Supply Chain Digitalization Framework for Service/Product Satisfaction

Lea Murumaa¹,², Eduard Shevtshenko¹,², Tatjana Karaulova¹, Kashif Mahmood¹, Janek Popell².

¹TalTech Ehitajate tee 5, 19086, Estonia, Tallinn
²TTK UAS Pärnu mnt 62A, 10135, Estonia, Tallinn

Corresponding author e-mail lea.murumaa@gmail.com

Abstract. It is essential for every enterprise existence to satisfy customer and consumer. 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 enables to increase the quality of product/service by monitoring, visualization and further digitalization of directly involved processes. In the long run, the solution will ultimately help to reduce/eliminate the number of customer reclamations in the supply chain.

The paper includes a customer satisfaction improvement feasibility case study for the approval of findings, where the garment field business processes are connected to KPI-s of product and service models. In addition, this work suggests modelling tools for faster product/service and business process modelling and evaluation (assessment) based on the selected strategic goal for each management level. The authors defend that the current research helps to create new digital solutions to increase reliability by moving toward the customer satisfaction.

Nevertheless, the proposed approach is adaptable to other fields also, whereas the small and medium enterprise (SMEs) focal player or project owner defines the processes that have the biggest impact on the product/service reliability.

1. Introduction.

The service sector is the largest and fastest growing sector in the world economy, accounting largest share in total output and employment in most developed countries [1]. Service enterprises have a lot of problems that they face every day, and the main of them is the Quality management problem. At the same time, it is essential for every enterprise existence to satisfy customer and consumer.

The main problems that small and medium garment producing enterprises have been facing are 100% order fulfillers expectation by customers and agile deliveries at minimized cost level while the order amounts and ordered products vary significantly. Garments are sold mostly via internet shops nowadays and customers are placing orders as restocking causing high level variety at small ordered amounts. Working at 95% quality level is not enough to respond to the increasing customer needs and companies are looking for a new solution, which helps to fulfil today’s customer’s expectations.
One of the main directions of the formation of strategic competitive advantages is the provision of services of higher quality in comparison with competitors [3]. There are different methodologies available to achieve that. For example, the SCOR reference model can be applied to define process architecture in a way that aligns with key business functions and goals [4, 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 Supply Chain in recent years, and this will continue in the future. The motivation of current research is to provide companies with the Supply Chain digitalization framework to satisfy current customer needs and at the same time to fulfil the strategic goals of the companies.

This article aims to define supply chain reliability metrics at various levels of process modelling which supports the Supply chain movement toward digitalisation. Introduced Supply Chain digitalisation framework defines business processes that directly influence the level of customer satisfaction and support the decision-making process to select the most efficient tools to improve them. In the current research, authors introduce how to connect SCOR model third level KPI to reclamations and quality data collected from the companies, and how to apply BBN methodology for supply chain reliability improvement.

The empirical part of the current research is limited to garment sector companies, however, the results can be successfully applied to different fields.

Supply Chain digitalisation framework analyses the current reliability level of the companies based on reclamations and processes quality data provided and points out the improvement needed business processes. The business process KPI-s are developed based on the SCOR model, and the efficiency of digitalised business processes is predicted by BBN tool. Authors recommend applying the framework to improve the reliability of the companies, by adjustment of current business processes accordingly to the customer needs.

The second chapter provides the reader with an important background, in the third chapter authors introduce the framework for supply chain digitalisation. The practical implementation is given in the forth chapter followed by conclusions and discussion section.

2. Background

2.1. Service sector

The service sector is the largest and fasted growing sector in the world economy, accounting largest share in total output and employment in most developed countries. The share of the services sector in total GDP is 47 percent in low income countries, 53 percent in middle income countries and 73 percent in high income countries [1].

Service sector is the lifeline for the social economic growth of a country. It is today the largest and fastest growing sector globally contributing more to the global output and employing more people than any other sector. For most countries around the world, services are the largest part of their economy [2]. Almost all service enterprises belong to Micro, Small and medium-size enterprises.

Service enterprises have a lot of 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 large losses in the market share. That is why the service provider must as accurately as possible identify the needs and expectations of its target customers. Unfortunately, the quality of the service is harder to judge and even harder to determine. This is the main reason for our paper to considerate the quality and reliability aspects in supply chain definition.

2.2. Supply chain reliability metrics

The SCOR model supports the operational evaluation metrics at three levels. The metrics of level one provides an approach to the supply chain to assess management, and the metrics of levels two and three include more specific and detailed criteria regarding the categories and elements of the processes. The metrics of level one are systematically divided into five operational criteria, three of which, reliability,
flexibility, and responsiveness, are customer-facing attributes, and the other two, costs and assets, are internal-facing ones. Each of these metrics is further divided into minor metrics at the lower levels [4].

The purpose of the SCOR reference model, or business process framework, is to define process architecture in a way that aligns with key business functions and goals. The architecture here references how processes interact and perform, how the SCOR processes are configured [5] (see Figure 1).

The SCOR reference model consists of 4 major sections [5]:

- **Performance:** Standard metrics to describe process performance and define 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.

### Table: SCOR Reference Model - Levels and Descriptions

| Level | Description | Schematic | Comments |
|-------|-------------|-----------|----------|
| 1     | Major processes | ![Diagram](Diagram.png) | Defines the scope, content, and performance targets of the supply chain |
| 2     | Process categories | ![Diagram](Diagram.png) | Defines the operations strategy, process capabilities are set |
| 3     | Process elements | ![Diagram](Diagram.png) | Defines the configuration of individual processes. The ability to execute is set. Focus is on processes, inputs/outputs, skills, performance, best practices, and capabilities. |
| 4     | Improve tools/activities | ![Diagram](Diagram.png) | Use of kaizen, lean, TQM, six sigma, benchmarking |

**Figure 1.** SCOR - hierarchical process model processes [5].

“A metric is a standard for measurement of the performance of a supply chain or process. SCOR recognizes three levels of pre-defined metrics:

- **Level-1 metrics** are diagnostics for the overall health of the supply chain. These metrics are also known as strategic metrics and key performance indicators (KPI). First level metrics help to establish realistic targets to support the strategic directions.
- **Level-2 metrics** serve as diagnostics for the level-1 metrics. The diagnostic relationship helps to identify the root cause or causes of a performance gap for a level-1 metric.
- **Level-3 metrics** serve as diagnostics for level-2 metrics.” [5].

The analysis of the performance of metrics from level-1 through 3 is a first step in identifying the processes that need further investigation. (Processes are linked to level-1, level-2 and level-3 metrics).
2.3. Description of Perfect Order Fulfillment (POF) KPI

“The reliability factor is also one of the most effective criteria which mean the probability of the intact and flawless performance of the system for a definite and pre-scheduled period of time” [6]. The scope and boundaries of cooperation among the constituents of the supply chain include various activities from material ordering to final product control.

![Diagram showing the SCOR-POF framework for Perfect Order Fulfillment strategic metrics, its processes, and best practices.]

Figure 2. SCOR-POF framework for “Perfect Order Fulfillment” strategic metrics, its processes, and best practises.
The reliability factor is also one of the most effective criteria which mean the probability of the intact and flawless performance of the system for a definite and pre-scheduled period of time” [6]. The scope and boundaries of cooperation among the constituents of the supply chain include various activities from material ordering to final product control. Defect in one part of the system creates problems in other parts [4, 7]. To establish a successful new relationship in the supply chain, assessing the reliability of the relationship is among the crucial factors in this field [8].

“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 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.

Level three of the supply chain understudy also has minor and more detailed metrics for the assessment of the above-mentioned metrics.” [9]. In the Figure 2 are shown the structure of reliability metrics in the SCOR model and codification of metrics at three levels and their relationships with processes and processes elements. Best practices for the second level of metrics is also introduced in the framework. SCOR reliability metrics interconnection will allow as more correctly select the effective metrics and process elements for various levels of supply chain processes. Since we are dealing with network metrics structure, to calculate their values different network calculation methods may be used, such as Bayesian Belief Network (BBN) [10, 11, 12], TOPSIS [13,14], Petri nets [15, 16] (see Table 1).

Table 1. Comparison of different network calculation models.

| Network calculation models | Type | Description | Advantages | Parameters for calculation | Relationship type |
|----------------------------|------|-------------|------------|----------------------------|-------------------|
| Bayesian Belief Network (BNN), [10, 11, 12], | Graphic probabilistic model | Dependency model | Structure is the same as the SCOR structure; Successors of statistical approaches, AI and Data Mining | From ERP system | Causal |
| Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS),[13,14] | Multi-criteria Analysis Method | Utility-based method, compares each alternative directly depending on data in the evaluation matrices and weights. | Simple computation process; | From ERP system | Concept of distance measures |
| Petri nets, [15, 16] | Basic model of parallel and distributed systems. | Graph model for the control behavior of systems exhibiting concurrency in their operation | For modeling systems containing concurrent processes | From ERP system | Factor-process model with two types of components |

For our research, we introduce to use the Bayesian Belief Network (BBN), because the structure of the BBN is the same as the structure of the SCOR metrics (see Figure 3). Parameters for calculation is possible to obtain from ERP system. The Bayesian networks are natural successors of statistical
approaches, Artificial Intelligence and Data Mining. Particularly suited to considering uncertainty, they can be easily described manually by experts in the field. Bayesian Belief Network (BBN) is a graphic probabilistic model through which one can acquire, capitalize on and exploit knowledge. It consists of a set of interconnected nodes, where each node represents a variable in the dependency model and the connecting arcs represent the causal relationships between these variables [10].

3. Main idea of the research

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 way of definition and digitalisation of involved business processes. BBN model enables to select the digital tool, which will give the highest impact on Perfect Order Fulfilment KPI and predict the expected result after tool implementation.

The closed loop of a suggested framework (see Figure 3) consists of ten steps, that guarantee the continuous improvement of Supply Chain Business Processes and increase the level of customer satisfaction.

![Figure 3. The main idea of the research: Service/Product Satisfaction Based Supply Chain Digitalisation Framework](image)

**Step 1.** To develop the SCOR standard based BBN model to connect third level KPI RL.1.1 - Perfect Order Fulfilment POF KPI-s to appropriate AS-IS business processes.

**Step 2.** To select the Service/Product KPI-s data used to measure quality and customer satisfaction used in Supply Chain and to connect them to appropriate third level KPI-s.

**Step 3.** To transfer the Returns and Reclaims data together with Service/Product KPI data from the ERP system to the BBN model.

**Step 4.** Assess the current POF level calculated by the BBN model.

**Step 5.** Define the AS-IS business processes to be improved, which are connected to Returns/Reclaims received.

**Step 6.** To select the best practice SCOR digital tools for current AS-IS business processes improvement and to assess the predicted POF KPI.

**Step 7.** To decide on tools to be implemented in physical business processes and create a TO-BE business process model.

**Step 8.** Simulate the TO-BE business process and assess the result achieved.

**Step 9.** Apply change management process to current AS-IS business process.

**Step 10.** Monitor the improved business process and proceed with step a to close the continuous process improvement loop.
3.1. SCOR-POF structure

Figure 4. Processes for 3-level of metrics. A common scheme for BBN creation.

NOTES
sS1 - Source Stocked Product; sM1 - Make-to-Stock; sD1 - Deliver Stocked Product;
sS2 - Source Make-to-Order Product; sM2 - Make-to-Order; sD2 - Deliver Make-to-Order Product;
sS3 - Source Engineer-to-Order Product; sM3 - Engineer-to-Order; sD3 - Deliver Engineer-to-Order Product.
3.2. SCOR - BBN integration

![Figure 5. SCOR - BBN integration framework](image)

The Module for KPI codes selection is a software which helps to select from common SCOR structure needed KPI-s for definite types of production. It is possible by using of Interchange GeNIe file.

The integration module receives information about the probabilities of failures from the model of the process data (ERP) and reclamations related empirical data gathered from companies and start scanning the generated code of the template to find and leave active KPI code.

3.3. BBN common scheme for SCOR- POF

The template based on the common classifier must be created in the GeNIe (BBN tool) and this operation must be done once. The developed template based on the SCOR- POF structure given in Figure 6.

![Figure 6. BBN network based on SCOR- POF structure.](image)
4. Case study

The main problems that small and medium garment producing enterprises have been facing are 100% order fillers expectation by customers and agile deliveries at minimized cost level while the order amounts and ordered products vary significantly. Companies were chosen from garment production area of activities because this sector is facing severe transformation. Garments are sold mostly via internet shops nowadays and customers are placing orders as restocking causing high level variety at small ordered amounts. Working at 95% quality level is not enough to respond to the increasing customer needs.

To achieve high quality level expected by customers every garment is checked fully before delivery, defects found should be corrected and details with material faults replaced. Any deviation in quality causes a delay in payment or price reduction in the worst cases. Companies divide defects as internally found and externally found defects. All those defects that can be corrected before delivering the items are influencing companies results without influencing on customer relationship if the corrections are done within agreed delivery time and orders delivered in full amount. Some defects can be discovered too late then the orders are delivered without those items. Due to this the order is not perfectly fulfilled for the customer. Considering reduced ordered amounts even one item can be perceptually high part from the ordered amount.

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.

Defects can be divided by cause to technological, finishing and information quality. Technological defect includes an unsuitable solution for the material chosen for the order. Those defects usually are discovered already in process and corrected to avoid appearing at final checking. Some defects can occur at the final check, the technological solution often proposed by the customer is not always considering material peculiarities. Finishing defects can happen due to material singularities, the fibres used may have different finishing and temperature regulations. Sometimes the customers can choose materials that are not supporting their ideas in the best way and remain to them hence the producer is suggesting changes. Information quality is poor order placement quality, all product characteristics wished by the customer are not clearly clarified, in those cases the result of the process depends from knowing the customer preferences. Materials used have also impact on product’s fitting due to its peculiarities.

| Table 2. Empirical data received from companies. |
|-----------------------------------------------|
| Returns / Reclams                           |
| Internal | External | Returns % | Prepayment % | Warranty | OTIF | DIFOT | % of warranty returns | % of materials rejected | Online payments |
| Enterprise | Finishing, ironing, checking | Technological | Information quality | CAD-CAM | Finishing, ironing, checking | Technological | Information quality | CAD-CAM | 10 days after received | 50–100% | 90% | 90% | 10% | 8% | 74% |
| A | 30% | 20% | 50% | 49% | 13% | 62% | 38% | 4.5% | 93% | 93% | 7% | 9% | 81% |
| B | 39% | 45% | 16% | 44% | 32% | 76% | 24% | 4.5% | 90% | 90% | 10% | 8% | 74% |
| C | 51% | 28% | 21% | 63% | 35% | 98% | 2% | 4.5% | 95% | 95% | 5% | 5% | 70% |
| D | 71% | 22% | 7% | 31% | 46% | 77% | 23% | 4.5% | 92% | 92% | 8% | 6% | 89% |

NOTES: OTIF – On time, in full; DIFOT – Delivered in full, on time
The interviews conducted with four small garment producing companies gave qualitative data about defects occurred both internally and externally. Amount of defects is not similar, defects are presented as a percentage of total amount (see Table 2.) Based on data third level KPIs relevant to processes of interviewed enterprises were chosen and calculated, results are given in Table 3.

Table 3. Calculation of third level SCOR KPI-s

| KPI Description                                      | Formula                      | Value  |
|------------------------------------------------------|------------------------------|--------|
| 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 = 0.93        |        |
| Warranty and Returns                                 | RL 3.55 = % of Warrancy returns / 100 = 0.07 |        |
| Orders Delivered Defect free conformation            | RL 3.42 = 78% x 7%           |        |
| 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 calculated based on qualitative data gathered via interviewing companies were entered into BBN model (see Figure 7). Probability of processes having an impact on third level KPIs in interviewed companies is not known due to lack of analysis in companies. This is a matter of future discussion and thorough analysis. Until the impact of processes is cleared their probability is given in model as 50% / 50%.

![Figure 7. Definition of processes KPI](image)

However it is possible to analyse which third level KPI have the highest influence on Second level KPI and Perfect order fulfilment Strategic Target to select best practice, which helps to achieve the target.

![Figure 8. Evaluation of processes KPI BBN network after best practice tools implementation.](image)
For current case study the highest impact on second level KPI have the third level KPI “RL 3.35 Warranty and Returns”. Score is recommending to apply the “BP.089 Perfect Pick Put away” and “BP.147 Receiving Goods Inspection” best practices and after implementation of those practices it is expected to eliminate the problems related to current returns (see Figure 8).

Conclusion

A novel approach for Supply Chain digitalisation based on Service/Product Satisfaction introduced and tested on a selection of small garment producing companies working as service providers for different customers shows possibilities to solve digitally quality problems companies are facing due to rising consumer expectations. The developed framework enables Supply Chain dynamically to respond to the returns, reclaims, and quality related issues in the way of definition and digitalisation of involved business processes. BBN model enables to select the digital tool, which gives the highest impact on Perfect Order Fulfilment KPI and predict the expected result after tool implementation.

The preliminary results shown in BBN model created based on data gathered to determine the content of the future work to develop the approach and digital tool useful for service providers to dynamically respond the growing customer expectations (figure 7). For making usage of developed tool wider the processes and third level KPIs of other fields of activities should be studied and analysed for clearing out similarities and specificities. Also, the selection of companies in a field should be bigger and data should be ERP-based for enabling the use of quantitative analysis.

Authors are aimed to carry on the work at the developed framework in aim to offer the digital tool enabling solutions to quality issues. For current case study it is recommended to implement the digital solution that guarantee the Perfect Pick and Put Away and Receiving Goods Inspection. Based on empirical data authors proved that those tools have the highest influence on Second level KPI and Strategic Target fulfillment (see Figure 8).

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