulty of SMEs to increase their competitiveness.

**Keywords:** *supply chain management, customer Service, purchasing and procurement*

## SUPPLY CHAIN PLANNING USING ANYLOGISTIX™ DYNAMIC SIMULATION – A CASE STUDY

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This case study presents a complex supply chain scenario, that implements time-constraints, inner-walls behavior, dynamic inventory policies and uncertainty using Analytical Optimization tools and Dynamic Simulation demonstrated in anyLogistix software. The case leverages the different methods for managing and optimizing complex supply chain problems. Beyond simplistic spreadsheet-based modeling, the most powerful methods for supply chain planning are analytical optimization and dynamic simulation. Analytical optimization tools, such as those employing mixed-integer and linear programming solvers, are ideal for solving large-scale high-level problems (locating sites, determining productflows,conductingmasterplanningbyperiod).

These problems usually do not require a great level of detail in modeling but can be large-scale and data-intensive. However, there are problems that cannot be resolved this way, such as safety stock estimation, multi-echelon inventory optimization, risk assessment and determining how processes within the four walls of a network node may influence a network as a whole. To solve them, you need to consider the reality of your supply chain: the real-time network dynamics, real-world randomness and specific site-related rules. Analytical optimization cannot handle this level of detail and does not consider time or uncertainty. Such problems require dynamic simulation. anyLogistix software capabilities can solve issues, such as Facility Location Planning (CoG Method for Single/Multiple Locations), Network Optimization using Mixed-Linear Programming, Capacity Planning of Distribution Centers, Inventory Control Policies and Ordering Rules, Sourcing Policies (Single/Multiple Sourcing), Transportation Policies, Transportation Batching, Production, Sales, Bullwhip Effect and Ripple Effect Analysis.

**Keywords:** *analytical optimization; dynamic simulation*

**THE FIXED ROUTE DIAL-A-RIDE PROBLEM:  
AN OPTIMAL ALGORITHM BY GRAPH REDUCTION\***

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Dial-a-ride is a transportation solution with flexible routes and flexible schedules. The challenge of the Dial-a-Ride Problem (DARP) is to optimally fulfil a set of pickup and delivery ride requests using a given vehicle fleet. We present a DARP variant for which the route is known in advance. The problem, referred to as fixed route DARP (FRDARP), is then to set up the schedules according to the requests. For a given cost of operation, the aim is to maximize user satisfaction by minimizing the sum of passengers' waiting times. The FRDARP is represented by graph formulation and an algorithm is suggested for optimally solving the problem. Contrary to the general DARP, which is NP-hard, the presented algorithm is polynomial in the number of ride requests. While building the graph, different paths may contain the same nodes but in a different order, and are therefore redundant since they all yield the same solution. We suggest a heuristic, which avoids that by pruning transports that answer requests un-chronologically. We suggest several other heuristics to improve the basic algorithm.

In order to evaluate the algorithm we randomly generated problems, with 20-25 requests, served by two vehicles. We term an instance as solved if the algorithm returns a result within four minutes of run-time. The basic algorithm is evaluated, with and without applying the heuristics. The heuristics are shown to improve the percentage of solved instances from around 10% to around 90%. The average time to solution decreases by more than half by the heuristic improvement.

**Keywords:** *transportation, transportation management, scheduling*

\* This research was supported by the Israeli Ministry of Science and Technology.

**MOBILITY HABITS AND TRANSPORTATION NEEDS OF  
INHABITANTS OF ELDERLY HOMES IN ISRAEL \***

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Recent medical developments have led to a significant increase in life expectancy. In Israel the percentage of elderly (older than 65) is growing steadily along with the rise of a life expectancy above 80 years. Transportation needs of the elderly are different from those of the general population. The purpose of this study was to evaluate travel habits of the elderly in order to propose transportation solutions that better meet their needs. The study was conducted in five nursing facilities in Israel with a total population of 575 residents, of whom 126 residents (21.91%) agreed to participate in the survey by filling out questionnaires that included demographic data and different travelling scenarios. The average age of the residents was 78.5 years. The percentage of respondents in each facility, their age, gender and origin distribution did not differ significantly between the institutions. The data from the questionnaires were pooled together by using Microsoft's Excel and processed by R.

We found that the principal flaws of the public transport system, as viewed by the respondents in this study, were prolonged waiting time and difficulty in transitions. We found significant association ( $R^2 = 0.82$ ) between satisfaction from bus travel time and satisfaction from the bus service overall. In addition, between 76.8% and 93.5% of the respondents (depending on the travel scenario) were ready to try out a newly proposed dial-a-ride system.

In summary, transportation needs of the elderly population in Israel deserve improvement. New approaches may provide convenient and effective transportation solutions for the elderly.

**Keywords:** *transportation, transportation management, customer service*

\* This research was supported by the Israeli Ministry of Science and Technology.

**FIXED ROUTE DIAL-A-RIDE SERVICE: AN INTEGER PROGRAMMING APPROACH\***

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The dial-a-ride problem (DARP) is a demand responsive transportation solution in which passengers' requests for traveling are known in advance, and the vehicles' routes and schedules are built accordingly. DARP in general is an NP-hard optimization problem. Recently, a DARP model with fixed routes was introduced and shown to be polynomially solvable, yet with a high degree polynomial. In the present research we introduce two binary Linear Programming formulations for the FRDARP. The first is a simple 1-index formulation with an exponential number of variables. This formulation may serve as a master problem for the Column Generation technique. The second formulation is a more complicated 3-index formulation but with a polynomial number of variables and constraints. This Integer Program was tested using the CPLEX software and analyses. Optimal solutions were found within a few seconds for hundreds of randomly generated, uniformly distributed, instances of about 30 requests and 5 sites of interest. The results were analyzed and compared with a regular bus service. The main conclusions are:

1. FRDARP is significantly better than a regular bus service. The waiting times for the service were about one fifth of those needed by the regular bus service with similar resources (size of the vehicle fleet, capacity, etc.).
2. The most influential factor on the level of service is the number of trips per day, rather than other factors such as vehicle capacities, the size of the fleet, etc.

**Keywords:** *transportation, transportation management, scheduling*

\* This research was supported by the Israeli Ministry of Science and Technology.

**SOLVING THE FIXED ROUTE DIAL-A-RIDE PROBLEM  
USING A RECURRENT NEURAL NETWORK\***

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The task of allocating ride requests of different origins and destinations at different times to vehicles, such that the assignment would minimize the waiting time of the passengers while maintaining realistic constraints (vehicle fleet size, allowed number of transports, vehicle capacity etc.) is considered NP-hard. However, reducing it to a Fixed-Route-Dial-A-Ride-Problem (FRDARP) yields an optimal solution which can be computed in polynomial time. In the current study we exploited this fact to create a dataset of labeled examples, consisting of simulated requests lists and their corresponding optimal schedules and assignments to vehicles. This dataset is then used to train an artificial recurrent neural network. The requests are fed into the network in a sequential manner, and during training the network adjusts its parameters so that at test time it will output a solution with minimal waiting time. We study the possible advantages of using this method, where the parameter space of the problem (for example, how many vehicles to use or how many requests to answer) can be more easily explored. This can be achieved both by the fast and low computational cost process of the problem solution using a trained network, and by the observations acquired by an explicit examination of the inner representation of the problem in the deeper layers of the network.

**Keywords:** *Transportation, Transportation Management, Scheduling*

\* This research was supported by the Israeli Ministry of Science and Technology.

## ERGONOMIC ASSESSMENT OF ORDER-PICKING USING VERTICAL LIFT MODULES

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The efficiency of an order-picking operation both in manufacturing and distribution environments can be enhanced by automated storage/retrieval systems (AS/RS). The main advantage in most AS/RSs is that the operator (picker) stays in one general location and items are brought to the operator by the system, known as „part to picker“, „stock to operator“ or „end-of-aisle“ systems. Such a system is a Vertical Lift Module (VLM), in which an insertion/extraction (I/E) device is traveling vertically and extracts trays or totes from the shelves and brings them to the operator. Potential users are initially attracted to the high density of storage and small footprint of VLMs. However, there are other benefits as well, like increased productivity and better ergonomics, security and inventory control. Despite an increased usage of VLMs, few papers have been written that deal with a quantitative comparison of VLMs with shelving systems as their much more frequently used counterparts. Especially there are no papers dealing with ergonomic assessment of order-picking process with VLM. In this paper, VLMs are presented along with a review of methods for comparing VLMs with shelving systems in terms of space, time and ergonomics. The presented methods can serve managers as tools to additionally justify the VLM implementation.

**Keywords:** *warehousing, ergonomics in logistics, order-picking, vertical lift module (VLM)*

**PERFORMANCE ANALYSIS OF SHUTTLE-BASED  
STORAGE AND RETRIEVAL SYSTEMS VERSUS MINI-  
LOAD AS/RS**

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In this paper throughput performance analysis of Shuttle-Based Storage and Retrieval Systems (SBS/RS) versus mini-load AS/RS is presented. Mini-load AS/RS exist in the market for nearly 50 years or more. There are several designs (single- or multi-shuttle) of mini-load AS/RS. The throughput performance of the mini-load AS/RS is limited by the number of cycles per hour (FEM 9.851), which cannot cope with today's e-commerce order fulfilment services. For this reason, major material-handling providers have introduced to the market a new technology known as SBS/RS, which enables higher throughput, flexibility and scalability. According to the throughput performance analysis for the selected cases, SBS/RS will be properly evaluated and discussed.

**Keywords:** *logistics, automated warehouses, SBS/RS, performance analysis*



## **A LOGISTICS CENTER ORDER PICKING METHOD**

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The purpose of this paper is to develop a generic strategy for improving the efficiency of picking customer orders and replenishment relocation termed, a logistics center order picking and replenishment method (LCOPRM). The LCOPRM was tested in a large-scale logistics center for an office equipment retail company. The results show that by implementing the LCOPRM, the picking route for 51% of customer orders was minimized by 50%, the picking route for the other 49% of customer orders remained unchanged and the number of replenishment tasks was reduced by 38.75%.

**Keywords:** *logistics center, order picking, design and planning, interior design, case studies*

**EVALUATION OF WAREHOUSE WITH VIRTUAL TECHNOLOGIES**

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Logistics application can greatly benefit from virtual environments. In the context of Industry 4.0 and warehouse management, virtual warehouses are an intuitive way to show and predict processes and activities in the cyber-world and real-world. To understand the dynamic behavior of the systems and verify implemented designs or processes in a time frame, the use of simulation studies are necessary. Although the amount of time and data used to produce such studies are substantial, the 3D representation of the system produces a more complete understanding of the system behavior. This paper describes the use of 3D simulation to visualize workflows in the warehouse using standardized Web techniques. It presents ongoing research of integration of warehouse managements systems and applications that supports analysis and of the evaluation of the warehouses to improve the efficiency of warehouse management. This application provides input capabilities for setting up a number of customer scenarios, and provides 3D graphical output for each. Because the application is developed to handle parameter input combinations, the user doesn't need to edit or compile model code. An XML is used as interface definitions of nodes and their behavior characteristics parameters. Automated nodes and code generation of a dynamic XML Schema simplify the implementation. Scenarios can quickly be set up and run to get comparative results and see what would likely happen in the real warehouse. Virtualization, built on Industry 4.0 design principles, can create virtual models of warehouse operations that support smarter maintenance, improved planning and process optimization.

**Keywords:** *virtualization, 3D simulation, warehouse, digital factory*

**INVENTORY AND MARKETING POLICY IN  
A SUPPLY CHAIN OF A PERISHABLE PRODUCT  
UNDER A REVENUE SHARING CONTRACT**

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Consider a two-echelon supply chain consisting of a single manufacturer and a single retailer, who are producing and selling a perishable product. The parties interact by using a revenue sharing contract in which the retailer is the leader and the manufacturer is the follower. Specifically, under this contract, the retailer sets the revenue share given to the manufacturer, and then offers the contract to the manufacturer, who sets the product's selling price. Demand is affected by three factors: the selling price, the investment rate in sales effort, and the age of the product. Four cost components are considered: holding cost, production cost, investment in sales effort and fixed order costs. The holding cost is paid by the retailer, the unit production cost is paid by the manufacturer, and the investment in sales effort can be made either by the manufacturer or by the retailer. The manufacturer and the retailer apply an EOQ ordering regime, according to which an order of fixed size is made every fixed time interval. Three ways to determine the cycle length are analyzed: (i) the retailer sets it solely; (ii) the manufacturer sets it solely; and (iii) both parties bargain it. For each scenario (identity of the investor combined with the way of setting the cycle length), equilibrium is obtained by applying the Stackelberg game approach, in which the retailer makes the first move.

**Keywords:** *inventory management, perishable products, sales effort*

**INTEGRATING THE SIMULATION-BASED  
TRAINING APPROACH WITH TEACHING  
SUPPLY-CHAIN MANAGEMENT**

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In this research we tested the effectiveness of integrating the computer-based approach of Simulation Based Training (SBT) in teaching Supply Chain Management (SCM). Although the SBT approach has been tested extensively in a wide variety of domains and has proven to have great potential for learning, it has not yet been studied empirically in the SCM domain. Our research tests several aspects of SCM learning and skills acquisition. Firstly, we test whether SBT can allow students to achieve better learning and understanding of SCM models compared to traditional frontal teaching (recitation). Secondly, we investigate the effect of previous experience in SCM on students' ability to transfer knowledge and skills acquired using SBT in simple SCM problems to more complex problems. More specifically, we tested whether complex problem-solving capabilities could be acquired through SBT, and showed that inexperienced trainees can reach the skill of experienced users in a short time frame. We also tested users' satisfaction when using simulations in their studies and whether they believe that simulators assist their learning processes better than recitations. This research shows that using the Supply Chain Simulator (SCS) as an SBT tool clearly supports and improves SCM learning and can serve as a great supplement to frontal teaching. We conducted two experiments, based on the principals of SBT, in which we used the SCS as the teaching tool and simulation platform. In the first experiment we designed a mini-course, which covered two basic but important models in SCM, for undergraduate students studying Industrial Engineering and Management. The second experiment was conducted in two universities, one in Israel and one in Ireland. Students were given two SCM problems. The first problem was a rather simple one and the second a complex problem. We tested whether trainees were able to reach better results in earlier trials when solving complex problems after undergoing SBT with simple SCM problems. In addition, we compared the performance between the experienced students (Ireland) and the inexperienced students (Israel). We built relevant exercises for each model in each

experiment, and incorporated them into the curriculum of three different courses, two in Israel and one in Ireland. Combining these platforms and methodologies with the appropriate experiment design enabled us to conduct an experiment to test our hypotheses in a controlled environment. Results of the experiments were statistically analyzed and demonstrated that SBT using SCS when teaching SCM improves learning outcomes. We showed that students achieved significantly better test scores in both SCM models tested (Newsvendor Problem and Economic Order Quantity) after undertaking SBT with the SCS compared to their scores after a frontal recitation. In addition, we showed that SBT with the SCS helped inexperienced students reach the same level of complex problem-solving abilities as experienced students. We also demonstrated that both inexperienced and experienced students attained their best performance in the complex problems significantly faster (in earlier trials) than in the simple problems. A satisfaction survey given to the students participating in the first experiment indicated that they were happy with the simulation exercise and believed it assisted them in the learning process more than the frontal recitation.

**Keywords:** *supply chain management, logistics modelling and simulation, simulation based training*

**MINING FINANCIAL DATA TO CONSTRUCT VISUAL SUPPLY  
CHAIN MAPS TO CHARACTERIZE SUPPLY NETWORK  
STRUCTURE, EVOLUTION AND PERFORMANCE**

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Supply chain networks are complex and are often proprietary, yet the structure and dynamics of a company's supply chain is neither well known nor accessible. This research uses financial relationship data to construct digital network maps of modern supply networks. The data is sourced from Bloomberg and FactSet, which, when coupled with network visualization software and network science tools, enables a highly innovative perspective of the supply network to emerge. The visualizations enable us to characterize the supply network topology and temporal nature in terms of detailed structural metrics. We conclude with some preliminary insight into the relationship between these metrics and financial performance.

**Keywords:** *data visualization*

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