Jacek Szołtysek
Grażyna Trzpiot
University of Economics in Katowice

ASSIMILATION OF QUALITATIVE ANALYTICS METHODOLOGY FOR LOGISTICS MANAGEMENT

Introduction

Logistics as a task supporting economic activity, made its presence felt in Europe after the II World War. It gave an answer to the question nagging manufacturers of how to fend off ever-fiercer competition and address ever-decreasing consumer demand. Moreover, end-customers have become ever-demanding partners, who ceased to care solely about the quality and price. They learned to appreciate other product features, such as availability, time to completion and accompanying conveniences e.g. home deliveries. Logistics flourished during sixties and seventies of the last century, mainly finding applications in manufacturing organisation, whereas during eighties and nineties it was trialled to unite logistics processes under joint management on an intra-organisational scale – supply chains and networks were formed. Pragmatic search for economic benefits coincided with that development, in an attempt to monetise logistics approach put into practice.

Real-life implementations – orchestrated by hands-on managers, who sourced their ideas from achievements of military logistics – were closely followed by theoreticians. Their task was to generalise practical experiences, mostly to prepare curricula for educating aspiring logisticians – individuals trained in streamlining material flows within so called logistics systems. The work of theoreticians has generated, apart from valuable papers many misconceptions, particularly touching on:

1. nature and essence of logistics, attempts for its original definitions,
2. potential range of applications for logistics, merit (or lack of it) behind propagating logistics to other areas of life,
3. origin of methods, tools and their scope of application,
4. self-sufficiency and independence of logistics from other theoretical and practical fields.
5. connection between business logistics and military logistics,
6. impact of logistics on other branches of science.

In our opinion, search for identity of logistics[1], quite intense recently, gives evidence to overall sentiment of sincerity behind finding and distilling the very essence of this branch of science (thoroughly practical), and thereby proving the purity of logistics.

An author should not concentrate on defining logistics. Instead, they should demonstrate how logistics and numerical tools were developed, and whether those phenomena can be mutually stimulating and inspiring.

Logistics development trends and numerical tools

Military logistics

Historically, logistics was first used in the art of war. The ancient Chinese military treatise entitled The Art of War, attributed to the great Chinese commander Sun Tzu (544-496 BC), bears first signs of logistics tasks. In his deliberations, he postulated that military actions should be planned in a manner which would protect the national economic potential from destruction. He also characterised some ground rules for organising military resource management in terms of e.g. food rationing, using local resources, time management and use of space[2]. Other ruler – Byzantine emperor Leo VI the Wise also made references to logistics. In his literary work entitled Tactica, he distinguished logistics as a military science, apart from strategy and tactics, which predominantly dealt with infantry formations[3]. Mostly commonly though, The Art of War by Baron de Jomini published in Paris in 1837 has become acknowledged as the primary theoretical source for military logistics. In the sixth chapter of the work Logistics, or the practical art of moving armies, he bestowed impor-

[1] J. Szołtysek: *Problemy tożdiestwiennosti logistyki*. In: Praci Odeskogo politechnicznogo universitetu, 2011. Wip. 1(35), p. 278-282, Odessa 2011 (Ukraine).
[2] Sun Tzu: *Sztuka wojny.* Wydawnictwo Przedświt, Warszawa 1994.
[3] F.J. Beier, K. Rutkowski: *Logistyka*. Szkoła Główna Handlowa, Warszawa 1993.

tance to logistics, which propelled it to civil sciences. The general elaborates in his literary work on location and inventory supplies, planning and orchestrating marches, preparation of means of transports, assembling routes and supplies to troops[4]. The I World War has shown, how important military logistics really is. According to an English military historian, J. Keegan, all sides involved equally struggled with logistics, and all suffered defeat in that field[5]. When the II World War commenced, it had major impact of development of military logistics, which provided transport and supply processes. As the aforementioned J. Keegen claims, it was the logistics in tandem with the arms industry which were centrepiece to Allies victory in that single biggest military conflict in human history.

The burning issue of warfare is the material supplies. Those problems, on a different scale, are affecting modern military action, which requires ever--sophisticated set of tools.

Intensive development of logistics over the course of II World War was made possible by logistics officers being provided with decision support tools. Operational research was an important group. It was initiated in United States and United Kingdom, originally as a method enabling better decision-making in logistics training planning. Among other, it was confirmed that large convoys were safe.

Operational research is an academic discipline related to decision theory, which enables pinpointing a method and the solution to some issues concerning making an optimal decision. Historically, operational research traces its origins back to scientific management. Currently it has been acknowledged as a part of the decision theory. The classical decision theory deals with decision analysis and decision support. *Decision analysis* concentrates on a single case decision, made by an individual or a group. The analysis involves finding an optimal decision, and in case of wrong decisions, its origins are traced back. As far as decision support is concerned – we make an attempt to find the best solution based on certain knowledge and information resources about possible consequences. The same applies to group decision making.

W. Grudzewski[6] claims that "from the viewpoint of practical management, operational research is perceived as a scientific theory, which enables building models based on identified quantifiable situations and solving those models

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[4] Ibid.

[5] J. Keegan: *Historia wojen*. Książka i Wiedza, Warszawa 1998, after: M. Sołtysik: *Uwarunkowania logistyki w łańcuchach dostaw.* In: Logistyka. Ed. by D. Kisperska-Moroń, S. Krzyżaniak. Instytut Logistyki i Magazynowania, Poznań 2009.

[6] *Badania operacyjne w organizacji i zarządzaniu*. Ed. by W. Grudzewski. Państwowe Wydawnictwo Naukowe, Warszawa 1985.

for effective decisions, which would fulfil taken technical, economic and social criteria". T. Kasprzak[7] defines operational research by identifying discriminants characteristic for a given academic discipline. She gives the basic three:
– subject matter – strategic and tactical decisions,
– applied methods – decision modelling,
– approach to the problem – systemic analysis of decision modelling and preparation.

There are various decision modelling methods, including mathematical modelling i.e.: linear programming, discrete optimisation, zero-one programming, targeted programming, quadratic programming, non-linear programming and dynamic programming.

The aforementioned methods were among some of the first mathematical methods deployed practically. Mathematical programming is widely used in e.g. production cost structure optimisation. In terms of its first applications, operational research was employed to shed some light on problematic areas, where for some reasons decision-making was riddled with difficulties. Among those reasons are:
– high multi-variability,
– complicated decision situation (drafting rules, high service level at the lowest cost possible),
– possibility of high profits or high losses (decision on the best goal possible),
– complicated decision-making process (group decision making),
– weight of decision problem.

The above-mentioned examples show that decision theory methods are deployed everywhere where they provide bottom line value (both material and immaterial). Military operations rely on the following tasks: supplies (all--encompassing both at the front and in life), transport planning (broadly defined – for instance, historically long-haul to Normandy, today fresh food). Effectiveness of delivering those tasks rests on well-planned logistics, scheduling (of operations) etc.

Every real problem contains criteria narrowing down possible decisions. In first military applications, limited fuel supplies were those criteria. The possibility to pertinent optimisation framework to support decisions was used – transport underwent optimisation. Deployment of operational research methods proved crucial to military successes.

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[7] T. Kasprzak: *Badania operacyjne i systemowe teorie decyzji.* Katedra Cybernetyki i Badań Operacyjnych, Wydział Nauk Ekonomicznych Uniwersytetu Warszawskiego, Warszawa 1987; T. Kasprzak: *Badania operacyjne w nowoczesnym zarządzaniu.* Państwowe Wydawnictwo Ekonomiczne, Warszawa 1974.

In discussed field, logistics – through new and developing mathematical methods – is seemingly the main driving force, at least partly, behind the set of tools used in decision making. Potency of the military sector, its financial and organisation backing, did and still does provide main thrust of development and finding new application areas for logistics.

Business logistics

From the outset, business logistics attempted to integrate conceptually (and subsequently implement those solutions to) all areas of business activity related to flow of materials and information, and occasionally – financial flows. Initially, logisticians focused their interest on areas which were deemed mostly inefficient – issues related to material supplies and distribution. Both those areas are tightly connected with flow of materials, but they are also shaped by consumer demand and marketing influences. Hence, decisions made by logisticians ranged from day-to-day issues related to efficiency of material supplies, storage and arrangement of inventory, inventory levels to interdependency of neutral material flows (i.e. inventory) and different aspect of material flows. If finished output was to be approached as company material inventory, then the problem of distribution could be defined in a similar fashion. Logistics was supported back then (and nowadays) by optimisation[8] of logistics tasks and goals.

One of the most important features characterising objectives of optimisation – part of operational research – is utilisation of models. Mathematical model[9] plays a special role. By means of mathematical concepts it brings described system into quantities of interest. Three fundamental requirements a model has to fulfil are worth pointing out. It should[10]:

- give exact account of decision problem,
- correctly represent links between individual,
- elements of modelled system and its surrounding,
- be free of insignificant details.

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[8] Optimisation is a method of finding best (optimal) solution (mathematically, extremum of the function is found) with regard to selected quality (e.g. cost, routes, efficiency, time) criterion (factor). Historically, finding minimum was first attempted by G.W. Leibniz (1646-1716) and L. Euler (1707-1783), which gave grounds for optimisations used by I. Newton (1643-1727), J. Bernoulli(1655-1705) and D. Bernoulli (1700-1782). Mathematical grounds were laid by J.L. Lagrange (1736-1813) and W.R. Hamilton (1805-1865). The method of using approximation to find extrema of certain complicated functions was devised by L. Rayleigh (1842-1919), W. Ritz (1878-1909) and B.G. Galerkin (1871-1945).

[9] S. Krawczyk: *Matematyczna analiza sytuacji decyzyjnych*. PWE, Warszawa 1990.

[10] H.M. Wagner: *Badania operacyjne*. PWE, Warszawa 1980.

This approach to modelling stems from the fact that finished model is not only subject to some general deliberations on links between its elements and surrounding devoid of functional links, but also at latter stages it is used for optimisational computations, concluding with a real-life solution. Strong connection between practical issues and their models, force a research team to build models, which could be described by mathematical models, algorithisated and be fit for numerical experiments. Building such model usually involves three stages[11]:
- determining the weight of decision problem,
- deriving the conceptual model,
- formalisation of conceptual model into a mathematical model.

Bearing in mind the above-mentioned information one should note, that over the course of building a model, a situation might arise, where the model created seems redundant in practical applications. Effectively, development of those models is ceased and they are not used in day-to-day management.

Deploying well-structured models should be justified by relevant potential benefits, i.a.:
- it facilitates comprehension of system's operating principle,
- it enables repeatable empirical observations and drawing pertinent conclusions, and theoretical assumptions about the system to be verified,
- enables concentrating attention on given elements of system and their impact on the entire modelled system,
- accelerates required analyses,
- determines and facilitates testing desired system modifications,
- enabled investigating decision variables in terms of their impact on the entire modelled system,
- is more cost-effective than direct system analysis.

Today, widely used in decision-making mathematical optimisation methods[12] are the following: network programming, stochastic programming, game theory, stochastic programming, game theory, queuing theory, inventory theory, calculus of variations, functional analysis methods, transport issues (transport algorithm), travelling salesman problem.

Attempts by the manufacturing lobby striving to elongate the production process through long production batches, over-stock finished output and pushing it downstream through the distribution chain so that the end-customer would be provided with a low-cost unified product, failed miserably. Consumer pull for highly-individualised products started to be ever-stronger. To meet that demand, the benefits of integrated logistics on a wider scale were called upon. Integration commences within a single organisation, then expands to multiple organisations

[11] T. Kasprzak: *Badania operacyjne i systemowe teorie decyzji*..., op. cit.
[12] S. Krawczyk: *Metody ilościowe w planowaniu (działalności przedsiębiorstwa).* Academia Oeconomica, C.H. Beck, Warszawa 2001.

by linking them together in a supply chain, then a network and ultimately they are all perceived as a meta-organisation[13]. Joining forces logistically over larger areas, effectively increasing the number of variables, which have to be taken into account to make a quality decision, entailed handling dynamically changing quantities, representing the actual as-is state. It also meant factoring in historical data (accumulated in organisation systems, usually in an uncoordinated manner, grouped around divergent goals, and formed differently thus incompatible with each other), and forecasts. For a long time, that systemic approach was impossible within meta-organisations, due to shear number of variables, exceeding human ability to draw correct conclusions from complex data. This changed, when computer aided support became affordable and publicly available. It was based on network connectivity and network data exchange. Sharing data by different entities, its accumulation and concurrent usage (including processing), required the risk to be shared as well. That in turn meant a novel value in business – trust among competitors. The notion of coopetition has already firmly sunk into business dictionaries, but it failed to spread around businesses. Both the supply chains and networks, which emerged to manage those businesses use state-of-the-art tools for decision support. The practice of how either functions, shows high usefulness of multi-criteria optimisation methods[14]. Multi-criteria optimisation is used in a range of fields[15]: designing product and production process, finance, air plane designing, chemical industry, car design. Essentially everywhere, where decision-making requires compromises between mutually exclusive goals. Examples of multi-criteria optimisation include profit maximisation and cost minimisation, efficiency maximisation and low fuel consumption, as well as decreasing equipment weight whilst increasing each component strength.

Supply chains and networks having been identified as practical aspect of commercial activity raised a range of doubts among logisticians over its interpretation. To a large extent, they started to identify logistics chains and networks with a much wider scale phenomenon of supply chains and networks[16]. Managing a supply chain requires other aspects than logistics to be taken into account (e.g. related to retail, marketing, environment, technology and social aspects as well).

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[13] More on the subject: J. Szołtysek, S. Twaróg: *Kształtowanie systemu logistycznego meta-organizacji*. In: *Logistyka. Współczesne wyzwania*, nr 2. Ed. by J. Szołtysek, B. Detyna. Państwowa Wyższa Szkoła Zarządzania im. Angelusa Silesiusa w Wałbrzychu, Wałbrzych 2011, p. 37-52.

[14] Practical applications include both single-criteria and multi-criteria optimisation.

[15] E. Konarzewska-Gubała: *Programowanie przy wielorakości celów.* PWN, Warszawa 1980.

[16] Serve as an example can definition of logistics given by A. Harrinson, R. van Hoek: Logistics is the task of managing material flow and information flow in a synchronous way without interruptions throughout the whole supply network (A. Harrinson, R. van Hoek: *Zarządzanie logistyką.* PWE, Warszawa 2010.

Multi-criteria optimisation also requires reaching further, past financial analysis, by factoring in technical, technological, organisational, environmental and social aspects. The decision on choosing an alternative, also necessitates to investigate each alternative's impact on the entire system. Their positive, negative or neutral influence has to be recognised. Positive aspects will include benefits and opportunities, whereas negative factors related to costs and risk. Unfortunately, the aforementioned aspects are rarely quantifiable thereby difficult to evaluate. Many variables and criteria are often rated on fuzzy rating scales. Cases of multiple decision evaluation criteria are analysed by sub-discipline of decision theory called multi-criteria decision analysis[17]. There are two definitions of the multi-criteria problem under the multi-criteria decision analysis.

– multiple criteria decision making (MCDM) – used by American academia,
– multiple criteria decision aid (MCDA) – mostly used in Europe.

Those methods enable multiple criteria to be aggregated to solve the issue of choosing a ranking scale or describing available alternatives in different disciplines. One of those methods is the Multiple Criteria Decision Making (MCDM), multi-criteria decision support methods. MCDN methods are a modern sub-discipline of operational research, which are developed and implemented as tools for supporting the decision-making process. Currently, they are centrepiece to decision procedures. There are:

1. MODM Multi-Objective Decision Making Methods,
2. MADM Multi-Attribute Decision Making Methods – also referred to as Discrete Multi-criteria methods[18].

MODM methods investigate decision problems, where the set of all permissible decisions is a continuous set, containing infinite number of feasible alternatives (solutions). Those problems are described by a set of quantifiable objectives, which underpin the decision and a set of predefined restrictions on values of possible alternatives' decision variables. As far as MADM methods are concerned, their distinguishing feature is a limited and small number of predetermined alternatives, which are selected based on fixed criteria, which not necessarily have to be quantifiable. Because problems of that nature are quite

[17] French-Italian economist V. Pareto (1848-1923), formulated multi-criteria optimisation framework for economic issues, which later was named Pareto optimality. In layman's terms, a solution is Pareto optimal, if it is not possible to find a better solution with regard to at least one criterion, without having to compromise others.

[18] T. Trzaskalik: *Wprowadzenie do badań operacyjnych z komputerem*. Wydanie 2. PWE, Warszawa 2008.

common, the following methods were devised to resolve them: PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluations), ELECTRE (Elimination Et ChoixTraduisant la Realite), TOPSIS (Technique for Order Performance by Similarity to Ideal Solution), SMART (Simple Multi Attribute Rating Technique), AHP (Analytic Hierarchy Process), ANP (Analytic Network Process).

The AHP method is one of the most frequently used mathematical methods world-wide. This method enables comparison between quantitative and qualitative criteria[19]. In order to select the best alternative, its positive and negative impact has to be factored in. The AHP method uses the BOCR analysis for that purpose (*benefits* (*B*), *opportunities* (*O*), *costs* (*C*) and *risks* (*R*)).

Among various multi-criteria optimisation methods, particularly interesting are:

1. *Weighted Objectives Method* – it involves bringing multi-criteria optimasation to single objective optimisation assigning weights to the different criteria by introducing an equivalent criterion – sum of weighted criteria.
2. *Hierarchical Optimization Method* – it also involves bringing multi-criteria optimisation to single objective optimisation carried out with respect to all criteria.
3. *Trade-Off Method*, e-*constraint Method* – this *a priori* method involves fixing value levels permissible for each criterion, consequently restricting feasible solutions space. A multi-criteria optimisation problem is brought to a problem of optimisation with regard to selected criterion constrained by other criteria.
4. *Global Criterion Method* – here criterion formulation for single objective optimisation is solved for an approximate solution (an extremum for criteria studied on an individual basis might be the solution).
5. *Method of Distance Functions*, *Min-Max Method* – similar to the global criterion method, where at preliminary stages of the procedure approximate solution (or ideal) is selected by minimising the distance between the ideal solution and the optimum solution (Method of Distance Functions) or according to the Min-Max Method by minimising maximum deviations of optimal solution from the approximate solution.

[19] *Metody wielokryterialne na polskim rynku finansowym*. Red. T. Trzaskalik. PWE, Warszawa 2006.

6. *Goal Programming Method* – is a general multi-criteria optimisation technique. Here, criteria are viewed as objectives, which are to be achieved or thresholds, which could not be exceeded by criteria.
7. *Utility Function Method* – known from economics[20], this method uses the heuristically determined utility function, additive with regard to investigated criteria.
8. *Evolutionary Algorithms* – are a group of methods amongst artificial intelligence techniques. Their usefulness becomes apparent only in case of problems, where the number of feasible Pareto optimal solutions can reach high numbers (order of thousands or more). Then, traditional methods are less effective than evolutionary algorithms.

All the above-mentioned methods are similar in the way the solutions are selected. In order to solve for solution, the initial multi-criteria problem is brought to an equivalent problem in terms of predetermined procedure. Consequently the problem presents less of an evaluational challenge. Every different type of application requires thoughtful selection of the way tasks are delivered and methods chosen. Various fields of practical applications are tested by those algorithms. For instance, transshipment of food at a vast seaport or flight plans compiled by airlines require different approaches due to possible consequences of incorrectly evaluated solutions by any particular algorithm. Of course, testing of those tools is only possible owing to development of information technologies and database-enabled software, capable of storing terabytes of data (e.g. the SAS system). Moreover, it is not a field limited neither to practitioners nor formal methods proposing novel solutions. Software development has also opened new opportunities in that respect.

Social logistics

The beginning of XXI century was marked by anticipation for numerous changes. P.F. Drucker[21] was the author of the new management paradigm for the XXI century. Most notably, informatisation and globalisation became much more prominent as did human, who is ever-often seen as a valuable asset. The same human, is on one hand said to long for individual utopian happiness, devoid of interpersonal relationships, barren of love and truth, deficient in responsibility and common sense – a sheer axiological, moral, spiritual void,

[20] G. Trzpiot: *Multicriterion Analysis based on Marginal Conditional Stochastic Dominance in financial analysis*. In: *Multiple Objective and Goal Programming*. Ed. by T. Trzaskalik, J. Michnik. Advances in Soft Computing Series, pp. 401-412, Springer Verlag Company 2002.
[21] P.F. Drucker: *Zarządzanie XXI wiekiem*. Muza SA, Warszawa 2000.

where personal beliefs are redundant. But on the other hand, great emphasis is put on the fact, that human is the fundamental building block of society, the source and the ultimate purpose of social life. Such perception allows to protect human dignity and statutory human rights across the board. People have to be a part of society, and social structures are created to empower and enable people to fulfil their lifelong aspirations. That perhaps a bit lengthy disquisition was brought up, to justify the importance of logistics support in ever-growing number of socially beneficial activities, often determining their success. Normally there would not be anything surprising about it, however, it sparks the need to reflect over such use of logistics, which diverges from already explored applications – often referred to as classical (military and business). The aforementioned transition involves shifting the usual bundle of goals thereby influencing the way material flows are shaped. Although military and business applications of logistics have never compelled logisticians to spare a thought, and diversity of approaches to decision-making was perfectly justifiable, doubts arose among theoreticians over social applications of logistics. They questioned the rationale behind distilling that potential new field shaping logistics decisions as a separate subjective scope. Rejecting the idea presents least hardship in addressing a few aforementioned problems, in particular:

7. could we distil the field of social logistics, is it necessary,
8. should people be included as part of material flows,
9. are there really differences in how bundle of goals is created, and consequently are they significant compared to conventional applications,
10. are tools used by classical logistics any different (divergent).

Without going into too much detail about the definition it is worth noting, that social logistics as a new field of application for logistics – requiring a new approach to issues on the table – gains ground both in Poland[22] and beyond. It is

[22] First papers concerning the subject emerged at Asian scientific centres (e.g. Takahasi Teuro, *Planning of Social Logistics*, Bulletin of the System Science Institute, Waseda University 1988; Liao Wei, He Zhenggang, Zhang Jin: *Correlation Analysis of Social Logistics Demand and Economic Activities*. International Conference of Transportation Engineering 2009, Vol. II, ASCE, USA 2009), in USA it attracted attention (e.g. Jay Deragon, *Social Logistisc and Productivity*, Conversational Currency. The New Paradigm, 14.04.2010), Europe (e.g. Sirpa Tenhunen, *Mobile Technology in Village: ICTs, Culture, and Social Logistics in India*. „Journal of the Royal Anthropological Institut" 2008; J. Szołtysek, P. Kołodziejczyk: *Epistemologia logistyki społecznej*. „Przegląd Organizacji" 2009, No. 4, pp. 21-24; J. Szołtysek: *Typologia obszarów stosowania logistyki – propozycja rozwiązania*. „Gospodarka Materiałowa i Logistyka" 2010, No. 8, pp. 2-6; J. Szołtysek, S. Twaróg: *Establishing of an objectives bundle of modern supply chain management. Conditions o social logistics establishment, Czestochowa University of Technology* 2011; J. Szołtysek: *Socialnaja logostika – novoje napravlenije razvitija teorii i praktiki logistiki*. „Logistics and Supply Chain Management" 2011, No. 2(43), pp. 13-18 (Russia)). Global concerns also seem to have started care about their social footprint (e.g. DHL intends to reduce congestion in cities by creating local courier services).

worth pointing out here, that among those applications is urban logistics, logistics concerning broadly defined safety (e.g. mass events, gatherings, waste management, humanitarian aid), leisure and recreation (sporting events, journeys, tourism) and health care (hospitals, blood donation, transplantology, sanatoriums) and to sustain democracy (e.g. electoral organisation).

Described in previous item multi-criteria methods can be deployed provided one assumption is made – scores assigned to optimisation criteria are clearly defined and are deterministic. In reality, this assumption is not always true. The information about scores is generally approximate, subjective[23], fuzzy[24]. Thus a number of methods were derived, which use non-deterministic scores[25]. Among those the most note-worthy are cognitive decision theories, which seek sufficient/effective solutions for so called *real world problems* and *ill defined problems*. Descriptive approach reflecting a typical human behaviour when being presented with a decision situation. The impact of personality traits on decision-making is taken into account, e.g. selection of subjective evaluation criteria for individual alternatives, risk propensity[26]. Social criteria are also investigated: decision maker's rank within the organisation, impact of management style, group decision making and related conflicts[27].

Additional aspect comes in form of hidden variables (*hidden/latent variable*) – variables that are not directly observed but effect directly other variables that are observed. The difference between a hidden variable and a model parameter lies in constant value a parameter takes across the sample, or at least a major part of it. Hidden variable in turn varies for different observations. That has great importance in social logistics research. Some statistical methods are meant to reproduce hidden variables occurring in those models. For instance factor analysis and PCA assume descriptive variables to be linear combinations of hidden factors.

Those methods are particularly useful in social logistics, due to the objective being different i.e. the human well-being. As far as decision-making is concerned, apart from classical quantities (available resources, service level, costs etc.) a new immeasurable quantity emerges in form of broadly defined human

[23] M. Zawisza, G. Trzpiot: *Multicriterion Analysis based on Stochastic and probabilistic Dominance in measuring quality of life*. In: *Multiple Objective and Goal Programming*, ed. T. Trzaskalik, J. Michnik: Advances in Soft Computing Series, pp. 413-424, Springer Verlag Company 2002.

[24] T. Trzaskalik, G. Trzpiot, K. Zaras: *Modelowanie preferencji z wykorzystaniem dominacji stochastycznych*. Akademia Ekonomiczna w Katowicach, Katowice 1998.

[25] G. Trzpiot: *Statystyczna analiza danych*. Uniwersytet Ekonomiczny w Katowicach, Katowice 2011.

[26] T. Szapiro: *Co decyduje o decyzji?* PWN, Warszawa 1993.

[27] T. Tyszka: *Decyzje. Perspektywa psychologiczna i ekonomiczna*. Scholar, Warszawa 2010.

well-being. Consequently, the thus far mentioned models are insufficient for the decision-maker. In turn, the methods reflected upon throughout this section of paper are used in different disciplines e.g. sociology and psychology (e.g. examination of stressors). Provided decision-making in social logistics is founded on hidden, intangible premises, the above-mentioned methods should fundamentally improve its effectiveness, as they adhere better to sensitive mature of social intricacies.

Conclusion

Development of logistics keeps up the pace of changing social needs. References originating from military applications and emulated successfully by business undergo constant modification, which takes account of shifting bundle of goals and consequently – different way decisions are made. The process of expanding logistics applications to social objectives – as part of applications emerging for social logistics – is subject to the same ground rules of development, as previous forms of logistics were. Mathematical methods – as constituents of tools supporting decision-making – undergo constant development independently of logistics itself, however, they work perfectly fine in described field. An assumption can therefore be safely made, that concurrent development of discussed tools and logistics enables effective assimilation of qualitative analytics methodology for logistics management.

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