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ORIGINAL PAPER

FUZZY PROCESS MATURITY MODEL FOR SERVICE ENTERPRISE

Agnieszka Stachowiak[1], Karolina Werner-Lewandowska[1], Piotr Cyplik[1], Agata Skowrońska-Domańska[2]

1. Faculty of Engineering Management, Poznan University of Technology, Poznań. **Poland**
2. Archicom S.A., Wrocław, **Poland**

ABSTRACT. Background: The purpose of this article is to present a model of process maturity assessment dedicated to service enterprises. The model developed is validated in a company in the development services sector.
Methods: The implemented research methodology includes literature analysis, expert research, fuzzy set theory, and a case study.
Results: The results indicate that the developed model provides a solid and practical diagnostic tool, based on a fuzzy index to measure the process maturity of a service company.
Conclusions: The proposed model may have practical implications for the assessment of process maturity in the service sector. It will allow a diagnosis of the current state and will indicate the direction of further improvement in process management. From an epistemological perspective, the proposed model fills the research gap in the field of maturity models dedicated to service enterprises and extends knowledge on adapting fuzzy set theory to assessing process-orientated maturity of enterprises.
The originality of the proposed approach results mainly from the research object that was used to validate the model.

Keywords: process maturity model, BPM, fuzzy assessment

INTRODUCTION

Business processes, organisations, and environments are becoming more and more complex, advanced, and continuously changing. Enterprises face numerous challenges, including the following: shifting the conditions of running a business from the model of slow and continuous changes to the model of dynamic and revolutionary ones, caused by turbulence of the environment, in which changes are taking place faster and faster, are unpredictable, and have a long, global impact (e.g., Covid-related lockdowns on a global scale); the pressure of global competition caused by interpenetration of geographic and sectoral boundaries, enabled by globalisation and e-commerce development and consequently facilitating international business operations for micro and SMEs; new distribution channels and ways of contacting customers and suppliers, resulting from IT development; changes in products and processes driven by global and counteracting trends, such as consumerism shortening of the product life cycle; ecology that sets consumer expectations regarding the quality of products and services higher and product lifecycle longer; and changes in technology and society that produce new customer needs.

All of these challenges are confronted with the need to generate profit, reduce costs, and meet customer expectations, making business more difficult and demanding.

In order to survive and grow, enterprises must demonstrate maturity. According to Hammer, maturity is the systematic improvement of organisational skills and the processes implemented in it in order to achieve higher efficiency in a specific time (Hammer, 2007). The above indicates that maturity is the property of an object. It relates to a person or a

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subject and is a state that enables gradual continuous improvement (Gokalp et al., 2017; De Carolis et al., 2017). The maturation process is the ability of an organisation, including its processes, to systematically improve the results delivered as part of the conducted activity (Mielcarek, 2017). Process maturity is perceived as the scope in which processes are formally defined, managed, flexible, measured, and effective (Grajewski, 2007). In other terms, process maturity is indicated as a degree of optimal allocation of the organisation's resources in stable and measured processes (Grela, 2013).

Process maturity mainly concerns the degree and scope of implementation of management concept processes in the organisation through the use of methods and techniques specific to it (Röglinger et al., 2012). Process maturity of an organisation is expressed within the scope in which the processes are dealt with (Dahlin & Gunnar, 2020), which usually refers to defining the processes, managing them, measuring them, and constantly improving them. The concept of a "process-mature" organisation is usually referred to as an organisation whose processes can be considered mature from a qualitative point of view. For a process to be considered mature, it has to be efficient, predictable, and deliver high-quality results (Kalinowski, 2020).

The latest publications on maturity refer to its technological aspects (Klessova et al., 2022), digital transformation maturity (Rodríguez-Espíndola et al., 2022), project management maturity (Alghail et al., 2022, Jawad & Ledwith, 2022), Industry 4.0 maturity (Naeem & Garengo, 2022, Ramanathan & Samaranayake, 2022), network maturity (Kuchenmüller et al., 2022), supply chain risk management maturity (Dellana et al., 2022), Shopfloor Management (SFM) (Kandler et al., 2022), and lean maturity (Muiamba, 2022), which is in line with the latest high-technology and digitization-based business orientation. The approaches presented focus on the idea of maturity itself, confronting it with various aspects of a company's activities.

While academics focus on epistemological aspects of maturation, the utilitarian perspective is not commonly implemented, making the comparison of the maturity assessment of various companies difficult even within the same model due to differences in data collection, processing, and interpretation schemes. To exploit the utilitarian perspective and develop the approach to assessing maturity in a service enterprise, we designed a research procedure driven by the following research questions.

RQ1: What criteria should be used to assess the maturity of processes in a service enterprise to reflect the intangibility of services?

RQ2: How should maturity criteria in a service enterprise be assessed?

RQ3: How should the assessment of individual maturity criteria be integrated into the process maturity assessment?

The development of a model dedicated to the service sector is justified by the importance of this area. According to data recovered from Eurostat (https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20211021-1, access: 18.06.2022), in 2020, services were the largest economic activity in the EU measured in terms of gross value added (GVA) generated. Services represented 73% of the total GVA of the EU, followed by industry and construction (25%) and agriculture (2%). In all EU countries, services had the greatest weight in the economy, varying between 58% in Ireland and 87% in Luxembourg. According to Eurostat, industry and construction-related activities had significant weights in the economies of Ireland (41%), Czechia (34%), Slovenia (33%), and Poland and Slovakia (both with 31%). Furthermore, 72.9% of the EU's employed population in 2020 was employed in the service industry, while 22.5% was employed in industry and 4.5% in agriculture.

LITERATURE REVIEW

The key terms recognised for the needs of the paper include the process approach (as service enterprises are generally process orientated) and the maturity model. BPM (Business Process Management) is a philosophy of process thinking management that offers solutions to today's problems (Jeston & Nelis, 2014). In fact, BPM is a comprehensive system

for managing and transforming organisational activities (Röglinger et al., 2012). An important point of focus in BPM is process management in such a way that customers receive products and services effectively and efficiently (Hermkens et al., 2022; Glykasa & Kokkinaki, 2018).

BPM is a valuable tool in the process of gradual change, increasing the chance for process improvement (Melão & Pidd, 2000; Tolsma & de Wit, 2009; Jeston & Nelis, 2014; Schmiedel et al., 2020). It uses existing processes as a starting point for improvement and allows for an in-depth understanding and assessment of the current state, covering all aspects related to business processes in all areas of the organisation (Schmiedel et al., 2020; Vom Brocke & Mendling, 2018; Van der Aalst et al., 2016; Jacobs et al., 2013; Rosenbaum et al., 2018). The rapid pace of digitization in the 21st century increases the demand for BPM, because it allows for a more detailed examination and understanding of the processes in their organization (Mendling et al., 2020). Implementing BPM not only requires a completely new way of working, but also involves looking at your organisation from a different perspective. (Binci et al., 2019; Jeston & Nelis, 2014), combining technical aspects with human-centric orientation in a new and synergetic way (Binci et al., 2019; de Pádua et al., 2014; Tolsma and de Wit, 2009; Kerpedzhiev et al., 2020). The approach is not free from limitations and constraints, yet they can be dealt with using the BPM Maturity Model (Schmiedel et al., 2020; Pereira et al., 2019).

The idea of a maturity model was first described by Nolan (1973) and Crosby (1979). Maturity models are defined as a set of different tools and practices that allow, on the one hand, the skills of a given organisation in terms of management to be assessed, but also enable the improvement of key factors leading to the achievement of the set goals (Looy, 2014; Pullen, 2007; Hermkens et al., 2022). Maturity models are an established way to support requirements such as assessing the current situation, identifying a desired situation, and obtaining a possible evolution path (Becker et al., 2009), as they perform both descriptive and prescriptive/comparative functions (Becker et al., 2009; Pöppelbuß & Röglinger, 2011). They are a powerful tool that organisations can use to achieve their strategic goals (Klisenko et al., 2022; Klisenko et al., 2022; Klötzer & Pflaum, 2017).

The best-known IT maturity model is the Capability Maturity Model (CMM). Originally proposed by Paulek, Curtis, Chris, and Weber (1993) to aid this software development process, particularly in government projects, CMM later evolved as a tool for overall business process improvement (Klisenko et al., 2022).

Maturity models have become a practically used tool to evaluate processes and organisations, and the multitude of applications proves the importance of their role in the area of management. Among the dominant areas in which maturity models are used, the following have been identified (Santos-Neto & Costa, 2019): software (e.g. Ehrensperger et al., 2021), process management (e.g. Hamrol & Grabowska, 2020), knowledge management, project management, sustainable development (e.g.: Golińska-Dawson et al., 2021; Stachowiak & Pawłyszyn, 2021; Vásquez et al., 2021;), logistics (e.g.: Werner-Lewandowska & Kosacka-Olejnik, 2019; Werner - Lewandowska & Golińska-Dawson, 2021; Facchini et al., 2020), risk management (e.g. Resende et al., 2022), supply chain (e.g. Soares et al., 2021), education (e.g. Cardos et al. 2022), public sector, construction (e.g. Alankarage et al., 2022), service management (e.g. Werner-Lewandowska, 2020), medical sector, human management, product lifecycle management, and resource management (e.g. Golińska-Dawson et al.,2021). The above areas prove the important place occupied by maturity models in management sciences.

Maturity models were adopted as methods of measuring the progress of an organization in striving for continuous improvement in various areas of management. The assessment performed in the maturity models is carried out using methods such as (Santos-Neto and Costa 2019, p. 736): six sigma, ATC algorithm, fuzzy logic (e.g., Caiado et al., 2021; Soares et al., 2021), diagnostic survey method (questionnaires), AHP, and Grey Decision Making (GDM) (for example: Golinska et al., 2015; Oleśków-Szłapka et al., 2019). Since the Hammer and Champy business revolution manifesto (1993),

the management and improvement of business processes have been the basic tasks of organisational design (Becker & Kahn, 2010; Buhl et al., 2011; Gartner, 2010; Sidorova & Isik, 2010; vom Brocke et al., 2011;). Among the various approaches supporting business process management (BPM), attention is increasingly paid to maturity models (Bucher & Winter, 2010; Weber et al., 2008; Scott, 2007; Becker et al., 2010).

In terms of BPM, two types of maturity models can be distinguished: process maturity models and BPM maturity models (Rosemann & vom Brocke, 2010; Lee et al., 2007; Hammer, 2007; Weber et al., 2008). BPM maturity models allow organisations to gain an insight into their current BPM maturity level and highlight the possibility of further improving BPM implementation by comparing the current maturity level with higher maturity levels (Hermkens et al., 2022).

MATERIALS AND METHODS

The research methodology designed and implemented in the research is presented in Figure 1. To answer the research questions defined and presented in the Introduction section, we first designed a list of processes that are implemented in service enterprises (Stage 1). The definition was based on the literature review and included 3 groups of processes: basic, support, and specific industry. In the next stage (2), we define the list of decision criteria (DC) to assess the maturity level in a service enterprise in order to answer RQ1. Concerning the management functional areas, we identified potential assessment/description options. The general criterion applied was the identification of the function – whether it is recognised within a specified process or not. If the function is not recognised in the process analysed, its maturity is recognised at the lowest level possible.

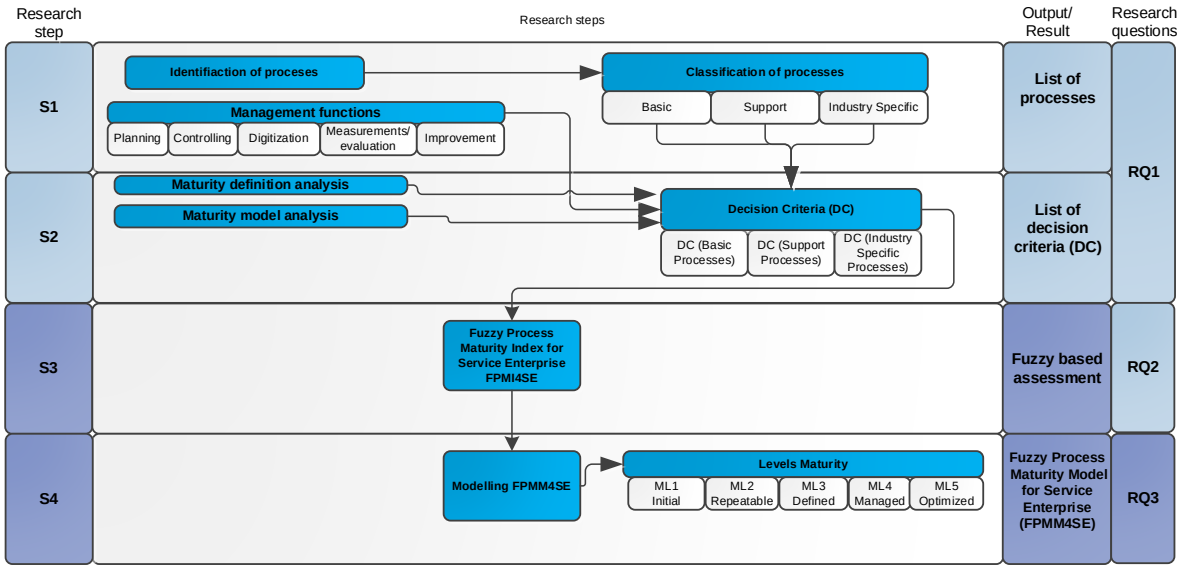

Fig. 1. The research methodology
Source: own work

If the function is recognised, its realisation mode is used as a detailed criterion. That is, the realisation of the function for the process analysed could be informal, ad hoc, systemized, and integrated. The criteria are organised in ascending order to show the path towards perfecting the function or the process. Example of Decision Criteria for Management Function (MF): the planning is presented in Table 1.

Table 1. Decision criteria (DC) - example

Decision criteria (DC)	Assessment
The process is not planned	Non-existent
The process is planned based on the experience of employees (no formalized methods)	Low level
The process is planned using own methods and tools	Medium-level
The process is planned using the best practices taken from the outside.	High-level

Source: own work

We used the list of decision criteria (DC) to develop the fuzzy process maturity index for service enterprise (FPMI4SE) in stage 3. It is based on linguistic variables and linguistic values used in processes assessment, and the calculation procedure had two steps: 1) calculating Fuzzy Process Maturity Index (FPMI) for every process and 2) calculating Fuzzy Process Maturity Index for Service Enterprise (FPMI4SE) as a fuzzy average of maturity assessment of individual processes. The calculated FPMI4SE is converted back into a linguistic value in the defuzzification process with the use of the Euclidean distance method.

The FPMI of predefined processes (Basic, Supportive, and Industry Specific) is calculated with formula 1.

$$FPMI_j = \frac{\sum_{i=1}^{n} MF_i}{5} \quad (1)$$

Where: *FPMIj* - Fuzzy Process Maturity Index of j-process, *j*- process index (j=1..5 for Basic processes, j=1..7 for Supporting processes and j=1..x for Industry Specific processes), *MFi* - level of individual management function i (non-existant, low, medium, high), and *I* - management function index.

After calculating FPMI for each process, it is possible to aggregate them into Basic Process Maturity Index, Supporting Process Maturity Index and Industry Specific Maturity Index, and holistic FPMI4SE.

In this stage, we strive to explain how to assess maturity criteria in a service enterprise (RQ2). Since the respondents gave their opinions in a descriptive way, we decided to translate them into fuzzy and use the fuzzy approach to calculate maturity level and understand the level of maturity of processes. For that purpose, triangular fuzzy numbers corresponding to low, medium, and high descriptors were implemented. To assess process maturity in the context of response to changes, we use the indicator based on the Fuzzy Agility Index (FAI) (Lin, 2003). As in the case of FAI and other examples indicated in the literature (Lin 2003; Lin et al., 2006), the use of elements of the theory of fuzzy sets in management is justified by the difficulties in formulating a precise assessment on a numerical scale. For process maturity assessment, we developed Fuzzy Process Maturity Index for Service Enterprise (FPMI4SE).

Stage 4 presents a conceptual approach on how to integrate the processed knowledge on the value of maturity assessment criteria (RQ3). As indicated in the theoretical background section, Business Process Maturity Models are useful from a company's perspective and strive toward continuous improvement. That is why we decided to use BPM approach and set the FPMM4SE (Fuzzy Process Maturity Model for Service Enterpricse) in the BPM Maturity Models framework, merging the approach presented in (Snabe et al., 2008) and the one by Gartner (O'Leary, 2009). The product of the merge is the model preselected in Figure 2.

Its structure comprises five levels, ordered incrementally. The levels are described in the context of planning, controlling, measurement and evaluation, improvement, and digitization.

To implement the model and assess the maturity of processes, descriptive characteristics of the levels should be used, addressed to functional areas of management identified in the previous stage. Consequently, if the processes are not planned, organised, controlled, measured, or improved, they are at an initial level of maturity, while if they are fully planned, organised, controlled, measured, and digitised, moreover continuously improved, they are at an optimising level of maturity.

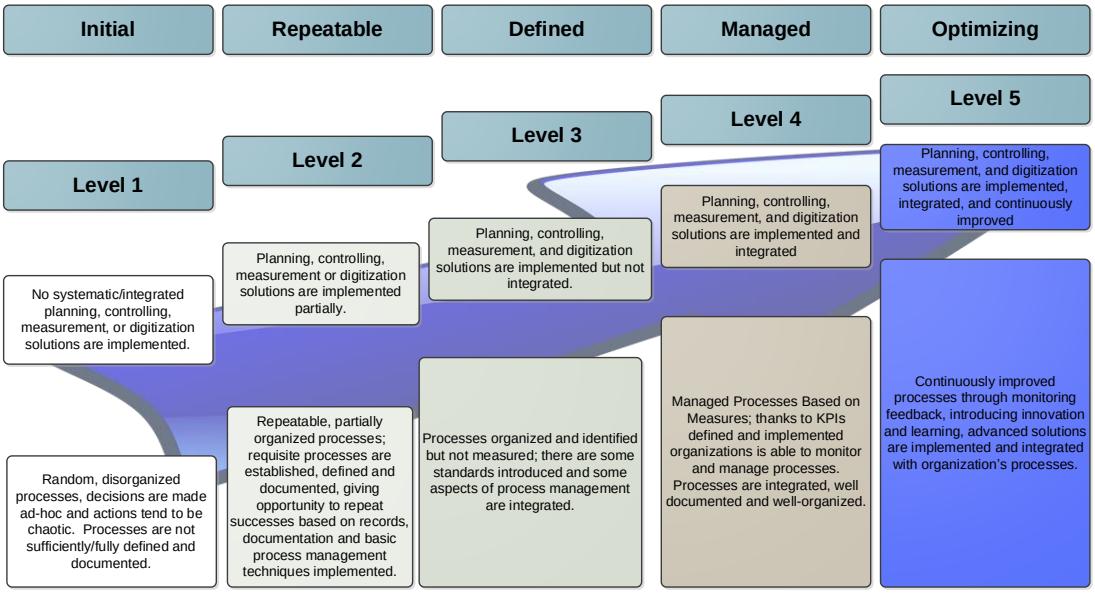

Fig.2.The Fuzzy Process Maturity Model for Service Enterprise – FPMM4SE
Source: own work

To identify the level of maturity, the Fuzzy Process Maturity Index for Service Enterprise (FPMMI4SE) was implemented. The procedure is presented in Figure 3, while the calculation scheme for fuzzy assessment is explained in the previous sections.

The procedure needs outputs in the form of business processes identified (BP - Basic Processes, SP, Support Processes, ISP, Industry Specific Processes) that are analysed in the context of management functions (MF) and assessed with the descriptive decision criteria by the experts. The assessment is translated into the fuzzy scale and after the assessment is completed, data is aggregated into FPMI4SE.

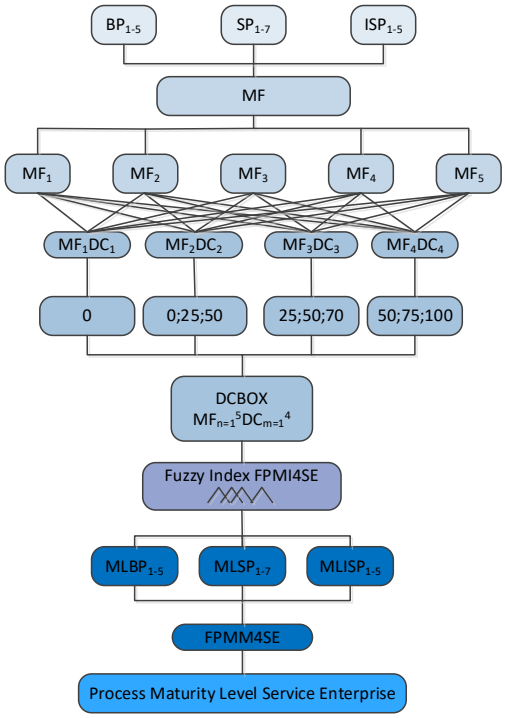

Fig.3. The procedure of Fuzzy Process Maturity Index for Service Enterprise - FPMMI4SE
Source: Own elaboration

The index is translated into the descriptive maturity level in the last stage of the procedure. As the index is based on FOMI, we used the same approach for defuzzification process. Hence, regarding the presented FPMI4SE measure, calculation of the Euclidean distance between a given fuzzy number and each of the fuzzy numbers representing the range of natural language expressions is implemented, as it is the most intuitive, and the others are difficult to implement (Lin, 2003). The following formula is used to calculate the Euclidean distance (formula 2).

$$d(FPMI4SE, JN_i) = \sqrt{(\sum_{x=1}^{p} f_{FPMI4SE}(x) - f_{Ni}(x))^2} \quad (2)$$

Where, *Ni*, natural language expression (assessment of the feature), *x* - point at which distance is measured, i, number of the point, p, number of points, FPMI4SE(x) - value at point x, for which natural expression is identified. fNi(x) - the distance in every x point.

The linguistic value closest to the determined index corresponds to the level of the assessed process. The assessments of individual features are used to determine the aggregated maturity level. Thus, aggregated maturity level calculation requires the determination of evaluation for maturity features and then calculation, based on the identification of a number of average or higher-rated features, drawing conclusions about the overall (aggregated) assessment. Simple decision rules (IF..THEN…) are used to aggregate the assessment (Table 2).

Table 2. Decision rules for aggregating the assessment

	Number of MF	Assessment		Maturity Level
IF	0	assessed at a medium level or higher	**THEN**	Initial (ML1)
	most 2			Repeatable (ML2)
	3	assessed at a medium level or higher		Defined (ML3)
	4 or more	assessed at a medium or higher level		Managed (ML4)
	3 or more	evaluated at a high level;		Optimised (ML5)

Source: own work

The presented procedure is based on the assumption that all processes are equivalent and that the level of maturity is evidenced by their joint and synergistic occurrence at least at a medium level.

RESULTS

The research was carried out in a real business environment to validate the procedure designed and benefit from the feedback from the organisation evaluated. Research was carried out in the period from December 2021 to February 2022 and followed the stages presented in the previous section.

The research procedure was implemented to assess process maturity in a selected company representing the service industry. Following the research procedure, we needed to identify processes realised in the enterprise. We used the basic and supporting processes list and after consulting experts representing the enterprise completed it with a list of Industry Specific Processes. Experts evaluated the processes according to the adopted decision criteria (DC). 21 experts — process managers (process owners) — participated in the study. The analysis of the responses allows us to assess process management and identify process maturity. Each process was evaluated with the implementation methodology. Data were collected with respect to research ethics and privacy, and contribution was voluntary. The inputs and outputs obtained in the research are presented and characterised in Table 4.

Table 4. The inputs and outputs

Linguistics Variable	Type	Range	Value	Triangular fuzzy number
MF1-MF5 v (management functions)	Input	0-100	Non-existant	-
			Low	(0, 25, 50)
			Medium	(25, 50, 75)
			High	(50, 75, 100)
ML1-ML5 (maturity level)	Output	0-100	Initial (ML1)	(0, 0, 25)
			Repeatable (ML2)	(0, 25, 50)
			Definition (ML3)	(25, 50, 75)
			Managed (ML4)	(50, 75, 100)
			Optimised (ML5)	(75, 100, 100)

Source: own work

On the basis of the defuzzification process described in the previous sections, linguistic expressions referring to maturity were identified. The calculation results indicate that the process maturity of basic and industry-specific processes is one level higher than the process maturity of support processes. The assessment is quite homogeneous, as only Level 2 and Level 3 are identified. In the assessment of management functions, however, the spectrum is wider, as low, medium, and high assessments are identified. The functions assessed at the low level are the ones requiring improvement. They are executed using an ad hoc approach without procedures or best practices, and no systemic tools are designed and used for them. The functions executed at the medium level can be improved, yet some effort has already been made to organise and systemise them. The functions executed at the high level are systemized and continuously improved, which means they can be a benchmark in the company. The management functions executed at the highest level in the company assessed were planning and controlling, which seems to be a good starting point for increasing maturity: high-quality planning initiates high-quality performance. Concerning the processes, the ones best assessed are basic ones and industry specific. The results of the calculation are compared with the decision rules presented in the previous sections. The procedure is based on the assumption that all processes are equivalent, and the level of maturity is evidenced by their joint and synergistic occurrence at least at a medium level.

There are differences in maturity assessment with the calculation procedure (results of assessment of management functions are aggregated as fuzzy average) and conditional assessment (results of assessment of management functions are used in IF..THAN conditions designed). There is greater variety in results obtained in conditions-based procedure (the levels vary from initial to managed, while in calculation procedure there is only repeatable and defined level). The possible reasons for the difference can be the following. The IF..THAN procedure is not precisely designed, the calculation procedure gives the result in the form of the average, eliminating higher and lower results.

Taking into account the above, the use of both approaches seems to be justified. The conditions-based procedure is more sensitive and identifies slight deviations from the maturity levels in the maturity model, which can be useful when analysing processes in detail, while the calculations-based average identifies the overall process maturity.

CONCLUSIONS

This paper proposes a novel service enterprise process maturity assessment model, FPMM4SE, based on a fuzzy probabilistic expert system (FPMI4SE) that overcomes the inaccuracy and uncertainty often found in process maturity models. This article fills the research gap by providing a theoretically grounded and methodologically rigorous Process Maturity Model (PMM) for a service enterprise. By referring to the research questions posed in the introduction, the article fills the gap in the epistemological and utilitarian aspect.

First, it indicates how to select the scope of the maturity assessment (RQ1): highlighting the issues of main, auxiliary, and industry-specific processes, which is in line with the process approach, focused on processes that add value to the customer. In companies providing services,

due to the intangible nature of the product offered on the market, basic processes are often not diagnosed or incorrectly defined, which is why they are improperly managed.

Secondly, the proposed model FPMM4SE gives clear and measurable evaluation criteria (RQ2), which is legible for the assessor, thus eliminating ambiguity and subjectivity.

The FMMI4SE developed by us enables the processing of knowledge concerning the value of the maturity assessment criteria (RQ3). The original model of process maturity integrates the processed knowledge concerning the value of the maturity assessment criteria. It allows the assessor to clearly state at which of the five possible maturity levels (ML) the processes implemented in the enterprise are.

From an industrial perspective, this article presents a robust diagnostic tool to help service companies manage their process by enabling them to discover the true level of process maturity in FPMM4SE.

As for directions for further research on the process maturity of service enterprises, we indicate the improvement of the proposed model, its validation in other service sections, and its adaptation to other areas of enterprise activity, such as logistic, digital, and sustainable maturity.

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Agnieszka Stachowiak ORCID ID: https://orcid.org/0000-0002-1874-9218
Faculty of Engineering Management,
Poznan University of Technology, Poznań. **Poland**
e-mail: agnieszka.stachowiak@put.poznan.pl

Dr. Karolina Werner-Lewandowska ORCID ID: https://orcid.org/0000-0002-1874-9218
Faculty of Engineering Management,
Poznan University of Technology, Poznań. **Poland**
e-mail: karolina.werner@put.poznan.pl

Piotr Cyplik ORCID: https://orcid.org/0000-0002-5775-6760
Faculty of Engineering Management,
Poznan University of Technology, Poznań. **Poland**
e-mail: piotr.cyplik@put.poznan.pl

Agata Skowrońska-Domańska
Archicom S.A., Wrocław, **Poland**
e-mail: agata.skowronska-domanska@archicom.pl