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QUANTITATIVE METHODS FOR SUPPORT OF MANAGERIAL DECISION-MAKING IN LOGISTICS

Vladimira Vlckova[1], Filip Exnar[2], Otakar Machac[3]

University of Pardubice, CR-53210 Pardubice, Studentská 95, Czech Republic
Email: [1]vladimira.vlckova@upce.cz; [2]filip.exnar@upce.cz; [3]otakar.machac@upce.cz

Abstract. The present entrepreneurial environment can be characterized by the speed of changes, rapidly developing ICT, and application of differentiated CRM, particularly in the area of logistics services. These all place high demands on the speed and optimization of all material flows not only within the company, but also in the entire supply chain, where quantitative methods can play an important role. The paper deals with their utilization, especially in the chemical industry enterprises in the Czech Republic. It is based on the outcomes of the recently carried out survey and on the authors' experience with the given problems from the business practice. The paper aims are to make an overview of quantitative methods suitable for application in individual areas of logistics management, to show preconditions that have to be met for their application, and particularly to specify the main barriers preventing more effective utilization of these methods in the corporate practice.

Keywords: quantitative methods, optimization of material flows, decision-making, logistics, chemical industry enterprises.

Jel classification: L65, M19, C89

1. Introduction

What is most important for the present well-informed and demanding customers while deciding about purchase are availability, quickness of reaction and the provided services. A significant condition for a business to be successful on the market is thus the supplier's ability to meet the customer's requirements to their full satisfaction. At the same time, the typical features of the present markets are changeability, high rate of change dynamics, difficult predictability, globalization, international migration, progress in the areas of information and communication technologies, transport development, bigger emphasis on the environment and creation of networks. All these factors significantly affect logistics and supply chain management. However, isolated introduction of logistics solutions or a solution to just one area of problems in the logistics chain has only limited effectiveness, and so it is necessary to achieve overall optimization, coordination and synchronization of all the activities within the logistics chain related to the key activities. Changes in area of logistics are important part of restructuring changes in business area (Tetřevová 2003). Progressive methods are being developed and applied in logistics using modern information and communication technologies, economic entities are being distinctly interconnected in networks, logistics costs are being thoroughly monitored and optimized through integration of purchase, production and distribution, coordination and cooperation not only with the customers but also with the suppliers are being deepened. All the above activities are aiming to achieve synergic effects. An important role is, without any doubt, played by quantitative methods as a tool supporting the management decision-making. That is why the survey focused on monitoring changes in the logistics management of the chemical industry enterprises in the Czech Republic included separate research of very closely linked topics in the area of utilization of logistics technologies, information systems and quantitative methods for management of logistics processes. The survey was carried out in the form of written questioning within the diploma thesis in 2010-11 (Kubínová 2011).

The questionnaire was emailed to 82 production companies from which 11 were chemical industry businesses. However, even though they were sent by e-mail repeatedly, the rate of returned questionnaires was only 20%. (The filled-questionnaire was returned by 16 companies, from which 11 were chemical industry

Table 1. Overview of used quantitative methods for logistics processes management (Adapted by authors using data from Kubínová 2011)

Do you use any quantitative methods and optimizing or simulating models for management of your logistics processes in the following areas?				
Answers	**YES**		**NO**	
Optimization of inventory and warehouse management	**6**	3	**5**	2
Optimization of manufacturing planning (range of products, size of bath, order matching etc.*)*	**4**	4	**7**	1
Demand and sales forecasting	**4**	3	**7**	2
Optimization of transport	**4**	1	**7**	4

The numbers of companies of chemical industry are in bold

businesses, 3 food industry businesses, 1 metal-working company, and 1 ceramics producer). Low return of the questionnaires in combination with the used method of written questioning, big diversity of the respondents (from small companies to large corporations with multinational management), did not make it possible to generalize the outcomes. By completing the survey with the authors' personal experience acquired within other surveys, carried out, above all, through in-depth interviews with logistics managers in the chemical industry enterprises in the Czech Republic, it is possible to make a relevant idea of the explored problem. For the resulting answers to the question whether the companies use quantitative methods and optimizing or simulating models for management of their logistics processes, see the table 1.

The outcomes showed that these methods are used only in about one third to a half of the companies. They are mostly used for inventory and warehouse management (a positive answer by 56% respondents), and less for optimization of manufacturing and transport planning, and least for the demand and sales forecasting (only 31% respondents).

The paper aims are (i) to make an overview of quantitative methods suitable for application in individual areas of logistics management, (ii) to show preconditions that have to be met for their application, and (iii) particularly to specify the main barriers preventing more effective utilization of these methods in the corporate practice. Being aware of these barriers then means better chance of finding ways how to mitigate or eliminate them, and thus support utilization of quantitative methods for support of the management decision-making, particularly in the medium-sized and small enterprises of chemical industry.

The research methods were used a method of structured literature research and a method of in-depth interview with managers of selected chemical and food processing companies.

2. Quantitative methods application in logistics management

Utilization of quantitative methods in management spread significantly after the Second World War in relation to the rapid development of the computing technology and information systems and technologies. In the 60's and 70's, application of quantitative methods and optimization models developed mostly within the so-called Operation Research. The thing that was emphasized from the very beginning was the system approach to problem solving, which enabled getting over the partial and local interests in the company while solving manufacturing, supply, transport, and other operations. A typical problem of that time is the first model of inventory optimization looking for the EOQ (Economic Order Quantity), which is basically compromising countervailing of diverse interests of the production, storage and finance managers.

Further development of application went parallel with development of management from the so-called operation management to the process management. The process management aims to steer in the integrated way not only individual operations, but also the entire processes, often going beyond the borders of individual enterprises. The development got as far as the requirements for integrated management of the whole supply chains and networks. This also gave rise to new quantitative methods application requirements in the meaning of optimization of the entire processes and networks.

Approximately in the 80's, new approaches to new quantitative methods applications started to develop parallel with the Operation Research under the designation Management Science. Nowadays, there are already countless and extensive publications dealing with these problems (Render *et al.* 2009; Gros 2009; Pinney *et al.* 2009; Ravindran 2008; Albright, Winston 2009; Hillier, Lieberman 2005; Jablonský 2002; Pabedinskaitė 2006).

Development and structure of individual parts of the Management Science fundamentally follow two basic lines:

1. Primary focus on individual areas of application and on particular problems. Solution methods and algorithms are here a tool, and it also happens that the given problem can be solved by more various procedures and algorithms.
2. Primary focus on development of solution methods and algorithms generally, i.e. usually mathematically formulated problems. In this case, it is, by contrast, possible to use the same or suitably adapted method for solving problems with different contents.

As an example, we can mention a problem of production planning, where it is possible to apply a number of various methods like prediction of the demand, linear programming, matching algorithms, etc. On the other hand, linear programming as a certain algorithm can be used for solving a number of further factually diverse problems like transport problems, mixing problems, etc. It is possible to give a lot of such examples.

Present-day logistics management heading more and more obviously from material flow management in separate enterprises towards integrated material flow management in the entire supply chains and networks, places new challenges in front of the quantitative methods applications, too. Basically, it is a shift from partial optimization in separate operations and partial processes towards optimization of the global processes in the entire supply networks. (Burkov *et al.* 2010; Krivács *et al.* 2010). This is closely linked with development of modern information systems and technologies, which often include some optimizing algorithms and models. Thus, for example, information system APS for complex logistics planning in a company and information system SCM for integrated planning and management in the entire supply chains already include a number of optimizing procedures. These advanced information systems are mostly very costly and demanding concerning applications. That is why there is still a significant space for application of optimization methods as specific tasks to improve particular logistics processes, especially for small and medium-sized enterprises, which cannot afford to acquire too expensive and sophisticated information systems.

As inspiration for an overview of possible applications in the area of logistics management, we have chosen the scheme shown in Figure 1, as adjusted according to (Ravindran 2008) resp. (Ballou 2004).

The advantage of this scheme is the fact that it shows possible applications of individual quantitative methods in their context and integrating tendencies. For instance, optimal location of cooperating premises affects, without a doubt and fundamentally, the transport costs in the routine operation, and optimization of the transport itself then just fine-tunes the whole system. However, what we miss in the scheme is production planning and controlling, as we think that it is also a part of the integrated supply chain management.

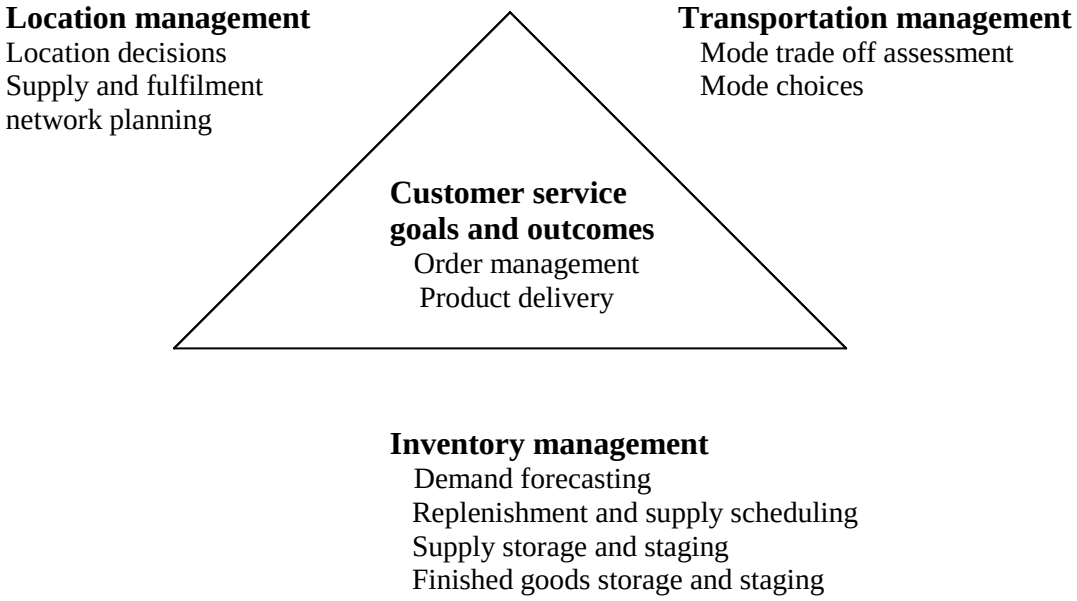

Fig.1. Drivers of supply chain management strategy (Adapted from Ballou 2004)

In fact, production planning and scheduling is closely related to inventory management, which can be, from the point of view of logistics, understood as more or less undesirable interruption in material flow smoothness. And thus we will hereinafter structure the overview of applicable quantitative methods into four mutually linked areas.

1. Location models

Models dealing with location of cooperating premises (production plants, warehouses, etc.), among which the material flows, half-finished products and products are moved, are an important area of quantitative methods applications in logistics. Location optimization then significantly helps decrease the transport costs, and so it is a part of the managers' strategic decisions. Models can be classified according to the number of located premises, according to the set of available sites, and according to the fact whether the number of premises is given in advance or it is necessary to determine it (Gros 2009).

2. Transportation models

A large number of applications and models are documented for the area of transportation. Apart from the classic transport problem, which belongs to the oldest optimization models at all, it is possible to state a number of other tasks, as e.g. those concerning optimal connection of the sites, optimal routes within the networks, transport network throughput, etc. (Meidutė 2010; Cisko, Klieštik 2006). A relatively comprehensive overview of these methods and models, based largely on the theory of graphs and networks, is given by Pastor and Tuzar (Pastor, Tuzar 2007). The so-called Travelling Salesman Problem is a specific transport problem. It is a task where more customers should be served in different locations in the way each of the customers is visited just once, and the salesman returns to the point of departure. For more information about one application in a company distributing chemical products, see (Exnar, Machač 2011).

3. Production models

The list of applications in this area can start with prediction of the demand. It is primarily an area for application of statistical prognostic methods, especially extrapolation of trends on the basis of a time series analysis. Although in this case it is not explicitly the optimizing model, it is necessary to realize that the quality of the demand predictions has strong influence on the dynamics of the distribution systems and on the completeness, timeliness and quality of the services provided to the customers. That implies that good prediction of the demand supports optimization of the entire SCH. High-quality prediction always requires combination of quantitative method with qualitative assessment of the situation on the basis of the managers' experience and intuition in the given area. (Vlčková, Paták 2010; Branská 2010).

In the area of production management, you can meet a number of optimizing models. For instance, for the product range planning you can use, on certain conditions, the classic linear programming model. This model can help determine the optimal production structure and the production quantities of individual products in the given planning period in the way the chosen purpose function (e.g. the sales, the added value, the profits, etc.) reaches the maximum possible value under the given limiting conditions. In the serial productions, it is possible to meet the task to find the optimal size of a series or a production batch. This task has a similar structure to seeking the optimal size of the order in the inventory theory. Another task of production planning is production task scheduling, also known as the Calendar Planning. In some productions, particularly those of the mechanical character, you can meet the need for assigning individual production tasks to individual machines, workplaces, etc. For this purpose, it is possible to use so-called assignment models. And finally, structural models are used for comprehensive production planning and for system calculations in multilevel chemical productions (Böhmová, Machač 2001). However, what is valid in all these cases is the fact that the models must be adapted to the concrete conditions of the given production process and to the customers' requirements concerning services in particular (Krivács *et al.* 2010; Poliačiková, Harazinová. 2006). Thanks to this fact, many production models are combined with heuristics rules (Lenort *et al.* 2012).

4. Inventory models

A significant space for optimization is also provided by inventory models. Inventory is a by-product of the material flow in the whole supply chain. Inventory management aims to choose such a way of replenishment, maintenance and their utilization to ensure their economically effective functions in the whole supply chain. Practically, optimization in this case means balancing the following several types of storage costs: cost of storing individual items for unit quantities and periods, financial costs of maintaining the average inventory in the given period, cost of ordering and takeover of a supply, and potential cost and loss resulting from inventory shortage (business interruption, loss of customers, etc.). Inventory models are usually divided into deterministic and stochastic ones, which count with accidental fluctuations in the demand and delivery time. That is why the stochastic models also include safety inventory, which can be a subject of optimization itself. The basic variables that are being decided about in the

models are the order size and the order terms aka the ordering cycle.

For completeness, let's add that some of the above optimizing models are now parts of information systems ERP, APS and SCM. (Basl 2002) Nevertheless, these advanced information systems are mostly not, particularly in small enterprises, available, and so quantitative methods are applied in them only rarely or not at all. For a general overview of the possibilities of utilization quantitative methods and optimizing methods broken down by individual areas of logistics activities, see the table 2.

3. Barriers and problems of QM applications in enterprises

Problems with quantitative methods applications and the reasons for their potential failure can be explained, on the one hand, by the wrong approaches of the managers as their users and, on the other hand, by the frequent shortcomings on the side of IT specialists and model authors.

The above research implies that, as for the company managers, it can be their ignorance of the possibilities being offered by quantitative methods at the present time, or it can be the general aversion to mathematical methods (Kubínová 2011), but we have also met with excessive expectations leading to the corresponding larger disappointment in the case the applications did not bring the expected benefits. What is always important is the standpoint and support of the top management and potential inclusion of the applications into the strategic corporate plans. As for the efficient first line managers who commonly use some quantitative methods in their work, we have also found that they protect their own procedures as their specific "know how", and they are not willing to disclose them to anyone else, and even less willing to disclose the exact algorithmization, which would make it possible to transfer their decision-making process to a computer programme. This way, they create a certain status of "irreplaceability" within the company (Roháčová 2009). Nevertheless, their solution might not be absolutely optimal. For instance, Horecký tried to optimize areal distribution of various photographic paper formats while they are cut length wisely and cross wisely, off a big roll (Horecký 2011). The cut is set up by the production manager on the basis of the running plan of production of individual formats.

It is required that the quantity of paper waste is as small as possible while the production plan is met. This task is obviously resoluble by linear programming. The author proved that using the optimal cutting plan the producer could, in the order of 1000 pieces of photographic paper of three different formats, save about 3 metres, i.e. 8.6% of 35 metres that are needed for production of the order using the standard empirical solution.

Table 2. Overview of quantitative methods by application area of logistics activities

Areas of Application	Quantitative Methods and Models
Location models	Discrete-Location Models
	Continuous-Location Models
Transportation	Network models (The Shortest Path Model, the minimal Spanning Tree, the Maximum Flow/Minimum Cut Model)
	Transportation Problem
	Travelling Salesman Problem
Production and Service	Demand Forecasting and Planning
	Linear Programming model for product mix decision
	Dynamic Programming for production and inventory planning
	Input-Output Models for Multistep Production Planning
	Production scheduling
	Assignment models for manpower and machine assignment
	Model of the Economic Production Run
	Waiting lines models (queues)
Inventories	Simple EOQ Model
	Models with Variable Demand and Lead Time
	Models of Optimal safety Stocks
	Single-Period Inventory Model

We have found that some well-informed managers are able to identify the problem that could be solved using an optimization method, but at the same time they state that they do not have enough time to analyse the problem thoroughly before dealing with it. In these cases they gladly accepted the offer of analysing and solving the given problem by a student within his/her diploma or dissertation thesis. As example can be used utilization models for demand forecasting (Paták 2009; Roháčova 2009).

The research in numerous companies showed if the companies do not use systems controlled by the forecast, whether for they do not trust the final forecasts or for they are not able/willing to work with them, they must seek other ways of compensating this insufficiency in the reliable forecast creation competence. The production companies must then often face very unbalanced utilizations of all the capacities and solve these situations only at with great effort leading often to inadequate rise of costs, e.g. by rising the stock of finished products, extraordinary shifts, hiring large numbers of contemporary staff at the expense of the regular staff (Vlčková, Paták 2010).

Although the expected result may not be always achieved, such cooperation is usually beneficial for both parties, also in the form of some secondary effects. For example, Heinclová was solving an assignment in one of the big companies distributing electric material to optimize cutting cables from big reels into lengths specified by the customers in the way to achieve the smallest possible residues of unsalable cables (Heinclová 2011). The problem analysis showed that the task is, within the used inventory information system, insoluble. On the other hand, the research showed that this relatively sophisticated information system is not utilized in all the branches to the full extent and that the staff should be better-trained and checked more closely.

The research showed that in the situation where new information system or new procedures, including mathematical models for decision-making, are to be applied, some workers show the phenomenon known as distaste for changes. The workers then stand up for the old “time-proven” procedures and refuse to accept new procedures, even though they are more effective both for them and for the institution. However, it is necessary to add that the fault can be sometimes found on the side of information analysts and/or the quantitative methods authors, who are not able to explain their IT and models to the users convincingly and clearly enough, and transform the results to understandable and clearly arranged user-friendly outputs.

The essential condition for successful application is a very thorough analysis of the initial situation and the problem to be solved. During this analysis, the author of the model must cooperate closely with the manager as the model user. Apart from the aim of the model, it is necessary to specify all the limiting and secondary conditions, and to define the target function on the base of which the task will be optimized. Also, it is necessary to verify what information is available, how the data is stored, and how it can be exported for further processing within the model. If they are models exceeding the framework of individual companies, it is necessary to analyse the possibilities of sharing information by the entire chain. Provided that individual components of the chain are independent units, information sharing encounters the problem of mutual confidence between partners and the possibility of misusing this information in the competitive environment (Vlčková 2011). The final target, which is considerably difficult to achieve, is to optimize the integrated material flow in the entire supply chain. A tool for achieving this goal can also be for example the integration of the business logistics system with logistics systems of suppliers and customers on the basis of CPFR methods - Collaborative Planning, Forecasting and Replenishment (Branská, Lošťáková 2011; Vlčková 2008). The ability of managers to build functional networks of relationships and contacts becomes more important (Vlčková, Bednaříková 2007).

4. Conclusions

Present-day logistics management is heading more and more obviously from material flow management in separate enterprises towards integrated material flow management in the entire supply chains and networks. It thus places new challenges in front of the quantitative methods applications. Basically, it is a shift from partial optimization in separate operations and partial processes towards optimization of the global processes in the entire supply networks. This is closely linked with development of modern information systems and technologies. These often include some optimizing algorithms and models.

These advanced information systems are mostly very costly and demanding concerning applications. That is why there is still a significant space for application of optimization methods especially for small and medium-sized enterprises.
Problems with quantitative methods applications and the reasons for their potential failure can be explained, on the one hand, by the wrong approaches of the managers as their users and, on the

other hand, by the frequent shortcomings on the side of IT specialists and model authors.

General aversion to mathematical methods and resistance to changes in general, excessive expectations leading to the corresponding larger disappointment in the case the applications did not bring the expected benefit, not enough time of managers to analyse the problem and to solve it are main barriers of quantitative methods implementation. It was also found that even existing relatively sophisticated information system is not utilized within the entire company and that the staff is not sufficiently trained and checked. Information sharing in the frame of the entire supply chain encounters the problem of mutual confidence between partners and the possibility of misusing this information in the competitive environment.

On the basis of the outcomes of our research and on the basis of our further experience and cooperation with enterprises in the area of logistics, we can make a conclusion that quantitative methods and optimizing models have a large application potential as a tool for support of managerial decision-making in supply chain management. However, this potential is still not fully utilized in the Czech Republic, particularly in small and medium-sized enterprises.

In this paper following objectives were fulfilled: (i) the general overview of quantitative methods in individual areas of logistics activities with examples of successful applications was given to inspire some other companies in their effort to use them more intensively; (ii) the preconditions that have to be met for their application were shown (support of the top management and potential inclusion of the applications into the strategic corporate plans, optimization of the global processes in the entire supply networks, appropriate information system and technologies, a very thorough analysis of the initial situation and the problem to be solved, close cooperation between authors of the model, IT specialists and managers as the model user, sharing information by the entire chain, well trained and checked staff, results transformed into understandable and clearly arranged user-friendly outputs etc.); (iii) the barriers connected with application of quantitative methods were identified (status of "indispensability", lack of time to analyse the problem thoroughly, wrong approaches of the managers as quantitative methods users, shortcomings on the side of IT specialists and model authors, ignorance of the possibilities quantitative methods, general aversion to mathematical methods, distaste for changes, exacting models implementation, defence of the old "time-proven" procedures, excessive expectations, reluctance against information sharing, mutual no-confidence between partners and the possibility of misusing this information in the competitive environment, etc.).

This knowledge should help avoid unnecessary mistakes in quantitative methods introduction and utilization. The quality and effectiveness of the entire process of supply chain management will undoubtedly increase together with support of convenient and well-applied quantitative methods.

References

Albright, S. CH.; Winston, W.L. 2009. *Management Science Modeling*. Revised 3rd Edition. Canada: South-Western Cengage Learning. 992 p. ISBN 978-0-324-66346-4.

Basl, J. 2002. *Podnikové informační systémy*. Prague: Grada Publishing. 144 p. ISBN 80-247-0214-2.

Ballou, R.H. 2004. *Business Logistics/Supply Chain Management*. Fifth edition. Upper Saddle River, NJ: Pearson Prentice Hall. ISBN 9780131076594.

Böhmová, S.; Machač, O. 2001. Sensitivity Analysis in Cost Input-Output Models, in *The 19th International Conference „Mathematical Methods in Economics"*. Hradec Králové, Czech Republic 5–7 September 2001. 13-18. ISBN 80-245-0196-1.

Branská, L. 2010. Management of supporting processes in quick response system, in *The 6th International Scientific Conference "Business and Management"*. Vilnius, Lithuania 13-14 May 2010. Volume II. Selected papers. Vilnius: Technika, 2010, 788–795. ISSN 2029-4441. http://dx.doi.org/10.3846/bm.2010.104

Branská, L.; Lošťáková, H. 2011. CPFR Method Application in Supply Chain Involving Continuos Production, in *The 20th Anniversary International Conference on Metallurgy and Materials*. Brno, Czech Republic 18-20th May 2011. ISBN 978-80-87294-22-2.

Burkov, V.N.; Burkova, I.V.; Zaitseva, Y.L. 2010. Network programming method for management optimization problems, in *The 6th International Scientific Conference "Business and Management"*. Vilnius, Lithuania 13-14 May 2010. Volume II. Selected papers. Vilnius: Technika, 2010, 802–807. ISSN 2029-4441. http://dx.doi.org/10.3846/bm.2010.106

Cisko, Š.; Klieštik, T. 2006. Application of graph theory in intelligent transportation system, in *International Conference "Business development possibilities in the new European area"*. Vilnius, Lithuania 21-22 September 2006. Part I. Scientifics proceedings. 63–68. ISBN 9986-19-936-0.

Exnar, F.; Machač, O. 2011. The travelling salesman problem and its application in logistic practice, *WSEAS Transactions on Business and Economics* 8(4): 163–173. ISSN 1109-9526.

Gros, I. 2009. *Matematické modely pro manažerské rozhodování*. Prague: Publisher VŠCHT Prague. 282 p. ISBN 978-80-7080-709-5.

Heinclová, K. 2011. *Řízení zásob v distribučním podniku* . Diploma work. University of Pardubice. Pardubice.

Hillier, F. S.; Lieberman, G. J. 2005. *Introduction to Operations Research.* Eight Edition. NY: McGraw Hill. 1062 p. ISBN 007-123828-X.

Horecký, D. 2011. *Plánování výroby v podniku fotochemického průmyslu*. Diploma work. University of Pardubice. Pardubice.

Jablonský, J. 2002. *Operační výzkum* [Operations Research]. Praha: Professional Publishing. 326 p. ISBN 80-86419-23-1.

Krivács, K.; Hartványi, T.; Tápler, C. 2010. Basic requirements of material traceability in warehouses, in *The 6th International Scientific Conference "Business and Management"*. Vilnius, Lithuania 13-14 May 2010. Volume II. Selected papers. Vilnius: Technika, 2010, 849–855. ISSN 2029-4441. http://dx.doi.org/10.3846/bm.2010.113

Kubínová J. 2011. *Stav logistiky v podnicích chemického průmyslu*. Diploma work. University of Pardubice. Pardubice.

Lenort, R.; Klepek, R.; Samolejova, A. 2012. Heuristic Algorithm for Planning and Scheduling of Forged Pieces Heat Treatment, *Metalurgija* 2(51): 225–228. ISSN 0543-5846.

Meidutė, I. 2010. Applied research of the transportation links on the example of Lithuania, in *The 6th International Scientific Conference "Business and Management"*. Vilnius, Lithuania 13-14 May 2010. Volume II. Selected papers. Vilnius: Technika, 2010, 876-883. ISSN 2029-4441. http://dx.doi.org/10.3846/bm.2010.117

Pastor, O.; Tuzar, A. 2007. *Teorie dopravních systémů*. Praha: ASPI. 312 p. ISBN 978-80-7357-285-3.

Pabedinskaitė, A. 2006. Modeling of management decisions, in *International Conference "Business development possibilities in the new European area"*. Vilnius, Lithuania 21-22 September 2006. Part II. Scientifics proceedings. 402–410. ISBN 9986-19-937-2.

Paták, M. 2009. *Analýza procesu předpovědi poptávky a prodejů ve vybraném podniku*. Diploma work. University of Pardubice. Pardubice.

Pinney, W.E.; McWilliams. D. B.; Ormsby, J. G.; Atchinson, M. 2009. *Quantitative Methods for Management.* Third Edition. Ohio: Thomson Custom Publishing. ISBN 075933812-4.

Poliačiková, E.; Harazinová, M. 2006. Entrance and influence of trade networks on production sphere in Slovak Republic and effects of these processes, in *International Conference "Business development possibilities in the new European area"*. Vilnius, Lithuania 21-22 September 2006. Part II. Scientifics proceedings. 430–433. ISBN 9986-19-937-2.

Ravindran, A.R. 2008. *Operations Research and Management Science Handbook.* Boca Raton, FL: CRC Press. ISBN 0-8493-9721-9.

Render, B.; Stair, R. M.; Hanna, M. E. 2009. *Quantitative Analysis for Management*. Tenth Edition. Upper Saddle River, NJ: Pearson Prentice Hall. 748 p. ISBN-13:978-0-13-603625-8.

Roháčová, J. 2009. *Předpověď poptávky a prodejů ve vybraném podniku.*. Diploma work. University of Pardubice. Pardubice.

Tetřevová, L. 2003. Strategic Financial Restructuring, *Engineering Economics* 32(1): 14–19.

Vlčková, V.; Bednaříková, M. 2007. Influence of CRM Strategy usage on the Human Resources Development, *VADYBA/MANAGEMENT* 2(15): 83–89. ISSN 1822-3133.

Vlčková, V. 2008. Demand Forecasting in CPFR, in *The 13th International Scientific Conference „Economics and Management – 2008"*. Kaunas, Lithuania 10-11th Apríl 2008. Kaunas University of Technology, Lithuania, 2008, 336–342. ISSN 1822-6515.

Vlčková, V.; Paták, M. 2010. Role of demand planning in business process management, in *The 6th International Scientific Conference "Business and Management"*. Vilnius, Lithuania 13-14 May 2010. Volume II. Selected papers. Vilnius: Technika, 2010, 1119–1126. ISSN 2029-4441. http://dx.doi.org/10.3846/bm.2010.151

Vlčková, V. 2011. Reasons of Insufficient Cooperation in Information Sharing within Czech Entrepreneurial Environment and its Impact on Supply Chain, in *The 20th Anniversary International Conference on Metallurgy and Materials*. Brno, Czech Republic 18-20 May 2011. Proceedings of the conference, Brno: Tanger spol. s.r.o., 2011, 1259–1264. ISBN 978-80-87294-24-6.