відростків, якщо в кластерах відростки містять більше 10 частинок, то на експериментальних точках, отриманих для визначення розмірностей, апроксимація стає неможливою.

Квазісиметричні кластери мають проміжки, де спектр розмірностей А. Реньї перестає задовольняти співвідношенню розмірностей. У проміжку від 30 і до 200 частинок, що входять до складу квазісиметричного кластеру, весь спектр розмірностей визначається коректно, що показано на рис. 2б. За межами представлених значень двох типів кластерів структурна самоподоба відсутня, що перестає відповідати визначенню фрактальних об'єктів.

СПИСОК ЛІТЕРАТУРИ

1. B. M. Smirnov. Properties of a fractal aggregate. Sov. Phys. Usp. 32, 181 (1989).
2. H. Haken. Synergetics. Introduction and Advanced Topics. Berlin: Springer, 2004.
3. Асланов А.М., Герега А.Н., Лозовский Т.Л. Две модели стохастических процессов в центробежных фильтрах с обратными связями. // Журнал технической физики, №6. – 2006. – С. 134 – 136.
4. Асланов А. М., Ботнарь К.В., Герега А. Н. О корреляции свойств потока и кластеров в модели агрегации частиц // Сборник трудов «Информационные системы и технологии». – Одесса, 2006 – С.105 – 110.
5. Кривченко Ю. В. Комп'ютерне моделювання самоорганізації кластерних систем: залежність структури від генезису та керуючих параметрів / Ю. В. Кривченко // Науковий журнал ЧНТУ «Технічні науки та технології». – 2018. – Вип. 4 (14). – С. 166-174. // ISSN 2411-5363 / ISSN 2519-4569

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MEASUREMENT AND EVALUATION OF SUPPLY CHAIN BUSINESS PROCESS MODELS

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Abstract. *This paper considers the supply chain management and its most remarkable business process reference model SCOR. This model is considered as a hierarchical system of business process definitions amended with respective indicators and practices. Supply chains are tend to be described using business process modeling notations such as BPMN, while design flaws could cause supply chain defects and, hence, monetary losses and time delays. Therefore, this study is aims to improve the quality of supply chain business process models in order to ensure correct execution of the supply chain activities.*

Introduction. In the past decades, supply chain management and corresponding models have been considered in multiple research studies. There have been proposed a significant number of models used to measure, analyze, and improve supply chains in various industries. Snyder and Shen have proposed a simple but interesting and accurate definition of a supply chain: activities and infrastructure, which purpose is to move products from where they are produced to where they are consumed [1]. Therefore, the Supply Chain Management (SCM) discipline is considered by the same authors as the set of practices required to perform the functions of a supply chain and to make them more efficient, less costly, and more profitable [1].

The SCM includes multiple practices based on complex mathematical models and methods, such as forecasting, linear programming, and decision making. All these models serve to support such practices, as production planning, inventory management, transportation decisions, location and distribution decisions, supplier selection, risks management [2]. However, it would be a complicated task to consider all the SCM processes and practices together without any reference that already combines best practices of a supply chain management and baseline activities. The Supply Chain Operations Reference (SCOR) model was introduced by the Supply Chain Council in 1996 for the first time. It serves to systematize business processes, measures, and business practices related to execution of supply chain activities [3]. The SCOR model aims to create an "ideal" supply chain model, which defines five basic processes: Plan, Source, Make, Deliver, and Return. Its process areas could be measured by metrics and are supported by best practices. Processes with the related indicators and best practices are outlined in details through the levels of the SCOR model (Fig. 1) [4].

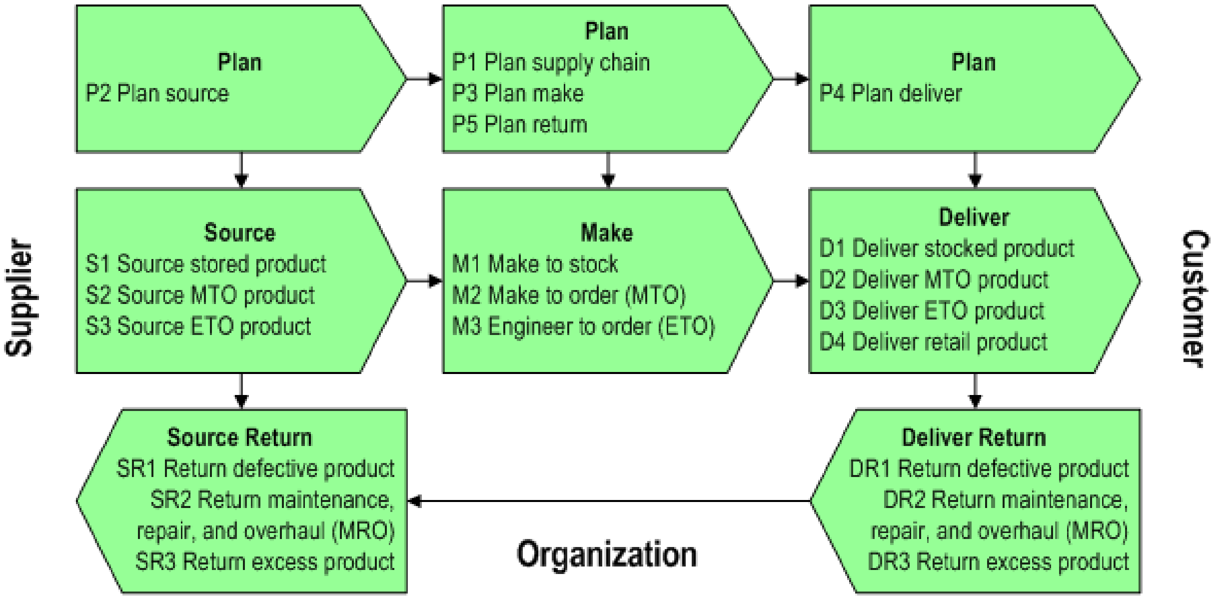


Figure 1 – General overview of the SCOR model

Above in Fig. 1 processes of the SCOR levels 1 and 2 are demonstrated, while SCOR level 3 processes are more detailed and they are related to the specific indicators. As the example, the Source Stocked Product business process decomposition is demonstrated below together with the assigned metrics (Fig. 2) [4].

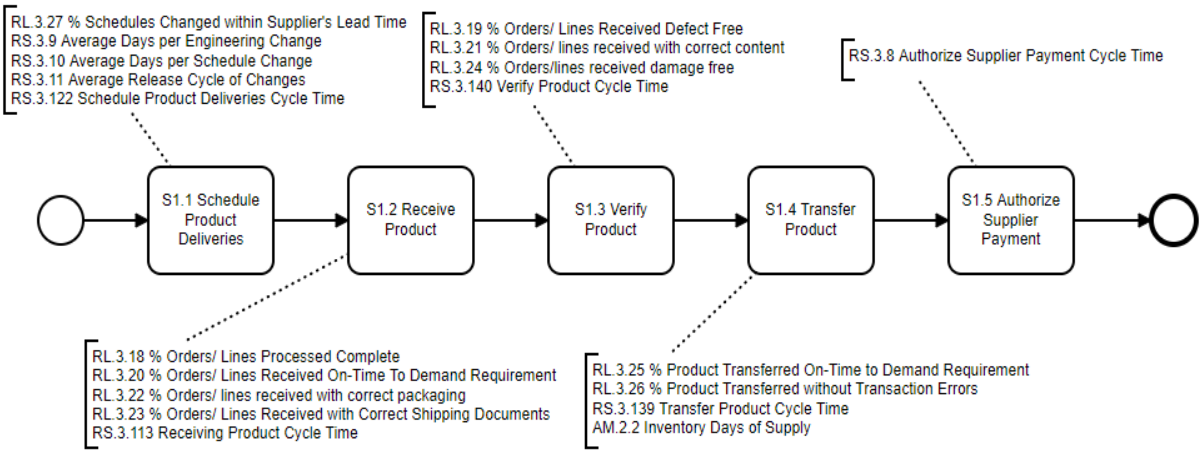


Figure 2 – Decomposition of the Source Stocked Product business process

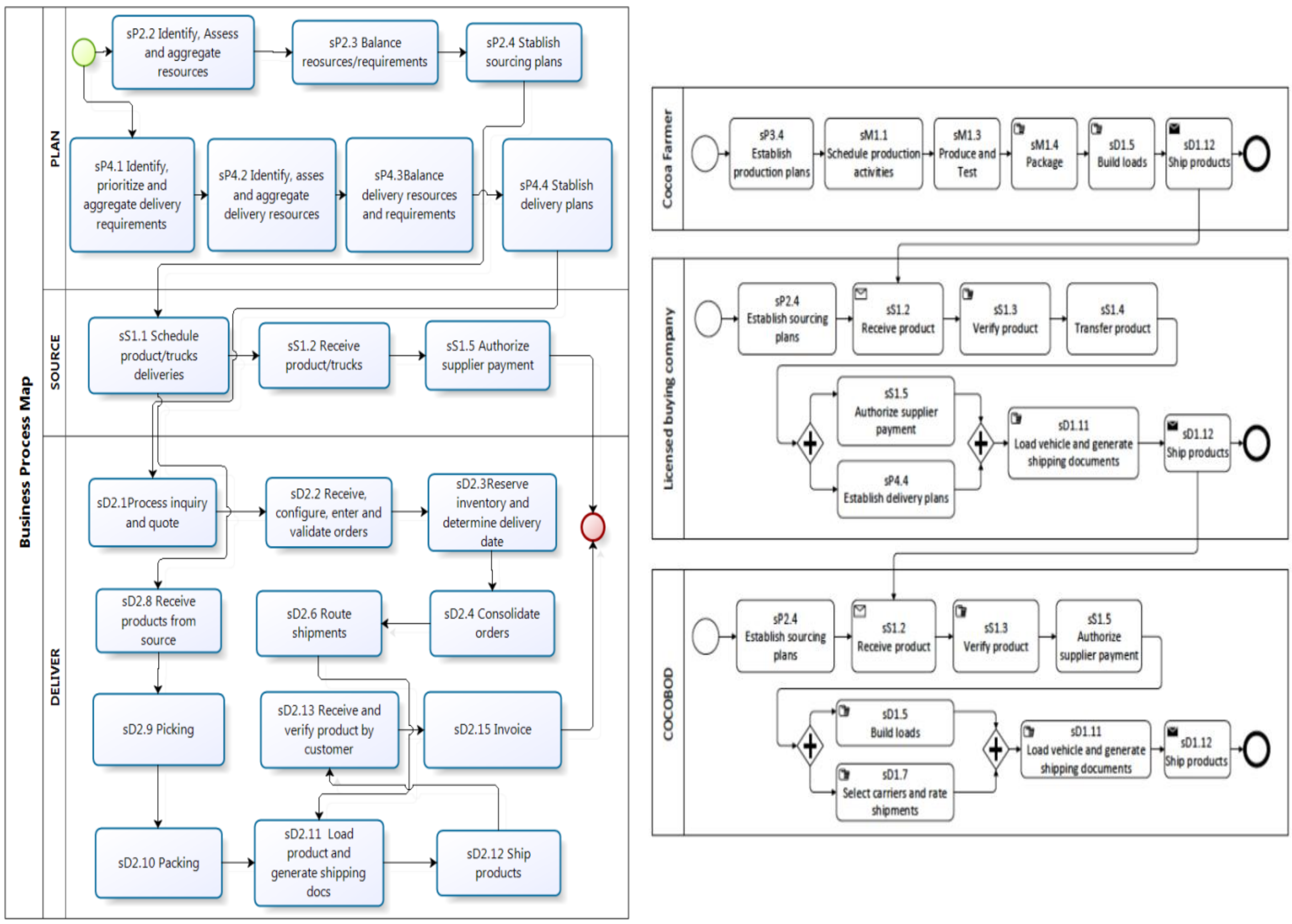
As the process-based model, SCOR is used together with Business Process Management (BPM) tools, such as process modeling. It is natural for supply chains to be represented graphically, thus the Business Process Model and Notation (BPMN) standard is widely used to describe supply chain activities. BPMN is by Ahoa et. al. to describe agri-food supply chains [5]; by Franconetti and Ortiz to describe road transport processes [6], and by Cheng and Law to describe generic SCOR level 3 processes [7].

It is not surprising, since BPMN makes complex business systems understandable and facilitates the understanding of flows and processes between different parties. Also BPMN models can be easily converted into executable scenarios for BPM automation suites [7]. Nevertheless, the success of business process modeling depends on the correctness of the designed diagrams. Incorrect models are considered as sources for errors, delays and, therefore, extra expenses at all stages of the BPM lifecycle (process analysis, re-design, deployment, and monitoring).

Error-prone process models are dangerous for SCM and could cause significant damage to the whole supply chain. It means that supply chain business process models should be continuously examined for their quality and the flawed fragments should be immediately detected and eliminated. Hence, this study aims to improve the quality of SCM business process models in order to prevent supply chain defects.

Methodology. We have selected BPMN models proposed in [5] and [6] (Fig. 3) to be analyzed.

Considered supply chain process models (Fig. 3) have been analyzed using the following process model measures: (i) total number of gateways (TNG), (ii) density (DEN), (iii) the coefficient of connectivity (CNC), (iv) sequentiality (SEQ), and (v) connectivity level between lanes (CLP). These measures have been systematized by Boomsma in [8]; they are based on sub-measures, such as number of nodes etc. All of these measures have threshold values used to evaluate models efficiency from (1) very inefficient to (4) very efficient. The set of process model measures (i)-(v) should be used to define efficiency levels 1-4 for each measure and then to define the general efficiency level of a supply chain business process model (Fig. 4).



a b

Figure 3 – Supply chain BPMN models: a – the model proposed in [6], b – the model proposed in [5]

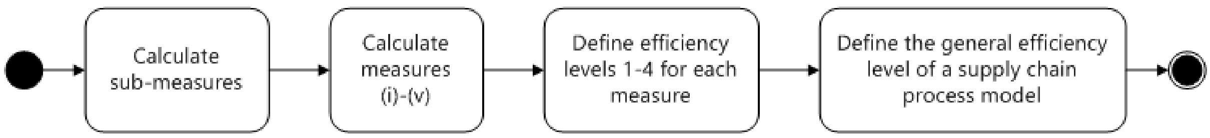


Figure 4 – Proposed business process model evaluation procedure

Proposed procedure (Fig. 4) could be used to evaluate supply chain business process models, including those demonstrated in Fig. 3.

Results. Calculated measures of the supply chain process models (Fig. 3) are shown in Table 1.

Table 1 – Calculated measures of the considered business process models

Measure	Threshold values and efficiency levels				Calculated measures	
	1 – Very inefficient	2 – Fairly inefficient	3 – Fairly efficient	4 – Very efficient	Model 1 (Fig. 3, a)	Model 2 (Fig. 3, b)
TNG	17	10	5	0	0; level 4	4; level 4
DEN	0.6	0.22	0.001	0	0.04; level 3	0.03; level 3
CNC	1.7	1.1	0.6	0.4	1.04; level 3	1.03; level 3
SEQ	0.1	0.35	0.6	0.7	1; level 4	0.63; level 3
CLP	7.5	4.23	2.2	0.2	0; level 4	0; level 4

Obtained results show that analyzed supply chain process models are mostly efficient (fairly or very for different measures). However, there are boundary values for TNG, CNC, and SEQ values, which requires to introduce a generalized measure based on the set of considered measures (i)-(v).

Conclusion. In this paper we have outlined the relevance of supply chain management and considered the de-facto standard in SCM domain, which is the SCOR model. We have considered the SCOR model first of all from the business process perspective, as the process reference model. Therefore, the study is focused on the BPM-related capabilities of SCOR, such as business process modeling and analysis. In this context the process modeling plays a major role, so we have measured and evaluated existing SCM process models proposed in [5] and [6]. In this study we have used existing measures [8], however the generalized measure of process model quality should be proposed in future, e.g. to deal with the boundary values issue.

References.

[1] L. V. Snyder and Z.-J. M. Shen, *Fundamentals of Supply Chain Theory*. John Wiley & Sons, 2019.

[2] A. Ravindran and D. Warsing, *Supply Chain Engineering: Models and Applications*. CRC, 2012.

[3] R. G. Poluha, *The Quintessence of Supply Chain Management: What You Really Need to Know to Manage Your Processes in Procurement, Manufacturing, Warehousing and Logistics*. Springer, 2016.

[4] Available: SCOR Revision 11.0, https://docs.huihoo.com/scm/supply-chain-operations-reference-model-r11.0.pdf [Accessed: October 3, 2020].

[5] E. Ahoa, A. Kassahun, and B. Tekinerdogan, “Configuring Supply Chain Business Processes using the SCOR Reference Model,” In Book of Proceedings of BMSD 2020, Springer, Cham, pp. 338-351, 2018.

[6] P. Franconetti and A. Ortiz, “Enhanced Supply Chain Management Using SCOR and BPM. Application to the Spanish Road Transport SME,” In. Book of Proceedings of the 7-th International Conference on Industrial Engineering and Industrial Management, pp. 418-426, 2013.

[7] J. C. Cheng, K. H. Law, H. Bjornsson, A. Jones, and R. D. Sriram, “Modeling and monitoring of construction supply chains,” *Advanced Engineering Informatics*, vol. 24, no. 4, 435-455, 2010.

[8] R. D. Boomsma, *An evaluation of thresholds for business process model metrics*. Eindhoven University of Technology, 2017.

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ВДОСКОНАЛЕННЯ МЕТОДУ ПОБУДОВИ ГРАФОАНАЛІТИЧНИХ МОДЕЛЕЙ КОМПОНЕНТІВ ЕЛЕКТРОННИХ КІЛ

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Одним з основних завдань інформаційних технологій є вдосконалення існуючих та розробка нових методів формалізованого запису різних логіко-динамічних процесів перетворення аналогових та цифрових сигналів в електронних системах управління, збору та обробки інформації. Етап формалізованого запису будь-яких процесів перетворення сигналів має бути поданий у вигляді аналітичних символів, які у своїй послідовності повинні формувати функціонально закінчену математичну модель. Запропонований в роботі вдосконалений метод побудови математичних моделей компонентів електронних кіл для їх представлення в графоаналітичному вигляді з підвищеним інформаційним змістом дозволяє виконати інтеграцію розроблених моделей елементів електронних кіл з об’єктно-орієнтованою мовою програмування у вигляді функціональних структур для виконання параметричного аналізу та інших завдань, пов’язаних з моделюванням електронних систем.