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Development of SCOR Database for Digitalisation of Supply Chain Customer Feedback Analysis

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High-level customer service, with improved quality at a lower cost, is imperative in today's global supply chain, where customers have myriad options across borders. This is in line with the primary objective of supply chain management, which is to enable and deliver high-level customer service with lower costs, reduce lead time, and improve the quality of products/services. The Supply Chain Operations Reference (SCOR) model based on KPI metrics enables an increase in the quality of products/services by monitoring and digitalising involved processes. The current paper suggests the structure of the SCOR database for Supply Chain process improvement by applying the best practices of the SCOR for Business Processes improvement. We recommend the Bayesian Belief Network (BBN) and Case-Based Reasoning (CBR) methods to estimate the influence of these improvements on Supply Chain efficiency through key performance indicators before implementation. Integrating the methods proposed in this article focuses on an approach that minimises supply chain failures, decreases failure elimination time, understands consumer needs, and offers more accurate price proposals and lead times to improve customer satisfaction. Accordingly, the integrated SCOR-based Business Process Modelling (BPM) was not previously combined with BBN to identify the most efficient ways to improve the reliability of a Supply Chain by applying best practices, which impacts the entire supply chain. Our research is limited to SME companies in electronics manufacturing, but our ambition is to develop a universal framework suitable for broader areas. The study aims to analyse how the customers see the company by combining the CDA (Customer Delivery Accuracy) and Customer Complaints measures and find the optimal way to improve business processes by applying best practices. Still, it is limited to SCOR reliability performance metrics.

Keywords: *Supply Chain (SC); Supply Chain Operations Reference (SCOR); Key Performance Indicators (KPIs); Bayesian Belief Network (BBN); Digitalisation; Reliability; Customer Service Quality; Case Base Reasoning (CBR).*

Introduction

The target of current research work is to contribute to the customer satisfaction field and to analyse the customer view of services provided. To achieve the target authors further develop the Supply Chain digitalisation framework (Shevtshenko *et al.,* 2022) by combining CDA (Customer Delivery Accuracy) and Customer Complaints business measures. To support this research the authors collected extensive data related to Customer Delivery Accuracy (CDA) and reclamations from the Estonian electronics industry. The authors applied the Supply Chain Operations Reference database (SCORE DB) to analyse the data and suggested using Case-Based Reasoning (CBR) to store previously successful best practices. This improvement enabled the case study company to keep track of previous decisions and related explanations, thereby speeding up the customer feedback process. With access to existing knowledge, the company can reject non-valid reclamations and apply previously successful corrective actions to improve the reliability of the supply chain.

The authors present how to apply the Bayesian Belief Network (BBN) methodology for supply chain reliability improvement, which was previously successfully used for reverse logistics management (Shevtshenko & Wang, 2009).

Physical and information flows connect the supply chain's organisations. Supply Chain Management (SCM) is based on the combined efforts of several intra-organisational activities covering everything from product development to delivery to consumers or other businesses. Companies need to analyse processes to make the right decisions. Developing strategies that ensure operatable systems efficiency and effectiveness is essential for enterprises. At the same time, maximum customer satisfaction should be accomplished. (Lebas, 1995; Shevtshenko *et al.,* 2022).

To achieve the goal of customer satisfaction, an efficient supply chain is needed, it could be done through the coordinating and controlling of the business processes. (Ayyildiz & Gumus, 2021; Shevtshenko *et al.,* 2022). "As firms successfully streamline their operations, the next opportunity for improvement is better coordination with their suppliers and customers." (Sunil Kumar, 2016). Supply chain management improves the partner's collaboration and increases inventory transparency and turnover (Njoku & Kalu, 2014).

"Businesses can use the SCOR model to assess how advanced or mature the supply chain processes are and how well they aligned with business objectives." (CIO, 2021). The SCOR reference model can be applied to define process architecture that aligns with essential business functions and goals (Taghizadeh & Hafezi, 2012; APICS, 2017). The accuracy of the SCOR model's definitions enables companies to standardise the vocabulary and to validate the performance of the supply chain by benchmarking between the platforms of customers and logistic services providers (Ganga & Carpinetti, 2011; Mahmood *et al.,* 2018). This standardisation helps ensure that all parties involved in the supply chain use the same terminology, reducing confusion and misunderstandings. Further, benchmarking provides a means for companies to compare their performance with others in the industry, which can help identify areas for improvement and best practices.

The SCOR model simplifies the standardisation of business processes, the definition of KPIs, the tracking of progress, and to track the measurable results. The authors suggest measuring its performance using key indicators built based on the SCOR model and standardised supply chain performance metrics to keep an efficient and effective supply chain. It may be achieved by developing the SCOR database to establish the links between processes with performance metrics and best practices (Shevtshenko et al., 2020). The suggested approach can be used across industries using standard definitions for any supply chain process.

Digitalising the supply chain is crucial to breaking down communication barriers between supply chain stakeholders. The collaboration between processes in Digital Supply Chain enables creating and sharing the data in a suitable format, eliminating bottlenecks, decreasing failures and minimising the disruption recovery time. Indeed, effective communication supported by real-time information over digital platforms enables prompt decision-making for improved supply chain performance.

According to Tortorella and Fetterman (2017), digital technologies will help achieve Industry 4.0 and form new strategies for improving process efficiency. It will also contribute to the increase in product quality. Proposed mechanisms for digitalisation of supply chain analyses find business process improvement areas. It is done based on customer reclamations and production defects (Shevtshenko *et al.,* 2022; Shevtshenko *et al.,* 2022). SCOR model processes are connected with KPIs on a different level. BBN is used to analyse supply chain reliability and find the best practise that influence the strategic KPI the most.

SCOR Concept

Measuring and tracking goods is essential for the supply chain; a SCOR database was developed to do so. To ensure efficient supply chain management, it is crucial to monitor, adjust and improve it from the perspective of customer order. SCOR model provides a standard supply chain effectiveness measurement process using uniform criteria (McCann, 2021; Shevtshenko *et al.,* 2022).

As researchers and practictionaries use the SCOR model to benchmark operations management activities and can be extended when needed, Quality management is a cornerstone for improving productivity and applying lean practices (Muller, 2019). The SCOR model is a base for supply chain improvement projects in today's business environment. Several companies have built their production and supply chains based on the SCOR model to standardise their processes.

Economic relationships between the SC participants are shown in the SCOR model. Thus, the model will help to analyse the supply chain showing bottlenecks and possible solutions for building or improving an enterprise logistics system. SCOR is a valuable framework to help firms achieve their desired supply chain performance when designing or reworking it. SCOR provides different performance strategies (Dhanya & Sarmah, 2014). Performance attributes could be measured in terms of reliability, responsiveness, agility, costs, and asset management (APICS, 2017). The first three attributes are customer-focused, dealing with the effectiveness of the supply chain processes. In contrast, the others are internally-focused attributes, dealing with efficiency (Chorfi *et al.,* 2018). Only part of the model is used when selecting one strategy, consisting of processes and metrics that affect the top supply chain reliability strategy (APICS, 2017).

The SCOR reference model consists of 4 major sections:

1. *Processes:* Standard descriptions of management processes and process relationships.
2. *Performance:* Standard metrics to describe process performance and define strategic goals.
3. *Practices:* Management practices that produce significantly better process performance.
4. *People:* Standard definitions for skills required to perform supply chain processes (APICS, 2017).

The ***SCOR processes*** are those that a supply chain must execute to meet its primary objective of fulfilling customer orders. For each unique operation, SCOR only has one representation. The SCOR model comprises the six primary management processes: Plan, Source, Make, Deliver, Return, and Enable (APICS, 2017). These SCOR processes can design and maintain the supply chains of various complexities across multiple industries.

Figure 1 introduces the hierarchical processes model according to SCOR Model.

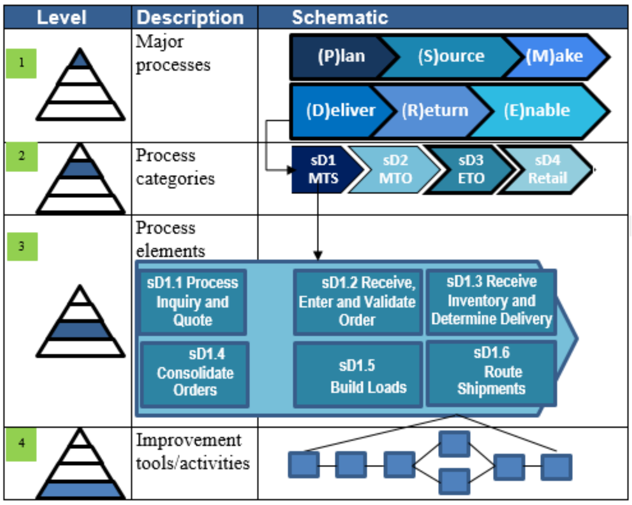

Figure 1. SCOR - Hierarchical Processes Model (APICS, 2017)

The four levels include:

Level 1: Six major processes: plan, source, make, deliver, return, and enable. That defines the supply chain's scope, content, and performance targets.

Level 2 includes subtype process categories: Make to Stock, Make to Order, Engineering to Order and Retail, for the processes described in Level 1. Subtype categories fall under the "parent" categories in Level 1. This level described the operations strategy and required capabilities (CIO, 2021).

Level 3: includes the process element, which describes the activities performed in each supply chain process (CIO, 2021). Process elements define the configuration of individual processes and the ability to execute them based on processes, inputs/outputs, skills, performance, best practices, and capabilities.

Level 4: Improvement tools/activities using Kaizen, lean, TQM, Six Sigma, benchmarking, etc. Controlling business processes is an essential part.

Controlling the performance of processes through KPIs is crucial for improving Supply Chain Management, which can be defined as coordinating the Supply Chain stakeholders (Gunasekaran *et al*., 2004).

The ***SCOR performances*** consist of two elements: Performance attributes and metrics. An attribute is used to set strategic direction (APICS, 2017).

The SCOR metrics are constructed as a hierarchical three-level structure to measure supply chain performance. Performance metrics or KPIs support the visualisation of the supply chain to analyse the gap between the performance of planned and actual activities and to discover and solve possible problems. (Chae B, 2009). Customer-focused metrics are specific parameters for quantifying and measuring supply chain performance attributes.

Performance measurement models based on the SCOR can be used in different industry sectors. Figure 2 and Figure 3 illustrate the level 1 and 2 performance metrics. Lower-level metrics will serve as diagnostics to identify upper-level root causes of performance gaps.

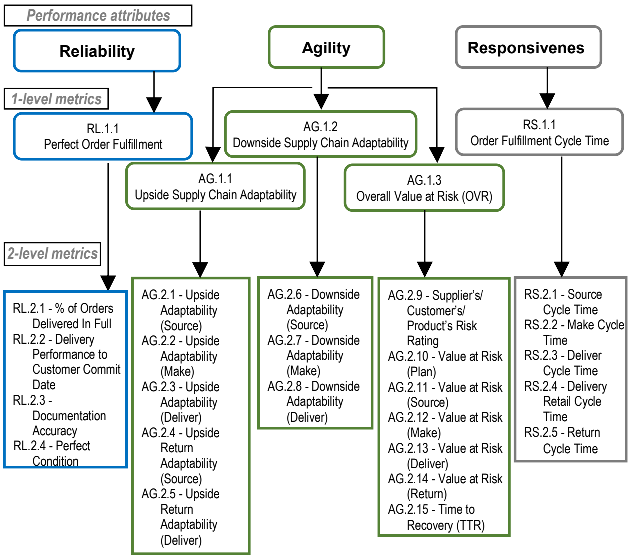

Figure 2. SCOR Customer-Focused Performance Metrics Dealing with the Effectiveness of the Supply Chain Processes

Companies are using metrics to plan and measure the supply chain performance attributes requirements by priority.

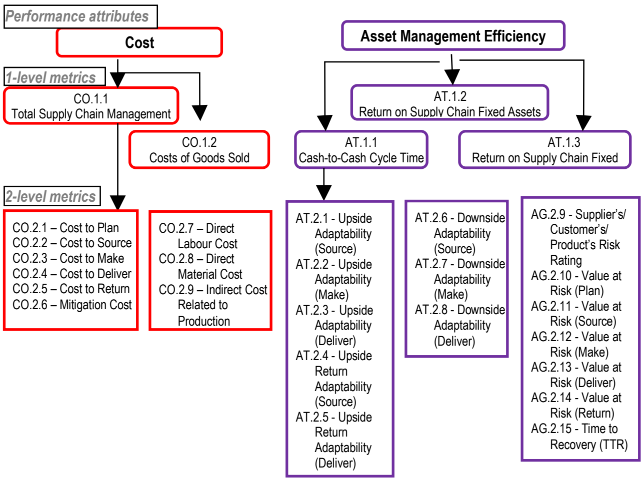

Figure 3. SCOR Internally-Focused Performance Metrics Dealing with Company Efficiency

The best practice is guidance to improve the efficiency of a process or a set of procedures. Different industry SCOR practitioners develop the recommendations. Best Practices can cover process automation, implementation of technology, application of skills, recommendation of the most optimal sequence of activities or optimal distribution and connections of processes within the supply chain partners. Still, their efficiency can vary for different sectors or supply chains. (Georgise, et al., 2013).

The people section focuses on supply chain SCOR skills required for successful implementation, metrics, and practice reference components (APICS, 2017). Organisations should be able to develop strategies, make knowledge-based decisions, and control and manage the business process development to enable them to reach the supply chain's highest profitability and effectiveness and customer satisfaction goals.

The interconnection of SCOR sections Processes, Performance, and Best Practice is introduced in Figure 4. SCOR framework for "Perfect Order Fulfilment" strategic metrics, its processes (3 levels), and best practices (several colours mark several levels of processes) (Shevtshenko *et al.*, 2022).

The Main Idea of the Research

A manager's objective is to optimise SC performance for strategic goal fulfilment.

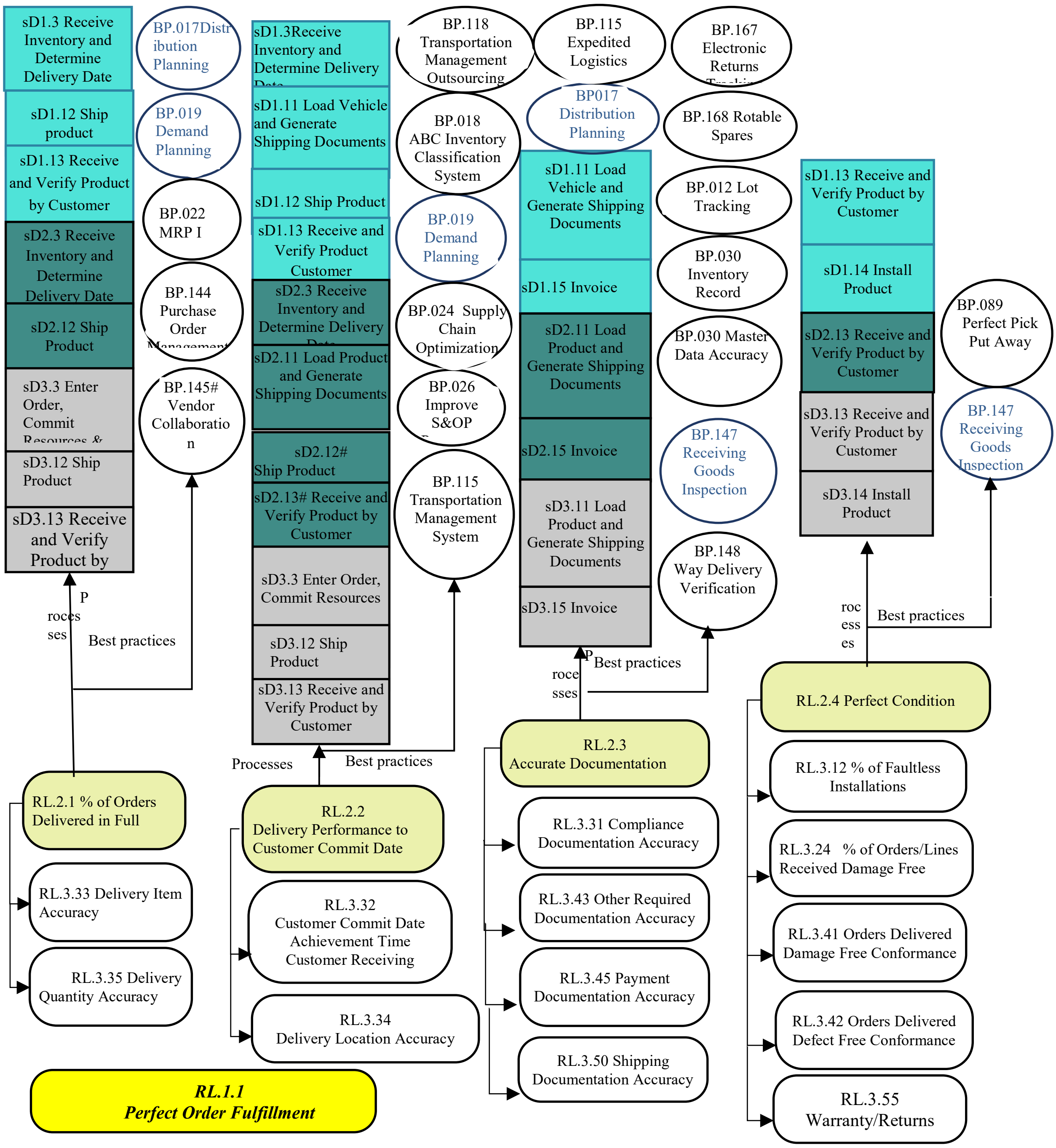

Figure 4. Interconnection of SCOR Sections *Processes, Performance,* and *Best Practice,* for Example, "Perfect Order Fulfilment" Strategic Metrics

These objectives could be achieved by quickly finding a solution for improving supply chain processes and correcting key performance indicators using the SCOR standard's best practices.

For operating the SC systems with the highest efficiency and effectiveness, our research group suggests a database structure based on the Integrated DEFinition Method (IDEF1x) (Mahmood *et al.,* 2019), including all SCOR sections: *Processes, Performances, Best Practices, and People.* This SCOR-DB is shown in figure 5.

The benefits of using the SCOR-DB include the following:

- The database allows an SC manager to quickly find a failed process due to the process's hierarchical structure and the SCOR attributes. (The example of searching the needed operation for primary management processes *Make* is shown in Figure 6).

- The database suggests all applicable best practices for processes, metrics, and practice reference components.
- SCOR-DB allows determining the impact of changing one metric on another performance metric.
- The database allows the addition of new processes and attributes to a specific process based on enterprise skills.

DB techniques make maintaining large volumes of information more accessible and apply other data analysis methods. Figure 5 shows the SCOR database structure with examples of its table filling.

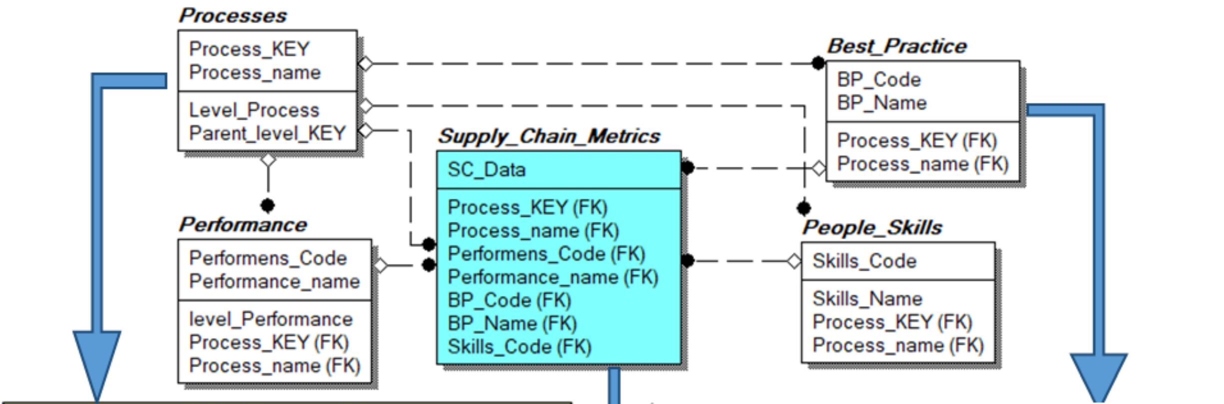

Table "Processes" data

Level Process	Parent level KEY	Process KEY	Process name
1		sM	Make
2	sM	sM1	Make-to-Stock
3	sM1	sM1.1	Schedule Production Activities
3	sM1	sM1.2	Issue Material
3	sM1	sM1.3	Produce and Test

Table "Best Practice" data

Process KEY	Process name	BP Code	BP name
sM1.1	Schedule Production Activities	BP.011	Production Line Sequencing
sM1.1	Schedule Production Activities	BP.088	360 Degree Closure
sM1.1	Schedule Production Activities	BP.172	Production Scheduling Optimization Using Enabling Technologies

Table "Supply Chain Metrics

Process KEY	Process name	Perform. Code	Perform. name	BP Code	BP name	Skill Code
sM1.1	Schedule Production Activities	RL.3.49	Schedule Achievement	BP.011	Production Line Sequencing	HS.0065, HS.0082, HS.0103
sM1.1	Schedule Production Activities	RL.3.49	Schedule Achievement	BP.088	360 Degree Closure	HS.0065, HS.0082, HS.0103
sM1.1	Schedule Production Activities	RL.3.49	Schedule Achievement	BP.172	Production Scheduling Optimization Using Enabling Technologies	HS.0065, HS.0082, HS.0103
sM1.1	Schedule Production Activities	RS.3.123	Schedule Production Activities Cycle Time	BP.011	Production Line Sequencing	HS.0065, HS.0082, HS.0103
sM1.1	Schedule Production Activities	RS.3.123	Schedule Production Activities Cycle Time	BP.088	360 Degree Closure	HS.0065, HS.0082, HS.0103
sM1.1	Schedule Production Activities	RS.3.123	Schedule Production Activities Cycle Time	BP.172	Production Scheduling Optimization Using Enabling Technologies	HS.0065, HS.0082, HS.0103

Figure 5. SCOR-DB Structure Performed by IDEF1x Method with **an** Example of Database Tables Filling

The supply chain optimisation process follow the steps:

1. All complaints and Customer Delivery Accuracy (CDA) data should be collected during a selected period.
2. The process manager associates each complaint or missed delivery with a specific SCOR process. It can be done by process levels, as shown in figure 6.
3. Using the Process Code from the database, you can find out what Best Practices can be used to improve the process and what metrics it is associated with.
4. To find ways of process improvement, the authors suggest using the Bayesian Belief Network (BBN) to analyse the efficiency of corrective action to SC performance indicators. Performance indicators (reliability, responsiveness, agility, assets management, and cost) should be considered (all or some of them) depending on company strategy.
5. If the company has experience using Best Practices for supply chain improvement, then the Case Base Reasoning method (CBR) can be applied to find the best solution.

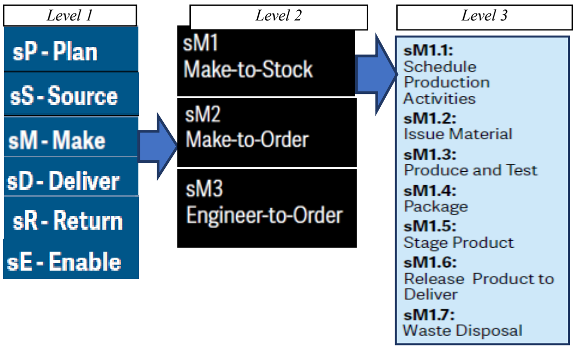

Figure 6. The Sequence of Processes Selection by Levels

Methods Used in Research

This literature review includes an overview of methods for solving decision problems in business. We focus on methods for optimising business processes in the supply chain and their implemented areas by applying techniques on data to optimise business processes to increase CDA level and to receive fewer customer reclamations by providing better-quality goods. SMEs could use our research findings to create a realistic customer view of the supply chain. The most commonly used methods for evaluating supply chain processes are Multi-criteria Analysis Methods (TOPSIS, AHP, FAHP) and the Graphic probabilistic BBN approach. Authors use those methods to combine the scores provided by the supply chain participants to rank alternative solutions and select the best one. Researchers name such methods as single analytical and hybrid/mixed.

For our research, selecting the method with the highest advantages and implementing it efficiently is essential. For comparison, we grouped the available techniques in Table 1.

Table 1

Comparison of Different Calculation Methods

Calculation method	Type	Description	Advantages
BNN - Bayesian Belief Network (Neapolitan, 2003) (Shevtshenko & Wang, 2009) (Karaulova *et al.,* 2012) (Lockamy & McCormack, 2012) (Mahdi *et al.,* 2015) (Garvey *et al.,* 2015) (Mkrtchyan *et al.,* 2016) (Qazi *et al.,* 2017) (Wiecki & Kumar, 2019) (Hosseini & Ivanov, 2021) (Rolf *et al.,* 2022) (Qazi *et al.,* 2022)	Graphic probabilistic method	Dependency model. Based on statistical data	Successors of statistical approaches, AI and Data Mining. The BBN is a flexible tool that can be used in many ways. BBN allows you to describe the structure of SCOR accurately. Possible modelling and quantifying the impact of supply chain disruptions.
TOPSIS -Technique for Order of Preference by Similarity to Ideal Solution (Sachdeva *et al.,* 2009) (Shevtshenko *et al.,* 2019).	Multi-criteria Analysis Method	The utility-based method uses the evaluation matrixes and weights to compare the alternative depending on data.	Good computational efficiency and ability to measure the relative performance for each alternative in a simple mathematical form
AHP - Analytical Hierarchy Process (Huan *et al*.,2004) (Saaty, 2008) (Synlvain *et.al,* 2014)	Multi-criteria Analysis Method	Structured technique for organising and analysing complex complex systems.	For the aggregation of opinions from a group of respondents. For selection, the best project with low risk during project selection.
FAHP (Fuzzy Analytical Hierarchy Process) +TOPSIS (Mahmoodzadeh *et al.,* 2007) (Gumus, 2009) (Joshi *et al.,* 2011) (Mustafa, 2013) (Francisco *et al.,* 2014) (Ertugrul *et al.*, 2021)	Multi-criteria Analysis Method	The method is applied to find the importance degree of each criteria. The method can be used for estimating suppliers and partners.	Fuzzy AHP can be utilised as an approach for supplier selection problems. Fuzzy AHP and Fuzzy TOPSIS are used for supplier and partner selection.

As can be seen from Table 1, the BBN method has been quite actively used in recent years for supply chain analysis. Let's consider how other authors used it in Supply Chain Management.

Bayesian Belief Network (BBN)

A Bayesian network model converts probabilistic relationships of the different events of the object under research. It can be applied for data analysis by visualisation of two or more events co-occurring (Heckerman, 1996).

- The model helps to aggregate the solution by considering the interrelationships between all variables under conditions when some data do not exist. It encodes dependencies among all variables, aggravating the solution where some data entries are missing.

- The Bayesian network supports the research of causal dependencies, helps to clarify the problem's domain and can forecast the effect of corrective action influence on the final result.
- The model includes causal and probabilistic aspects to consider prior knowledge and data received in a causal format.
- Bayesian statistical methods used in combination with Bayesian networks avoid data over-fitting. (Heckerman, 1996).

Hosseini and Ivanov (2021) discovered the frequent use of Bayesian methods in SCM applications. In this study (Rolf *et al.,* 2022), a multi-level Bayesian network model was used to assess the impact of supply chain disruptions. Other authors (Garvey *et al.,* 2015; Qazi *et al.,* 2017; Qazi *et al.,* 2022) found a BBN to be an excellent way to assess supply chain risks. Example cases are essential as they provide confidence that they will be suitable also for our research.

There are findings (Mkrtchyan *et al.,* 2016) that Bayesian is a universal tool used in different contexts. Researchers stated that it is used frequently in risk analysis to model multiple, interrelated influences on risk. Our research does not consider risk management but includes a SCOR database containing related and dependent matrices. Bayesian allows the inclusion of all the prior information about the structure of the problem into the model, so decision-makers don't have to learn everything from the data like ML (Machine Learning) will do (Wiecki & Kumar, 2019). Therefore it will skip the ML "black box" problem and help communicate the findings easily to all supply chain stakeholders.

There are also combinations of BBN and SCOR found in (Case-based reasoning (CBR), a technique that solves a problem using past experiences, where a case stores these past experiences called cases). It was used to improve supply chain performance. They used SCOR metrics, and the Bayesian Network measured the SC performance.

The other technique we applied in current research is Case-Based Reasoning.

CBR technique

The researchers of Yale University validated that most people solve problems based on working experience under similar conditions. Case-Based Reasoning (CBR) solves a problem by applying previously received knowledge, called cases. (Barman et al., 2020). Using the knowledge-based simplify the storage and processing of valuable information.

CBR is described in several research libraries (A. Aamodt *et al.* 1994; J. L. Kolodner, 1992; A. Smiti *et al.*, 2011; Smiti A. *et al.,* 2013). Recurring problem solutions are optimal to use again when the nature of the problems is the same. To understand the similarity, cases should be held somewhere. CBR method can suggest a solution by learning from similar cases in the past (precedents). It is a way of solving problems based on already-known solutions.

"CBR should be used whenever possible because it is often the fastest way to gain an adequate solution among the available techniques." (Anthony Jnr. & Che Pa, 2016). A four-step process for CBR includes:

1. Retrieve: To extract the closest case in the past.
2. Reuse: To solve the new problem based on previously stored knowledge.
3. Revise: To assess the solution under new conditions.
4. Retain: Saving the solution for future use.

Kumar and Viswanadham (2007) applied the CBR approach to decision-making system development, which considered past knowledge and risks in the construction field for new project planning. Jiang-Hong Man and Qing-Li Da (2003) used CBR for a generalised approximate set of operations in a supply chain. Chen et al. (2017) used CBR methodology in merchandise authorisation systems for supply chain management and for analysing the customer service behaviour of its customer relationship management. In our research, we will use the same problem solutions again as it will be a more optimised way to compute answers.

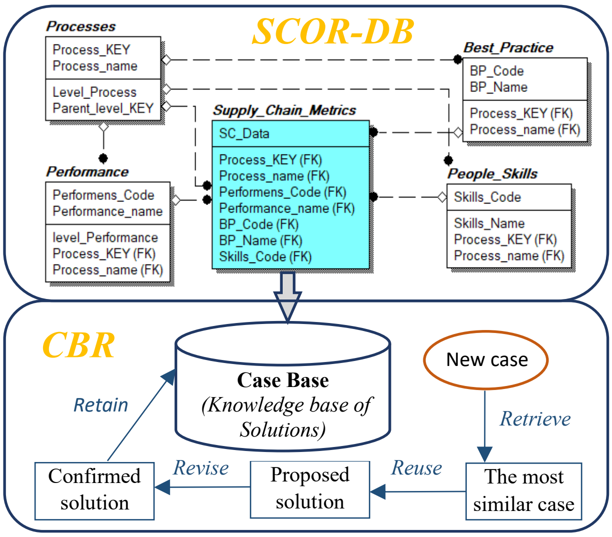

Figure 7. Case-Based Reasoning Cycle

Our research suggests using the CBR technique to find the right solution for Best Practices from the SCOR database. The mechanism of joint use of the SCOR database and CBR is shown in Figure 7. The authors focused on customer service and found a gap in assessing effective supply chain processes. Authors used the previously known methods in a novel integration framework: developed SCOR model database applied with best practices and skills with related supply chain processes, CBR for storage and selection of best practices, BBN for analysis of corrective action impact on performance.

Methods Application

For our research, we have developed the Bayesian Belief Network (BBN) template using the SCOR 3-level aligned with company KPI-s. The required data can be received in Excel form and usually includes the data related to internal and external processes. Bayesian Belief Network (BBN) is a probabilistic tool to collect and analyse knowledge visually. The model consists of interconnected nodes of variables connected by relational arcs. (Neapolitan, 2003; Murumaa *et al.,* 2021). BBN is a valuable tool for decision-making under uncertainty. "Anything that is not measurable is not manageable. Risk modelling aims to get insight into the system performance, represent or express the uncertainties, identify the risk contributors and see the effect of changes". (Abolghasemi *et al.,* 2015).

Shevtshenko et al. (2022) introduced how to use BBN to visualise the SCOR structure. Third level reliability metrics were connected to SCOR processes to estimate the influence of corrective actions on the reliability performances of the supply chain. BBN analysis connects problems with SCOR processes, third-, second- and first-level metrics to select best practices to achieve strategic reliability targets in the supply chain. The authors continue with SCOR database development for Perfect Order Fulfillment (POF) in the current research. The SCOR database connects the reasons for non-conformities with business processes, KPIs and best practices.

"The rate of reliability, the operational criterion, is 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 order condition" (Stephan & Badr, 2007).

The methods are applied in the following order:

1. Development of SCOR Database
2. Mapping of company data with SCOR processes codes.
3. Selection of most efficient existing company best practices by CBR knowledge base.
4. Adding SCOR attributes measures: reliability, agility, responsiveness, cost, asset management efficiency, best practices, and skills to each process.
5. Analysis of SCOR best practices by BBN.
6. Business process reengineering was followed by analysing best practices and adding them to CBR.

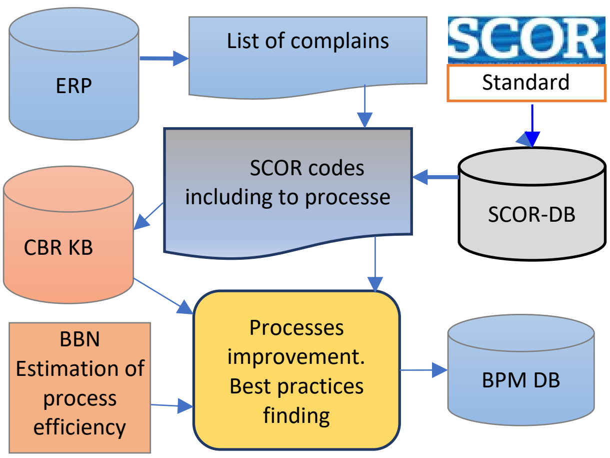

Figure 8. Customer Processes Improvement Based on Complaints

Figure 8 visualises the sequence of steps for identifying the halting in the supply chain based on user complaints and customer delivery accuracy data. Based on CBR and BBN analysis, the decisions for more efficient use of a supply chain should be taken.

The steps for finding and eliminating failures in the supply chain include the following:

1. *Clearing the complaint list*. It is necessary to highlight complaints that resulted from improper use of products. In the list of reclamations (see Table 1), they are marked as not acceptable (not ACC).

2. *CBR analysis.* Using the CBR archive solution is possible to find the most effective solution used for the same cases for similar products. This is possible if the company has sufficient experience and a database of claims cases.

3. *Join the list of reclaims with SCOR-DB.* For this aim, the list of complaints is supplemented with the SCOR process code (process KEY). The finding of the needed process KEY is shown in Figure 6. It is possible to find all information connected with this process in SCOR-DB by using process KEY. Figure 9 shows joined structure of SCOR-DB with the complaint list.

4. *BBN analysis*. BBN is used to estimate the influence of corrective actions for performance efficiency in the supply chain. As corrective actions are used, best practices from SCOR-DB. We should select more suitable practices from the suggested ones by SCOR best practices or consider the influence on the supply chain effectiveness.

5. After corrections and implementation, it is necessary to include new cases in the Case Base Archive of a solutions database

Case Study

A company from the automotive electronics production area was chosen to illustrate the current research.

Products have restricted requirements for quality; expectations are 100 % order fulfilment for the electronic producing enterprise. Products should be checked before delivery, and all found defects should be corrected before. Deviation in quality could lead to a price reduction or delay in the payment (Murumaa *et al.,* 2021). There could be external and internal problems occurring with products. External defects are found by the customer mainly as the defect is happening by the wrong care procedures or it could be from physical damage. Internal defects are made during production. Quality checking could avoid technological defects during production or before delivery (Shevtshenko *et al.,* 2022).

Table 2 shows the complaints that require consideration and action for their correction. As mentioned earlier, excluding those marked as "not ACC" from the table lines in the column "Decision" is necessary. These cases should be included in the CBR database for quick decision finding next time for similar failures. The CBR method should be used for all other shortcomings if the enterprise has enough experience and a case archive database. The current paper will not impact finding decisions by the CBR method. In the present research, we try to show how to find solutions in the face of uncertainty using standard relationships and decision paths for more effective supply chains. For this aim, it is necessary to complement the list of reclaims (see Table 2) with the SCOR process code (KEY) and its name. Tables 2-4 also contain Customer Delivery Accuracy (CDA) failures.

Defects could be corrected before delivery or when still occurring proposed mechanism proposes best practices to eliminate the problems happening again. It will assure the customer that reorders are free of the same issues. When defects are discovered too late, delivery without those items is done. It will also influence how customers see us regarding reliable partners (Murumaa *et al.,* 2021).

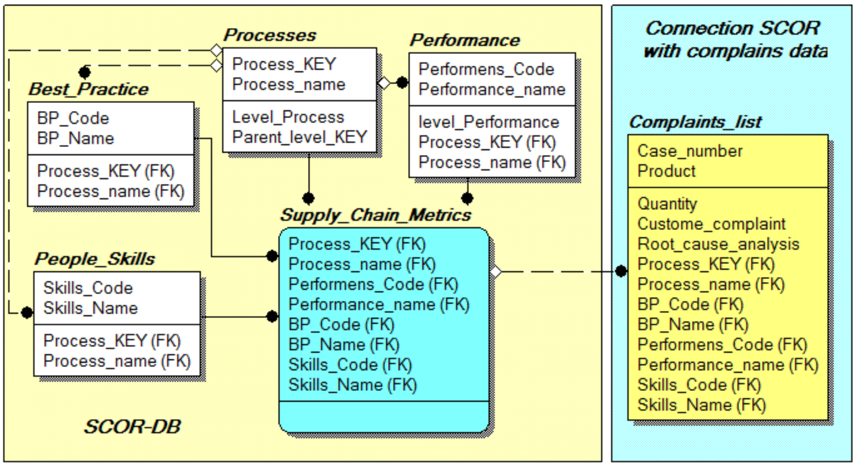

Figure 9. Connection SCOR-DB Data with Company Complaints List *Data Collecting and Ordering*

Table 2

List of Complaints

Case number	**Product**	**Quantity**	**Customer complaint**	**Root cause analysis**	**Decision (ACC or not ACC)**	**Process KEY SCOR name**
Case 1	Prod 1	2	Function failure	Component 1 component damaged, suspect that it happened in the router, monitoring	ACC	sM.1.3: Produce and Test
Case 2	Prod 2	3	Function failure	Component 2 burned, suspect that happens during ICT using an old fixture	ACC	sM1.3: Produce and Test
Case 3	Prod 3	2	No communication with the display	Customer damage	not ACC	
Case 4	Prod 4	5	It cannot be programmed	Boot flag wrong value	ACC	sM1.3: Produce and Test
Case 5	Prod 4	5	The program cannot be loaded	Component 8 mode activated, customer issue	ACC	sD1.14: Install product
Case 6	Prod 4	1	No parameterisation possible	Wrong configuration - Component 8 mode (customer issue)	ACC	sD1.14: Install product
Case 7	Prod 5	2	Missing marking	The sub-supplier issue, pass-through	ACC	sS2.3: Verify product
Case 8	Prod 6	4	The unit does not power on	Fault confirmed, but the claim is not accepted because of customer damage	not ACC	
Case 9	Prod 7	2	Functional error	Cancelled by the customer since it was their internal error	ACC	sD1.14: Install product
Case 10	Prod 8	2	Display defect	1 Display broken – crack between legs, 1 Component 9unfunctional, 1 Component 10 burned out	ACC	sM1.3: Produce and Test
Case 11	Prod 9	3	Display defect	The supplier confirmed that the issue is related to the display PCB, awaiting per Customer 3ent corrective actions from the supplier.	ACC	sS2.3: Verify product
CDA- Customer Delivery Accuracy failures (Continues of Table 2)						
Case-CDA1		12	Lack of production capacity			sM1.1 Schedule Production Activities (sM1 Make-to-Stock)
Case-CDA2		11	Increased customer demand near the time			sS3.3 Schedule Product Deliveries
Case-CDA3		9	Lack of material from an external source			sS1.2 Receive product

Table 3

Selection from SCOR-DB for Our Case Study

Process KEY SCOR name	**Performance**					**People**	**Best Practices**
	Reliability	**Responsiveness**	**Agility**	**Cost**	**Asset Manag. Eff.**		
sM1.3 Produce and Test	RL.3.36 Fill Rate **RL.3.55 Warranty and Returns** RL.3.56 Warranty Costs RL.3.58 Yield L.3.59 Yield Variability	RS.3.4 Asset Turns RS.3.101 Produce and Test Cycle Time			AM.3.5 % of production materials reuse AM.3.6 % of products consisting of previously used components	HS.0043 Engineering HS.0065 Lean Manufacturing HS.0099 Production	BP.012 Lot Tracking BP.152 Automated Data Capture (ADC)
sD1.14 Install product	RL.2.4 Perfect Condition **RL.3.12 % Of Faultless Installations**	RS.3.46 Install Product Cycle Time				HS.0043 Engineering HS.0105 Project Management	
sS2.3 Verify product	RL.3.19 % Orders/ Lines Received Defect Free **RL.3.21 % Orders/ lines received with the correct content** **RL.3.24 % Orders/lines received damage-free**	RS.3.140 Verify Product Cycle Time				HS.0002 Acceptance testing HS.0108 Quality Management HS.0112 Requirements acceptance criteria	BP.011 Production Line Sequencing BP.069 Raw Materials Receiving Process BP.147 Receiving Goods Inspection
sM1.1 Schedule Production Activities (sM1 Make-to-Stock)	RL.3.49 Schedule Achievement	RS.3.123 Schedule Production Activities Cycle Time			AM.3.9 Capacity Utilisation	HS.0065 Lean Manufacturing HS.0082 Optimisation HS.0103 Production Scheduling	BP.011 Production Line Sequencing BP.172 Production Scheduling Optimisation Using Enabling Technologies
sS1.1 Schedule Product Deliveries	RL.3.27 % Schedules Changed within Supplier's Lead Time	RS.3.9 Average Days per Engineering Change RS.3.10 Average Days per Schedule Change				HS.0069 Logistics Management HS.0074 Master Scheduling HS.0080 MSDS/CoC/BoL/Environmental Interpretation HS.0083 Order Management	BP.043 Consignment Inventory Reduction BP.122 Vendor Managed BP.144 Purchase Order Management BP.145 Vendor Collaboration
sS1.2 Receive product	RL.3.18 % Orders/ Lines Processed Complete **RL.3.20 % Orders/ Lines Received On-Time to Demand Requirement** RL.3.22 % Orders/ lines received with correct packaging RL.3.23 % Orders/ Lines Received with Correct Shipping Documents	RS.3.113 Receiving Product Cycle Time				HS.0046 ERP Systems HS.0049 ID & Damage Inspection HS.0058 Inventory Management HS.0066 Legislation and Standards HS.0069 Logistics Management	BP.006 Consignment Inventory BP.012 Lot Tracking BP.068 Supplier Delivery Performance Analysis BP.069 Raw Materials Receiving Process BP.164 Consignment Inventory Management

Table 4

Joint Complaints List with Reliability Performances (RL) and Best Practices (BP)

Case number	Product	Quantity	Customer complaint	Root cause analysis	Process KEY/Name SCOR	Performance Code/Name SCOR	Best Practices Code/Name SCOR
Case 1	Prod 1	2	Function failure	Component 1 component damaged, suspect that it happens in the router, monitoring	sM1.3: Produce and Test	RL.3.55 Warranty and Returns	BP.152 Automated Data Capture (ADC)
Case 2	Prod 2	3	Function failure	Component 2 burned; I suspect that happens during ICT using an old fixture	sM1.3: Produce and Test	RL.3.55 Warranty and Returns	BP.152 Automated Data Capture (ADC)
Case 4	Prod 4	2	It cannot be programmed	Boot flag wrong value	sM1.3: Produce and Test	RL.3.55 Warranty and Returns	BP.152 Automated Data Capture (ADC)
Case 5	Prod 4	5	The program cannot be loaded	Component 8 mode activated, customer issue	sD1.14: Install product	RL.3.12 % Of Faultless Installations	
Case 6	Prod 4	5	No parameterisation possible	Wrong configuration - Component 8 mode (customer issue)	sD1.14: Install product	RL.3.12 % Of Faultless Installations	
Case 7	Prod 5	1	Missing marking	The sub-supplier issue, pass-through	sS2.3: Verify product	RL.3.21 % Orders/ lines received with the correct content	BP.147 Receiving Goods Inspection
Case 9	Prod 7	2	Functional error	Cancelled by the customer since it was their internal error	sD1.14: Install product	RL.3.12 % Of Faultless Installations	
Case 10	Prod 8	4	Display defect	1 Display broken – crack between legs, 1 Component 9unfunctional, 1 Component 10 burned out	sM1.3: Produce and Test	RL.3.55 Warranty and Returns	BP.152 Automated Data Capture (ADC)
Case 11	Prod 9	2	Display defect	The supplier confirmed that the issue is related to the display PCB, awaiting per Customer 3ent corrective actions from the supplier.	sS2.3: Verify product	RL.3.24% Orders/ lines received Damage-Free Conf. Customer	BP.147 Receiving Goods Inspection
CDA- Customer Delivery Accuracy							
Case-CDA1		12	Lack of production capacity	Lack of production capacity	sM1.1 Schedule Production Activities (sM1 Make-to-Stock)	RL.3.49 Schedule Achievement	BP.172 Production Scheduling Optimisation Using Enabling Technologies
Case-CDA2		11	Increased customer demand near the time	Increased customer demand near the time	sS1.1Schedule the Product Deliveries	RL.3.27 % Schedules Changes within Supplier's Lead Time	BP.145 Vendor Collaboration
Case-CDA3		9	Lack of material from an external source	Increased customer demand near the time	sS1.2 Receive product	RL 3.20 % Orders/ Lines Received On-Time to Demand Requirement	BP.068 Supplier Delivery Performance Analysis

The interviews with large electronic companies gave qualitative data about internal and external faults. Order failures can be divided into missed order delivery rows and customer complaints. Technological defect includes the non-appropriate use of component or programs. Those non-conformities can be discovered by testing embedded into the process, during the functional test and after recovering controlled during final testing. The total order amount during the considered period (one year) was 6935. The number of defects depends on a particular process connected with SCOR process KEY.

Based on the data, third-level KPIs relevant to the processes were calculated, and the list of 3-level SCOR KPIs required for BBN analysis is given in Table 5.

Table 5

Empirical Data is Structured Accordingly to SCOR Measures

	Reliability target 99,5%						
	Internal (CDA)			**External (Complaints)**			
Electronics Enterprise data	RL 3.49 Lack of production capacity	RL 3.20 Lack of material from an external source	RL 3.27 Increased customer demand near the time	RL 3.55 Warranty and Returns	RL 3.12 % Of Faultless Installations	RL 3.21 % Orders/ lines received with the correct content	RL.3.24 % Orders/ lines received damage Free
Failures indexing	12/32 37,5 %	11/32 34,4 %	6/32 8,1%	11/26 42,3 %	12/26 46,2 %	1/26 3,8 %	2/26 7,7 %
% of failures for the total amount	12*100/6935 =0,17 %	11*100/6935 =0,15 %	9*100/6935 =0,13 %	11*100/6935 =0,15 %	12*100/6935 =0,17 %	1*100/6935 =0,01 %	2*100/6935 =0,02 %

Data analysis by using the Bayesian Believe Network

Figure 13 introduces the structure of BBN, created according to Table 4. The structure includes three levels of performance metrics (RL), processes level (sS, sM, sD), and correction actions level (BP) for reliability improvement. To achieve the highest result for Perfect Order Fulfilment (RL.1.1), all corrective actions must be performed. However, even implementing some with the highest failure index can yield good results.

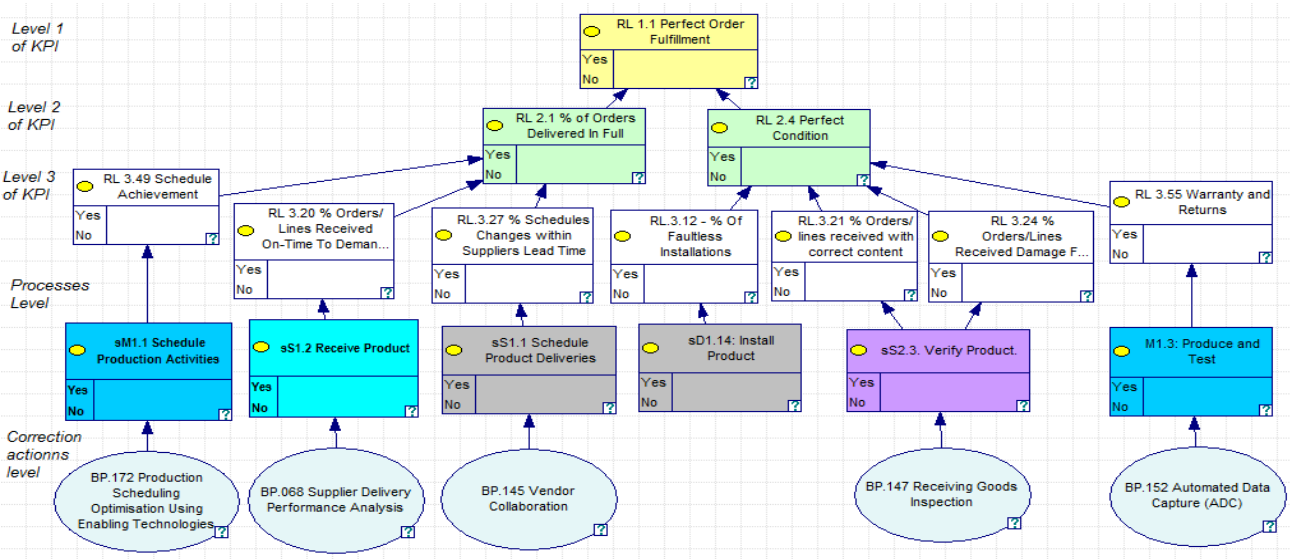

Figure 10. BBN Structure is Based on Table 4

Third-level SCOR KPIs probabilities are extracted from data submitted by electronics companies (see Figure 10). Currently, the impact of related processes equals the likelihood of related SCOR. By BBN, it is possible to discover which 3 Level KPI has the highest impact on the 2 Level KPI and strategic target of the supply chain - Perfect order fulfilment. Finding which SCOR best practice is the most efficient for reaching the strategic goal is essential.

The highest impact on the second-level KPI for the current case study is the third-level KPI, "RL 3.49 Schedule Achievement", RL 3.21 and RL3.24. The SCOR recommends applying the "BP.0172 -Production Scheduling Optimisation" B.147 best practice. After implementing this practice, the companies will solve the problems related to current returns and, in future, the items will be delivered to customers on time, see Figure 14.

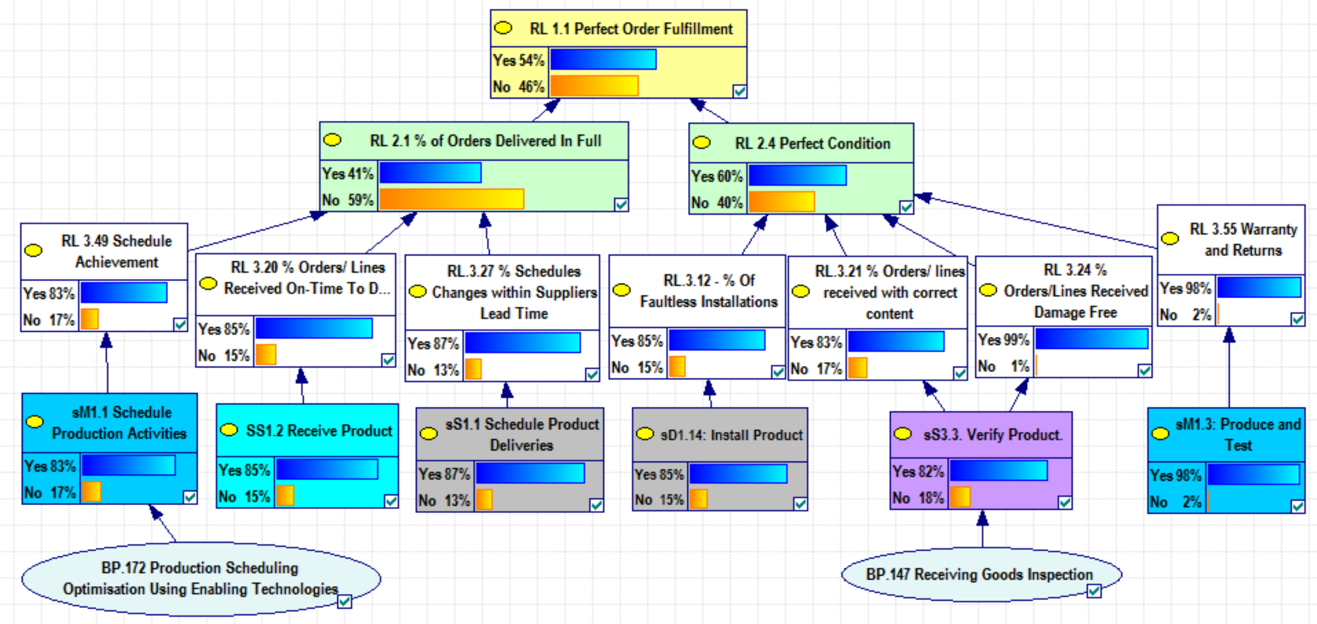

Figure 11. Evaluation of Processes KPI BBN Network After Best-Practice Implementation

Discussion

This paper provides an overview of analysing SC performance using the SCOR database and addresses challenges related to production. Prior to conducting the case study in this research, the company regarded reclamation and internal problems as separate performance indicators. However, to assess how customers perceive the company, it is essential to consider both reclamation and internal problems. From the customer's perspective, whether the product is defective or if there are issues with the lack of materials from external sources, the conclusion remains the same – the reliability of the enterprise is not high.

In the case study, the reclamation score was 99.6 %, and the internal problems score was 99.8 %. Putting them together for a better view of how the customer sees the enterprise, the final score was 99.3 %. It could be concluded that watching them separately will lead to a biased idea of how the customer feels about the company's reliability.

The authors' purpose is to introduce the digital SCOR database to help automate and connect problems with processes in the company. All issues' related processes were found and associated with corrective actions, and KPIs were located and connected with corresponding processes. The solution enables finding KPIs relevant to the company's strategic goals and defining best practices to improve the processes. Improvement will lead to better KPI-s results as expected and helps companies to achieve strategic objectives.

BBN network helps to visualise and analyse the network of the SCOR model with related processes, KPIs and best practices, where every problem is connected to processes and influences different levels of KPIs. The third level is the second, and the second is the first. Analysing problems and KPI-s with BBN will determine what process improvement will influence the first level KPI the most.

When a best practice has been successfully employed, the problem description and the corresponding best practice can be stored in the knowledge base. Subsequently, when a similar problem arises, the knowledge base enables the application of the previously successful best practice, thereby expediting the resolution process compared to analysing it using the BBN. Utilising a knowledge base also aids in reducing processing time for false reclamations by maintaining a predefined list of reclamations that can be automatically rejected. Moreover, the knowledge enables swift customer responses. Upon receiving a customer reclamation, an automated lookup can be performed against the knowledge base, allowing for the communication of possible lead time to the customer.

Conclusion

The competition in today's global supply chain is intense, and high-level customer service, with improved quality at a lower cost, is imperative for the survival of companies. Customer reclamation/return-related issues due to failure along the supply chain are a growing concern that can impact the performance of organisations. As suggested in the current research, using methods and standards like the SCOR, BBN, and CBR is appropriate and significant to select the best practices based on workable solutions for feedback/reclamation/return-related issues. Therefore, this research introduced a SCOR database and Bayesian Believe Network for Supply Chain process improvement by applying the best practices and skills and subsequently determining their impact on one or another performance metric. The proposed method was used to the customer reclamation data from an automotive electronics production company. This case was selected because the order amounts and ordered products in this sector vary significantly; products have strict requirements for quality and the general expectation of 100 % order fulfilment and agile deliveries at a minimised cost. The reclamation and failure data were first sorted into groups based on the types of failure, after which the various groups were analysed and mapped with the most suitable reliability metrics and best practices in line with the

SCOR model. Subsequently, a BBN structure is created in three levels of performance metrics (RL), processes level (sS, sM, sD), and correction actions level (BP) for reliability improvement. Integrating the methods proposed in this research minimises the number of supply chain failures and the time required for their elimination and improves customer success.

Currently, the case study in this research is limited to SME companies dealing with electronics manufacturing but can be adapted to other domains. Also, the reclamation analysis is limited to reliability performance metrics to analyse how the customers see the company but combines the CDA (Customer Delivery Accuracy) and Customer Complaints measures. Future work will be dedicated to Customer Journey mapping and improvement through related Business Processes.

The originality of the research is the application of a combination of the SCOR database, BBN and CBR to improve the reliability of a Supply Chain by applying best practices, as well as the analysis of the effectiveness of best practices using BBN, which impacts the entire supply chain.

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