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A conceptual model for measuring the competency level of Small and Medium-sized Enterprises (SMEs)

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A B S T R A C T

Small and Medium-Sized Enterprises (SMEs) are of major importance to developing countries. SMEs are the main drivers to strengthen society in sustaining economic growth and development. Governments provide various support programs to improve their industrial power and to increase the number of enterprises in the market. The enterprises must be assessed and suitable funds should be provided to those in need, to achieve an effective support program in the most efficient way.This requires implementing an assessment methodology based on a predefined set of scientific criteria. The current literature is comprehensive enough to assess the healthiness of the enterprises concerning strategic, technologic, financial as well as intellectual competencies but on the other hand, it lacks of an assessment model. This study aims to introduce a general framework for sustaining an effective assessment methodology for SMEs to eliminate this gap. The proposed model measures five different types of competencies such as Technological Competency, Strategic Competency, Financial Competency, Intellectual Competency, R&D and Innovation Competency. These competencies are to put forth the conditions in which the enterprises are running accurately. A real-life case study is conducted to ensure the baseline of the model to be implemented. The governmental organizations may utilize the model for sustaining their support role effectively to SMEs.

A R T I C L E   I N F O

Keywords:
Small and medium-sized enterprises (SMEs);
Competency assessment;
Technological competency;
Strategic competency;
Financial competency;
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1. Introduction

SMEs are considered to be the foundation pillar of a country's economic and social development. SMEs have a series of positive characteristic such as, their ability to adapt quickly in changing markets, flexibility in their production structures, their contribution to balanced growth between regions and their influence on the reduction of unemployment and creation of new areas of employment. Since most of the SMEs try to survive with a limited capital and to do business mainly by experienced manual labor, they always need state-support to improve their infra-structure especially at the age of Industry 4.0. The era of digital transformation offers various opportunities for enterprises to sustain competitive advantage. New business models enabled enterprises to grow their market share. A comprehensive assessment of the existing capabilities and competencies are required, in order to achieve better utilization of technology for the sake of digitization. While considering quality, cost, efficiency and environment, the enterprises should also perform the necessities of transition to Industry 4.0. Being able to utilize the technology especially digital operations and methods like autonomous systems would improve the capability of the respective SME to respond to the market requirement in an early and effective manner. This would definitely contribute to the competency of the enterprise ensuring sustainable competitiveness. Therefore, digital transformation and intelligent (smart) devices are considered to be one of the core elements of respective (technological) competency. The effects of smart and intelligent manufacturing to the competency level of the enterprise are explained below.

SMEs may increase the economic situation through producing products and services as in the same way large companies operate. They have to be supported to both improve both quality and variety of products semi-finished products the produce. In this way, SMEs may contribute to the whole economy as well as related innovation and creativity. It should be kept in mind that these enterprises, whose goal is to stay on their feet and grow in the cutthroat competition of today's business world, are the barometer of economic buoyancy. Economic buoyancy needs to create a competitive environment by growing as many SMEs as possible and by challenging the birth of lots of new enterprises and some existing industry leaders.

There is no universal definition of the term, SME, which may vary in different countries and regions. However, generally, the size of the labor force or the value of assets thy possess are considered as indicators. As claimed by Frijns and Vliet (1999) [1], the number of employees in a company is an important factor for measuring the size of industrial enterprises, particularly in developing countries. They suggested two categories for small industries: micro-enterprises (1-9 employees) and small-scale industries (10-50 employees). Even though, the limit for the number of employees in a company to indicate a small or medium company varies in different countries. For example, in Mexico and Brazil, any company with fewer than 100 staff is considered an SME, in Australia, this number rises to 200 employees, and in the United States and Denmark, a company of up to 500 employees would be categorized as an SME (Hillary, 2000) [2].

The given definitions in most OECD countries are also based on labor figures where 500 employees are considered as the upper limit of the SMEs. On the other hand, the definition most commonly accepted and used nowadays in that of Eurostat of 19 European countries states that an SME must have no more than 250 employees. Manufacturing and services of SMEs are also considered in various scope within this definition (OECD Report, 2013) [3]. Another distinguishing feature of an SME is whether it is an independent organization or linked to a larger enterprise or group. Above all, the management structure also influences the classification of SMEs in some countries (OECD Report, 2004) [4]. The last OECD report published in 2013 clearly states that any enterprise can be called an SME if it fulfills the criteria for the number of staff and one or more of the financial criteria as provided in Table 1.

As stated above, the SMEs which are greatly important for national economies should able to stay on their feet and grow in a place of global competition through receiving the support of various funds provided mainly by the governments. That is the main reason for many countries to establish associations such as KOSGEB in Turkey where KOSGEB stands for the *Association of SME Development* which is responsible for supporting the SMEs. All nations provide support to their SMEs. There ise a necessity of an assessment methodology in oderd to validate and verify the fund distribution processes. In the developed countries, a well-structured information system is set up to follow the fund distribution programs as well as the progress along with the use of these funds. This makes it easier to carry out the respective evalutions of applicants. However, in the countries such as Turkey, there has not been a fully integrated IT system between the government and industry and business community yet. Therefore, an industry independent and separate assessment system is employed which may lead to several problems such as the inadequate distribution of funds among the sectors as well as a waste of resources in the areas which

Table 1 SME definition by European Union (OECD Report, 2013)

Enterprise category	Headcount	Turnover (€)	or	Balance sheet total (€)
Medium-sized	50-249	≤ 50 million		≤ 43 million
Small	10-49	≤ 10 million		≤ 10 million
Micro	< 10	≤ 2 million		≤ 2 million

may require less attention. This clearly requires an extensive study on defining a well-suited funding and assessment system which is also one of the major motivations of this research.
Note that, the SME support in Turkey Is carried out by KOSGEB. Currently, the funds are distributed through various programs and respective assessments carried out by institutional procedures.

KOSGEB estimates that the number of enterprises considered SMEs has remarkably increased to approximately 3,500,000 in the last five years (KOSGEB, 2019) [5]. On the other side, considering the limited amount of support funds available, providing funds on adequate by *as-needed* bases become very critical. Here the main question is to determine what support should be given to which enterprise? The funds will not produce the desired output (objectives of the funder providers) if they are arbitrarily provided to anyone who asks for them. By being aware of this, KOSGEB continuously seeks alternative support programs to increase the expected benefit for the enterprises. The project-based support system is one of these. This program has now become the leading SME support system in Turkey. SMEs should generate a project and indicate that the results of the project contribute to the development of the enterprise by increasing productivity, flexibility, mobility, profitability, service time, quality, and so on. The qualifications required by KOSGEB for project-based support are a strong financial structure and a history of successful completion of previous projects carried out by the claimer.

Similarly, KOSGEB implements more than 30 different support programs. The current assessment system employed is designed as a manual review system and it is easy to assess various enterprises at the same standard. However, it is very difficult to install a system to monitor the post-support state of SMEs. Since KOSGEB is the only agency that employs SME assessment and selection criteria, it was considered to be important to review its structure as well as support related operations for the success of this study. During this analysis, it was found that one of the basic tools used by KOSGEB to manage the support programs is the Beneficiary Situation Detection Form called YDTF.

Currently, each applicant fills in an SME Statement Form, providing respective information to find out whether or not they can be classified as an SME. If approved, they are then asked to fill in the Beneficiary Situation Detection Form (YDTF). The information given by the applicant in this form is reviewed by the experts and categorized into one of four groups (A- Micro, B-Small, C-Medium, and D-Large) in accordance with enterprise characteristics. The respective support is granted following the results of this assessment.

This classification is carried out using a set of criteria developed by KOSGEB through several years of experience. Interview with some of those experts indicated that the funding algorithm based on the classification of SMEs under these four groups makes it difficult to catch up with socio-economic developments over time, as well as making it difficult to perform the assessment in harmony with the present conditions. Furthermore, as stated above, having the fact that the number of enterprises falling within the scope increased more than eight times (from 400,000 to 3,500,000) within a very short period (in five years) also makes it difficult to manage the support programs with the currently available human resources. This obviously creates a negative impact on the performance and efficiency of the manual assessment and monitoring. A Computer-aided intelligent assessment system seems to be essential to remove this negative impact as it may clearly highlight the effectiveness of the assessment programs with limited funds available.

Similarly, several countries have developed and installed assessment systems aligned to their own national economic vision. Countries also manage to solve this problem to some extent by making their relevant agencies work in coordination and cooperation with each other employing a certain but common assessment system on a single database. Furthermore, it is claimed that if recently developed information technologies such as cloud computing are adapted to the infrastructure of such agencies, their systems would be more functional and the need to install an assessment system specific to an enterprise or sector could be minimized (Mell and Grance, 2011) [6]. For countries where such infrastructure is not available or is in the process of being developed (as in the case of Turkey), manual methods are utilized. Note that the lack of some competency-related data prevents effective assessments. Although some simulation studies like the one proposed by Dragic and Sorak (2016) [7] are carried out to define and predict SME data for the assessment, the right set of data is always subject to the effectiveness of the models utilized which are not easy to validate. This is also valid for some studies limited in scope and bounded by implicit requirements (see for example Emebo *et al*., 2017) [8]. It is believed that the framework proposed in this study may be a good reference for handling competencies for better assessment along this line.

The proposed assessment model focusing on certain competencies could be effectively adapted to the distribution of support provided by agencies, and make an important contribution to the installation of a flexible and dynamic fund management system. It may also be used to help SMEs increase their performance and industrial productivity in the medium and long terms as well as to monitor the sustainability of productivity with valuable and important feedback.

In the proposed model five basic modules have been developed to assess and measure the competencies of SMEs as explained below. For the sake of clarity, a literature review is provided first.

2. Literature review on SME assessment

There have been various assessment studies presented in the literature some of which are discussed below.

Sohn *et al*. (2007) [9] suggested a Structural Equation Model (SEM) based on mainly financial performances and management of technology for granting the respective supports to SMEs. Direct and indirect relations between technological and financial indicators are established and analyzed. Similarly, Xiao-hong *et al*. (2008) [10] concentrated the financial parameters and proposed an evaluation index that measures and evaluates the performance of funds provided to small and medium-sized enterprises in China. This study clearly indicates that the size and quality of an enterprise have a positive influence on the growth rate and record time of the enterprise, whereas the status of ownership does not have much effect. In terms of financial dimension factors, *solvency* was proven to have a negative effect on the business progress.

Moon and Sohn (2005) [11] proposed an evaluation model for distributing governmental funds by performance data using the decision tree method and data envelopment analysis. Consequently, they proposed a fund management system through an intelligent probability-based approach. Similarly, Yang (2006) [12] developed a *technical efficiency index* for SME assessment in Korea using data envelopment analysis (DEA). In this study, the eligibility of the SMEs for state funds is decided based on this index and the effectiveness of the program is analyzed through a comparison of enterprises both supported and not. The analysis in this study is restricted to efficiency, but it can be considered to serve as a starting point and light the path for more comprehensive analysis. Sohn and Kim (2007) [13], on the other hand, developed a random effect-logistic regression model using financial and non-financial factors in order to estimate the performance of SMEs that are supported by the government but do not fulfill their commitments. They identified that SMEs that did not fulfill their commitments often encountered refund delays, cheques bouncing, non-commercialization of products, or poor management. Similarly, an approach aiming to monitor SMEs as being part of an integrated assessment and fund management system is presented.

Ying and Li (2009) [14] presented an evaluation model based on both fuzzy logic and Analytical Hierarchy Process. They used both quantitative and qualitative data analysis in especially, evaluating innovation capability. Five evaluation stages such as *perfect*, *very good*, *good*, *medium* and *poor* were identified for each criterion to constitute a fuzzy matrix in assessing the innovation capability of Shaoxing Textile Enterprise Group. A similar study to assess the innovation capability in Austria is provided by Kaufman and Tödling (2002) [15]. Ahmad and Qui (2006) [50] also employed both AHP and DEA to measure enterprise manufacturing performance. In general, this study was limited to the re-evaluation of SME performance but did not provide any information about a support providing model. Innovation was also the main focus of the study carried out by Cheng and Wang (2009) [16] who studied destructive innovation evaluation and risk analysis in SMEs yielding the result that destructive innovation has an important role in survival in competitive environments.

Wang (2008) [17] provided a different but statistical approach taking the effect on external environmental factors for SMEs' living conditions into account. Six main factors mainly, external environment economy, politics, technology, social culture, human capital, and natural sources were examined using Structural Equation Model (SEM), Fuzzy Analytic Hierarchy Process (AHP), and Main Component Analysis (MCA) with the results of 12,000 surveys resulting that SEM performs better in comparison to other two.

Some of the research along this line produced performance assessment systems such as those carried out by Hvolby and Thorstenson (2001) [18], Barnes *et al*. (1998) [19], Hudson *et al*. (2001) [20], Delisle *et al*. (2004) [21], Brem *et al*. (2008) [22], Hanif and Manarvi (2009) [23], etc. Those provide assessment systems with little differences in the focus of the research or the methodology implemented. Some take delivery time, delivery duration, capacity ratio, quality levels, and cost accounts whereas others concentrate on strategic objectives or institutional control mechanisms. While some of them utilizing computerized technology such as expert systems, some implemented face-to-face meetings, some concentrated on a balanced scorecard approach. Some of those such as Kim *et al*. (2008) [24] implemented an adapted learning network to support the assessment process by examining various factors based on products and administrative properties. Some researchers were very keen on performing the comparison of performance modes provided in the literature (see, for example, Abouzeedan and Busler (2004) [25]. Note that in those studies, attention was paid not only to financial criteria but also to all criteria affecting the performance of the SMEs. Hanif and Manarvi (2009) [23], on the other hand, focused on quality, productivity, innovation, and investigation of learning initiatives. A hierarchical cluster analysis was conducted using the K-means algorithm. An interesting remark was provided by Ozturk and Coskun (2014) [26] by noting that the balanced scorecard was not an effective assessment tool for banking if it was not used properly.

Lin and Tong (2010) [27] constituted a two-step credit rating model using the Cox model and Support Vector Machine (SVM). They classified SMEs in Taiwan using a two-step model and presented that the accuracy rate was better than existing gradual credit rating models.

There have been some studies on assessing the organization for other purposes not focusing the attention on funding, rather identifying areas to be improved in comparison to others. Some of them are discussed below.

Little research such as the one provided by Katwalo (2006) [28] concentrated on the competency improvement of SMEs. SMEs in England were studied in terms of foreseen competency improvement capabilities. A brief description of competency and general information about competency improvement was introduced. Existing models were compared and factors making it easier to understand competency improvement were discussed. Although SME competency was the main focus, little information is provided in conjunction with the support assessment program.

Cassell *et al*. (2001) [29] studied the effectiveness of comparison methodologies designed to improve SME benchmarking. The most effective comparison factors were identified as financial indicators, customer satisfaction, and quality of products or services. But the focus of the assessment was not on providing support to improve the areas requiring improvement.

Vanhoof *et al*. (1995) [30] developed an agent-based information system. They evaluated within the context of Strength-Weakness-Opportunity-Threat (SWOT) analysis which is an important tool for identifying the strategic objective of any organization.

Fernandes *et al*. (2006) [31] applied the balanced scorecard approach using a systematic structured methodology in a case study. They claimed that SMEs in Britain's manufacturing industry had several problems. The right approaches and methodologies could help sort them out. They also listed the application results of the proposed method, and their experiences, successes, and lessons learned during the implementation process are highlighted.

The literature review provided so far indicates that enterprises, and especially SMEs, are evaluated in many different ways mainly employing the assessment criteria related to the field, structural properties, and respective specializations. The proposed methodologies include BSC, AHP, Fuzzy AHP, DEA, SEM, etc. (see for example Sohn *et al*., 2007 [9]; Moon and Sohn, 2005 [11]; Ying and Li, 2009 [14]; Hanif and Manarvi 2009 [23]). Furthermore, The Survival Index

Value Model (SIV) is unique to enterprise, and approaches such as the Two-Step Credit Rating Model, and the Structural Equality Model are implemented by improvements (as described by Abouzeedan *et al*., 2004 [25]; Lin and Tong, 2010 [27]; Romano *et al*., 2000 [32]).

In the assessment studies, making the actual status of an enterprise crystal clear is essential as well as some environmental circumstances. Although some general indicators are proposed for observing the enterprise status, the literature still highlights the need to identify a set of criteria specific to the enterprise under assessment for more detailed analysis. Moreover, it is shown that, in the assessment of enterprises, not only determining the criteria but also choosing the correct methods and approaches is also important.

3. Proposed methodology

The proposed framework is explained below with respect to its philosophy components and respective issues.

3.1 Understanding the competency of an organization

The topic of competency has a great variety of definitions. However, most of the definitions are focused on individual competency which is related to a person having sufficient knowledge and skills to carry out a certain responsibility. Mostly, competency is considered as the basic requirements to be satisfied by the employees in an organization.

The term *competency* was first appeared in the paper of R.W. White in 1959 introduced for performance motivation. Later, it has been popularized by other researchers especially in performance improvement activities after the 1970s (Audrey, 1989) [33].

Although there have been some studies on competency as an individual, there is little research going on for the competency of the enterprises. This is one of the reasons for aiming to examine and assess the competency of the organizations, especially of the small and medium enterprises (SMEs) in this study. Organizational competency can be defined as "the capability of an enterprise to adapt itself to changes in technology, methods, and methodologies, processes, managerial approaches as well as the changes in customer behavior". The best competent organization is assumed to be the one well capable of managing the change and dominate the market in any aspect related to the business.

Hitt *et al*. (2015) [34] defines competency as the combination of both resources and capabilities. They state capabilities that are valuable, rare, difficult to imitate, and difficult to substitute as the core competencies which would be the baseline to the strategic competitiveness.

In this study, this definition is taken as a baseline and the competency is defined from the organizational point of view as such that the technical competency, financial standing, strategic restructuring, and intellectual capacity of the enterprise, as well as its ability to utilize those, are considered to be the core competency areas. Additionally, it is accepted as important to focus on the ability of the enterprise to convert its commercial and managerial resources into a benefit, and to what extent that it could use these qualities effectively and efficiently. The model proposed in this study, therefore, focuses on these areas.

3.2 Competency assessment approach of the proposed model

The concept of competency that forms the foundation of the proposed model is an indicator of any aspects of the enterprise such as background, knowledge, applications, approaches, methods, and the most developed equipment, etc. As shown in Fig. 1, these capabilities have been grouped and collected under five evaluative areas. For each of these, the capability and skills to be assessed have been uniquely defined. In other words, the proposed model so-called ASME (Assessment of Small and Medium Enterprises) is made up of five main components such as:

- Technological competency,
- Financial competency,
- R&D and innovation competency,
- Strategical competency,
- Intellectual competency.

The goal of each of these components is to measure the competency of an enterprise in a certain aspect. Setting out these five areas of competencies, the factors having the most important or the biggest effect on the development and improvement of the enterprises are taken into account. A nested and staged representation (leveled architecture) is introduced. A scoring system is also developed in order to measure the general status of the SMEs under assessment using the ASME Model.

The general status of the enterprise under assessment is first evaluated through a pre-assessment procedure. That is to identify the business type and respective business operations to be assessed. Note that each component and respective levels specified by the proposed model are weighted to validate adequate funding for the most needed areas.

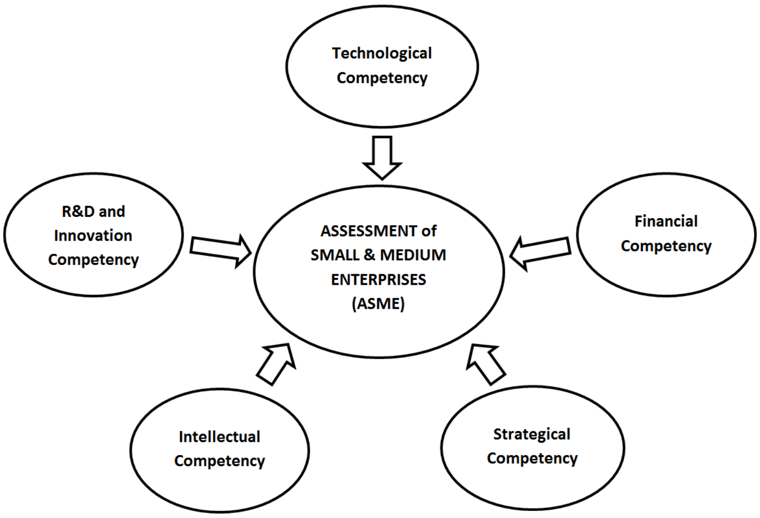

Fig. 1 Components of proposed generic model for assessment of SMEs (ASME)

In the proposed model, each area of competency has been divided into six levels where each level has a predefined requirement within the scope of related competency at that level. The main objective of the model is to match the existing state of the enterprise to the most suitable level of the competency. The reason for separating the areas of competency into levels is to create a nested assessment system in the organizations as shown in Fig. 2. In the proposed nested structure every level of competency naturally covers the related characteristics of the lower levels. For example, the sixth level indicates that the SME is to be in the highest degree of competency and means that the SME has all the qualities of the levels.

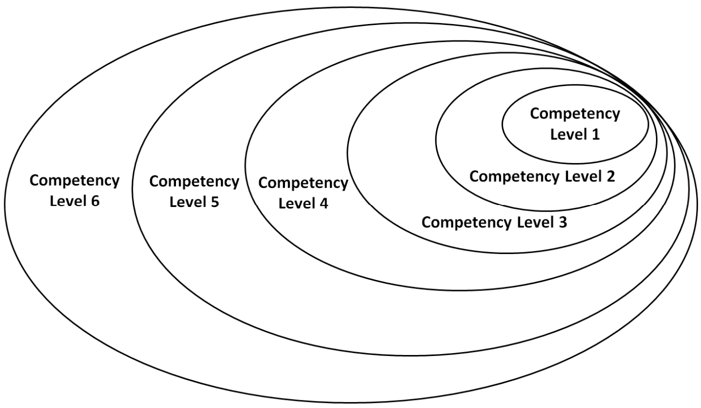

Fig. 2 Nested illustration of Competency Levels

For any SME, the important thing is to be able to develop itself in respective areas of predefined levels of certain competencies producing the point of competency scale for that enterprise. This unique point of the scale allows the provision of support in order to establish a course of action in conducting the assessments. If the enterprise that cannot fulfill one or more of the criteria for a particular competency level is not considered to move into a higher level, and cannot claim the support and funds assigned to that particular level.

A measurement scale between 0 to 100 has been created in order to identify the competency 6 levels of the SMEs as such that 10 points indicate the level score (*LS*) that the enterprise has the first and weakest level of competency (level 1) whereas 20, 40, 60, 80 and 100 points are assigned as the level scores to the subsequent levels respectively.

As an example of a score-matching card, sub competency of Technological Competency is illustrated in Table 2. The same matching card is used for each five core competency which is proposed in the model.

Note that the in Score-matching card, each assessment factor (*AF*) determines the respective competency level of the enterprise as *retained level* (*RL*) since each level and operational capability has its predefined scores. After summing up the scores obtained for all assessment factors, the generic component competency score is calculated by dividing the total value by the number of factors assessed. Here in the example, some most known assessment factors are used for IT Infrastructure as seen in table 3. In order to establish which assessment factor will be in which level, the level identification table as it is seen as an example in Table 3 will be used. The table is arranged that each higher level encapsulates the other lower levels. Every five key competencies with sub-competency have a similar identification card but due to paper limitation rest of the tables could not find a place in this study.

In the Table 3, the scope of each level has been described using general terminology. This is so that a generic and flexible model that covers different sectors and SMEs can be established. Considering the recent technological transformation as well as developments, not many enterprises will have so much love competency indicated by the first level. However, this level is still kept in this approach for the sake of completeness and wider coverage of the assessment system. In order to sustain and validate the applicability of the model a flexible structure is generated which has high potential to be updated according to the requirements of the fund providers and strategic objectives of funding.

Table 2 An example score-matching card for IT system as a Sub competency of Technological Competency

	Level 1 (0-10)	Level 2 (10-20)	Level 3 (20-40)	Level 4 (40-60)	Level 5 (60-80)	Level 6 (80-100)
Level Assessment Factors (Af_i)	No information technology (LP_1 Point: 10)	Independent software use (LP_2 Point: 20)	Integrated electronic data exchange (LP_3 Point: 40)	Integrated developed electronic data exchange (LP_4 Point: 60)	Software-based decision making (LP_5 Point: 80)	Automated decision making (LP_6 Point: 100)
Af_1 Operation systems	Retained level (RL_1)	-	-	-	-	-
Af_2 Accounting programs	-	-	Retained level (RL_3)	-	-	-
Af_3 MRP System	-	Retained level (RL_2)		-	-	-
….	-	-	Retained level (RL_3)	-	-	-
Af_n ERP system	-	-	-	-	Retained level (R_5)	-
Level score	$LS_1 = \Sigma LP_1$ $LS_1 = 10$	$LS_2 = \Sigma LP_2$ $LS_2 = 20$	$LS_3 = \Sigma LP_3$ $LS_3 = 40 + 40$	$LS_4 = \Sigma LP_4$ $LS_4 = 0$	$LS_5 = \Sigma LP_5$ $LS_5 = 80$	$LS_6 = \Sigma LP_6$ $LS_6 = 0$
Sub-competency of technology (SC_2)	$SC_2 = \sum_{i=1}^{6} LSi \,/\, \#Af$					

Table 3 An example level identification table for IT system as a Sub Competency of Technological Competency

Technological level	Explanation
Level 6 Automated decision making	An SME at this level is at the most developed level of information technology. Every sort of work and data storage is carried out on a cloud server and satellite connections are used to allow for the fast buying and selling of data. In terms of hardware, tools are not used except for data entry and screening. ERP and MRP type programs are integrated and restored smart systems can carry out every kind of work without human intervention. Managers can access any information they want instantly (with devices such as mobile telephones, tablets and computers, etc.). The system has a very flexible and smart reporting function. Employees can access and carry out their work without being in close proximity to the system by connecting via mobile phones or personal computers. Every hardware and software infrastructure is in place to run unmanned manufacturing enterprises.
Level 5 Software based decision making	At this level, every kind of software used is integrated, and necessary data can be ascertained, used, and shared without human intervention. Using a fast network infrastructure system, the software can share data with systems in other regions, and when necessary can find data on the internet to be used with smart decision-making mechanisms.
Level 4 Integrated developed electronic data exchange	At this level, many programs are used across a network and data can be shared. As with general-purpose software, specific purpose programs can be integrated and a central data repository can be used.
Level 3 Integrated electronic data exchange	Programs that are used generally to reduce a company's workload come under this level. Programs specific to the sector or enterprises are used independently. They can be used in a network and to provide inclusion of electronic data handling.
Level 2 Independent software use	At this level, there are independent programs and computer hardware. The programs are used generally for the running of the enterprises rather than for any particular purpose.
Level 1 No information technology	At this level, no form of computer hardware or programming products is used for any purpose in the enterprises. Every form of calculation, drawing, and planning work is performed by hand.

After defining the competency score for all sub-components of Technological Competency and five components of the model, the overall competency score (Competency Grade) of the enterprise is calculated by multiplying each main component competency score with its respective weight values which is represented as α_i and adding them up. A case study in a valve manufacturing process is assessed for proof of the concept of the proposed model.

A competency function with the purpose of showing the degree of corporate competency is established as shown in Fig. 3. The following abbreviations are used for sub-components of Technological Competency.

- SC_1 Machinery suit; Machinery suit (infrastructure) weight: $\alpha_1 = 0.5$;
- SC_2 IT systems; IT systems weight: $\alpha_2 = 0.2$;
- SC_3 Manufacturing support operations; Manufacturing support operations weight: $\alpha_3 = 0.1$;
- SC_4 Storage & delivery; Storage & delivery deight: $\alpha_4 = 0.2$

Technological competency score: $TCs = \Sigma\alpha_i \cdot SC_i$

The other four components of the model are not considering any subcomponent. Note that the weights of the sub-competencies and main core competencies are defined by using SWARA (Step-wise Weight Assessment Ratio Analysis) methods which is one of the most used multi-criteria decision techniques (Keršulienė, *et al*. 2011 [35]; Zolfani, *et al*. 2013 [36]).

Table 4 indicates some examples of weighing schemes for different sectors. Note that these weight values are defined by a series of expert view studies using SWARA methods. However, the model does not impose these values, the assessor organization can define the respective values in accordance with their suitability and can be defined by a specific purpose. The model requires that the weight provided in Table 4 is to be multiplied by the level of competency of the enterprise yielding a score called *competency score* (CS).

Table 4 Competency weightings of selected sectors

Competencies \ Sectors	Mining	Energy	Construction	Manufacturing	Other services
Technological competency (*wtc*)	0.3	0.3	0.2	0.3	0.2
Strategic competency (*wsc*)	0.1	0.2	0.1	0.1	0.2
Financial competency (*wfc*)	0.2	0.3	0.3	0.2	0.2
Intellectual competency (*wic*)	0.3	0.1	0.3	0.2	0.2
R&D and innovation competency (*wrdi*)	0.1	0.1	0.1	0.2	0.2
Total weights	1.0	1.0	1.0	1.0	1.0

Weights for application in this study are imported from table 4 for the manufacturing sector. The calculation is carried out using a defined abbreviation as seen below:

- TCs – Technological competency scale calculated as overall of sub-components for Technology
  Weight of technological competency: wtc = 0.3
- FCs – Financial competency scale (will be accrued from related score matching card)
  Weight of financial competency: wfc = 0.2
- SCs – Strategic competency scale (will be accrued from related score matching card)
  Weight of strategic competency: wsc = 0.1
- $RICs$ – R&D and innovation competency scale (will be accrued from related score matching card)
  Weight of R&D and innovation competency: $wrdi$ = 0.2
- IC – Intellectual competency scale (will be accrued from related score matching card)
  Weight of intellectual competency: wic = 0.2
- OCS – Overall competency score

The SME corporate competency level is calculated by multiplying the degree of competency and the weights as such:

- Technological competency score: $TCS = TCs \cdot wtc$
- Financial competency score: $FCS = FCs \cdot wfc$
- Strategic competency score: $SCS = SCs \cdot wsc$
- R&D and innovation competency score: $RICS = RICs \cdot wrdi$
- Intellectual competency score: $ICS = ICs \cdot wic$

Competency function is then given by the following equation:

$$OCS = TCS + FCS + SCS + RICS + ICS$$

Defining OCS in this way indicates the enterprise has one of the following technological competency states:

$00.00 \leq OCS \leq 9.99$ → Very poor
$10 \leq OCS \leq 19.99$ → Poor
$20 \leq OCS \leq 39.99$ → Insubstantial
$40 \leq OCS \leq 59.99$ → Just enough
$60 \leq OCS \leq 79.99$ → Good/Perfect
$80 \leq OCS \leq 100.00$ → Excellent

Fig. 3 is the radar graph of different competency scores with a visual representation of the competency scale area to better understanding.

Each competency in the proposed model is assessed by measuring several assessment factors represented by Af_i. This is defined to be able to calculate the total level score as such. Retained level point of Af can be placed on those of existed levels in the table L_1, L_2, L_3, L_4, L_5, L_6 then each Af will get a Level Point that is symbolized by an abbreviation LP. Summing all assessment factors will be divide into several assessment factors used in the table.

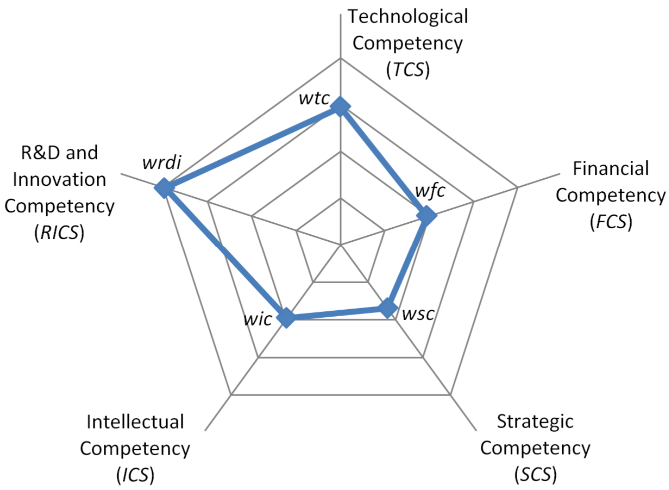

Fig. 3 Radar Diagram of SME Competency Scale

Based on this, each Competency Score (CS) will be calculated as multiplying each component score with its respective weight values and adding them up ($\Sigma\alpha_i \cdot SC_i$). For a more detailed assessment, a second alternative can be used by the assessor assigning another weight to each assessment factor. Since the existing study is only comprised of generating a framework model, it is not considered in this study.

3.3 Components of the proposed model

The SME competency assessment model comprising five core concepts that are introduced in a generic framework and the scoring system. The reason for identifying five areas of competency is clarified through supporting the idea by existing literature and scrutiny of the importance of them in terms of SMEs. A brief definition of each competency and the respective model elements with assessment tables are explained below.

Technological competency

The success of business nowadays is strictly related to the technological competency of the enterprise, particularly in the manufacturing industry. Companies are competing by their know-how and technology suits to facilitate their expertise for the sake of improving their power of competitiveness. This capability is even becoming more and more important especially with the introduction of Industry 4.0 (Sari *et al.*, 2020) [37]. As such, studies in this area are no longer focus on just technology but are also associated with innovation and unmanned operational capability. Developments in technology get the ball rolling for innovative products and processes to spring up. The continuation of a company is now directly related to its ability to adapt to technological advancements. Medic *et al.* (2019) [38], highlighted the importance of advanced Industry 4.0 technologies in manufacturing and they provided several criteria to perform a digital assessment with respect to technological progress. They particularly pointed out the necessity of integrated software suite like ERP systems. The technological competency would not be ensured without taking this into account. IT capability is therefore directly linked to competency progress in this study. Moreover, faster and higher quality presentation of products and services by discovering and utilizing the domain knowledge through IT utilization. From the past to today (from the 1 revolution to the recently announced 4th one), technology, along with social, economic, and cultural factors, has become one of the components with the biggest influence on the change of societies. The introduction of new system developments and generation of the tools and machines fueled the agricultural revolution to digitalization. The transformation continues from industrial society towards the knowledge society. This kind of change and effect that technology brought about to societies led to various definitions and commentaries of this concept throughout history (Kibritçioğlu, 1998 [39]; Durand, 2004 [40]). On the other hand, the belief on "something that can't be measured can't be managed" has created the need for technology to be managed and adopted. Many studies on technology management in this line have become very popular (see, for example, Kropsu-Vehkapera, 2009 [41]; Cetindamar *et al*., 2009 [42]; Tekin, 2006 [43]).

In this study, a six-step scaling system for technological capability has been proposed to identify the level of the technological infrastructure of a certain enterprise. A hierarchical structure is proposed in such a way that each level includes the characteristics of all the levels below in the hierarchy. Besides, a set of criteria for each degree of competency within a level has been specified. The main aim of this is to define the competency level of an enterprise in terms of stated criteria at that level. Thus, the technological competency assessment is performed on the available foundational infrastructure. The core infrastructure is made up of a machine system that is effective in every area of production by directly adding value to the business. In order to increase the applicability of the model to different sectors and business branches, it is designed with a general assessment logic. Four core infrastructures (Sub-Competencies of Technological Competency Module) that are considered to have great importance in every sector are taken into account as such (Fig. 4).

- Machinery suit (infrastructure),
- IT Systems (examples are given in Table 2 and Table 3),
- Manufacturing support operations,
- Storage & delivery.

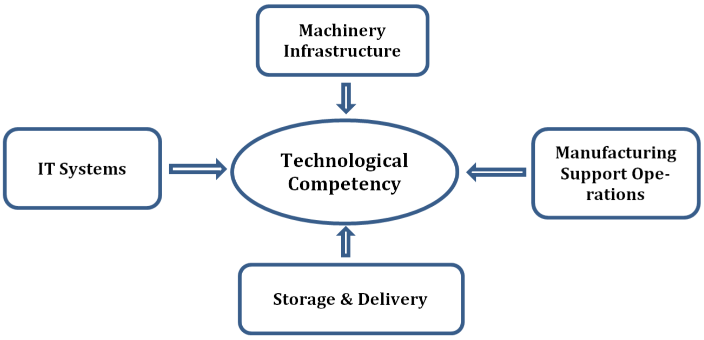

Fig. 4 Sub-Competencies of Technological Competency

In order to make the analysis and evaluation of the processes easier, an assessment Score-Matching Card has been created that the necessary and required information for each level is stored on this card. Note that, these cards are structured in a table format where every column highlights the levels of operational competence and each row indicates the available business operations/capabilities/systems such as machining, programming, etc.

As shown in Fig. 4, the technological competency is assessed by four sub-competency infrastructures stated above. These sub-competencies have been identified by considering the areas in business where technology has to be implemented. A basic weighting and scoring system is also proposed. As each level encapsulates the lower levels, the degree of technological competency increases level by level. A score for generic technological competency level is calculated by multiplying the level scores of the operating infrastructure as defined weights by experts similar to main competency weights.

Financial competency

As stated above, most of the SME evaluations are based on financial indicators with respective analyses. Due to quantifiable measures, this attracts the assessors to check out the corporate strength of any enterprise, especially SMEs. In business society, it is strongly believed that financial power indicates the continuum lifecycle of the companies in any nature. That is the main reason for relying on a financial indicator such as ratio analysis for the assessments. As financial ratio provides some information such as liquidity, indebtedness, and profitability of the enterprise it attracts not only the assessors but also other main stakeholders. For example, the banks or bankers use this ratio as the baseline for deciding on credits (loans) and perform risk assessments. In the scope of this paper, a different point of view and interpretation is presented on the ratios concentrating on the competency. With this in mind, Altman's (1998) [44] Z score model has been taken as a basis as it is also proven to be more consistent and correct (Altman, 2000) [45]. This model introduces a weighting scheme for analyzing respective financial ratios. His analysis is based on the relationship between assessment components which are experimented with a multiple discriminant method. Note that, this analysis predicts the financial ratio by several characteristics such as *safe*, *grey* or *distress* zones.

A level boundary table is created and financial position is scored according to the corresponding level of this table. First of all, financial data is analyzed and respective ratio values are calculated. They are then compared with the industry standards. This level-based analysis is expected to identify first and foremost state the enterprise's financial level and its respective score. The percentages for the levels have been stated in accordance with the conditions of the period subject to the assessment. In this study, the ratios have been leveled taking the difference out of standards. For example, if an enterprise ratio is more than 50 % away (below) from the industry standards, that enterprise is considered to be at the second level of competency whereas the sixth level indicates that the enterprise is well operating and is 50 % above the standards.

The level boundary table has been described before states that a level for each financial ratio is evaluated individually. As with the scoring of the other competencies, a score is given to each ratio using a scorecard and the level warranted. The Financial Competency score is calculated as the following.

Financial Competency Level Score = ∑ Ratio Score / #Ratio

By using the level competency score-matching card and listing the ratios from the leveling table that is similar to example table 3, it is clearly seen at which level the enterprise standing for its financial capability. The overall financial competency score is obtained by averaging all scores. The following factors are assessed under this component:

- Sales profitability,
- Asset turnover,
- Working capital ratio,
- Debt burden,
- Debt-equity ratio,
- Working capital turnover.

Strategic competency

Strategic management and planning are defined as the systematic way for an organization to reach its long-term objectives, the methods used in resource allocation necessary to attain these goals, and applications in the light of these methods. The strategy is seen as an administrative tool that provides innovation, advancement, and interaction with the business's environment and that keeps changes under control. It is hard for an enterprise that is not strategically strong to achieve satisfactory and permanent productivity and effective operations. Therefore, the evaluation of an SME's strategic competency is considered to be an important matter in the assessment. By been aware of this, Husseyin and Jahanzaip (2018) [46] proposed a conceptual manufacturing framework that is structured by three elements as Ideal, Strategy, and Architecture in order to sustain a continuous business. They considered strategic planning, being the combination of transformation sustainability and competitiveness as the core element. However, measurement in strategic competency is important but extremely difficult. Taking the internal and external conditions of enterprises into account, it is important that the short and long-term plans of an SME are correctly set up. While preparing these plans, appropriate strategies should be employed, and these strategies need to be well managed. For an SME, first, the mission and vision and then the goals and aims of the business must be identified. Then the strategies need to be stated according to the business structure and market position, and in time, updated accordingly (Ulgen and Mirze, 2004) [47].

As has been done for the other competencies, a six-step assessment table has been created for strategic competency assessment as well. The proposed strategic competency model is expressed in terms of environmental analysis, strategic thinking, planning and implementation, department-based operations, control evaluation, and continuous improvement within this scope as well as key performance indicators. The following factors are considered to be sufficient in performing the assessment for this type of competency (for more precise calculation, each factor can be weighted as well):

- Environmental analysis,
- Strategy formulation,
- Planning and implementation,
- Department constitution,
- Control and evaluation,
- Feedback and continuous improvement.

Similar to other components of the competency model, the strategic competency will be scored using a leveled table. Using the scorecard, it will be determined whether or not the parameters of strategic management, analysis of environmental conditions, strategy creation, implementation, and control assessment are in place or not. The score-matching card is used in a similar manner. Each level is marked depending on the score achieved through the control of whether the necessary processes are being fulfilled or not. As with the other competency modules, it is possible to rearrange the scoring of the strategy levels in the scorecard according to the situation or strategy of the business that will use the leveling model.

Intellectual competency

The world is on the edge of the information era. It is now very clear that the effective usage of knowledge in operations becomes more important, especially, with the transition from industrial to the information revolution. The information with respective knowledge has a direct impact on many areas such as company strategies, corporate performance management, and customer satisfaction. This is also very much related to the transformation of organizational culture as revealed by Draskovic *et al*. (2019) [48]. With this in mind, one of the most important issues corporations experience today is how to use the right knowledge in the right place at the right time and in the right way. That is the main reason for taking knowledge management as one of the main indicators of institutional competency. The companies without strong knowledge management capability it is extremely hard to solve the problems. An SME with strong corporate culture and effective utilization of knowledge and information systems is considered to develop its related competency.

A similar six-step scaling system has been created for evaluating intellectual capital as well. The levels are stated in six stages starting from the first level. The first level shows the weakest position of an enterprise's intellectual competency whereas the sixth level shows the highest degree of intellectual competency. Similarly, a scorecard method is used and a score is defined for each level of intellectual competency. In the proposed leveling system for intellectual competency, each level will be assessed from five perspectives such as:

- Information management
- Education level,
- Career management,
- Process and improvement, and
- Generation of new ideas.

In the scorecard, the first and lowest level is defined as *implicit knowledge possessed*, the second level as *knowledge providing*, the third, *understanding of knowledge*, the fourth, *analysis of knowledge*, the fifth, *evaluation of knowledge*, and the sixth and most developed level as c*reating of knowledge*.

The scoring of intellectual competency will be carried out in the same fashion as the previous competency modules by evaluating the state of the enterprise in each intellectual dimension according to the definitions which are tabled and marking the level on which an enterprise possesses on the scorecard. After every intellectual dimension has been marked, the level scores are summed up and divided by the number of dimensions. Thereby, by multiplying the result by the intellectual competency weights, an intellectual competency score to be used in general assessments is obtained.

Research & Development (R&D) and Innovation Competency

Global competition among corporates has inevitably created the need for businesses to conduct R&D and innovation in business (i.e. on products or processes). Due to the importance attached, R&D and innovation have become an important necessity all over the world for the growth of SMEs and the marketing of more products or services. Furthermore, over the past few years in developing countries, the studies related to entrepreneurship attracted the attention of fund providers and the support of new entrepreneurs has increased. Businesses that can increase their productivity could gain a competitive advantage in the markets. Increasing productivity depends on gaining competence in innovation on a global scale (Chen *et al*., 2009) [49]. Consequently, the existence of R&D and innovation in SMEs and to what degree they are effective has come forth as important criteria in searching out a better assessment model and it is considered that innovation and R&D, evaluated as an important area of competency.

Innovation and R&D mean turning an idea into a marketable product or service, a new or developed manufacturing or distribution method, or a new social service method. For successful innovation and R&D management, the respective innovation strengths of businesses must be explored and evaluated.

For this reason, as with the other competency tools above, the potential and performance of a business through measuring the company's R&D and innovation competency and capacity are considered to be taken into account. Similar to the others, The R&D and innovation competency assessment model has also been constructed using a six-step leveling table as with the other competency modules. Each level is examined from three core perspectives defined as *commercialization*, *R&D and innovation culture*, and *R&D potential and structure*. The definitions of these three areas have been leveled separately in a nested structure as defined earlier.

As with the previous competencies, a scorecard is used for the scoring of R&D and innovation competency. According to the scorecard, technological competency, strategic competency, and intellectual competency other competencies, and the R&D and innovation structure, scoring will be done determining will be used in the measurement of this competency. In addition to these, R&D and innovation structure will be scored with the assessment table mentioned in the previous sections. Thus, the R&D and Innovation structure will be evaluated with three competencies that are components of the proposed model.

The scoring of R&D and innovation competencies in enterprises uses a different approach than that of the other competencies. In this competency, it is necessary to consider the situation of the technological, strategic, and intellectual models. Therefore, the scores previously obtained for these three competencies are also added to the R&D scoring table. In addition to this, R&D potential and infrastructure, R&D and innovation culture, and commercialization will be used in the scoring. However, the model has a flexible structure and an enterprise using the model can create its assessment table and update the proposed table as necessary.

4. A case study: Implementation of the proposed assessment model

The validity of the competency model proposed in this study is illustrated by performing an assessment of an enterprise operating in the metal industry. KAYALAR ARMATUR of KAS GROUP where the model is implemented is a medium-sized valve manufacturer. Although, the proposed model has a general structure; this application provides information regarding the applicability of the model in the manufacturing sector. As stated earlier, the model requires sector-based weight values to indicate the importance of each component of the model for a defined sector. The competency weights given in Table 4 for the manufacturing sector are used.

The assessment is carried out for each competency using the scorecards explained earlier in related table 2 that is exampled on IT System as a sub competency of Technological Competency.

By comparing the information obtained for the company with the competency level descriptions, the retained level for each assessment factor for each competency is identified and marked on the scorecard. A competency score for each competency is calculated and by adding together these scores for each operation and dividing by the number of operations. Note that the four sub-competency of technological competency is previously calculated to find the score of technological competency.

The total of these scores states the enterprise's overall competency score which is calculated to be:

$$\textit{Overall Competency Score}\ (OCS) = TCS + FCS + SCS + RICS + ICS$$
$$OCS = (TCs \cdot wtc) + (FCs \cdot wfc) + (SCs \cdot wsc) + (RICs \cdot wrdi) + (ICs \cdot wic)$$

$$OCS = (31.75 \cdot 0.3) + (56.66 \cdot 0.2) + (23.33 \cdot 0.1) + (24 \cdot 0.2) + (33.30 \cdot 0.2)$$
$$OCS = 9.525 + 11.33 + 2.33 + 4.8 + 6.66$$
$$OCS = 34.645$$

$$20 \leq OCS \leq 39.99 \quad \rightarrow \quad \text{Insubstantial}$$

Considering the scale created earlier, since the company score is between 20- 39,99 then, it can be defined that this enterprise competency is insubstantial. Company score together with respective module scores shown in Fig. 5. After find to a retained level of each assessment factor for each competency TCs is calculated and then to find the competency score weight of related competency is used. Weight values are defined by the experts who work operationally in the sector of the company.

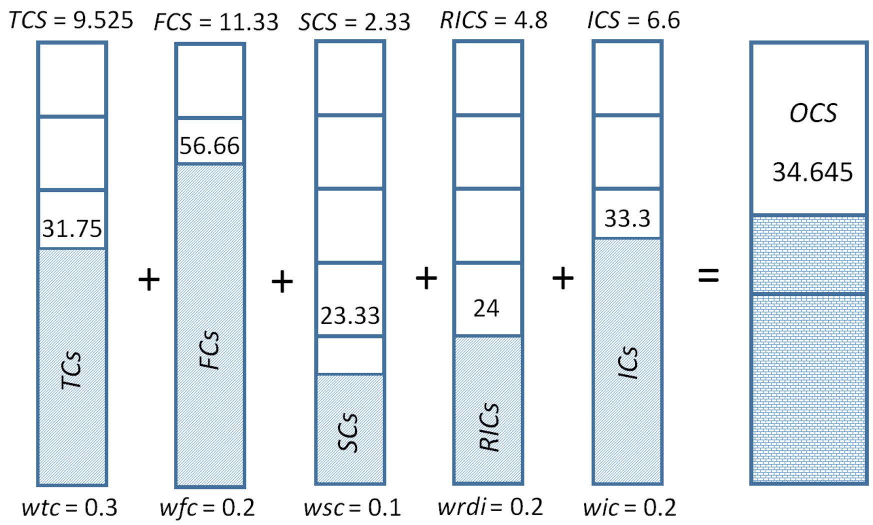

Fig. 5 Visual Representation of the competency assessment of KAS VALVE Inc.

In the general competency assessment, since the KAS VALVE Inc. is a manufacturing enterprise, the highest weighting it received for any of the five competency components was 0.3 for technological competency. As for the four sub-competencies that make up technological competency, 0.5, the highest weighting, has been applied to machine infrastructure, with 0.1, 0.2, and 0.2 being applied to the other areas respectively. In the technological competency assessment, the four sub-competencies scores were found to be as follows:

- Machine Infrastructure Score: 33.3
- Manufacturing Support Operation Infrastructure Score: 35
- Storage & Delivery Infrastructure Score: 28
- IT Systems Infrastructure Score: 30

Taking these scores and multiplying them by the relevant weightings gives a competency score of 31.75 for technological competency.

$$TCs = 33.3 \cdot 0.5 + 35 \cdot 0.1 + 28 \cdot 0.2 + 30 \cdot 0.2 = 31.75$$

This score shows that the enterprise's technological competency is at level 3. Similarly, the scores 56.66, 23.33, 24, 33.3 were calculated for financial, strategic, intellectual, and R&D and Innovation competencies respectively. Thus, the overall competency level of the enterprise has been defined according to a value that is calculated and represented above as OCS = 34.645.

KAS VALVE Inc.'s strongest area of competency with a score of 56.66 contributing to the overall competency level by 11.33 is financial competency. The next strongest competency is technological competency with a score of 31.75 (overall score of 9.525), which is due to the enterprise being a manufacturing company. This shows that after the enterprise's financial infrastructure, its technological infrastructure is strong. Even though the R&D and Innovation competency score is low, it is a competency that is necessary at certain levels for a manufacturing company with a competency score of 6.6. It is seen that the strategic and intellectual competency scores of 2.33 and 4.8 are comparatively low. Therefore, it is predicted that KAS VALVE Inc. would not be able to apply for support from KOSGEB in strategic and intellectual areas as support is classified according to certain scores. It is recommended that the assessed enterprise increase its strategic and intellectual competency by strengthening any missing components, or by securing support to strengthen these competencies. The strengthening of weaker competencies can also have the effect of raising other competencies to higher levels.

5. Conclusion

SMEs whose number is remarkably increasing day by day can also be seen as the locomotive of economies in most of the countries. Therefore, it requires a considerable effort to make them operate efficiently and effectively with compatibility capabilities. They are mostly supported by the official agencies to sustain the level of competency possessed.

With the increase in the number of various supports offered by government authorized organizations such as KOSGEB, the fund utilization and effectiveness of support programs are the main concern. Due to the environmental, political, and social effects as a result of globalization, it is not easy to sustain competitive advantage. Since, the number of SMEs in need of government funds increasing, defining a more selective method and fair distribution of these limited funds is at the top of the agenda. Giving the right amount of funds to the right enterprise is of great importance for increasing both the benefit to the enterprise itself and also to the country.

It is known that every country has its own methods for assessing the benefit of funds provided to enterprises according to its political and economic conditions. In evaluations that have been carried out, it is seen that these kinds of problems have been over overcome due to strong integration between government organizations, particularly in developed countries. Many problems can be solved from the beginning through the collective process of data collection, sharing data, and use of highly integrated automation systems. In many countries, the assessment of companies who wish to receive funds is carried out by experts using a variety of formulas. This process cannot identify the extent of the benefit of the funds to an enterprise just as it cannot test the strength of the enterprise applying for the governmental funds. Therefore, it is possible that much of the funds given by the government are in fact used by enterprises that cannot reap the expected benefits. Besides there is a need for information gathering and processing capability on how effective the given supports are to the enterprises. Hence, a custom made monitoring system is required for each country.

In this study, it is demonstrated that in reality, the desired results of an assessment will not always be obtained by just considering the financial data. Initially, a generic evaluation framework is defined. Within this framework, it is expected that the fund distribution schemes need to be improved through not only concentrating financial ratios but also other capabilities such as technological, strategic, financial, R&D as well as intellectual capabilities. Therefore, governmental organizations such as KOSGEB in Turkey that provide a variety of funds and support to enterprises need more effective and dynamic assessment systems. For the creation of such systems, it is first necessary to well-understand the competencies of enterprises from different aspects and measure those.

Implementation of the model in an actual enterprise indicated that the model can be easily employed and there is no difficulty in collecting the required information to perform the assessment.

The proposed model can easily be improved and turned into a systematic structure through a programming language to considerably facilitate the assessment of applications made by millions of SMEs. It is foreseen that such an agent-based framework model also can considerably facilitate the following secondary objectives:

- Determining relevant performance indicators to accomplish dynamic analysis of the state of SMEs.
- Determining the SMEs to be supported and the amount to be provided.
- Estimating what support will bring what kind of benefits, and building an infrastructure to plan the next support under such estimations.
- Displaying what types of support provided SMEs with more successful results.
- Making suggestions to SMEs on how to use the support they receive in a better way and providing SMEs with the computer-assisted distant training courses.
- Analyzing clusters of SMEs by industry or assessing SMEs within an industry.
- Analyzing how the support efficiency by industry should differentiate per industrial needs.

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