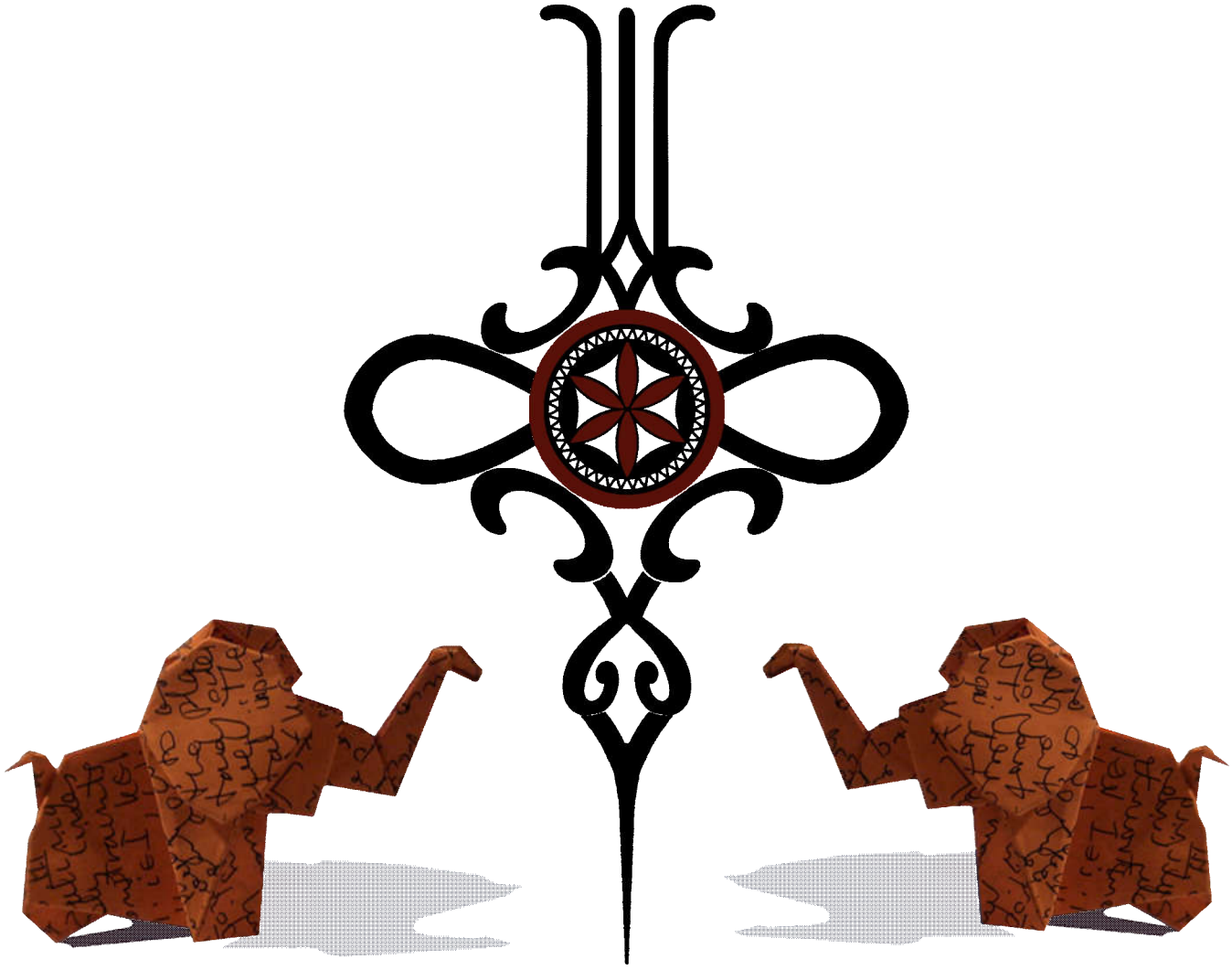
100 YEARS OF AGH UST

BOOK OF ABSTRACTS

22nd International Conference

DECISION MAKING IN MANUFACTURING AND SERVICES



DMMS 2019

Zakopane, Poland

SEPTEMBER 26—29, 2019

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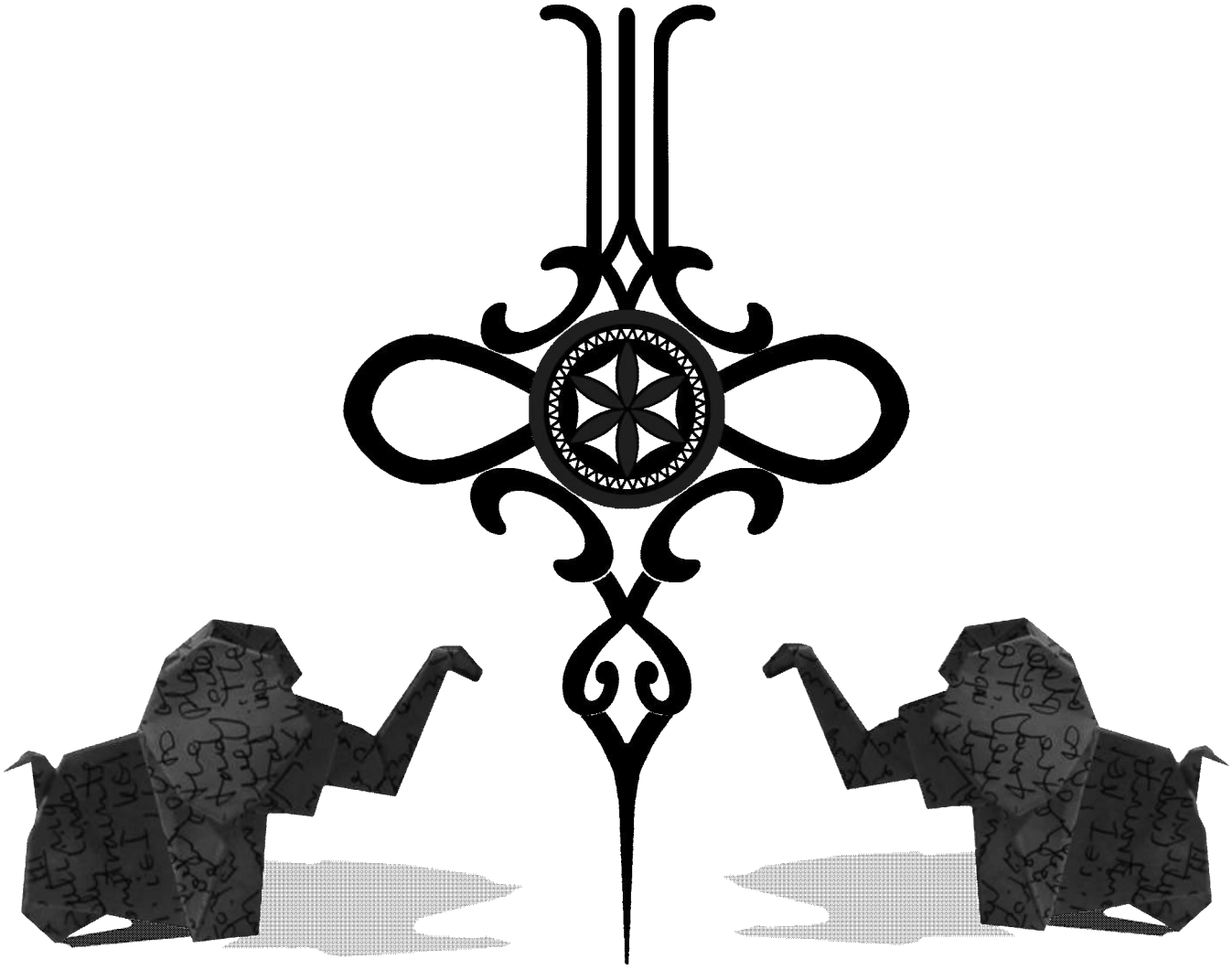

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Editor's foreword

As conference chair, this is my pleasant duty to present this *Book of Abstracts*, which contains the abstracts of papers from the 22nd International Conference on Decision Making in Manufacturing and Services – DMMS 2019. The conference took place in Zakopane, Poland, from September 26 to September 29, 2019. It was hosted by the Department of Operations Research, AGH University of Science and Technology, Kraków, Poland. The DMMS 2019 is a continuation of "Applications of Systems Theory", a National Symposium organized 20 times since 1979 by AGH University. The Jubilee XX Symposium on "Applications of Systems Theory" was held in Zakopane in 2017 along with DMMS 2017 conference. The objective of the biannual Conference is to gather experts working in a broad range of industrial decision-making. The DMMS 2019 conference features a multidisciplinary program that brings together researchers from different countries.

I would like to express sincere gratitude to Katarzyna Gdowska, Roger Książek, Joanna Marszewska and Bartosz Sawik without whom the handling and organizing of this conference would have been impossible. Finally, it is my pleasure to acknowledge financial support for DMMS 2019 of Polish Ministry of Science and Higher Education.

On behalf of the organizing committee, I wish that all of you take the opportunity of attending DMMS 2019 to enjoy your stay in Zakopane, capital of Polish Tatra Mountains.

Tadeusz Sawik, PhD, ScD
Department of Operations Research
AGH University of Science & Technology
Kraków, Poland

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22nd International Conference on Decision Making in Manufacturing and Services 2019

Invited Speakers

Managing Resilience and the Ripple Effect in Supply Chains

Dmitry IVANOV

Berlin School of Economics and Law, Berlin, Germany

In the first part or our talk, we discuss practical principles to manage supply chain resilience and the Ripple effect. We analyse state-of-the-art frameworks and model-based decision-making support in designing the resilient supply chain with a low exposure to the Ripple effect. In the second part of the presentation, we uncover methodological principles of data-driven disruption risk management and theorize a notion of a digital supply chain twin – a computerized model that represents the network state for any given moment in real time. We explore the conditions surrounding the design and implementation of the digital twins when managing disruption risks in SCs. Particularly, we show which risk data is needed in model-based decision-making support in SC disruption management, and how to integrate this data in simulation-optimization models in order to improve the quality of proactive resilient network design, reactive real-time disruption control, and performance impact assessments.

Short bio: *Prof. Dr. habil. Dmitry Ivanov is professor of Supply Chain Management at Berlin School of Economics and Law (HWR Berlin) and executive board member of Institute for Logistics (IfL) at HWR Berlin. His research explores supply chain structural dynamics and control, with an emphasis on global supply chain design with disruption risks, optimal control and scheduling in Industry 4.0 systems, supply chain simulation and risk analytics in the digital era. His record counts around 300 publications, with 66 papers in prestigious international academic journals and leading books "Adaptive Supply Chain Management", "Global Supply Chain and Operations Management", „Structural Dynamics and Resilience in Supply Chain Risk Management", and "Handbook of the Ripple Effects in Supply Chains". He is a recipient of German Chancellor Scholarship (2005-2006) and Best Paper Award of International Journal of Production Research (2018). He is leading working groups, tracks and sessions on the Digital Supply Chain, Supply Chain Risk Management and Resilience in global research communities. He is Editor of International Journal of Integrated Supply Management, Associate Editor in International Journal of Production Research and Interna-*

tional Journal of Systems Science, and editorial board member and guest editor in several international journals. He is Chairman of IFAC TC 5.2 "Manufacturing Modelling for Management and Control" and General Chair of the 9 th IFAC MIM 2019 Conference.

A Generic Multi-Commodity Heterogenic Energy Market Desig by Eugeniusz Toczyłowski

Eugeniusz TOCZYŁOWSKI

Warsaw University of Technology, Warsaw, Poland

A generic multi-commodity market design model (Toczylowski 2000) was proved to be a promising theoretical framework for long-term evolutional development and integration of the heterogenic energy market designs. The market segments are in the form of the multi-commodity auctions for improved coordination between renewable and nonrenewable energy, energy options and reserves products, and obligation transmission rights trade, under the transmission flow model constraints. The approach allows us to achieve the multi-commodity market balance for joint energy, reserves, options and transmission rights products through joint dispatch/optimization and market clearing.

Short bio: *Eugeniusz Toczyłowski is a Full Professor at the Warsaw University of Technology (WUT) in the Institute of Control and Computation Engineering. His main research interests are centered around designing operations research decision models and methods for control and management of complex systems, including designing auctions and competitive market design for the networked infrastructure systems, such as electric power or telecom systems, that operate under various conditions and constraints. As the project leader, he has over 20 years of experience in the Polish electricity market developments, in cooperation with the Polish Transmission System Operator, PSE S.A in the area of designing new market design and algorithms to support efficient and incentive-compatible solutions at the national and regional level. He is the author of a generic multi-commodity market design model, which is a promising theoretical framework for long-term evolutional development and integration of the heterogenic energy market designs at the EU level.*

Genetic Algorithm for Solving a Real Life Vehicle Routing Problem

Marek KARKULA, Jerzy DUDA

AGH University of Science and Technology, Krakow, Poland

The Vehicle Routing Problem (VRP) is one of the classical optimization problem and its widely used as benchmark for testing capabilities of various solvers. Many different variants have been proposed as an extensions to the original problem defined in 1959 by Dantzig and John Ramser. The most popular are Capacitated Vehicle Routing Problem (CVRP) in which trucks carrying the goods that have to be delivered have limited capacity, Vehicle Routing Problem with Time Windows (VRPTW) in which deliveries must be made in a given time period of a day and Vehicle Routing Problem with Pickup and Delivery (VRPPD) in which goods have to be delivered from a depot to customers but can be also picked from customers and transported to other location (either another customer or the depot). Such extensions are also quite well explored by the researchers and efficient algorithms solving them are implemented in optimization libraries like OR-Tools. However, their combination still remains a challenge, especially when there are additional, nonstandard constraints. Such problems are called Rich Vehicle Routing Problems (RVRP) and refer to real problems occurring in logistic practice. On the other hand, in recent years there has been an increase in interest from business who, in the face of growing competition and rising transport costs, are trying to optimize its transport operations. The article focuses on the problem of RHVRP, which is a combination of CVRP and VRPTW, and additionally includes limitations related to drivers' working time and preferences regarding means of transport. Additionally the fleet is heterogeneous, meaning that trucks have different capacity. Another restriction is number of points that can be visited by a single truck during a single route. The most commonly used method to solve such complicated problems are metaheuristics. A genetic algorithm was proposed to solve it, in which specially designed crossover and mutation were used.

Short bio: *Marek Karkula, PhD, DSc is a graduate of the Faculty of Electrical and Computer Engineering at Cracow University of Technology. He currently works as associate professor in the Faculty of Management, in the Department of Engineering Management at AGH University of Science and Technology in Krakow, Poland. His current research interests are in: discrete event*

simulation and different modelling methodologies applied for analysing and optimizing of logistics and transportation processes, discrete optimization, supply chain optimization, data analytics, machine learning and soft computing applications in supply chain, digital supply chains, business process management. He has authored/co-authored over 100 scientific publications in monographs and scientific journals. He also has rich industrial experience in designing, analysis, modelling and simulation of logistics systems and processes.

Short bio: *Jerzy Duda is an Assistant Professor in the Department of Applied Computer Science at AGH University of Science and Technology, Faculty of Management located in Cracow, Poland. He owns a PhD in management from AGH University and Postgraduate Diploma in Software Engineering from Jagiellonian University. He was a contractor of many projects in the field of information technology and production management, including the ones financed by the European Union. Currently he is the head of scientific and research team in a POIR project for Walstead Central Europe. He is the author of two patent applications and several dozen publications in the field of production management, optimization and applications of information technology. He is the member of IEEE Computational Intelligence Society and EU/ME The Metaheuristics Community. His research interests are computational intelligence in production management, distributed integrated information technology systems, heuristic algorithms, single and multi-criteria optimization, advanced planning and scheduling systems, uncertainty modelling using interval arithmetic and fuzzy theory.*

22nd International Conference on Decision Making in Manufacturing and Services 2019

Book of Abstracts

A Cross-Impact Analysis of Eight Economic Parameters in Iceland in the Context of Arctic Climate Change

Thordur Vikingur FRIDGEIRSSON[1], Freydis Dögg STEINDORSDOTTIR

[1]Reykjavik University, Reykjavik, Iceland

Previous studies have identified eight parameters as being the most influential on the Icelandic economy in the light of prevailing climate change. This study aims to investigate these economic parameters in relation to the Arctic Region and the Icelandic economy. The study is rooted in the theoretical framework of decision analysis and is intended to contribute to strategic and tactical decision making in the context of Iceland and developments resulting from climate changes in the Arctic Region. The study results could eventually lead do a "What if" decision model, where multiple scenarios can be analyzed by inserting/entering different probabilities of a particular outcome. The parameters under screening/review are interdependent, and to construct a decision model these interdependencies must be assessed. The Delphi method was employed, along with the cross-impact analysis, to shed light on the interconnections between eight of these parameters. Diverse views are revealed concerning the impacts between parameters, although a consensus was reached in the second round of the survey. In some instances, the level of agreement was high, while other estimates showed a wide range of responses. The diversity in answers suggests a higher level of uncertainty regarding some parameters and events compared to others. The survey also indicates how challenging the Delphi and cross-impact methods are in terms of the involvement of experts. However, when data is scarce, these methods provide significant insight.

JEL category: *E17, E66, F47, F62, L78, M21, M38, O11, O22, O33, P21, R10, Z30.*

Keywords: *packet scheduling, HSPDA, scheduling algorithms, round robin.*

An Optimal Control Model of an Online Advertising Campaign

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[2]*Dept. of Mechanical and Industrial Engineering, University of Toronto, Toronto, Canada*

1. Introduction

This paper develops a mathematical model of an online advertising campaign. The model incorporates a general 'effectiveness function' that determines the relationship between the value of an advertising bid at a given time and the number of newly exposed users at that time. The goal is to divide a given campaign's budget between several users' segments and dynamically allocate each budget fraction over time. The optimization problem aims at minimizing the length of the campaign given a desired level of exposure for each marketing segment. Closed-form solutions for dynamic budget allocation are developed for several forms of the effectiveness function. We combine optimization techniques with learning and show how the shape and parameters of the effectiveness function can be estimated online by a curve fitting regression procedure.

The marketing decision-making literature suggests a variety of formulations of aggregate advertising response models, (see, e.g., Little, 1979; Feichtinger *et al.*, 1994; and Sethi, 1977a, 1977b for comprehensive reviews of this literature). In traditional advertising settings, it is difficult to measure consumer responses (such as sales, brand awareness, or goodwill), as well as to establish that any changes in these measures are an outcome of advertising expenditures. In online advertising environments, however, users' exposure to a campaign translates into a direct action (such as a click on the ad), which can be accurately measured to capture the advertiser's return-on-investment (Golbeck *et al.*, 2011, Singer, 2018, Lee, *et al.*, 2018). To address additional features characterizing online advertising settings our model accounts for a more general budget effectiveness function, whose shape and parameters can be learnt online. The model considers a campaign in which measurement of effectiveness is based on precise metrics provided online,

e.g., the exact sizes of segments population, and the proportions of those segments that have been exposed to the ad, as a function of time. We also extend the model to fit the features and needs of different users' sectors simultaneously.

2. Problem formulation

We consider a single advertiser who manages a single advertising campaign, targeting several different segments, and with a total campaign budget of *B*. Let S be the group of target segments. For each segment s, $s \in S$, its size, denoted by h_s is known to the advertiser, through data provided by the online platform. At each time *t*, the advertiser places a bid $b_s(t)$ to expose target segment *s* to the ad. The relationship between the bid value at time *t*, $b_s(t)$, and the number of newly exposed users from audience *s* is determined by an effectiveness function (our use of this concept draws from Mahajan and Muller 1986). This function is denoted by $r(b_s(t), g_s(t), t)$ and is assumed to be dependent on the bid value, $b_s(t)$ and the number of users exposed up to t, $g_s(t)$. The goal is to determine the minimal campaign length *T* and the bidding functions $b_s(t)$, $s \in S$, $t \in [0, T]$, such that a given minimal percentage of users in each segment *s* (denoted p_s, $0 < p_s < 1$) is exposed to the campaign within the time frame; and the sum of bids across the time frame does not exceed the campaign budget *B*. By changing *B*, one then obtains the Pareto frontier of the bidding strategies, i.e. the strategies that minimize *T* given *B* and the strategies that minimize *B* given *T*. As noted above, we assume that the number of newly exposed users from audience *s* to the campaign at time *t* is determined by an effectiveness function. Specifically,

$$\frac{dg_s(t)}{dt} = (h_s - g_s(t)) \cdot r(b_s(t), g_s(t), t).$$

We further assume that the effectiveness function captures both the direct impact of the bid on user exposure and exposure caused by social interactions between exposed users and unexposed users. That is,

$$r(b_s(t), g_s(t), t) = f(b_s(t), t) \cdot \left(1 + a_s g_s(t)\right),$$

where $f(b_s(t), t)$ is the effect of the bid at time t on the number of newly exposed users in audience *s*, and a_s is the coefficient of interaction between the exposed and unexposed users in *s*.

The problem is,

$$\text{Minimize } T \quad \text{s.t.}$$

$$\frac{d}{dt} g_s(t) = \left(h_s - g_s(t)\right) \cdot f(b_s(t), t) \cdot \left(1 + a_s g_s(t)\right),\ g_s(0) = q_s h_s\ ,\ g_s(T) \geq p_s h_s\ \forall s,$$

$$\frac{d}{dt} z(t) = \sum_{s \in S} b_s(t)\ , \quad z(0) = 0, \quad z(T) \leq B,$$

$$b_s(t) \geq 0.$$

Here $z(t)$ is the total bidding amount spent up to t, and q_s is the initial exposure in segment s. By normalizing the cumulative number of people exposed to the campaign, $g_s(t)$, to the audience size for each segment, h_s, i.e., by changing the decision variables, $g_s(t) := \frac{g_s(t)}{h_s}$, and the parameters $a_s := a_s h_s$, the dynamic equation for $g_s(t)$ is re-written as

$$\frac{d}{dt}g_s(t) = \big(1 - g_s(t)\big) \cdot f(b_s(t), t) \cdot \big(1 + a_s g_s(t)\big),\ \ g_s(0) = q_s,\quad g_s(T) \geq p_s.$$

3. Solution methodology and results

The problem stated in Section 2 has a canonical form of optimal control. The optimality conditions for the problem are derived by means of the maximum principle (e.g., Hartl *et al.*, 1995). The analysis of the optimality conditions allows characterizing an optimal policy. In particular, we show that for a stationary effectiveness function, the optimal bid is independent of time and unique for each market segment, $b_s^*(t) = b_s^* > 0\ \forall t$. As a result, the budget is allocated to all the segments along the entire campaign, so that all segments attain the required exposure levels simultaneously. When the bid effect function explicitly depends on time, the budget is shown to be allocated to all the segments only at the beginning of the campaign. Then, some segments run out of the campaign when reaching the required exposure. The remaining segments that reach the required exposure simultaneously close the campaign. As a general solution framework, we develop a numerical algorithm that calculates the optimal bid at each time period and updates the parameters of the problem online, as the data regarding newly exposed users become available.

4. Conclusions

We have formulated the problem of determining an optimal policy of dynamic budget allocation for an online advertising campaign. A solution method that combines optimization and learning is suggested. For a given budget and a set of target exposure levels for specific market segments, our method determines (i) the optimal bidding policy for each segment over time, and (ii) the minimal campaign time that attains the desired exposure levels, without exceeding the budget constraints. We have shown the applicability of the suggested method by using data from a real-life ad campaign.

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Keywords: *advertising campaign, optimal control, online learning.*

Empirical Investigation of Bullwhip Effect with Sensitivity Analysis in Supply Chain

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1. Introduction

An unrivalled problem in the supply chain research, that has gain much attention from the past five decades, is the phenomenon extensively known as "Bullwhip Effect" i.e. a condition where demand distortion magnifies as moves up in the supply chain. Forrester (1961) was the founding father, who explored demand amplification in supply chain dynamics, also called "Forrester effect" or the "Law of Industrial Dynamics" at the Massachusetts Institute of Technology. This attracted many researchers and triggered a curiosity among them to understand its causes. Forrester identified that demand amplification is due to system dynamics and can be tackled by reducing delays in the supply chain. Then, Sterman (1989) explored the bullwhip effect in a "Beer Distribution Game" and concluded that this phenomenon occurs due to "irrational behavior" of supply chain players. Five causes of bullwhip effect in the supply chain dynamics are demand signal processing/demand forecasting, order batching, price fluctuation, rationing and shortage gaming (Lee, Padmanabhan, & Whang, 1997a, b) and lead time (Chen, Drezner, & Simchi-Levi, 2000; de Souza, Chaoyang, & Zice, 2000). Disney and Lambrecht (2008) wrote a textbook to identify the causes and provide some remedies. In past, the researchers tried hard to eradicate the menace of bullwhip effect. However, this problem is persistent in the supply chain management, and it is a source of continuous perturbance for the industrialists.

It is generally advocated that in supply chain management, the bullwhip effect occurs mainly due to uncertainty. As a matter of fact, uncertainty is the mother of sensitivity analysis (Vorst, Beulens, Wit & Beek, 1998). Wernerfelt and Karnani (1987) indentified sources of uncertainties that were demand structure, supply structure and externalities. Although, win-win situation cannot be achieved if uncertainty exists among different tiers in the supply chain. Uncertainty has a number

of baneful consequences: difficult decision making process, offensive production scheduling, ineffective product delivery process, inaccuracy in forecasting, and safety stock requirements. Additionally, it leads to more investment, extra production capacity, and increased storage space (Chatfield, Kim, Harrsion & Hayya, 2004).

Sensitivity analysis is a key enabler that is used to determine how much of uncertainty exists in the model (Freudenberg, Looze & Cruz, 1982; Alexander, 1989; Wagner, 1995; Pannell, 1997; Hall & Posner, 2004; Castillo, Conejo, Minguez & Castillo, 2006; Saltelli, Ratto, Andres, Campolongo, Cariboni, Gatelli, Saisana & Tarantola, 2008; Baucells & Borgonovo, 2013; Borgonovo, Hazen, & Plischke, 2016; Mizgier, 2017). To enlightening the sensitivity analysis further, it can be expressed as the analysis of potential changes and their impacts on conclusions to be drawn from the model (Baird 1989 as cited Pannel 1997). Though variability can be seen through the dynamic behavior of the model, and its response to the changes of the model inputs (Borgonovo & Plischke 2016). The basic phenomenon is revolving around for the improvement of overall efficiency and usefulness of the results (Hall & Posner 2004). Sensitivity analysis is directly linked with the design parameters of the model. To gain the optimum level of results, decision makers needs to identify the robustness of model parameters settings (Alexander, 1989). According to Pulkkinen and Huovinen (1996) there were two essential part of uncertainties, i. e. parameter uncertainty and model uncertainty. Parameter uncertainties leads to uncertainty in the true values of the model parameters and model uncertainties came when it is not taken into account. Several approaches has been identified by the past researchers for sensitivity analysis. A widely total six approaches has been found in the literature, i) local sensitivity analysis (Smith & Smith, 2007; Borgonovo, 2010; Borgonovo & Plischke 2016) ii) global sensitivity analysis (Borgonovo, 2010; Borgonovo & Plischke 2016) iii) factorial sensitivity analysis (Smith & Smith, 2007; Ligmann-Zielinska & Sun 2010) iv) variance bases sensitivity analysis (Sobol 2001; Borgonovo, 2010; Borgonovo & Plischke 2016) v) sampling based sensitivity analysis (Box, Hunter & Hunter, 1978) and vi) density based sensitivity analysis (Borgonovo, 2010; Borgonovo & Plischke 2016).

The current article focuses on empirical investigation of sensitivity analysis issues regarding bullwhip effect with real time data. For this present paper the primary data has been collected from the rice industry of Pakistan. This paper fills a missing piece in the landscape of sensitivity analysis issues regarding bullwhip effect for supply chain applications in academia. A few studies have been conducted in the context of supply chain management with reference to Pakistan. No real time data has been utilized by the past researchers. The supply chain model Automatic Pipeline Inventory and Order Based Production Control System (APIOBPCS) has been implemented with special reference to Pakistan.

It is a dire need in the contemporary era that a comprehensive study should be made on the sensitivity issues on demand amplification across two-tier supply chain that will provide empirical evidences. This will certainly guide the operation managers to take visionary and practical steps as regards with the bullwhip effect.

The rest of paper is split in six sections. Section 2, the research methodology is introduced and then the model is presented is section 3. Section 4 summarizes the sensitivity analysis and discussion is presented in section 5. Section 6 contains the conclusion.

2. Methodology

In this article, a case study approach has been selected as it is an apt method to describe and explore a new phenomenon. Keeping in view the dynamics of the issues, this research has applied the continuous simulation modelling technique and the case study research as a research methodology. To simulate the APIOBPCS model, "What-If" analysis has been applied in this research. To measure sensitivity analysis, variance based analysis has been applied. Computer software Microsoft Excel 2007 is used for simulation techniques.

3. Two-tier supply chain model

Figure 3.1 shows the simulation model of two-tier supply chain consisting of one manufacturer and one distributor. The APIOBPCS model expressed by John, Naim, and Towill (1994) as "Lets the production targets be equal to the sum of an exponentially smoothed demand (over Ta units of time) plus a fraction (1/Ti) of the inventory error, plus a fraction (1/ Tw) of the work in progress (WIP) error". The model comprises four parameters (each-tier) that are Ta, Ti, Tw, and Tp. Ta is the parameter that expresses how quickly demand is tracked in the exponential smoothing forecasting technique, while Ti suggests that the difference between the actual and desired/target inventory levels is added to the production/distribution order rate (ORATE). Tw describes how much of the discrepancy between the actual work-in-process (WIP) and desired/target WIP levels should be added to the production/distribution ORATE. Tp describes the actual pipeline delay between an order being placed and its receipt into stock.

In summary

Is the actual end customer demand

$$SALES = \text{Is the actual end customer demand} \tag{1}$$

$$SALES = ORATE \tag{2}$$

$$SSALES = SSALES + (SALES - SALES) * 1/Ta \tag{3}$$

$$ORATE = SSALES + EINV/Ti + EWIP/Ta \tag{4}$$

$$COMRATE = ORATE \tag{5}$$

$$AINV = AINV + COMRATE - SALES \tag{6}$$

$$DINV = SALES \tag{7}$$

$$EINV = DINV - AINV \tag{8}$$

$$DWIP = TPxSSALES \tag{9}$$

$$EWIP = DWIP - WIP \tag{10}$$

The values of the parameters from the APIOBPCS model applied in this research are Tp = Ti =Tw =6, and Ta = 2Tp =12, i. e. a good set of values in accordance with the findings of Mason-Jones, Naim, and Towill, (1997), Wilson (2007), Hussain and Darke, (2011).

SENSITIVITY ANALYSIS

Sensitivity analysis is carried out in the current paper for deep understanding of each parameter of the model. The parameters of the model react differently when the value of each parameter increases or decreases. The purpose of their testing is to find out how operation managers can select parameters or tune the parameters of the model that produces minimum bullwhip effect.

DISCUSSION

In this research, two case studies have been selected from the rice industry of Pakistan. The data for the study is collected from the demand and sales sheets of a group of four large rice manufacturers and their distributors (two-each) from the districts of Lahore and Islamabad, Pakistan. Since this is a case study research, therefore, the data from the four firms is considered sufficient to examine the sensitivity issues of the selected firms. The data of the rice firms pertains to two consecutive years, i.e. from December 2007 to December 2009.

In the current article, the APIOBPCS model has been applied that was improved by John et al. [21] form the base model IOBPCS which was developed by [38]. The values of the parameters from the APIOBPCS model applied in this research are Tp = Ti =Tw =6, and Ta = 2Tp =12, i. e. a sound set of values in accordance with the findings of [20-25-36].

The detailed investigation on the impact of design parameters on bullwhip effect has been tested through different scenarios' of simulation modeling technique. Simulation was carried out 520 times within 100 weeks, both from manufacturers' and distributors' perspective. The main purpose of this study is two-fold. Firstly, it is to find out the optimum level of model parameters and secondly, to make ease for supply chain managers and operation managers for mitigating the bullwhip effect.

The bullwhip effect plays a vital role for increasing the cost factor whether it is inventory holding cost, production cost, stock out cost, labor cost and transportation cost. However, due to this factor the managers are unable to forecast properly, but as a matter of fact forecasting methods plays an essential role for mitigating the bullwhip effect. For alleviating the bullwhip effect it is necessary that the supply chain managers must be orientated with the forecasting methods and better utilization of the parameter settings. By changing the values of alpha, they can control or reduce the bullwhip effect that means cost can be reduced by adjusting parameters appropriately, like alpha, Tp, Ti, Tw. In deliveries, the managers do not care about the lead time, in return they bear extra cost for not properly utilizing the lead time.

The managers can reduce the cost by controlling the value of alpha, reducing the lead time, providing proper delay in production, adjusting the value of Ti and by adjusting the value of Tw. In the rice industry of Pakistan, the managers are not well qualified and they are not aware about forecasting methods. If they apply the exponential smoothing forecasting technique and keep the value of alpha 0.1 or 0.2, they can better reduce the cost across the supply chain. By looking at the graphs or the analysis of this study, they can reduce the cost across the supply chain. It has been concluded in this research that if the managers reduce the lead time, they can control the cost.

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European Funds for the Years 2014–2020 and Transfer of Knowledge from B+R Activity on the Example of Małopolska

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From year to year, the importance of investment in research and development and cooperation of public and private entities in the commercialization of knowledge increases. This fact influenced the willingness to verify whether the current European programs translate into technology transfer from scientific units to the Małopolska SME sector. The research problem seems to be the search for various factors that will affect the effective transfer of knowledge to micro, small and medium enterprises. The main goal of the research is to determine the empirical relationship between financing research and development activities from public funds, and the use of the results of these works in the SME sector. The conclusions drawn from the study will allow to assess the benefits and disadvantages of supporting research and development investments by the Polish government and the European Union. The main assumption of the work is to examine the role of co-financing of B+R's activities in its business use by enterprises. The following research hypothesis will be verified: "The use of European funds for 2014–2020 translates into mutual cooperation between scientific units and enterprises resulting in the transfer of scientific knowledge to the economy". The basis for theoretical analysis of research will be mainly critical literature studies of available books, monographs, scientific articles, reports, as well as the results of research on theoretical and practical aspects describing knowledge transfer processes and the implementation of B+R. The author's own research will be used in the work as an analysis of questionnaires among representatives of the B+R sector in Małopolska. The evaluation will cover the sources of work financing, organizational structure of the company, cooperation with external entities, protection of industrial property. The graphical and tabular techniques will be used to present the results and present the relationships in the studied phenomena. Searching for favorable and limiting factors of the knowledge transfer process, in addition to the theoretical value, carries a broad practical dimension in updating economic programs at the national and EU level.

JEL category: *O – Economic Development, Innovation, Technological Change, and Growth.*

Keywords: *enterprise, subsidies, research and development, innovations, knowledge transfer.*

Scheduling of Prioritized Jobs with Respect to Bipartite Incompability Graphs on Uniform Batching Machines. An Application of Recent Advances in Graph Theory to a Resource Allocation Problem

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1. Introduction and the aim of the paper

Imagine that we are a corporation processing chemical substances. We have been asked by a customer to produce *n* products. We know that we can obtain them if we buy *n* sets of substrates and process them. That means we have to buy the substrates and after processing them we will be paid for the obtained product. The main part of the processing is a heating. We have several heaters that may heat the substances but with a different speed of work. Each of the heaters can process a batch of the substances at a time. We have to assign the sets of substrates to the batches in such a way that the substrates in two different sets assigned to the same batch will not react with each other – we do not want them to affect each other. However, we would like to do this in such a way that our corporation will have maximal financial liquidity. Precisely, we would like to minimize the time when our financial assets, invested into substrates, are not available.

In this paper we use recent advances on the cost coloring of weighted bipartite graphs to obtain results on the scheduling of weighted jobs on uniform batching machines with respect to conflict

bipartite graph. We show that there exists a $\frac{25}{24}$-approximation algorithm for $Q|p-batch; G_w = bipartite; p_j = 1|\sum w_j C_j$, by analyzing the worst case. We complement our study of the deterministic case by a theoretical and experimental study of a sequence of random bipartite graphs $\mathcal{G}_{n,n,p}$ to analyze if there exist simpler methods that perform well on average. Precisely, we provide observations which show that, if the instances have a dense conflict graph, for example the probability of an edge is $\frac{2\ln n}{n}$, then even the simplest algorithm is sufficient. And by performing computational experiments we analyze the case when the graph is sparse. On one hand, our study shows that the problem is strongly NP-hard, but it is possible to obtain algorithms with good approximation ratio, albeit quiet complicated ones. On the other hand, it shows that when the instances of the problems can be well described by a $\mathcal{G}_{n,n,p}$ model then the approximation ratio of the simplest algorithm tends to 1 if n tends to infinity.

2. Notation

Let $G_w = (V, E, w)$ be a graph with $|V|$ vertices, $|E|$ edges and where $w: V \to N_+$ is a function that associates with each $v \in V$ a weight $w(v)$, given by a natural number. A *proper coloring* of G is a coloring in which the sets $V_1, \dots, V_c$ are independent, i.e. $\forall_{1\le i\le c}\forall_{v_1,v_2\in V_i}\{v_1, v_2\} \notin E(G)$. For brevity we skip the word proper in most cases and we call a proper coloring simply a *coloring*. For a $k \geq 2$, by a *k-pseudocoloring* of G we mean any proper $(k-1)$-coloring or a *k-coloring* $Q = (V_1, \dots, V_k)$ in which V_k might not be independent. The *chromatic cost of* G_w *with respect to the sequence of color costs* $C = \{c_1, \dots\}$ is the minimum cost of a coloring taken over all proper colorings of G_w. For other definitions and a review on the results on Cost Coloring see (Pikies, Kubale, 2019). The set of jobs with priorities is modeled by a graph $G_w = (\mathcal{J}, E, w)$ where $\mathcal{J}$ is the set of the jobs, E models incompatibilities between the jobs, and w describes the priorities of the jobs. The set of the uniform batching machines is $\mathcal{M} = (M_1, \dots, M_m)$with corresponding speeds $(s_1, \dots s_m)$; we assume that the machines are ordered according to their speeds. Each of the machines is able to process infinitely many jobs simultaneously. The problem $Q|p-batch; G_w = bipartite; p_j = 1|\sum w_j C_j$ consists in finding a schedule for $\mathcal{J}$ on $\mathcal{M}$ that minimizes the $\sum w_j C_j$ criterion.

Hence we see that we can easily model $Q|p-batch; G_w = bipartite; p_j = 1|\sum w_j C_j$ by Cost Coloring, i.e. the graph for Cost Coloring is G_w, the weight of the jobs is the cost of the substrates associated with the product, and C is a sequence obtained by ordering the completion times of first n batches on the machines nondecreasingly. The weighted completion time of a job is a measure how long the money invested into substrates will be not available. Due to the fact that one may always use the batch slots provided by M_1 only, for costs $c_2, c_3, \dots$ we have the following inequalities $c_{i+1} \leq c_i + c_1$. Hence we identify the $Q|p-batch; G_w = bipartite; p_j = 1|\sum w_j C_j$ with a special case of Cost Coloring – i.e. a case when there is a bound on the maximal difference between color costs.

Given a real number $p, 0 \leq p \leq 1$ the binomial random bipartite graph, denoted by $\mathcal{G}_{n,n,p}$, is defined by taking as Ω the set of all bipartite graphs on vertex set $\{1, \dots, n\} \cup \{n+1, \dots, 2n\}$ and setting

$$\mathrm{P}(\mathrm{G} \in \Omega) = p^{|E(G)|}(1-p)^{n^2-|E(G)|}.$$

We assume that for such graphs $w(v) = 1$ for all v.

In this paper we analyze the behavior of the following algorithm, when applied to data corresponding to an instance of the $Q|p-batch; G_w = bipartite; p_j = 1|\sum w_j C_j$ problem.

Algorithm 1 Algorithm for the Cost Coloring optimization problem on weighted bipartite graphs.

Require: A weighted bipartite graph $G_w = (V, E, w)$, a sequence of color costs $C = (c_1, c_2, \dots, c_c)$ with length at least 4.
Ensure: An approximate cost coloring of G_w.
1: Let $\mathrm{Q} = (V_1, V_2, V_3)$ be a chromatic cost 3-pseudocoloring of G_w with colors C_1, C_2, C_3. {chromatic cost 3-pseudocoloring may be calculated using Algorithm 1 from (Pikies, Kubale, 2019).}
2: Let S_1 be a 2-coloring of G_w obtained by coloring V with colors C_1, C_2 in the best possible way – i.e. assigning the vertices with the highest total weight to C_1.
3: Let S_2 be a 3-coloring obtained by coloring V_1 with C_1 and 2-coloring V_2, V_3 with colors C_2, C_3 in the best possible way.
4: Let S_3 be a 4-coloring in which S_1 is assigned to V_1, C_2 to V_2 and V_3 is colored in the best possible way using C_3 and C_4.
5: **return** The best of S_1, S_2, S_3.

3 Analysis of deterministic case

Theorem 1 (Małafiejski, 2002). Sum Coloring *is* NP-complete *even when restricted to unweighted planar bipartite graphs with* $\Delta(G) = 5$.

Hence $Q|p-batch; G_w = bipartite; p_j = 1|\sum w_j C_j$ is NP-hard.

Proposition 1. *If the number of possible colors is at least 4 then the best known approximation ratio for* Cost Coloring *optimization problem is*

$$1 + \left(\frac{2c_1}{c_2 - c_1} + \frac{2(c_2 + c_1)}{c_3 - c_2} + \frac{2}{c_4 - c_3}\left(c_3 + 2c_2 + \frac{2c_1(c_3 - c_2)}{c_2 - c_1} \right) \right)^{-1}, \quad (1)$$

where c_1, c_2, c_3, c_4 *are the costs of four colors with the smallest cost. The ratio is achieved by* Algorithm 1 *running in* $O(|V||E|)$ *time.*

By a straightforward application of the algorithm to $\mathrm{Q}|\mathrm{p}-\mathrm{batch}; \mathrm{G_w} = \mathrm{bipartite}; \mathrm{p_j} = 1|\sum \mathrm{w_j C_j}$ and an analysis of the approximation ratio we obtain:

Lemma 1. There exists a $\frac{25}{24}$-approximation algorithm for $Q|p-batch$; $G_w = bipartite$; $p_j = 1|\sum w_j C_j$ problem.

4 Analysis of stochastic case

Theorem 2 (Jason, Łuczak, Ruciński, 2000).

$$\mathrm{P}\left(\mathcal{G}_{\mathrm{n,n,p}} \text{ has a perfect maching}\right) = \begin{cases} 0\colon \mathrm{np} - \log \mathrm{n} \to -\infty \\ \mathrm{e}^{-2\mathrm{e}^{-\mathrm{c}}} \colon \mathrm{np} - \log \mathrm{n} \to \mathrm{c} \\ 1\colon \mathrm{np} - \log \mathrm{n} \to \infty \end{cases}$$

Hence by König's Theorem (König, 1931) and by an easy observation that in a bipartite graph the complement of a vertex cover is an independent set we may characterize the cases in which asymptotically almost surely the independence number $\alpha\left(\mathcal{G}_{n,n,p}\right) = n$. We notice that for such cases Algorithm 1 restricted to S_1 almost always produces optimal solution in $O(|V| + |E|)$ time.

Our empirical study shows that even if $np - \log n \to -\infty$ then $\alpha(G)$ tends to the size of the bipartition. To be precise, if $G = (V_1 \cup V_2, E)$ is not connected then we may find a different partition of the vertices than into sets V_1 and V_2. Let (V_1', V_2') be a partition of $V_1 \cup V_2$ such that it forms a bipartition and V_1' has the greatest possible size. Our study shows that $\alpha(G)$ tends to $|V_1'|$, hence also the approximation ratio of Algorithm 1, even when restricted to the solution S_1, tends to 1.

5. Conclusions

It is interesting that our analysis has shown that the approximation ratio is in the range $\left[\frac{27}{26}, \frac{25}{24}\right]$. However, the analysis is rather unsophisticated, hence we guess that is is possible to enhance it to show that the approximation ratio is in fact $\frac{27}{26}$. We think that it will be very interesting to find a natural random bipartite graph generation model such that the outcomes of the model that will be challenging for our algorithm.

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Keywords: *cost coloring, uniform batching machines, scheduling, incompatibility graph, random bipartite graph.*

Valuation of Real Option in Case of Hybrid Evaluation of Uncertainty

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The cost-benefit analysis (CBA) plays important role in classical company valuation methods. By applying CBA, decision maker may assess possible income of investment. Unfortunately, traditional valuation methods are proven inadequate in situation when parameters of the model are burden with high level of uncertainty. In this situation such models as, real option comes into play. A real option describes available opportunity to the decision maker concerning considered investment. It is called real because it applies to tangible (e.g. machines), not financial investment. Typically, real options are related to expand, change or cut investment based on changing its economic, technological, or market parameters. Thus, the biggest value that real option adds to evaluation of investment is strategic flexibility which considers the presence of a high level of uncertainty.

In this article we will discuss how concept of uncertainty should be understand during real option valuation. Concept of uncertainty is used very often in different meanings. In this article uncertainty occurs when manager has not certain knowledge about future parameters which describe potential investment. So broadly speaking, "uncertainty" stems from incompleteness of knowledge needed to forecast future event. The analysis of real options assumes that there is an underlying source of uncertainty, such as the price of a commodity or the outcome of an investment project. Over time, the outcome of the underlying uncertainty is revealed, and managers can adjust their strategy accordingly.

As far as idea of real option is intuitive the real option valuation (ROV) is not. Typically models of ROV (real option valuation) assume that real option is so similar to financial option, that ROV may be made the same way as financial option valuation. The idea of similarity of real and financial option is widely accepted by researchers in strict sense. It means that assumption underlying the financial option valuation models are hold for ROV. This approach is seemingly true, but modern research points out that it is not always hold. The main difference between financial and real option is that real option refers to tangible investment usually big and complicated. In classical

evaluation of such investment with cost benefit analysis there are many parameters that should be taken into consideration. Those parameters come from different sources: technology, economic, market, etc. In contrast parameters that describe financial investment comes usually from one source – market. Probabilistic analysis is the most widely used method for modelling financial option. Such approach is correct because as we said before uncertainty is homogeneous taking into consideration source of creation. However, in situation of evaluation of tangible investment sources of uncertainty may be due to intrinsic variability of the phenomenon itself, to lack of knowledge and information and to increase complexity (increased number of the combinations of things and limited cognitive competencies of the decision maker). According to many scientists and also authors of this article, each type of abovementioned should be modelled in different way and then be propagated separately during ROV.

In literature there are many distinction between sources of uncertainty. In general, we can distinguish two kinds of uncertainty: epistemic uncertainty, which comes from the lack of or incomplete information and aleatory (stochastic), which has its sources in irreducible variability of historical data. In modern approach to risk analysis various uncertainties are modelled using different mathematical theories. In many problems only one type of uncertainty is present (It is case of financial option). In such case, we can use pure probability or possibility theory in parameter estimation. However, in some cases, such as tangible investment appraisal or real option, uncertainty of parameters comes from both variability and ignorance. Then we must use a hybrid approach, which combines probability and possibility theory.

So the aim of the article is to present challenges which are arises when we would like to provide hybrid real option evaluation. In the previous literature on real options there are very few attempts to analyze ROV model under different types of uncertainty.

Those hybrid approach is especially important in situation when we deal with big tangible investments. Valuation of real option are especially important in big tangible investments. Those investments have long construction times, long economic lives, and that are to a large degree irreversible. The characteristics of those investment cause that they are required methods that can consider estimation of imprecision and the value of managerial flexibility. The aim of this paper is to present how to asses real option in hybrid environment in case of giga investment in steel industry.

Keywords: *real option, evaluation of investment, possibility theory, fuzzy numbers.*

A Review on Cutting Tool Optimization for Titanium Alloy Machining

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1. Introduction

The history of manufacturing is dated back to the history of human being of the Stone Age. The early humans use different primitive methods to prepare their basic needs food, cloth and shelter. They used stone as cutting tool to cut and prepare hide, wood, and other materials at least 3 million years ago. With time they improved the cutting tool to a single point cutting method by using bones, ivory etc. [1]. Before the Industrial Revolution of the 18th century, metal hand tools were used to cut and shape materials for the manufacturing of goods such as cooking utensils, wagons, ships, furniture, and other products. The 20th century has witnessed the introduction of numerous refinements of machine tools in manufacturing, such as multiple-point cutters for milling machines, the development of automated operations governed by electronic and fluid- control systems, and nonconventional techniques, such as electrochemical and ultrasonic machining. [2]. The later (mechanical manufacturing system) is the most popular cutting processes these days. The rest are used for the special purpose jobs due to their constraints (application requirements, cost-effectiveness, production capabilities and customer needs) [3]. Researchers and manufacturers are continuously working on tool optimization by preventing, maintaining on break down or an early predicting the tool wear effect. Their aim is to gain high quality, in term of work piece dimensional accuracy, surface finishing, very high production rate, less wear on the cutting tools and in the term of economy of the cost saving [3,4]. Some of the most common coatings used these days are: Titanium Nitride (TiN), Titanium Carbo-Nitride (TiCN), Titanium Aluminum Nitride (TiAlN or AlTiN), Chromium Nitride (CrN) and Diamond [4]. To enhance the turning productivity in terms of tool life, surface finish, and surface integrity, variation in tool geometry is one of the major parameter to be considered. Tool geometry has been practiced by the researchers to study the machining performance in the past. The various geometries of the tool are: Rake angle, tool nose radius, approaching angle, groove on rake face, wiper (chamfer) honed edges and side cutting edge

angle [5]. The researches for cutting tool parameters such as depth of cut, feed rate, cutting speed and force are done either by directly or indirectly controlling these parameters [6].

2. Review of related works

2.1. Coolant/Flood Machining

Wong et al. [7], investigated tool life and cutting force, based on dry cutting, flood cooling, and minimum quantity lubrication (MQL) techniques. Their experimental results showed that MQL machining remarkably and reliably improved tool life, and reduced cutting force due to the better lubrication and cooling effect.

Ezugwu et al. [8], investigated the performance of uncoated carbide tools when rough turning Ti-6Al- 4V alloy, under flood cooling and with 7 MPa coolant supply pressure. Up to twofold increase in tool life was achieved when machining at a speed of 80 m/min with a high-pressure coolant supply of 7 MPa relative to a conventional overhead coolant flow.

2.2. Dry Machining and MQL Machining

Ginting and Nouari [9], focused on the machined surface integrity of titanium alloy under the dry milling process. They investigated roughness, defects, micro hardness and microstructure alterations. The result of surface roughness showed that the CVD-coated carbide tool fails to produce better Ra value compared to the uncoated tool.

Harona and Jawaidb [10], investigated surface integrity of the rough machining of titanium alloy Ti–6% Al–4% V with uncoated carbide cutting tools. The experiments were carried out under dry cutting conditions.

Patil1 et al. [11], investigated the effect of dry machining of Ti6Al4V on surface integrity of machined work piece. A change in subsurface deformation was assessed by varying cutting speed and feed rate keeping the cut depth constant. Various output responses viz. cutting temperature, surface finish, induced strain, deformed depth, micro hardness, were discussed and evaluated the surface integrity.

Liu et al.[12], experimentally investigated the wear rate, wear pattern and wear mechanism of two kinds of nanocomposite coatings, (nc-AlTiN)/(a-Si3N4) and (nc-AlCrN)/ (a-Si3N4), in dry and MQL conditions.

Rahim and Sasahara [13], studied the potency of MQL palm oil (MQLPO) as a lubricant in the high speed drilling of Ti–6Al–4V. They selected, MQL synthetic ester (MQLSE), air blow and flood conditions for the comparison.

Ibrahim et al. [14], investigated the effect of the use of vegetable oil on dry and cryogenic machining, minimum quantity lubrication (MQL) and minimum quantity cooled lubrication (MQCL), strategies on the flank tool wear, surface roughness and energy consumption during turning of titanium Ti-6Al-4V using uncoated carbide tool at certain speed and feed. The use of rapeseed vegetable oil in MQL and MQCL configuration turns out to be an overall sustainable alternative. Thus confirmed the promise predicted in the use of vegetable oil as a lubricant for machining.

Sadeghi et al. [15], experimentally compared vegetable and synthetic esters oil on the basis of the surface quality properties that would be suitable for MQL applications. The cutting performance of fluids was also evaluated using conventional wet (fluid) grinding of Ti–6Al–4V. As a result, synthetic ester oil was found to be optimal cutting fluids for MQL grinding of Ti–6Al–4V.

2.3. Coated and Uncoated Tools

Ezugwu and Wang [16], reviewed the main problems associated with the machining of titanium as well as tool wear and the mechanisms responsible for tool failure. They were able to find that the straight tungsten carbide (WC/Co) cutting tool continued to maintain its superiority in almost all machining processes of titanium alloys, whilst CVD coated carbides and ceramics had not replaced cemented carbides due to their reactivity with titanium and their relatively low fracture toughness as well as the poor thermal conductivity of most ceramics. They also discussed special machining methods, such as rotary cutting and the use of ledge tools, which had shown some success in the machining of titanium alloys.

Sharif and Rahim [17], investigated the performance of uncoated-WC/Co and TiAlN–PVD coated-carbide twist drills, when drilling titanium alloy, Ti–6Al4V. They studied the effects of cutting speed on tool wear, tool life and surface finish of the hole when drilling using coolant. Their results showed that non-uniform flank wear, chipping and catastrophic failure were the dominant modes of tool failure for both coated- and uncoated-drills.

2.4. Cryogenic Machining

Madhukar et al. [18], reviewed different researches done to overcome a difficulty of machining of titanium alloy, by the advanced technique, cryogenic cooling. From the experiments conducted they could prove that the work machined, using the liquid nitrogen had a good surface finish, decreased cutting forces, when compared to water-based Coolant; thus the liquid nitrogen was an advantageous and alternative coolant for machining of hard materials.

Yuan et al. [19], experimentally investigated the influence of the coolant strategies dry, wet, minimum quantity lubrication (MQL) and MQL with cooling air on performance in milling of the Ti–6Al–4V alloy with uncoated cemented carbide inserts. The cutting force, tool wear, surface roughness and chip morphology were experimentally studied to compare the effects of different cooling air temperatures. Their results showed that minimum quantity lubrication (MQL) with cooling air significantly reduced the cutting force, tool wear and surface roughness. Unfortunately, MQL (without cooling air) condition could not produce evident effect on cutting performance, and flaking wear on the flank surface of the insert had been found under this condition.

Hong et al. [20], studied how the temperature affected the Ti-6Al-4V properties, and compared different cryogenic cooling strategies. Based on their findings, they proposed a new economical cryogenic cooling approach, by using a minimum amount of liquid nitrogen (LN2). This innovation featured a specially designed micro-nozzle, formed between the chip breaker and the tool rake face, the nozzle lifted the chip and injected focused LN2 into the chip–tool interface at the point of highest temperature.

Kirsch et al. [21], investigated the effectiveness of cryogenic coolant during turning of Ti-6Al-4V at a constant speed and material removal rate (125 m/min, 48.5 cm3 /min) with different

combinations of feed rate and depth of cut. They found that the greatest improvement in tool life using cryogenic coolant occured for conditions of high feed rate and low depth of cut combinations.

Venugopal et al. [22], investigated the effects of cryogenic cooling on growth and nature tool wear while turning Ti-6Al-4V alloy bars with microcrystalline uncoated carbide inserts under dry, wet and cryogenic cooling environments in the cutting velocity range of 70–100 m/min.

2.5. Optimization of Machining

Knowledge of multidisciplinary engineering design optimization has been developed significantly by a group of researchers [23–50]. They could apply the design optimization algorithms in engineering applications. They showed that how various optimization methods can provide better results for a specific application like machining of light alloys and mechanical structures.

Zangera and Schulzea [51] experimentally analysed tool wear rate against change in temperature and sliding velocity (feed). Lath machine, Ti-6Al-4V (Titanium) alloy as work piece and tungsten carbide as cutting tool are used for experiment. They developed a model more convenient for different cutting tool velocities, which they recommend it for further (extra) researches in the future.

Wojciechowski and Twardowski [52] Experimentally studied cutting tool's vibrations generated during ball end milling process, including the influence of progressing tool wear. The process dynamics model including cutting parameters and tool wear width on the flank face was developed. Experiments were carried out on hardened alloy steel X155CrVMo12-1 with sintered carbide (TiAlN coating) and cubic boron nitride (CBN) cutters. Instantaneous cutting forces and vibrations values were measured in three directions, in the range of progressing tool wear.

3. Conclusions

Briefly, it can be indicated that the main issue is not located at the operation time in manufacturing industries. As, what is produced (manufactured) is according to the properly computed designs with models, parameters and highly accurate machines equipped a cutting-edge technology like Computer Numeric Controls (CNC) machines. The people working in these areas are also well trained and have full knowledge of the machines and the parts to be produced. Therefore, what goes wrong in the manufacturing industries is not inadequacy in the knowledge of the operation, selection of materials for the part or choosing kind of the cutting tool but the real problem occurs when manufacturing industries components' starts the action or operation. Here before the action (operation) starts, everything is 100% accurate as it is designed, by expecting the possible accident which may happen. By taking this into consideration and from the above reviewed researches most effect full research is studying the cutting tool's effect by monitoring the operation and the tool parameters directly or indirectly. Most specifically Dry and MQL machining along with coating the carbide cutting tools, were the best way for sustainable machining processes for Titanium alloy Ti-6Al-4V.

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Keywords: *tool wear, titanium alloy, optimization, cutting fluid.*

A Multi-Portfolio Approach to Supply Chain Disruption Management

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A multi-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's firm 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. Scenariobased stochastic MIP 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, the decision to be implemented during and after the disruption. The two decision-making approaches will be considered: an integrated approach with the perfect 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. The integrated decision-making selects a more diversified primary supply portfolio to hedge against all potential disruption scenarios. 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. Computational results will be presented and discussed.

The findings indicate that the developed multi-portfolio approach leads to computationally efficient MIP models with a very strong LP relaxation.

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Keywords: *supply chain risk management, disruption mitigation and recovery, primary portfolio, recovery portfolio, stochastic mixed integer programming.*

Product Quality Synthetic Index

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Nowadays we live in a world of illusion. Where needs and problems are too often created by marketing. Moreover, product lifecycles are precisely planned in order to provide expected income for producers. That is why making effective and optimal buying decisions becomes a real challenge for individual customers. Especially regarding marketing efforts resulting in opinions and rating served by bots or payed agencies. Word of mouth and personal recommendations are still useful. But in the flood of products, versions, personalized variants – it might be not sufficient. Because relatively narrow group of friends and family or even a trusted people presumably do not use all the product we might need or we are willing to use. In this paper concept of synthetic quality index will be discussed with it's links to communities as a reference source of soft data.

To solve the problem of accurate decision making usage of combination of hard and soft data could seems to be optimal. This product quality synthetic index (PQSI) should consist at least of combination of: opinions, ratings, claims and return rate. Background and some theoretical aspect of PQSI will be raised in order to form framework for further analysis based on real data.

Product quality were analyzed from various perspectives, but usually researchers tried to build complex measure, like American Customer Satisfaction Index (Fornell *et al*., 1996; Hsu, 2008) or concentrated on certain parameters describing given product (D. Curic *et al*., 2008). Promising analysis transform quality aspects into fundaments of customer satisfaction and loyalty (Matzler *et al.*, 1998). Product quality synthetic index is simplified indicator, that allows to verify relation between quality assessment components both in generalized and specific way. On one hand alignment of ratings and opinions may be cross checked with ratio of claims and returns – whether they are consistent or not. On the other – authorized recommendations and opinions form reliable source of detailed information about certain good.

Of course for real implementation some conditions must be fulfilled. First of them is the tool for authorization all the authors of opinions, recommendations and ratings. Second refers to source of claims and returns – connected to certain, respectively descending: brand, product line, product.

Third refers to statistically and really significant amount of data. Fourth refers to stratification of opinions and recommendations to improve sentiment analysis. Fifth refers to creating roadmap of implementation PQSI – to get functional, complete tool for individual customers as a final outcome.

This article forms outline of concept and method that will be developed in R&D project to verify assumptions and tune parameters to gain reliable and useful results that can be implemented in business reality.

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Keywords: *decision making, product quality, marketing.*

Support for Intangible Dilemmas-Related Decisions

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The actual effects of complex decisions taken today depend on the changes in the dynamic environment surrounding the subject of the decision. The complex – multidimensional – nature of the environment implies not only tangible, but also intangible impacts of both surrounding environment on the subject of the decision and the subject of the decision on surrounding environment. There may also appear important dilemmas that cannot be quantified, e.g. of a moral or ethical nature. In this situation, however, we are not helpless. It turns out that in order to properly include such dilemmas, we can use the well-known – traditional and universal decision support tool, namely pairwise comparisons. This possibility was illustrated in the paper.

Keywords: *decision, support, dilemma, intangibility, pairwise comparison.*

How to Use Project Configuration to Make Actual Project Implementation Less Sensitive to Possible Disruptions?

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Each construction project is implemented in a unique surrounding environment. This is why the organisation of the implementation of a construction project should be fitted to actual conditions of its implementation. The surrounding enviroment may nevertheless undergo adverse changes. This is why it is necessary to make the implementation of a construction project as much insensitive to possible disruptions as it is only possible. Construction projects consist of building processes which may be implemented in diverse orders. Each such order defines a concrete construction project configuration (structure) which makes a given project more or less sensitive to possible disruptions during project implementation. The choice of appropriate project structure may help, therefore, in limiting actual construction project implementation sensitivity to negative influences of surrounding environment. Hence, a general framework for the identification of adequate construction project structure is discussed in the paper.

Keywords: *construction, project, configuration, optimization, implementation, disruption, sensitivity, limitation.*

Cooperation Platform for Distributed Manufacturing

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1. Introduction

The problem of distributed manufacturing (DM) or production cooperation management within in dynamic network forms is being undertaken recently by quite many research and industrial groups. For example, some results of DM projects are described for cluster network systems (Akoorie and Ding, 2009; Liu *et al*, 2017), additive manufacturing in car industry (Durao *et al*, 2016), metal industry (Gąbka *et al*, 2012; Gąbka and Susz, 2016), administration in networked headquarters (Moghaddam *et al*, 2016) industrial environments. Unfortunately, the research and implementation projects to be found in distributed manufacturing or distributed production management research bibliography and industrial reports basically do not have advanced (i.e. ready to use in practice) results – usually final results are only pilot projects and experiments in planning and scheduling with an application of optimization, heuristic or evolutionary algorithms (also with simulation runs) for a particular cooperation system structure. And existing (so far) organizational and information based solutions (resolutions) in described case studies of distributed manufacturing cooperation platforms in network (cluster) forms have rather very limited range of functionalities. In practical DM implementation there is also an availability to apply many types of rather "classical" information and decision support systems (Rut, 2017), which are considered as versatile systems. However, because of new business strategies and business models emerge, based particularly on collaborative or cooperation, Industry 4.0, IoT, and sustainable development paradigms with "glocal" (global plus local) market focus, there is a strong need to develop new industrial systems – as dynamic network oriented structures. And these structures need new communication, knowledge based, and decision making support architectures to extend.

2. Aim of the paper

The aim of the article is to analyse contemporary trends in DM research (issues and challenges review with a comparison) and to present a concept to develop and test some task allocation,

planning and scheduling algorithms, to identify key factor criteria and reasoning policies and rules for production/manufacturing decision support system, and finally to draw a proposal for a development of a prototype decision support system with necessary communication and knowledge oriented modules to be implemented in an example of dynamic, distributed manufacturing and logistics network structure, particularly for very popular in Poland dynamic cluster form. From the pragmatic (a practical one) point of view, the main purpose of the system prototype to be developed is a support for manufacturing clusters of small and medium size enterprises by setting information and communication environment to manage (motivate, organize, plan, make decisions, control) dynamic system cooperation. In the paper, the evolution of DM, case studies of emerging DM applications (e.g.: Matt *et al*, 2015; Srai *et al*, 2016), and a description of a new DM paradigm and concept for emerging modelling and communication technologies and other supporting improvements, where manufacturing is a decentralized, autonomous near end user-driven activity are presented. Next, the economic, technological, societal and implementation issues that might limit the widespread adoption of DM, and future research agenda for the DM paradigm are described.

3. Methodological aspects

This study focuses on DM in the present industrial context. A mixed methodology was employed, involving production management journals' research papers data input, and followed by a multiple case study method. The case study objectives were to investigate the scope, challenges and opportunities of specific DM innovations and to identify future research agendas. The initial stage consisted of comparative study analysis of DM architectures, communications and information technologies applied in some practical implementations, modelling approaches to establish model repositories, methods of problem-solving in decision making, types of cooperation business models and ranges of application systems' functionalities, and possible market demand fulfillment. The case study of DM was structured to capture the following issues: description of the specific product and production technology system context, characteristics of DM for a given technology production system, enabling production technologies and infrastructure, governance and regulatory issues to be addressed, sustainability considerations, and transformation challenges. The cooperation platform proposal for DM is developed with systems approach (Akkerman, 2001), business modelling (Seidenstricker *et al*, 2017), cloud computing (Rauch *et al*, 2016, agent based technology (Jana *et al*, 2013), internet-based technology (Woo et al, 2008), graph theory technology, process management, and simulation modelling with group modelling (GMB) methodological contributions.

4. Results

The results of the paper are: the systematic review and classification of DM strategies, and a concept for collaborative DM platform to be developed. The concept is an architecture and prototype platform development process for manufacturing decision support and communication in DM environment with communication by SOA service oriented support, and modelling activities with knowledge oriented modules (Fig. 1). It tends towards a support to not only management in network oriented organisations as clusters or centres of excellence, but also towards a support to production managers.

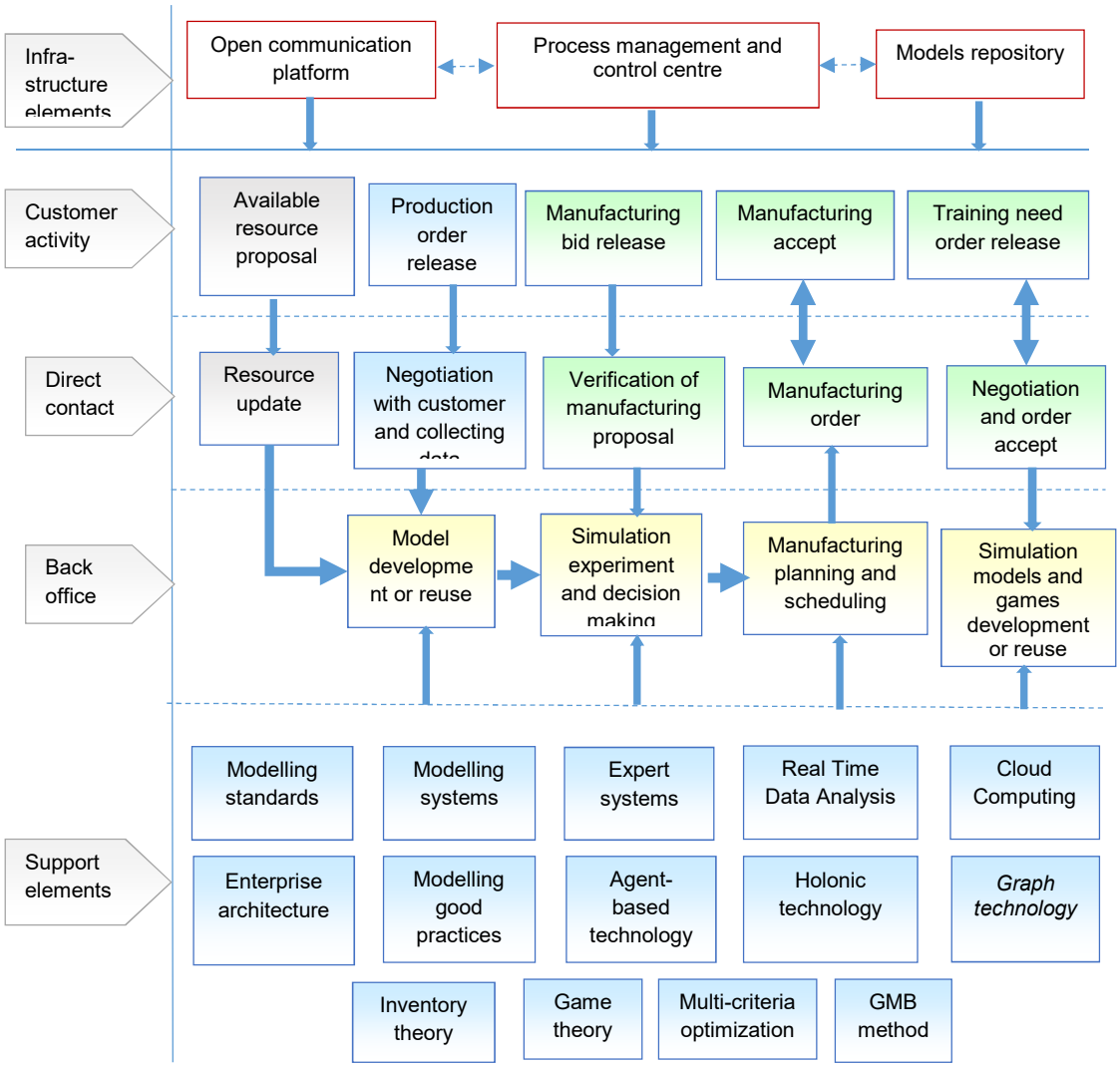

Figure 1. Service Blueprint process diagram of the cooperation process concept in DM network.

By complex simulations and multi-factor analysis suggested to develop in the research project, it would be possible to determine efficiency and effectiveness of resource and task or work allocation within manufacturing shop floor or line structures, modifications in product design and technology selection. It will allow better organisation and reduction of planning and manufacturing cycle times in cooperative, network model of manufacturing, also an integration of manufacturing network organisation with 5PL partners delivering logistics services, and finally an increase of effectiveness and competitiveness of network (e.g. cluster) by an increase of activities' range.

4. Conclusions

The manufacturing network organisation, supported by multi-criteria decision support system with communication and knowledge modules, can select the best, optimal technology due to resource utilisation, and also hierarchy of alternatives to satisfy customer requirements. The overall system allows not only systematic structuring of technologies, but also transparency of decision making process with flexibility – in the case of manufacturing deadlock or lack of sufficient resources it is

possible to recommend an alternative technology with some manufacturing results comparisons in a scope of criteria. The goal of the project is also to develop and test some task allocation, planning and scheduling algorithms, to identify key factor criteria and reasoning rules for production decision support system, and finally to develop a prototype decision support system with necessary communication and knowledge oriented modules to be implemented in an example dynamic, distributed manufacturing and logistics network structure in cluster form..

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Keywords: *distributed manufacturing, business modelling, production planning.*

Genetic Algorithm for Solving a Real Life Vehicle Routing Problem

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1. Introduction

The Vehicle Routing Problem (VRP) is one of the classical optimization problem and its widely used as benchmark for testing capabilities of various solvers. Many different variants have been proposed as an extensions to the original problem defined in 1959 by Dantzig and John Ramser. The most popular are Capacitated Vehicle Routing Problem (CVRP) in which trucks carrying the goods that have to be delivered have limited capacity, Vehicle Routing Problem with Time Windows (VRPTW) in which deliveries must be made in a given time period of a day and Vehicle Routing Problem with Pickup and Delivery (VRPPD) in which goods have to be delivered from a depot to customers but can be also picked from customers and transported to other location (either another customer or the depot). Such extensions are also quite well explored by the researchers and efficient algorithms solving them are implemented in optimization libraries like OR-Tools. However, their combination still remains a challenge, especially when there are additional, nonstandard constraints. Such problems are called Rich Vehicle Routing Problems (RVRP) and refer to real problems occurring in logistic practice (Cruz 2014). On the other hand, in recent years there has been an increase in interest from business who, in the face of growing competition and rising transport costs, are trying to optimize its transport operations.

The article focuses on the problem of RHVRP, which is a combination of CVRP and VRPTW, and additionally includes limitations related to drivers' working time and preferences regarding means of transport. Additionally the fleet is heterogeneous, meaning that trucks have different capacity. Another restriction is number of points that can be visited by a single truck during a single route. The most commonly used method to solve such complicated problems are metaheuristics (Doerner 2010). A genetic algorithm was proposed to solve it, in which specially designed crossover and mutation were used.

2. Mathematical formulation

Mathematical formulation of the RHVRP problem in our case can be presented as follows (Perez 2019):

$$\min \sum_{k\in\mathcal{V}} \sum_{i\in\mathcal{N}} \sum_{j\in\mathcal{N}} c_{ij} x_{ijk} \text{ s.t.,}$$

$$\sum_{k\in\mathcal{V}} \sum_{j\in\mathcal{N}} x_{ijk} = 1 \quad \forall i \in \mathcal{C},$$

$$\sum_{i\in\mathcal{C}} d_i \sum_{j\in\mathcal{N}} x_{ijk} \leq q \quad \forall k \in \mathcal{V},$$

$$\sum_{j\in\mathcal{N}} x_{0jk} = 1 \quad \forall k \in \mathcal{V},$$

$$\sum_{i\in\mathcal{N}} x_{ihk} - \sum_{j\in\mathcal{N}} x_{hjk} = 0 \quad \forall h \in \mathcal{C}, \forall k \in \mathcal{V},$$

$$\sum_{i\in\mathcal{N}} x_{i,n+1,k} = 1 \quad \forall k \in \mathcal{V},$$

$$x_{ijk}\left(s_{ik} + t_{ij} - s_{jk}\right) \leq 0 \quad \forall i,j \in \mathcal{N}, \forall k \in \mathcal{V},$$

$$a_i \leq s_{ik} \leq b_i \quad \forall i \in \mathcal{N}, \forall k \in \mathcal{V},$$

$$x_{ijk} \in \{0,1\} \quad \forall i,j \in \mathcal{N}, \forall k \in \mathcal{V}.$$

The goal function is to minimize the total travel time. First constraint ensures that each customer is visited exactly once. Second constraint limit the capacity of the trucks. Next free constraints ensure that: each truck must leave the depot; after a truck arrives to a delivery point it has to leave for another destination; and finally, all trucks must arrive at the depot n + 1. Sixth constraint provides the relation between the truck departure time from a delivery point and the next point. Seventh constraint checks the time windows are observed. Unused trucks have their routes modelled as (0, n + 1).

3. Genetic algorithm

Genetic algorithm use integer representation in which subsequent routes for individual trucks are coded (natural representation as in Evolutionary Programming). This is partly a hybrid algorithm – in the final phase, points on the routes are optimized using the 2-Opt algorithm.

An exemplary representation for 3 trucks and 12 delivery point is shown in Figure 1.

1/1: 2, 7, 10,12
1/2: 1, 3, 4
2/1: 6, 9
2/2: 5, 11
3/1: 8

Figure 1. Route representation in GA.

We follow standard GA implementation with binary tournament selection and fix size of the population. However, we defined dedicated evolutionary operators to deal with the presented representation.

Crossing operator defined by us from two parents creates one child (default probability of use: 50%). Sequentially for all trucks and all routes: the best route for the truck in terms of route length is chosen from two parents. Points already set are skipped. Finally, the missing points are filled up to the capacity limit and the number of points allowed on the route. An example of the crossover operation is shown in Figure 2. Routes 1/1, 2/2 and 3/1 were copied from the first parent, remaining ones were taken from the second parent, but already existed points were omitted. In the last stage remaining points are inserted keeping the truck's weight limit.

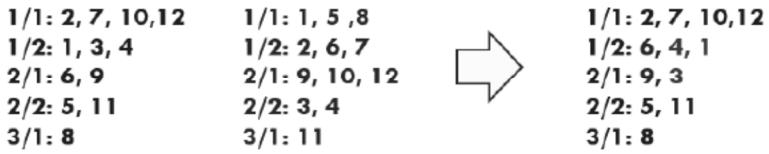

Figure 2. Crossover operator used in GA.

Three different mutations have been implemented.

(1) *MutSameTruck* – exchanging two randomly chosen points on two randomly drawn routes within the same truck, while maintaining the limit on capacity and the number of points allowed on the route; default probability of use: 15%

(2) *MutDifferentTruck* – exchanging two randomly chosen points on two randomly drawn routes of different trucks (restrictions must be kept); default probability of use: 80%

(3) *JoinRoutes* – connecting routes (if capacity and number of points on the route allow); default probability of use: 5%

The operation of all mutations is illustrated in Figure 3.

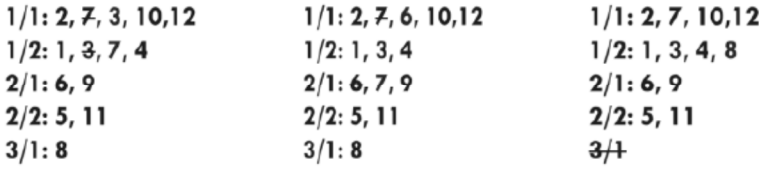

Figure 3. Three mutation operators used in GA.

4. Computational experiments

The proposed genetic algorithm has been tested on the data that were generated based on distributions simulating the real cases of one of the large retailers in Poland.

Three sets of problems were generated: 10 trucks and 50 delivery points (small size), 20 trucks and 100 delivery points (medium size), and finally: 40 trucks and 200 delivery points (large size). For each problem set 10 instances were randomly generated with different filling of overall trucks capacity (from 0.7 to 0.99). The time windows were also randomly generated from very tight ones (1 hours) to very loose (8 hours).

The results are gathered in Table 1:

Problem size trucks/points	**Average capacity filling**	**Average trucks used**	**Average time window violation**	**Average running time**
10/50	95.5%	8.8	0	42 sec.
20/100	91.4%	19.5	0.4 min	193 sec.
40/200	88.2%	39.9	15.2 min	621 sec.

As we can see for small problem sizes the proposed genetic algorithms works very efficiently. The average truck utilization is more than 95% and less number of trucks is used than available. For medium instances of the problem GA results are still good, however for some cases algorithm violated time windows. For larger instances GA algorithm more often generated results for which time windows were exceeded. Its running time raised to more than 10 minutes, which is still acceptable in practice.

We can see that there is still a room for improvement, especially for larger problem instances. One possible direction is to use local search to improve the best solutions in the population.

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Keywords: *rich vehicle routing problem, genetic algorithm, metaheuristics.*

A MILP Model for the Selective Solid Waste Collection Routing Problem

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Nowadays, in the European Union one of important responsibilities of municipalities is selective solid waste collection management. In Solid Waste Management (SWM) the main operational task is setting solid waste collection schedule and routes for waste collection trucks, so that the total costs of solid waste collection service can be minimized subject to a series of constraints which guarantee both fulfillment of obligations on solid waste management and desirable level of service quality. Optimization problem of waste collection trucks routing is a special case of the Capacitated Vehicle Routing Problem with Time Windows (CVRPTW) with following constraints: pickup nodes (clients) must be visited during their predefined time windows, the number and capacity of depots and landfills cannot be exceeded, each wast collection truck can be assigned to at most one depot, each route should be dedicated to the collection of a particular type of solid waste and the route must be served by a truck which can collect that type of solid waste, availability of trucks and drivers must be respected, each garbage truck must be drained at a landfill before going back to the depot. This paper contributes with a new MILP model for the Selective Solid Waste Collection Routing Problem (SSWCRP) with time windows, limited heterogeneous fleet, and different types of segregated solid waste to be collected separately. Results obtained for small and medium-sized instances of multi-depot garbage collection systems with time windows, limited heterogeneous fleet and different types of garbage are reported.

Keywords: *selective solid waste collection system, MILP, rich VRP, Solid Waste Management.*

Goal Programming Approach for Green Logistics in Food Distribution Companies

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This research presents a goal programming formulation of multi-objective green vehicle routing problem. The problem deals with green logistic for two food distribution companies. First one is located in the southern part of Poland and the second on is operating in northern part of Spain. Both companies deliver food in hills and mountain regions. Several goals related with G-VRP model are taken into consideration and validation. Implemented goals are responsible for finding optimal routes with consideration of the travelled distance by the running vehicles, the minimization of the negative environmental impacts caused by the fuel consumption, carbon emission and noise. Optimal number of trucks essential for fulfilling the demand is also considered in presented goal programming model. Constraints ensure that all vehicles begin and end their routes at the depot. The subtours solutions are going to be avoided. The results of computational experiments modeled after a real data from Polish and Spanish food distribution companies are reported for comparison. Analyses of obtained results could help decision makers to lead the initiative in the area of green logistics by saving money, time, fuel, minimizing pollution, and maximizing service level in delivery activities.

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Keywords: *Multi-Criteria Decision Making; Green Vehicle Routing; Goal Programming.*

Multi-Criteria Models for Green Logistics in the Western Pyrenees

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This research presents a mixed integer programming formulation of multi-criteria vehicle routing problems. The problems deal with green logistics for routes crossing the Western Pyrenees in Navarre, Basque Country and La Rioja, Spain. Several goals related with green logistics are taken into consideration and validation. The most significant objectives for finding optimal routes are the minimization of the travelled distance by the running vehicles, the minimization of altitude differences within the route, and the minimization of the negative environmental impacts caused by the fuel consumption, carbon emission and noise. Optimization models consist of bi- and triple-criteria formulations. Constraints ensure that all vehicles begin and end their routes at the depot. The subtours solutions are going to be avoided. Weighted-Sum approach and ε-Constraint method are implemented to solve multi-criteria green logistics optimization problems. The results of some computational experiments modeled after a real data from the Spanish food distribution company are reported. Analyses of obtained results could help logistics managers to lead the initiative in area of green logistics by saving fuel, minimizing pollution, maximizing service level and implementing backhauling for reduction of the amount of empty running in delivery activities.

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Keywords: *Multi-Criteria Decision Making, Green Logistics, Vehicle Routing, Weighted-Sum Approach, ε-Constraint Method, Mixed Integer Programming.*

Support of Decision-Making Under Risk by a Risk-Averse Decision-Maker

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The paper presents support of decision-making under risk by a risk-averse decision-maker. Decision-making under risk occurs when the outcome of the system is ambiguous and depends on the state of the environment. The decision-making process is modeled with a multi-criteria optimization problem. The decision support method consists of interactive conduct of the process of decision-making. The decision is made by means of solving a problem with controlling parameters, which determine the aspirations of the decision-maker and evaluating the obtained solutions. The decision-maker sets parameters, for which a solution is determined. Subsequently, he or she assesses the obtained solution, accepting or rejecting it. In the latter case, the decision-maker sets new values for the parameters and the problem is solved again. The present paper presents a discrete example of support of decision making under risk.

Keywords: *decision under risk, multi-criteria optimization, equitably efficient solution, decision support system.*

Multi Criteria Optimization Models for Green Logistics with Use of Electric vs. Diesel Trucks

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This research deals with multi objective optimization models for green vehicle routing problems by a mixed integer programming. Exact methods were implemented for computations. Real data instances from four food distribution companies located in Germany, Great Britain, Poland and Spain were used for computational experiments. Several goals related with green logistics were taken into consideration and validation. The most significant objectives for finding optimal routes are the minimization of the travelled distance by the running vehicles, the minimization of altitude differences within the route, and the minimization of the negative environmental impacts caused by the fuel consumption, carbon emission and noise. For comparison of environmental impact of road transport the electric vs. diesel trucks were considered. Optimization models consist of bi-criteria formulations. Constraints ensure that all vehicles begin and end their routes at the depot. The subtours solutions are going to be avoided with the use of Miller-Tucker-Zemlin subtour elimination constraints. Weighted-Sum approach and ε-Constraint method are implemented to solve multi-criteria green logistics optimization problems. The results of some computational experiments modeled after a real data from the German, British, Polish and Spanish food distribution companies are reported. CPLEX and GUROBI solvers were used for computational experiments. Analyses of obtained results could help decision makers to lead the initiative in area of green logistics: by using electric trucks, saving fuel, minimizing pollution, minimizing costs and optimally assigning truck fleet and drivers according to demand and obtaining reduction of the amount of empty running in delivery activities.

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Keywords: *Multi objective optimization, Green Vehicle Routing, Green logistics, Road freight transport, CO2 emissions, Mixed Integer Programming, Exact approach.*

Types of Natural Disruption Risk in Japanese Supply Chains

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Japan sits on the junction of four tectonic plates which exposes this country to a huge risk of earthquakes and tsunami. In addition, Japan location along the Pacific Ring of Fire is characterized by a large number of active volcanoes. Finally, Japan is regularly affected by typhoons because of its ocean surrounding.

The major Japanese landforms are chains of mountains that cover almost 80% of Japan area. The remaining rare plain regions are highly populated. All these circumstances cause various difficulties to choose non-vulnerable locations for manufacturers' plants and selection of their suppliers. Thus, the existing industrial supply chain networks in Japan are highly vulnerable to natural disasters that more frequently occur over recent years.

This paper discusses different types of major natural disaster risk that may severely disrupt supply chain networks in Japan and illustrates the presentation with real-world cases that occurred in the past.

Keywords: *Supply chain networks, Disruption risk, Natural disasters, Japan Archipelago.*

Stochastic Last-Mile Delivery with Crowdshipping

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1. Introduction

Sustainability concerns and the growth of e-commerce in recent years put pressure on companies to develop new business models to deal with last-mile delivery – the last stage of the supply chain, where a parcel is delivered to the final consumer. One innovative proposal follows the socio-economical idea associated to "shared economy" – it puts its foundations in a new delivery model where a professional delivery fleet is supplemented partially or fully with *crowdshipping*. Main idea of crowdshipping is to involve ordinary people in the delivery of packages to other customers who live on their route. In return casual couriers are offered a small compensation. Most papers addressing such delivery paradigms (either Wal-Mart or AmazonFlex) refer to same-day delivery. They combine delivery performed by casual couriers (CC) and a professional fleet (PF) in the following way: if some packages remain not assigned to CCs, they are delivered by the PF. In result, society benefits from reducing the number of freight vehicles (in the case of Wal-Mart) and companies reduces their total delivery costs (in both cases). A company's objective is to minimize the total delivery cost, i.e. the cost associated with performing delivery with the PF and the compensation paid to the CCs.

As the key to successful crowdshipping are adequate compensation schemes, in this paper we propose a new methodology to calculate adequate compensation values for CCs, taking into account the dynamics involved in the delivery process. For doing so, we consider several stochastic aspects associated to the problem and, accordingly, define a dynamic compensation mechanism.

Although this is an area yet to be explored, some problem variants have been addressed as matching and vehicle routing problems, among others by Agatz *et al.* (2011), Archetti *et al.* (2016), Arslan *et al.* (2016), Kafle *et al.* (2017), Dayarian and Martin (2017) and Gdowska *et al.* (2018).

2. Aim of the paper

Current models for vehicle routing problem with casual couriers consider a compensation scheme for the couriers where a certain amount is offered for a given task and assumed that CCs will accept that amount and execute the job. A more realistic model must consider some randomness in this process. Several facts should be taken into account: (i) there are no guarantees that a CC will accept the task proposed; (ii) it is likely that the probability of accepting a task increases with the amount offered; (iii) the optimum amount that should be offered for a given task depends on the costs incurred by the company, and hence depends also on the current solution.

As an example, consider a problem in one dimension. If a company located at $\mathrm{x} = 0$ has to do deliveries to customers on $\mathrm{x} = -5$ and $x = -10$, it probably should not propose a delivery at $x = -7$ to be crowdsourced; however, a delivery by a CC to a customer at $x = +10$ should be incentivized, as it will clearly reduce costs incurred by the companies fleet.

The aim of this work is to tackle the vehicle routing problem with casual carriers with a stochastic approach. We informally describe the model, propose a heuristic method, and delineate a prototype implementation for a dynamic compensation scheme in a LMD system with crowdshipping.

We report and analyze preliminary results, based on small instances adapted from the literature. As real-world data is not currently available, our purpose is to illustrate the feasibility of the approach and to identify potential bottlenecks, as well as highlight difficulties that may arise in terms of data collection.

3. Methodological aspects

We adopt as a point of reference for this work the integer programming model for the Vehicle Routing Problem with Occasional Drivers (VRPOD) presented in Archetti et al. (2016). In that work, a static compensation scheme with predetermined values is adopted, taking as granted that a CC will deliver any task assigned. Instead, we consider that each CC is an independent agent, who will accept a given delivery with some probability based on its own destination, on the customer's location, and on the compensation amount. We also consider that each casual courier is allowed to deliver as most one package.

We assume that there is a set of potential CCs to whom the company may propose a delivery task. After observing the subset of CCs that accepted the task, the company will solve a routing problem for the yet-unserved customers with the professional fleet. This is hence a bi-level optimization. The decision variables for the company are: the customer to assign to each CC (if some), the corresponding compensation amount, and the order of visit for the expected remaining customers in the first level; the (deterministic) order of visit of the remaining customers in the second level.

We propose a simulation-based optimization approach. The initial solution assumes no CC involved, and a local search method, where in each iteration either a customer served by the professional fleet is assigned to a CC, or an assignment of a customer to a CC is dropped. For a given assignment, the number of simulations necessary to have valid statistics on the expected cost is run. The compensation amount proposed to each task assigned to CCs is determined locally, based on the savings due to this assignment expected on the current solution.

4. Concluding remarks

The main contribution of the paper is an original and innovative dynamic compensation scheme methodology for LMD system with crowdshipping. The goal is to influence a potential CC to accept delivery tasks to particular locations because of the value of the offered compensation fee what, in turn, affected the total cost savings. Since the paper refers to pilot research on dynamic compensation fee scheme for a LMD system with crowdshipping, for simplification purposes the methodology considered that each available CC could be assigned at most one delivery task at one go. But this still represents a significant contribution to the state-of-the-art and dynamic compensation fee schemes have huge potential.

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