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DIGITALISATION OF SUPPLY CHAIN MANAGEMENT SYSTEM FOR CUSTOMER QUALITY SERVICE IMPROVEMENT

The main idea of the current research is to apply customer satisfaction level Key Performance Indicators (KPIs) for supply chain reliability improvement. The Supply Chain Operations Reference (SCOR) model-based KPI metrics increase the quality of product/service by monitoring, visualising, and digitalising directly involved processes. In the long run, the solution will ultimately help reduce/eliminate the number of customer reclamations in the supply chain. An industry-oriented performance measurement model based on SCOR can be easily adapted for different sectors. The approach proposed in the current research is based on identifying key factors of supply chain performance of the SCOR model connected with the predictive and diagnostic capability of Bayesian Believe Networks. The difference in performance can be reached via applying the best practices to processes, affecting the performance on a larger scale.

1. INTRODUCTION

Due to globalisation, a rapidly changing business environment, highly influenced consumers, fast-changing needs, and consumers' behaviours, there is a demand to make transactions and interactions faster, more reliable, customer, and consumer-friendly. Before we can satisfy all listed needs, we need to standardise related business processes.

Service enterprises have many problems that they face every day, and the main of them is the Quality management problem. Dissatisfaction with the service leads, as a rule, to significant losses in the market share. That is why the service provider must identify the needs and expectations of its target customers as accurately as possible. Unfortunately, the quality of the service is harder to judge and even harder to determine. This problem is the main reason for our paper to consider the quality and reliability aspects of supply chain definition. “One

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of the main directions of forming strategic competitive advantages is providing services of higher quality compared to competitors" [1].

Supply chains encompass the companies and the business activities needed to design, make, deliver, and use a product or service. Businesses depend on their supply chains to provide them with what they need to survive and thrive. Every business fits into one or more supply chains and has a role to play in them. [2]. A supply chain can be seen as a set of integrated business processes that encompass all activities related to the flow and transformation of goods, from the raw material stage to the delivery of the final product to the end customer [3, 4]. Controlling the Supply Chain processes is crucial for improving performance. Processes are controlled through metrics measurement. This control is part of Supply Chain Management and can be defined as the coordination of the Supply Chain stakeholders [5].

At the same time, the fast development of digitalisation, Industry 4.0 tools and working practices have had a significant impact on the performance of the Supply Chain in recent years, and this will continue in the future. Digitising the supply chain is crucial in breaking down communication barriers within a company, enabling stakeholders in the supply chain to easier data sharing, collaborating on important initiatives, and working together to guarantee that processes are seamless and free of bottlenecks, disruptions, and failures. The Supply Chain Operations Reference (SCOR) reference model can be applied to align process architecture with key business functions and goals [6, 7]. The accuracy of the SCOR model's definitions enables platforms to use a common language to standardise the vocabulary for a benchmark between the platform's customers and the logistic services provider [8]. The SCOR model-based KPI metrics enable increasing the quality of product/ service by monitoring and further digitalisation of directly involved processes in the supply chain, which in the long run ultimately reduce/eliminate customer reclamations.

The purpose of current research is to provide companies with the Supply Chain digitalisation framework to satisfy existing customer needs and fulfil the companies' strategic goals. This article aims to define supply chain reliability metrics at various levels of process modelling, which supports the Supply chain movement toward digitalisation. The introduced innovative Supply Chain digitalisation framework defines business processes that directly influence customer satisfaction and help the decision-making process select the most efficient tools and best practices to improve them. The authors introduce how to connect the SCOR model third level KPI to reclamations and quality data collected from the companies and apply BBN methodology for supply chain reliability improvement. As practical usefulness of research study, the companies are provided with Decision Support tools to assess the efficiency of selected best practices and tools for fulfilment of Strategic goals of the company before the investment decision is made and the solution is implemented.

Supply Chain Digitalisation (SCD) framework analyses the current reliability level of the companies based on reclamations, returns and processes quality data provided and points out the improvement needed in business processes. The business process KPI-s are developed based on the SCOR model, and the Bayesian Believe Networks (BBN) tool predicts the expected efficiency of digitalised business processes. The authors recommend applying the framework to improve the reliability of the companies by improvement of current business processes accordingly to customer feedback.

Our scientific usefulness is that we developed a novel decision support tool that links SCOR best practices and tools with Customer reclamation data. Outcomes of research provide the templates for digitalised frameworks that can be easily applied by industry and used for further research in this field. To the best knowledge of the research group, the combination of SCOR and BBN tools was not previously used for solving customer reclamation problems. Some studies implement the SCOR model and BBN in different contexts. In this [9] research, they gave an overview of the benefits and limitations of using SCOR in automotive industries. One limitation mentioned was many tedious metrics to select the right one. So, it is essential to use digital tools that help to navigate through the various metrics. The SCOR model has also been implemented [10] with perception neural networks for analysing and predicting performance metrics based on historical data. In a study [11], researchers have used adaptive network-based fuzzy inference systems to predict the SCOR model's performance metrics. In a study [12], authors deployed a fuzzy Quality function for managing SCOR performance indicators. On the other hand, BBN has been used in research [13, 14] for supply chain risk management, and it is a different context than when we implement BBN. BBN could be found in other fields, like a sanitary inspection for drinking water [15], to predict no show patients [16] and quality forecasting [17].

2. BASIC CONCEPTS OF THE SCOR

The SCOR represents a well-established model to describe operations management activities for practice and research purposes; the results can be compared and extended accordingly. Especially quality management can be seen as one of the pillars of improving productivity and therefore contributing to lean principles [17].

“SCOR model uses a unified system of key performance indicators, which are hierarchically structured. KPIs are used for the internal evaluation of performance and the external analysis of the supply chain and are assigned to each detailed process in the SCOR model. The hierarchical and multi-dimensional structure of key performance indicators allows processes such as processing time to be linked to performance indicators or service level to punctuality and delivery quantity, to improve performance” [18].

“The SCOR model provides a standard framework for easy communication, and it is a useful tool for the top management of a firm to achieve their desired performance by designing and reconfiguring the SC. To measure the performance of the SC, the SCOR model focuses on performance attributes. A performance attribute is a collection of metrics that aids in directing a strategy. SCOR identifies five core SCP attributes: reliability, responsiveness, agility, costs and asset management” [19]. The SCOR reference model consists of 4 major sections [7]:

- Performance: Standard metrics to describe process performance and strategic goals;
- Processes: Standard descriptions of management processes and process relationships;
- Practices: Management practices that produce significantly better process performance;
- People: Standard definitions for skills required to perform supply chain processes.

The purpose of the SCOR reference model, or business process framework, is to define process architecture that aligns with key business functions and goals. The architecture here references how processes interact and perform and how the SCOR processes are configured [7]. The SCOR model was developed to keep up the flow of goods from the manufacturer to the customer. A supply chain requires a permanent overview, adjustment, and improvement in order.

Thanks to the SCOR model, it is possible to create standard processes within the supply chain and evaluate their effectiveness using uniform criteria. The critical point of the model is the graphical representation of relationships between all SC participants and gives economic relations between enterprises. Thus, the SCOR model is an effective tool for controlling and diagnosing supply chains, clearly showing bottlenecks and possible alternative options for building an enterprise's logistics system.

The current paper considered the customer-focused Performance Attributes in detail:

- *Reliability* is focused on the predictability of the outcome of a process. Typical metrics for the reliability attribute include on-time, the correct quantity, and excellent quality.
- *Responsiveness* is the speed at which a supply chain provides products to the customer. Metrics include cycle-time values.
- *Agility* is the ability to respond to marketplace changes to gain or maintain a competetive advantage. SCOR Agility metrics include Adaptability (Up-side and Down-side) and Risk assessment.

Figure 1 illustrates the performance metrics of levels 1 and 2. Level-2 metrics serve as diagnostics to identify the root cause of performance gaps of level-1 metrics.

Reliability performance: "The reliability factor is also one of the most effective criteria, which means the probability of the intact and flawless performance of the system for a definite and pre-scheduled period" [20]. The scope and boundaries of cooperation among the supply chain constituents include various activities from material ordering to final product control. Defecting one part of the system creates problems in other parts [21, 22]. To establish a successful new relationship in the supply chain, assessing the reliability of the relationship is among the crucial factors in this field [23].

The rate of reliability, which is the operational criterion discussed in this article, is also assessed and measured at level one of the supply chain based on the SCOR model. The first level metrics of perfect order fulfilment consist of the following second-level metrics: orders delivered in full, delivery performance to customer commit date, accurate documentation, and perfect condition of the order.

Responsiveness performance: Responsiveness is the average actual cycle time consistently achieved to fulfil customer orders for each order. This cycle starts from the order receipt and ends with customer acceptance [24]. "Responsiveness" can be summarised as the speed of the supply chain to provide products for customers.

Agility performance: SC agility is a broad business capability, enabling the firm to respond to changing market environments [25, 26, 27]. Agility is characterised by flexibility and speed/responsiveness and spans organisational structures, processes, information systems and mindsets [28, 29]. SC agility thus extends beyond a single firm and involves alignment with significant customers and suppliers [30].

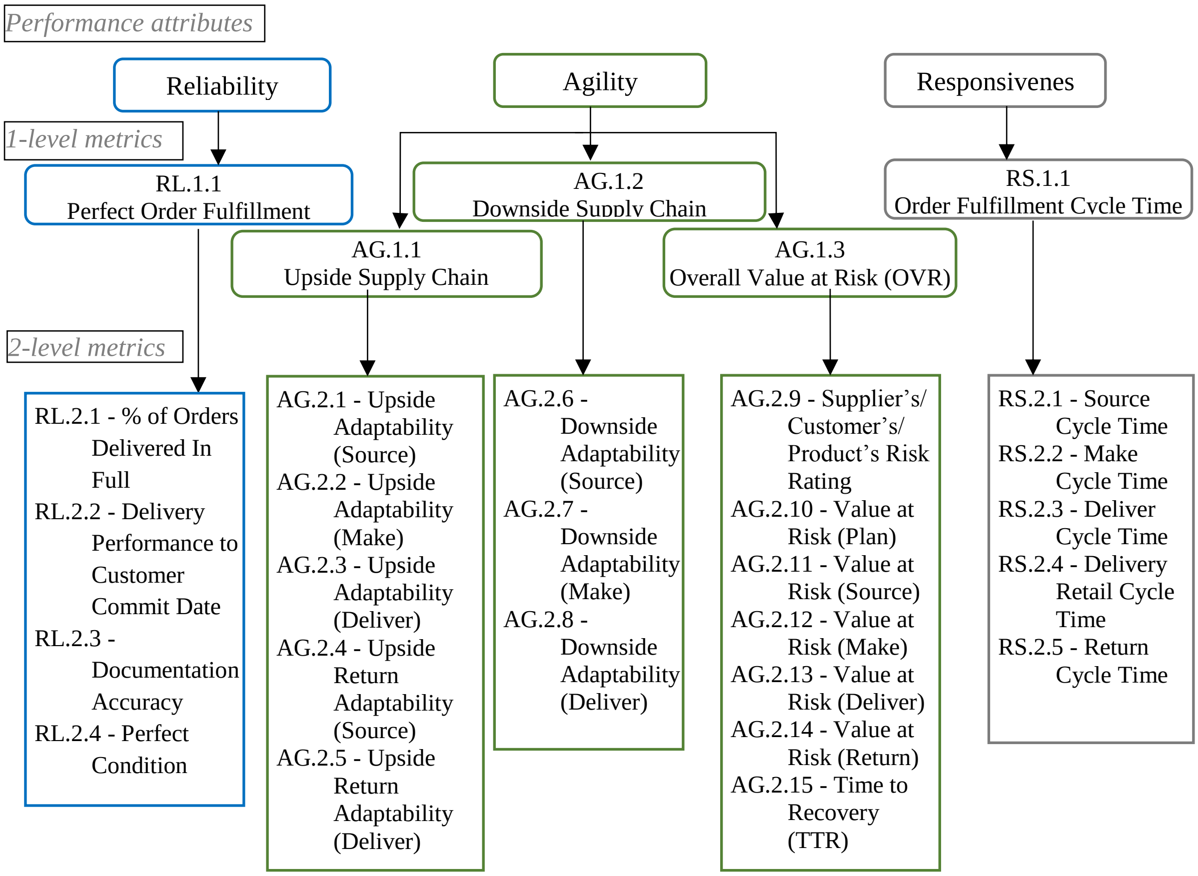

Fig. 1. SCOR performance metrics, APICS 2017

3. MAIN IDEA OF THE RESEARCH

The objective of company managers is an optimisation of SC performances, which could be achieved by using network models to generate a solution [31, 32].

The companies should make the right decisions and make analyses and developments. Providing the coordination and control of all the business processes will provide efficiency throughout the chain and easy access to profitability and customer satisfaction goals. [33]. Organisations must develop strategies for operating their systems with the highest efficiency and effectiveness while ensuring maximum customer satisfaction [34].

Performance metrics or KPIs offer the overall visibility of the supply chain and help assess the supply/demand plan (e.g. forecast accuracy) and the execution performance (e.g. actual sales versus forecast plan). KPIs reveal the gap between plan and execution and offer opportunities to identify and correct potential problems [35]. An industry-oriented performance measurement model based on SCOR can be easily adapted for different sectors. However, the SCOR model, which is frequently used in supply chain performance measurement, does not contain the requirements of supply chains for the digital age. For this reason, the performance measurement model in the literature needs to be updated, considering the needs of the digital age [33]. The current work is presented the supply chain effective performance measurement methodology.

The objective of company managers is the optimisation of SC performance. The goal could be achieved by using network models to generate a solution. The current work presents the supply chain effective performance measurement methodology. The SCOR model is designed hierarchically into three levels of process detail. Level I deals with process types where supply performance can be directly tied to an organisation's business objectives. Level II is the configuration level and deals with process categories, and Level III is the process element level. Levels II and III are used to describe detailed activities to provide greater insight into the operation of the SC [19]. To measure the performance of the SC, the SCOR model focuses on performance attributes. A performance attribute is a collection of metrics that aids in directing a strategy. SCOR identifies five core SC performance attributes. As mentioned above in this article, we will consider interrelated performance attributes: reliability (RL), responsiveness (RS), and agility (AG), the processes they are related to, and the Best Practices (BP) used to improve them, as shown in Table 1. The full description of the processes used in the table is visualised in Fig. 3.

Performance attributes are considered for every SCOR process. Also, the tables introduce best practices for every process by SCOR classification.

Table 1. Fragment of the SCOR performance attributes interrelation and their connection with the best practices*

BP	KEY	SCOR processes	Reliability	Responsiveness	Agility
		RL.1.1 Perfect Order Fulfillment			
BP.089, BP.176	sD1.3	sD1.3 Reserve Inventory and Determine Delivery Date	RL2.2, RL3.36,	RS.3.94, RS.3.116	
BP.012, BP.046, BP.176	sD1.12	sD1.12 Ship Product	RL2.2, RL.3.34, RL.3.35	RS.3.126	
	sD1.13	sD1.13 Receive and verify Product by Customer	RL2.2, RL2.4, RL.3.32, RL.3.33, RL.3.34, RL.3.35, RL.3.41, RL.3.42	RS.3.102, RS.3.103	
BP.089, BP.176	sD2.3	sD2.3 Reserve Inventory and Determine Delivery Date	RL2.2	RS.3.94, RS.3.115	
BP.012, P.046, BP.176	sD2.12	sD2.12 Ship Product	RL2.2, RL.3.33, RL.3.34, RL.3.35,	RS.3.126,	
	sD3.3	sD3.3 Enter Order, Commit Resources & Launch Program	RL2.2, RL.3.33, RL.3.34 RL.3.35,	RS.3.25, RS.3.94	
BP.012, BP.176	sD3.12	sD3.12 Ship Product	RL2.2, RL.3.33, RL.3.34, RL.3.35,	RS.3.126,	
	sD3.13	sD3.13 Receive and verify Product by Customer	RL2.2, RL2.4, RL.3.32, RL.3.33, RL.3.34, RL.3.35, RL.3.41, RL.3.42	RS.3102, RS.3.103,	
RS.1.1 Order Fulfillment Cycle Time					
BP.006, P.035,	sS1	sS1 Source Stocked Product	RL.3.18, RL.3.19, RL.3.20, RL.3.21,	RS.3.8, RS.3.9, RS.3.10, RS.3.11, RS.3.113,	AG.3.9, G.3.40, AG.3.42, G.3.46

BP.056, BP.131, BP.132, BP.134, BP.144, BP.145, BP.147, BP.148, BP.161, BP.163			RL.3.22, RL.3.23, RL.3.24, RL.3.25, RL.3.26, RL.3.27,	RS.3.122, RS.3.139, RS.3.140	
P.013, P.035, BP.131, P.132, BP.136, P.144, BP.145, P.148, BP.161, BP.163	sS2	sS2 Source Make-to-Order Product	RL.3.18, RL.3.19, RL.3.20, RL.3.21, RL.3.22, RL.3.23, RL.3.24, RL.3.25, RL.3.26, RL.3.27	RS.3.8, RS.3.9, RS.3.10, RS.3.11, RS.3.113, RS.3.122, RS.3.139, RS.3.140	AG.3.9, AG.3.40, AG.3.42, AG.3.46

*cont. Table 1

We can see that performance metrics are interconnected (Table 1) and form a specific network for detailed consideration of SCOR processes. To analyse how every process is connected with Best Practices in current research, the SCOR structure database (SCOR-DB) with a KEY attribute was elaborated, see Table 1. SCOR-DB allows: to define the influ-ence of one metrics changing to the other performance metrics; to find all suggested by SCOR Best Practice (BP); to add new BP to a specific process, based on enterprise skills.

The database structure (SCOR-DB), created using the IDEF1x methodology, is introduced in Fig. 2. In the current research, we use the Bayesian Belief Network (BBN) computational model based on graph probability theory for analysing performance metrics to consider uncertainty, easily described manually by experts in the field. Bayesian Belief Network (BBN) is a probabilistic graphic model consisting of a set of interconnected nodes. Each node represents a variable in the dependency model, and the connecting arcs represent the causal relationships between these variables [36].

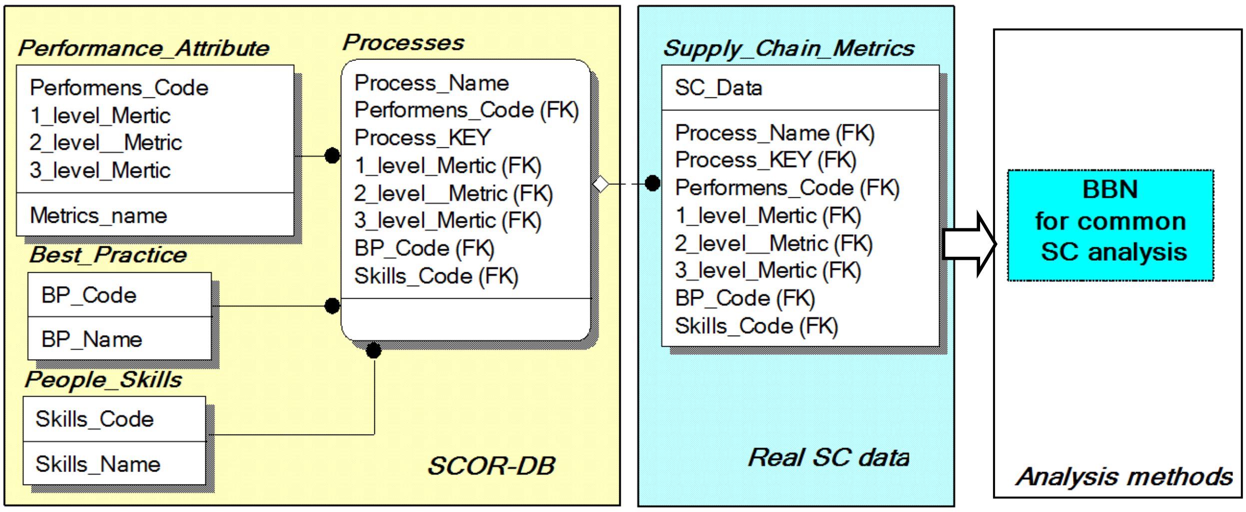

Fig. 2. SCOR-DB structure

We use BBN by plotting the SCOR structure. The current paper will be considered performance metrics for supply chain reliability improvement - Perfect Order Fulfillment (POF) see Fig. 3, where sS1 – Source Stocked Product; sM1-Make-to-Stock; sD1-Deliver Stocked Product; sS2 – Source Make-to-Order; SD2-Deliver Make-to-Order Produ dokleict.

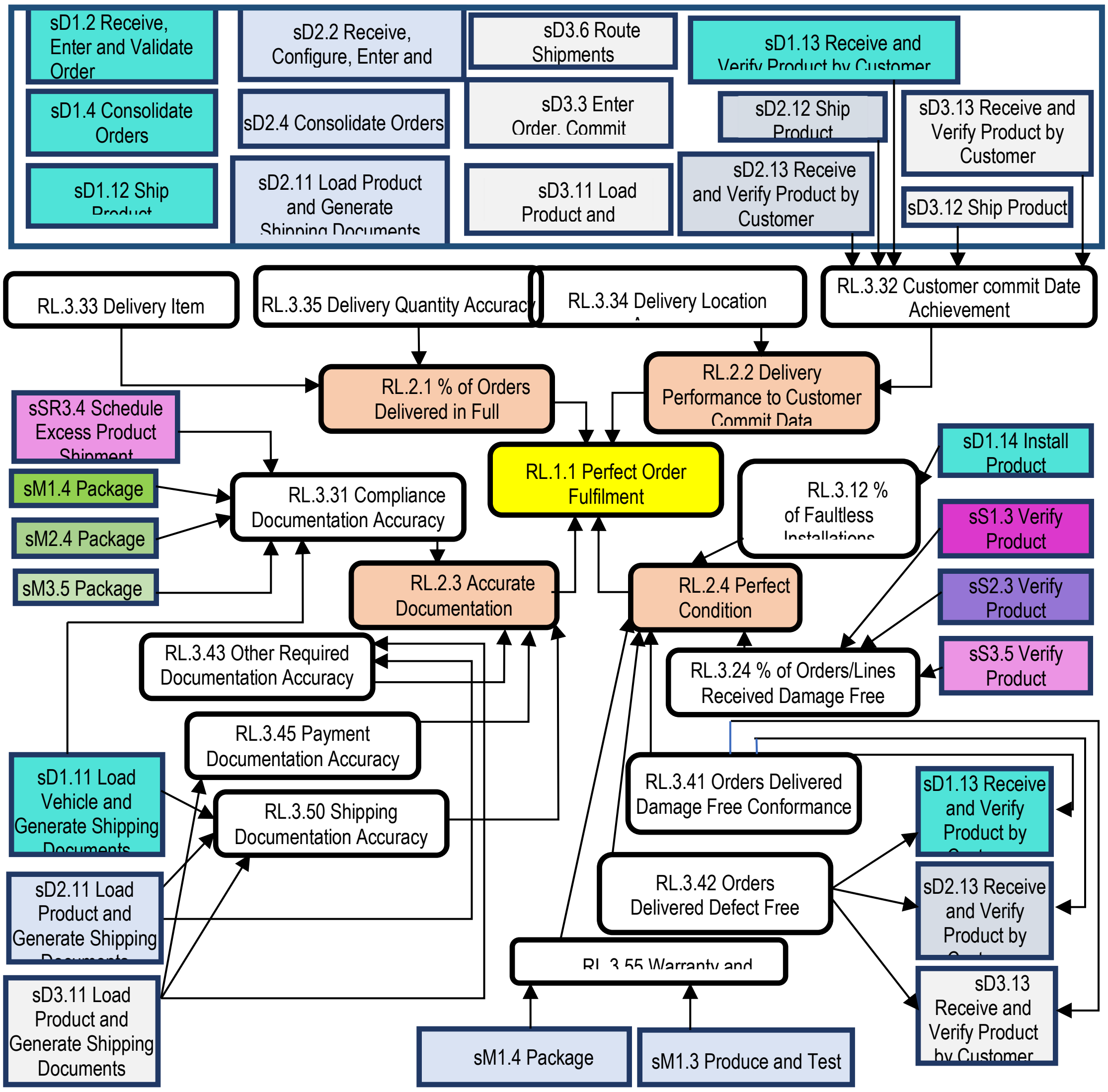

Fig. 3. SCOR structure with processes for Perfect Order Fulfillment (POF)

“The rate of reliability, which is the operational criterion discussed in this article, is also assessed and measured at level one of the supply chain based on the SCOR model through the metrics of perfect order fulfilment; at level two through the metrics of perfect order fulfilment, delivery performance to customer commit date, accurate documentation, and perfect condition of the order” [37]. Recently Site Reliability has opened a new technological challenge for Supply Chains [38]. Figure 3 shows the structure of reliability metrics in the SCOR model, the codification of metrics at three levels, and their relationships with processes and processes elements. The same structure by using GeNIe (BBN tool) is shown in Fig 4. The authors introduce a novel approach for Supply Chain digitalisation based on Service/Product Satisfaction. The developed framework enables Supply Chain dynamically to respond to the returns, reclaims, and quality-related issues in the definition and digitalisation of involved business processes. BBN model allows selecting the digital tool which will give the highest impact on the Perfect Order Fulfilment KPI and predict the expected result after tool implementation.

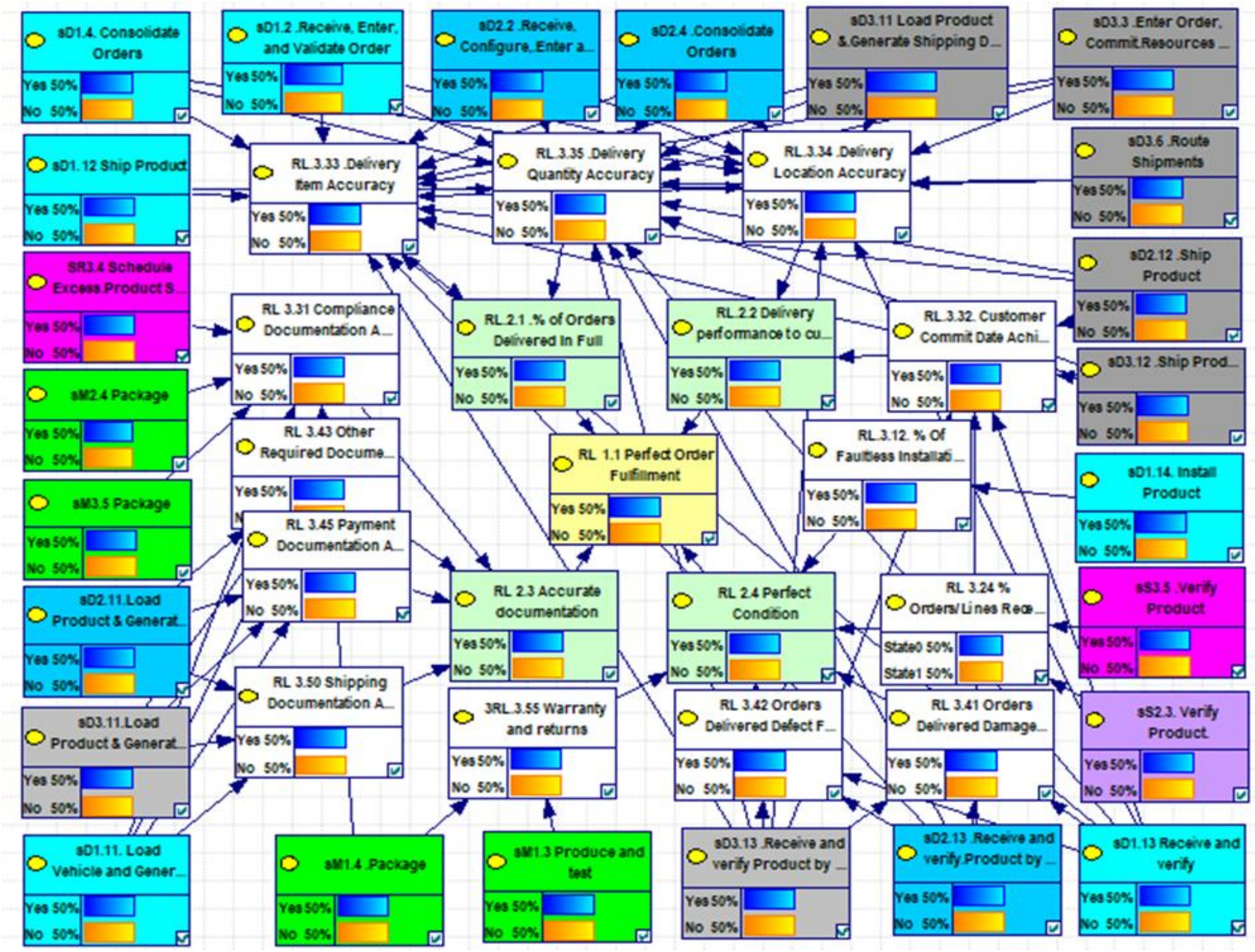

Fig. 4. BBN network based on SCOR-POF structure

4. CASE STUDY

The main problems that small and medium garment-producing enterprises face are the fulfilment of customer expectations and agile deliveries at a minimised cost. However, order amounts and ordered products vary significantly.

The authors chose the companies from the garment production sector, which is facing severe transformation. We have selected four representatives of small and micro companies in the garments industry.

The authors are using the case study based on qualitative and quantitative research methodology. During the research, the authors observed the commonly used internal and external processes related to returns and reclamations in the garment field; the data was collected, and the most frequently used reliability KPIs were applied. Finally, the authors simulated the impact of selected best practices on the reliability measures of the company by using the BBN model [39].

External defects can be found in some cases by the end customer; it can be a defect that occurs when wrong care procedures are used, or physical damage happens. Technological defects are avoided by quality checking in the production process and before delivery.

The interviews conducted with four small garment producing companies gave qualitative data about internal and external defects. The number of defects is not similar; defects are presented as a percentage of the total amount (see Table 2.).

Table 2. Empirical data received from companies

	Returns / Reclaims													
	Interna (%)			External (%)				Returns (%)	Prepay ment (%)	Warranty days	OTIF (%)	% of warranty returns	% of materials rejected	% of Ontime payments
Enterprise	Finishing - ironing, checking	Technological	Information quality, CAD-CAM	Finishing - ironing, checking	Technological		Information quality, CAD-CAM				Orders/lines received damaged free (%)			
A	30	20	50	49	13	62	38	4..5	50...100	10	93	7	9	81
B	39	45	16	44	32	76	24	4..5		10	90	10	8	74
C	51	28	21	63	35	98	2	4..5		10	95	5	5	70
D	71	22	7	31	46	77	23	4..5		10	92	8	6	89

Based on data, third level KPIs relevant to the processes of interviewed enterprises were chosen and calculated; results are given in Table 3 [39].

Table 3. Calculation of third level SCOR KPI-s

Faultless Installations	RL 3.12=100- %of internal rejected%of materials rejected of %Warrancy returns/100 = 0.70
Orders/lines received damaged free	RL 3.24 = OTIF (On Time In Full) =0.93
Warranty and Returns	RL 3.55=%Warrancy returns/100=0.07
Orders Delivered Defect free conformation	RL 3.42 =78%x7%
Another required documentation accuracy	RL 3.43=22%x%7=0.15
Payment documentation accuracy	RL 3.45 = 1%=0.01

Third level SCOR KPIs probabilities are calculated based on qualitative data gathered via interviewing companies and entered to BBN model. The likelihood of processes impacting third level KPIs in interviewed companies is unknown due to a lack of analysis in companies. However, it is possible to analyse which third level KPI has the strongest influence on the Second level KPI and Perfect order fulfilment Strategic Target to select best practice which helps achieve the target. The highest impact on the second level KPI is the third, "RL 3.35 Warranty and Returns," for the current case study. The score recommends applying the "BP.089 Perfect Pick Put away" and "BP.147 Receiving Goods Inspection" best practices. Implementing those practices is expected to eliminate the problems related to current returns (see Fig. 5).

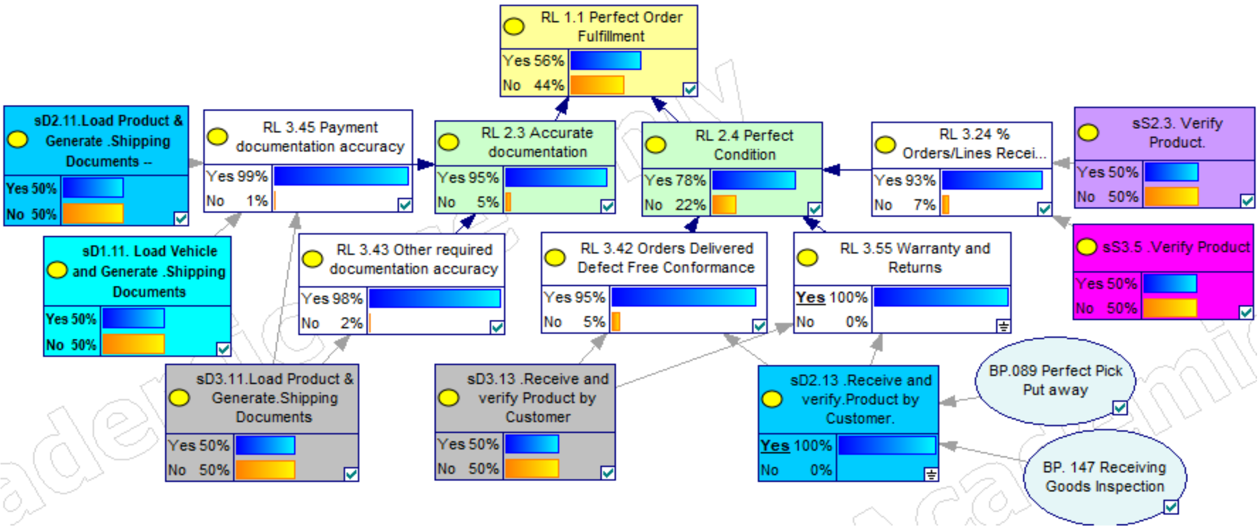

Fig. 5. Evaluation of processes KPI BBN network after best-practice tools implementation

5. CONCLUSIONS

Supply Chain digitalisation framework introduced and tested on a selection of small garment producing companies. Authors introduce how to solve digitally quality problems companies face and to respond dynamically to the returns, reclaims, and quality related BBN model allows selecting the best practices, which gives the highest impact on Perfect Order Fulfilment KPI and predicts the implementation results [39].

Authors have created data gathered BBN model to respond to growing customer expectations dynamically. In future research the processes and third level KPIs of other fields of activities will be studied and analysed to clear out similarities and specificities. Authors are planning to collect the data from ERP for quantitative analysis.

The current case study recommends implementing the digital solution that guarantees the Perfect Pick and Put Away and Receiving Goods Inspection. Based on empirical data, authors proved that those tools have the strongest influence on Second level KPI and Strategic Target fulfilment.

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