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COOPERATION IN LOGISTICS TECHNOLOGY RESEARCH: HOW TWINNING PROJECT AFFECTS R+D IN THE FIELD OF LOGISTIC SYSTEMS AND NETWORKS

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Abstract: The overall aim of the UMi-TWINN project was to reinforce the scientific excellence and innovation capacity in logistic systems of the University of Miskolc and its high-quality twinning partners for the benefit of different industries and logistics markets. To boost twinning partners' scientific excellence and innovation capacity in logistics technologies, as well as implementing a research and innovation strategy we have focused on the following three sub-topics: design of logistic systems and networks, intelligent transport systems and dynamical analysis of materials handling machines. Within the frame of this paper the authors describe the main results in the field of design of logistic systems.
Keywords: complexity, heuristics, Industry 4.0, last mile logistics, optimization, staff deployment, supply chain design

1. INTRODUCTION

The UMi-TWINN project is funded under the "Spreading Excellence and Widening" section of the Horizon 2020 Programme [1]. The Twinning scheme aims to strengthen a defined field of research in a knowledge institution through linking with internationally-leading counterparts in Europe. The UMi-TWINN project is focusing on logistics technologies at the University of Miskolc (Hungary). The consortium partners have three years to achieve the following objectives: strengthen UMi's research excellence in logistics technologies; enhance the research and innovation capacity of UMi and Twinning partners; raise the research profile of UMi and the Twinning Partners; contribute to the research and innovation priorities of Hungary; support research and innovation on a European level.

The research and innovation strategy takes the recent SWOT analysis of UMi as well as the national Hungarian research priorities and regional Smart Specialisation Strategy 'Advanced technologies in the vehicle and other machine industries' as well as the SMART technologies relevant to the Borsod-Abaúj-Zemplén county (e.g. 'Logistics' and 'Special materials, advanced materials, modern materials technologies') into account. The overall

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concept of the UMi-TWINN project and the position of design of logistic systems and networks topic is shown in Figure 1.

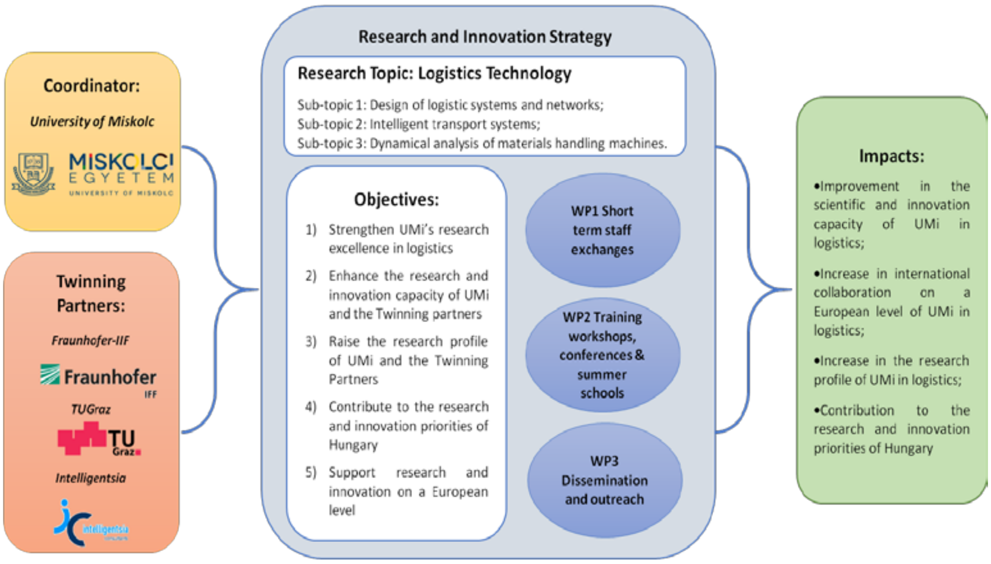

Figure 1. The overall concept of the UMi-TWINN project

2. ECONOMICAL BACKGROUND

The European logistics sector has recovered from the effect of the crisis in 2008/09 and the Eurozone economy grew 0.2 percent on quarter in the three months to September 2018, unrevised from a second estimate and following a 0.4 percent expansion in the previous period [2] supported by the manufacturing sector. New retail trends (e.g. e-commerce) are an increasingly important driver of change in the logistics sector. According to forecasts from Forrester Research, European online retail sales will increase at an average of 11.5% per year from 2018 to 2023. The European sector is also experiencing a continuing shift in activity towards the east, as logistics operators seek to build efficient distribution networks. Hungary benefits from its location in the centre of Europe and has potential to become a major European hub at the crossroad between Western and Eastern Europe, but also close to the Mediterranean region.

The aim of UMi-TWINN is to adapt, develop and integrate logistics technologies into new tailor made manufacturing in order to be used by the industry and especially small to medium-sized companies (SMEs). From that perspective the UMi-TWINN project will support UMi's research building capacity and promote its research excellence in logistics sciences and technology in Hungary but also in Europe.

The project and the design of logistics systems and networks topic contributed to the research and innovation priorities of Hungary. Hungary has defined their SMART specialisation strategy for the country and regions/counties. The Eye@RIS3 tool [3] available on the S3 platform defined the national priorities among them of the SMART Specialisation Strategy 'Smart Technologies'. The Hungarian Development and Innovation Office defined the priorities per county within a report highlighting the importance of

'Logistics' and 'Special materials, advanced materials, modern materials technologies' R&D for the Borsod-Abaúj-Zemplén county. Nevertheless the UMi-TWINN project contributed to most of the national SMART technologies listed in the report based on its three research sub-topics (see Figure 2).

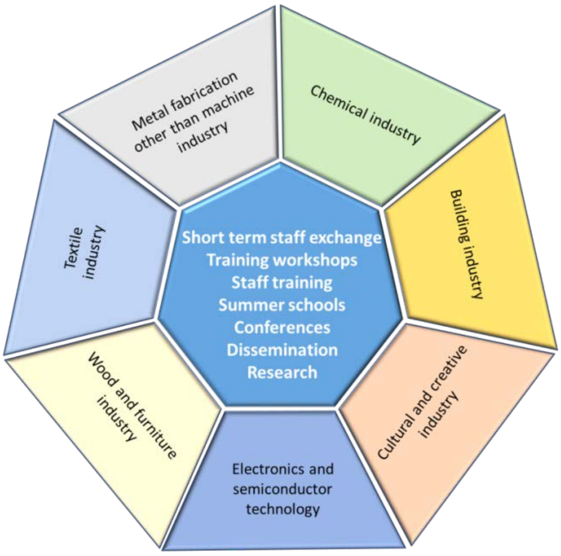

Figure 2. National SMART technologies and project activities

In Q1 2018 the volume of Hungary's GDP was up by 4.4 percent year-on-year. Seasonally and calendar-effect adjusted and reconciled data show that economic performance improved by 4.7 percent year-on-year and by 1.2 percent quarter-on-quarter. Market-based services were the main driving force behind the expansion [4]. Logistics technologies contribute to this growth and open new opportunities for the Hungarian and European economy. The UMi-TWINN impacts directly or indirectly the main national industries. The share of the business sector in the sources of R&D expenditures reached 56% or €777m, of the government sector 26% or €361m, while the foreign sources achieved 16% or €229m in 2016. The share of the domestic non-profit sector is negligible (0.7%). From the perspective of Hungary's society and economy, there are at least three groups of organisations that benefit from the UMi-TWINN project:

- **Automotive companies** constantly need to upgrade their production facilities and improve their logistics flow. The automotive industry is one of the main pillars of Hungarian manufacturing.
- **Electronic and mechatronics companies** requiring innovative logistics technology to develop new machine handling and improve the efficiency of their products.
- **Logistics companies** are the main concern by the UMi-TWINN project and benefit from every advancement made on the three research sub-topics.

Within the frame of this paper we are focusing on the research results of the project as follows.

3. RESEARCH RESULTS IN THE FIELD OF LOGISTICS SYSTEMS AND NETWORKS

However the main activities of this Twinning project were focused on mobility (staff exchange), trainings and conferences, but the scientific cooperation was also strengthened. Figure 3 summarises the main research fields, where the cooperation led to scientific results published in international conferences and scientific journals.

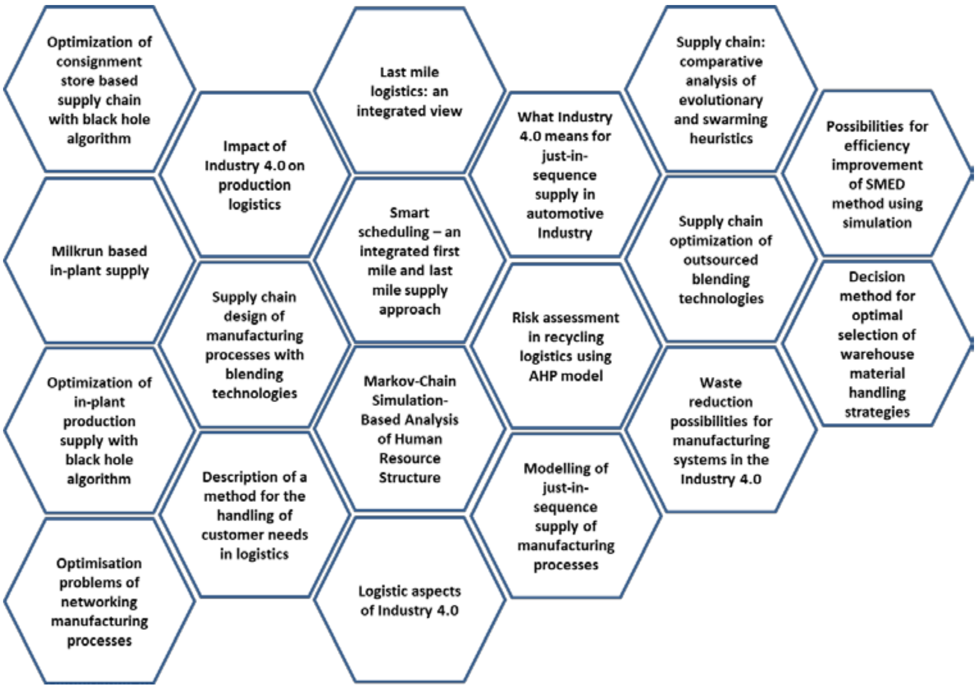

Figure 3. Main research fields related to twinning activities

3.1. Optimization of consignment store based supply chain with black hole algorithm

Within the frame of this research work we developed a methodological approach for design of consignment store based supply chains. Firstly we reviewed and systematically categorized the recent works presented for consignment store based supply chain optimization. Then, motivated from the gaps in the literature, a model for companies performing their purchasing through consignment stores was developed. Two models were proposed: the model framework shows the levels of supply chain while the second model as a case study focused on power plant supply. The integrated model included facility location and assignment problems, which was solved with black hole optimization algorithm. The sensitivity analysis showed the efficiency of two advanced BHO operators and a numerical example shows the efficiency of the algorithm.

The scientific contributions of this research work were the followings: integrated model for consignment store based supply chain, black hole optimization based heuristic algorithm with enhanced convergence through integration of phenomena of real black holes, like dynamic black hole location and decreased event horizon. The results can be generalized, because the model can be applied for in-plant supply, especially in the case of milk-run based just-in-sequence supply. The described methods make it possible to support managerial decisions; the operation strategy of the supply chain and the consignment contract can be influenced by the results of the above described contribution.

However, there are also directions for further research. First, although the transportation routes as distances among the locations are considered, the capacities of vehicles are not taken into consideration. In further studies, the model can be extended to a more complex model including capacities of vehicles and store capacities of locations. Second, this study only considered the black hole optimization method as possible solution algorithm for the described NP-hard problem. In reality, other heuristic methods can be also suitable for the solution of the problem.

Third, the convergence of the described algorithm can be improved using other operators and the behaviours of BHO to other optimization approaches can be tested. However there is a great body of research dealing with testing of performance of different metaheuristic optimization methods, especially from the point of view “novel” algorithm, but these tests are sometimes inconsistent. This inconsistency can be caused by the optimization behaviour [5].

3.2. Smart scheduling – an integrated first mile and last mile (FMLM) supply approach

Industry 4.0 solutions make it possible to improve traditional supply chain solution in hyperconnected logistics systems. Within the frame of this common research work we developed a methodological approach for real-time smart scheduling of first mile last mile delivery of cooperating delivery companies. Firstly we review and systematically categorized the recent works presented for the design of FMLM supply. Then, motivated from the gaps in the literature, a model for cooperating FMLM supply is developed. We proposed a general model. The described model includes different delivery routes of different companies, where the cooperation is based on Industry 4.0 solution including vehicle re-identification, GPS based methods and smartphone-based monitoring. The smart scheduling means the real-time optimization of assignment of open tasks to the scheduled routes depending on the captured information from the running processes. The smart scheduling problem was solved with a newly developed metaheuristic combining BHO (black hole optimization) and BBBC (big bang big crunch) algorithm. The sensitivity analysis showed the efficiency of the integration of both swarming heuristics.

The scientific contributions of this paper are the followings: model for the integrated real-time scheduling of first mile and last mile operations in a package delivery environment, where the hyperconnected operation is based on Industry 4.0 solutions; a new metaheuristic combining the Black Hole Optimization and the Big bang Big Crunch Algorithm. The results can be generalized, because the model can be applied to different supply chain applications, especially in the case of a multitier supply chain for the automotive industry. The described methods make it possible to support managerial decisions; the operation strategy of the package delivery companies and the cooperation contract among them can be influenced by the results of the above-described contribution [6].

3.3. Impact of Industry 4.0 on production logistics

The factory of the future is flexible and transparent. This means that the time of workflows, preparations and switching times can be accurately calculated, so you can determine where there are free capacities. This way, when you receive a customer order, you can accurately calculate when the order is being made and what capacities, machines, tools will be assigned, and what purchases will have to take place until the start of production.

Within the frame of this research we reviewed the technological background and main features of the fourth industrial revolution. We analysed the competitive advantages achieved through the vertical network of intelligent manufacturing systems and horizontal integration, demonstrated the properties of the smart cell, and determined the levels of services built into the smart product.

Our research work focused on the relationship-system of the company's production logistic system, with logistics-integrated production management tasks and with the competitive advantages. In solving a specific production logistic problem, we have demonstrated the competitive advantages of real-time scheduling. The above-mentioned research has many possible directions for further development, as Industry 4.0 is characterized by multidisciplinary that allows further research not only in technical but also in economic and social fields. In relation to production logistics, our future objectives include further examination of the service processes of complex manufacturing systems, in which we intend to set up in-house supply chains that ensure the efficient management of large complex production processes through integrated management of cooperative tools and sub-processes [7].

3.4. Last mile logistics: an integrated view

The solutions of last mile logistics make it possible to make decisions in supply chain networks aiming financial and environmental effects, and also reduce unnecessary movements of delivery. As the relevant state-of-art showed, significant financial savings are available for participants using the concepts of last mile. This result indicates the scientific potential of this research field including the problems of last mile logistic systems. This research field addressed the manufacturing and service participants to identify the logistic aspects from design and operation point of view of supply chain.

Therefore, the design aspects of supply chain processes still need more attention and research. There are four sub-types of last mile topology: semi-extended supply chain, fully extended supply chain, decoupled supply chain, and centralized extended supply chain (Table I). These topologies were analysed within the frame of this research field [8].

3.5. What Industry 4.0 means for just-in-sequence supply in automotive Industry?

The Industry 4.0 solutions make it possible to develop just-in-sequence supply chain among tiers aiming economic and environmental sustainability and also for capacity use. The featured models make it possible to analyse the just-in-sequence supply chain between tiers. Significant financial savings are available using optimized just-in-sequence solutions.

This study developed a methodological approach for modelling just-in-sequence supply. In this paper, firstly we reviewed and systematically categorized the recent works presented for just-in-sequence supply. Then, motivated from the gaps in the literature, a model structure was developed. Four models were proposed with direct/indirect supply and sequencing, with/without horizontal cooperation [9].

Table I.
Component of Last mile typology and their benefits (less important, *** necessary)*

Impacts	**Semi-extended supply chain**	**Fully extended supply chain**	**Decoupled supply chain**	**Extended supply chain**
Security	**	**	**	***
Inventory	***	***	***	***
Networks	**	***	**	**
SCM	***	***	***	***
Energy	**	***	**	***
Manufacturing	*	*	*	*
Delivery speed	**	**	***	***
Customer satisfaction	**	**	**	***
City logistics	**	**	***	***
Mobility	***	***	***	***

3.6. Supply chain optimization in automotive industry: comparative analysis of evolutionary and swarming heuristics

The automotive industry is one of the world's most significant economically and most dynamically developing industries. In order to compete with each other, they have to come up with new techniques, tools and services. These novelties are based on a well-established information system that supports communication, design, customer service and the company's entire internal system. It controls supply, production, distribution and waste management (see Figure 4). However, this requires a very large amount of data that needs to be elaborated and categorized so these solutions can be made to make things much more comfortable and accessible to us and we can easily intervene [10].

However, to accomplish these, very good and fast IT tools are needed, that are driven by algorithms. The algorithm we used for different tasks greatly influences the quality of the solution obtained and the speed of its calculation. In most of today's IT systems one of the variants of the genetic algorithm can be found. Within the frame of this common research work, we have sought to find out whether there is an algorithm that is faster and more reliable than this already proven and widely spread algorithm. Comparing the performance results with the Black hole algorithm in function analysis and warehouse positioning problem, we came to the conclusion that this recently presented algorithm can overcome the genetic algorithm both in speed and accuracy.

3.7. Milkrun based in-plant supply – an automotive approach

Within the frame of this research field we developed a methodological approach for the description and analysis of milkrun based in-plant supply. We reviewed and systematically categorized the recent works presented for milkrun supply. Then, motivated from the gaps in the literature, the morphology and three typical milkrun processes were described. The described supply systems were analysed from the aspect of cycle time and proportion of operations. The results can be generalized because the model can be applied for a wide range of milkrun strategies. The described methods make it possible to support managerial decisions; the strategy of resource management can be influenced by the results of the above described contribution [11].

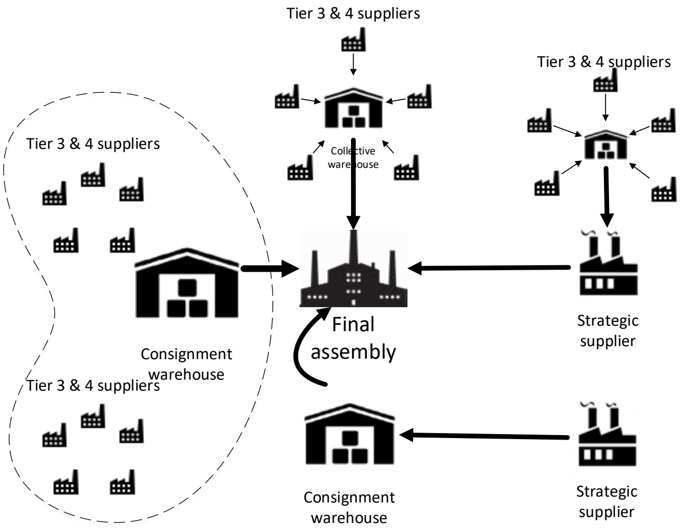

Figure 4. Model of warehousing in a supply chain

3.8. Supply chain design of manufacturing processes with blending technologies

Blending technologies play an important role in manufacturing. The design and operation of manufacturing processes using blending technologies represent a special range of manufacturing related logistics because the integrated approach of technological and logistic parameters is very significant. This research proposes an integrated model of supply of manufacturing processes using blending technologies. After a careful literature review, we introduced a mathematical model to formulate the problem of supply chain design for blending technologies. The integrated model includes the optimal purchasing strategy depending on the characteristics of components to be mixed in the desired proportion and the costs of supply. The integrated model is described as a linear programming problem. Numerical results with different datasets demonstrated how the proposed model takes technological and logistic aspects into consideration [12].

3.9. Optimization of in-plant production supply with black hole algorithm

Logistic processes are basic factors in the success of manufacturing plants' operation and have direct impact on its efficiency, flexibility and reliability. Today's successful operation of manufacturing processes addresses high priority to logistics to ensure maximum utilization of resources. The material supply of manufacturing processes in the automotive industry is usually based on supermarkets and milkruns. This research focused on the integrated supply model of manufacturing processes, which includes facility location and assignment. After a careful literature review, we introduced a mathematical model to formulate the problem of supermarkets and milkrun based supply of machines. The model seeks the optimal location of buffers as well as the optimal assignment of buffers and machines so as to minimize the material handling costs while taking into account order limits of machines and capacities of resources. Next, we demonstrated an enhanced black hole algorithm dealing with multi-objective supply chain model to find the optimal structure of the system. Numerical results demonstrated how the proposed model supports the efficiency, flexibility and reliability of the manufacturing process [13].

3.10. Optimisation problems of networking manufacturing processes

Manufacturing systems are more and more complex. Heuristic optimization offers powerful tools and methods to design networking manufacturing systems. Within the frame of this research we described two possible optimization methods of knapsack and traveling salesman problem with harmony search and firefly algorithm to support the optimization of various manufacturing related logistic problems. As a result of the demonstrated research it can be expected that in future years more and more optimization application will be developed in the field of supply chain. The results of this research can be used to improve the whole logistics process of companies (see Figure 5) from the purchasing through production logistics to distribution [14].

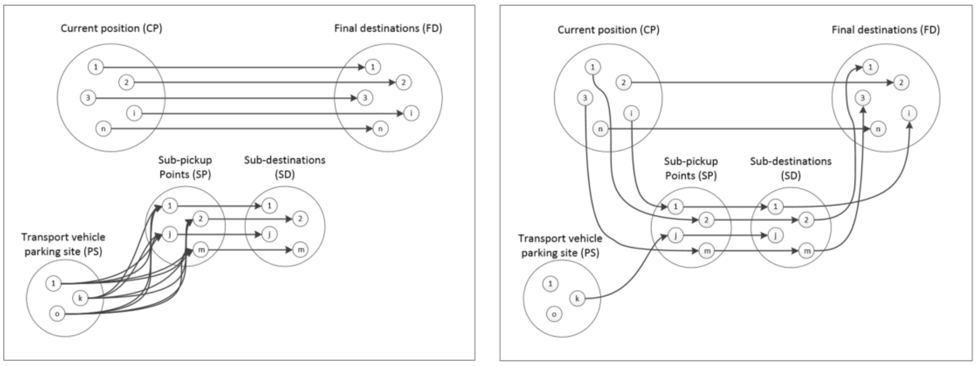

Figure 5. Structure of networking manufacturing processes

3.11. Supply chain optimization of outsourced blending technologies

This research activity of the UMi-TWINN project developed a methodological approach for supply chain optimization of manufacturing companies using blending technologies. Firstly we reviewed and systematically categorized the recent works presented for outsourcing optimization f supply chain. We analysed the selected articles. Then, motivated from the gaps in the literature, a model framework for supply chain including outsourcing possibilities of blending technologies was proposed: the model framework makes it possible to define typical models depending on the problem and complexity of the supply chain. We proposed a mathematical model for the description of a typical supply chain of blending technology based manufacturing including suppliers, manufacturers, outsourcing possibilities and customers (see Figure 6). The optimization problem includes three decisions: volume of components to be purchased to blend them in a desired proportion to produce goods in a defined quality; selection of suppliers and outsourcing allocation. Computational results of the described model were presented with different datasets.

As the results show, outsourcing possibilities are cost-cutting tools for blending technologies, but the parameters of logistics and technology influences the efficiency. The results can be generalized, because the model can be applied for other technologies,

especially in the case of assembly sector. The described method makes it possible to support managerial decisions; the operation strategy of the supply chain and the procurement contract can be influenced by the results of the above described contribution.
However, there are also directions for further research. First, although the logistic costs are considered, logistics strategies (e.g. inventory holding or routing) were not taken into consideration. In further studies, the model can be extended to a more complex model including logistic strategies. Second, this research only considered the problem as MILP (mixed integer linear programming) and MINLP (mixed integer nonlinear programming) problems but in the case of increased complexity the problem can be described as an NP-hard problem. Third, the model can be tested with real data sets. This should be also considered in the future research [15].

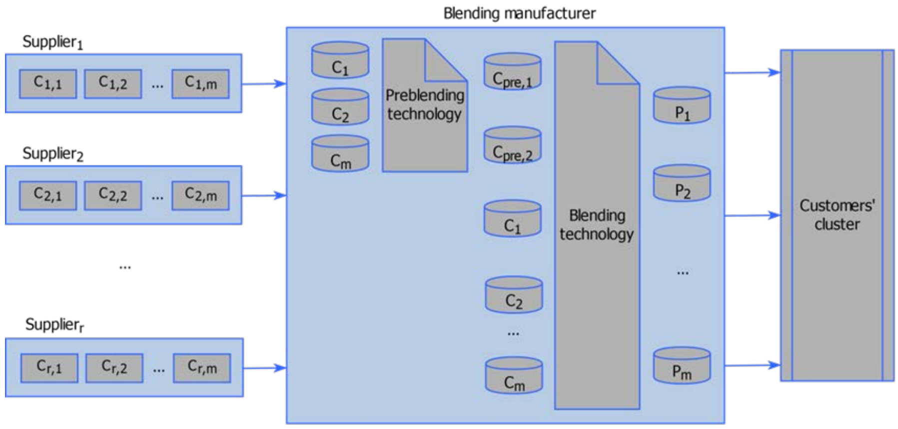

Figure 6. Supply chain of blending technology with multiple suppliers, pre-blending and direct supply

3.12. Logistic aspects of Industry 4.0

Through the fourth industrial revolution, today such technological innovations and methods have become available which enable the development of complex logistics systems where the entire supply chain can be operated in an automated way. The aim of this research field was to investigate how to increase the efficiency of logistics processes through the exploitation of the opportunities offered by the fourth industrial revolution. We summarised the essence of Industry 4.0, the technological conditions of the fourth industrial revolution, its opportunities and challenges, and examines its impact on both intra-corporate and non-corporate logistics processes. We analysed the operational processes of logistics networks and the efficiency gains achieved through Industry 4.0 applications. Reliability and quality assessment of logistics networks are a complex problem. We presented an innovative solution which is based on Industry 4.0 infocommunication solutions and the application of risk management and quality assurance tools, one that enables the optimal selection of logistics service providers in the network from a reliability point of view [16].

3.13. Modelling of just-in-sequence supply of manufacturing processes

Sourcing strategies are very important for a successful supply chain. It is important to understand how just-in-time based sourcing of manufacturing companies works to choose the best solution. Just-in-sequence solutions support the decrease of inventory levels, but the design and operation of these supply processes can be expensive. Within the frame of this research work we described a model framework (see Figure 7) of just-in-sequence supply and defined the most important JIS based supply strategies: ship-to-sequence, pick-to-sequence and build to sequence [17].

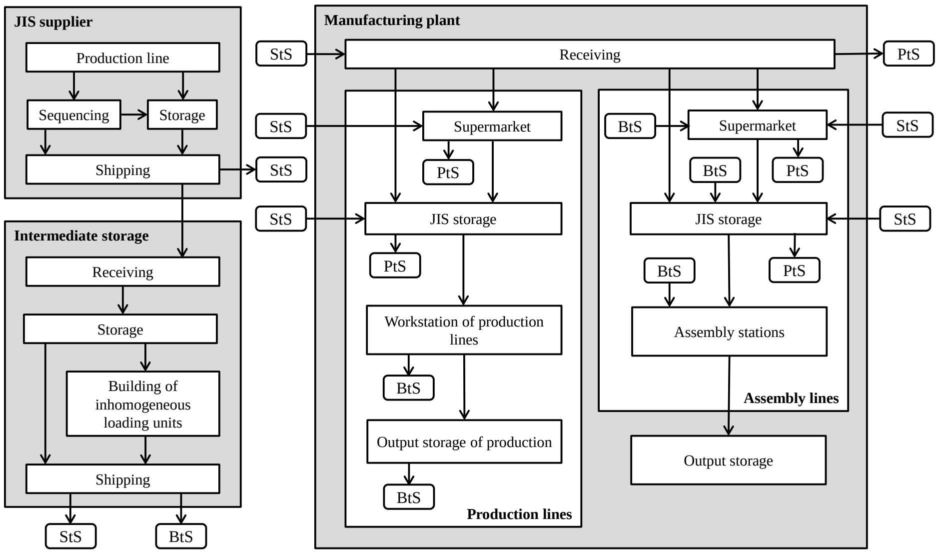

Figure 7. Model framework of just-in-sequence supply including possible relations of pick-to-sequence (PtS), ship-to-sequence (StS) and build-to-sequence (BtS) supply

3.14. Markov-Chain Simulation-Based Analysis of Human Resource Structure

Staff deployment and staffing is an essential problem in the human resource management domain because the structure of employees should be continuously in an optimal relationship to the jobs to be performed. The main focus of this research is the modelling and analysis of human resource deployment processes of manufacturing companies using Markov-chain mathematics, also taking the absorbing phenomena of employees' promotion into account. The main contribution includes the model framework of Markov-chain simulation of a human resource deployment problem; the mathematical description of different human resource deployment strategies with subdiagonal and superdiagonal promotion matrices; the computational results of the described model with different datasets and scenarios. In the case of a given human resource strategy, the Markovian human resource deployment process of a company was analysed (see Figure 8). The analyzed model was the HR deployment of assembly line operators in a multinational company, including six levels of promotion [18].

3.15. Risk assessment in recycling logistics using AHP model

The AHP is a widely applied multi-criteria decision making technique that was originally developed by Thomas L. Saaty in the 1970s. Since then, it has become one of the most popular methods with a wide range of applications. The goal of this research field is to examine which criteria affect more the accumulation of the additional risk related costs for the given customer. In other words, the risk factors will eventually be ranked by the amount of additional costs they are generally responsible for at the given customer, determined through the use of the decision hierarchy. In general, the more additional cost a risk factor is responsible for, the higher its priority should be at the end of the analysis.

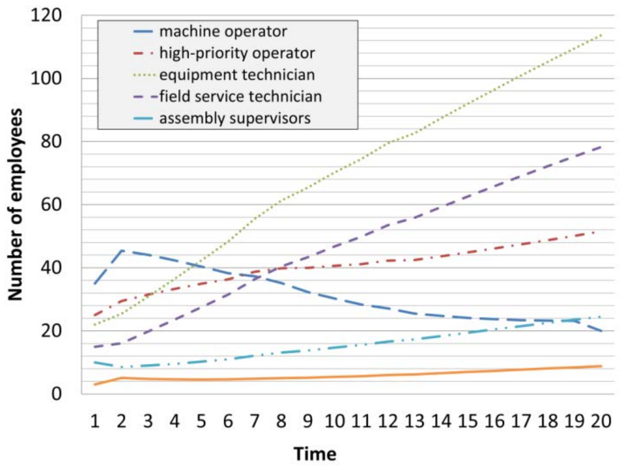

Figure 8. Results of AMC simulation of a Scenario - Distribution of employees through the time window

The proposed decision hierarchy has four levels (Figure 9), where the first node on the first level is the “Risk related cost” (the goal of the analysis), the main criteria level (second level) is composed of the “Inner processes”, the “Environment”, the “Managed cargo”, the “Partners”, the “Reputation” and the “Alternative scenarios” nodes, while the third level is constructed from the different sub-criteria related to the main criteria (the fourth level is composed of the decision alternatives, which in this case are the risk factors).

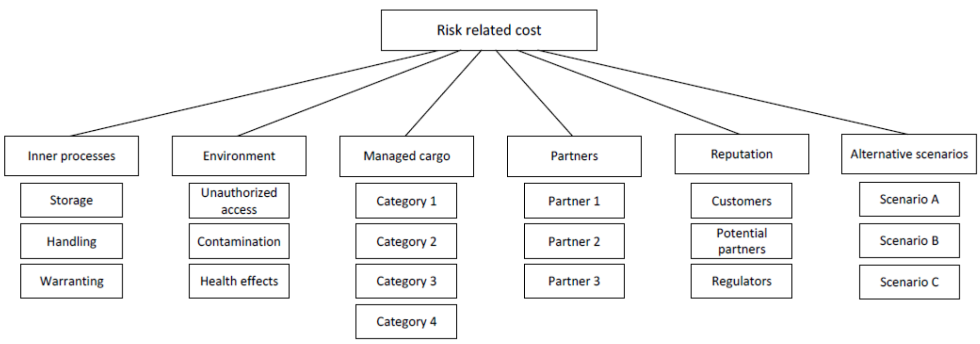

Figure 9. Decision hierarchy of the proposed risk-assessment model

A possible way for the evaluation of the results was also presented, which can be helpful for supporting the selection process of logistics service providers in the aforementioned networks. The longer term intention would be to further develop the concept into a general tool that can be applied in a wide variety of integrated logistics networks. As the core model in the approach is flexible enough for customization, there should be no theoretical barriers to achieve this goal, which would greatly aid the various parties of the modern logistics industry in effective risk assessment and partner selection [19].

3.16. Description of a method for the handling of customer needs in logistics

Logistical problems and tasks arise in all areas of the industry and economics. This puts a lot of requirements on the comprehensive field that is today called as logistics. In the meantime, logistics is under constant change due to the technical innovations and the changing social and political boundary conditions. The diverseness and the system dynamics present a great challenge for the logistics professionals of the future, as intelligent and economical solutions are awaited from them. Within the frame of this research topic, we developed an application of the QFD (quality function deployment) method, a technique used for the evaluation and proper realization of the different customer expectations, in the quality management of logistics systems. Both the theoretical basics of the method, as well as the main steps of its implementation were described. The implementation itself was presented with the help of a practical example that is strongly related to both the logistics and the automotive industries, as the latter especially relies on complex supply chains that require the extensive utilization of quality management tools. Besides the previous, the research also provided an overview of all the possible areas of utilization for the QFD in the logistics industry. Therefore, the developed method can have a great value from both the academic and the industrial perspectives [20].

3.17. Examining the possibilities for efficiency improvement of SMED method using simulation modelling

Nowadays the improvement mode of logistics processes has a relevant effect on an enterprise’s competitiveness. Most production companies have three kinds of objectives, namely reduction of the production lead time, cost reduction, and improvement in quality, all of which can be realised by using the tool and rule system of the lean philosophy. To explain the essence of the lean philosophy, it is the reduction of the lead time between the ordering and the payment with elimination of wastes, according to the most popular explanation. The lean philosophy has two “pillars” which are JIT and jidoka. The essence of jidoka is that we have to separate the human and the machine work with “human sensors” (for example: we do not need to supervise a machine if we put a mechanism into the machine which is able to stop the machine in the case of some problem). We can better utilise the human and machine resources using this principle. We can reach significant results in the field of waste reduction in production processes with application of the tool and rule systems of lean philosophy. One of the frequently applied lean methods is SMED (Single Minute Exchange of Die), which is able to reduce the changeover times and the resulting wastes. Length of the changeover time has a relevant effect on several parameters of the production process (inter-operational inventories, batch sizes, production lead time, manufacturing flexibility, etc.), consequently its reduction is an important competitive factor for a companies. The paper introduces in detail the role of the set-up time in production logistics and its reduction possibilities in real-life situations as well. We examined and summarized the application possibilities of simulation modelling for the efficiency increase of the SMED method as well. A future research topic can be the elaboration and realisation of a simulation framework that is able to automatically create the examination models [21].

3.18. Waste reduction possibilities for manufacturing systems in the Industry 4.0

The industry 4.0 has been making a relevant changing at the manufacturing systems' formation and actuation. The appearance of the IoT (Internet of Things) and the cyber physics systems, as well as the big data have created a significant research potential regarding the more efficient actuation and continuous improvement of the logistics systems. The communication between the devices, the information which are derive from the product's tracking, as well as the possibilities in the network collaboration will provide a more widespread optimization possibilities for the manufacturing companies. This research topic introduced in details the process of formation of the industry 4.0, as well as its current devices, possible improvement directions. We also outlined the more relevant research possibilities in the case of the unit loads' manufacturing process' improvement/waste reduction. The value stream mapping's method was created with use of the Toyota's material and information flow diagram. This method's relevant aim is the reduction of the wastes with improvement of the logistics processes. The value stream mapping's method (see Figure 10) has been simultaneously used for improvement of one product line's logistics processes so far [22].

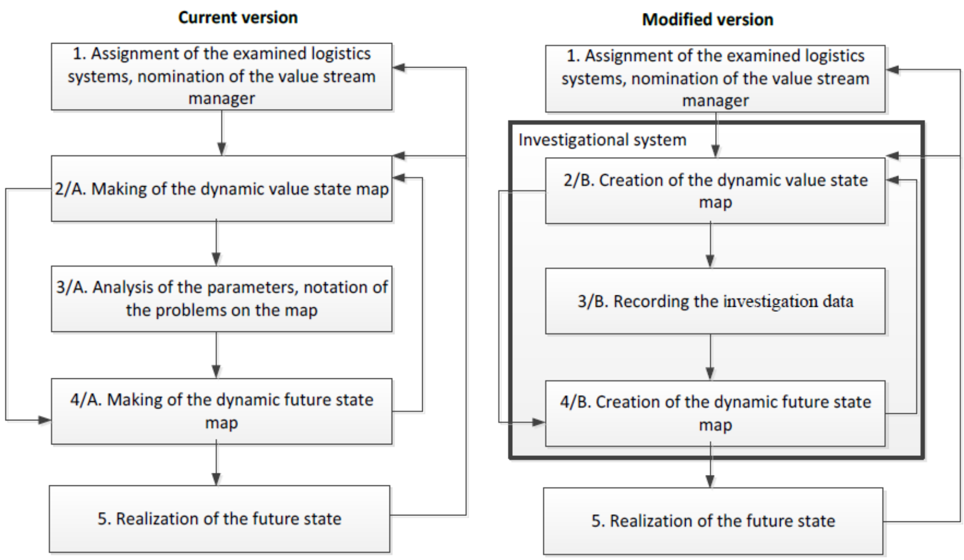

Figure 10. Steps of the dynamic value stream mapping.

3.19. Decision method for optimal selection of warehouse material handling strategies by production companies

In practical life, companies have paid small attention to select the warehouse strategy properly. Although it has a major influence on the production in the case of material warehouse and on smooth costumer service in the case of finished goods warehouse because this can happen with a huge loss in material handling. Due to the dynamically changing production structure, frequent reorganization of warehouse activities is needed, on what the majority of the companies react basically with no reactions. This research topic includes a simulation test system frames for eligible warehouse material handling strategy selection and also the decision method for selection [23].

4. SUMMARY

The purpose of the optimal design and operation of logistics systems and processes is quite clear. In today's economy, the pressure is on to make the operations of supply chain from purchasing to distribution more efficient. The supply chain includes the logistic operations of purchasing, production, services, distribution and recycling. These functions are complex. The economical production or manufacturing of complex products and the realisation of related services is a core problem of profitability of companies. The specific challenge of this research project ass to address gaps and deficiencies between the Hungarian researchers and the high performing Member States in the field of design and optimisation of logistics systems and networks. The UMi-TWINN project boosted the work in this field, without the support of this project the above described research would have not been possible.

This research topic focused on both production and service companies and includes a wide set of tools and methods. We are interested to exchange knowledge and be trained on subjects relevant to the design of logistic systems and networks, such as:

- Modelling and mathematical description of systems and processes of materials handling and logistics.
- Development of new equipment selection methods for production systems.
- Meta-heuristic optimisation of large scaled and networking systems, supply chain.
- Design and operation of warehouses and storage systems.
- Computer-aided simulation and scenario analysis of production and service processes.

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