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# Measuring commercial soft technology maturity in smes: An adapted SCAPE–AHP model for emerging technology readiness Bushehr persian gulf science and technology park

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### ABSTRACT

Commercial soft technology comprises intangible human-centered processes that improve firms' operational effectiveness and amplify the value of technological assets. This study develops and validates a measurement model for assessing the level of commercial soft technology in small and medium-sized enterprises (SMEs) using a sequential mixed-methods instrument-development design. In the qualitative phase, thematic analysis of in-depth interviews with 25 SME experts and park managers produced 185 codes, which were organized into 78 basic themes, 25 organizing themes, and five global themes. These findings informed a SCAPE-based measurement model consisting of five components (technology mechanism, human technology, information technology, technology supply, and technology transfer) and 28 subcomponents. The model was implemented and piloted in a technology unit within the Persian Gulf Science and Technology Park; process-level scores were standardized and aggregated, and component weights were derived via AHP to compute a composite Commercial Soft Technology Measurement Coefficient (CSTMC = 0.691 for the pilot unit). To ensure methodological rigor, qualitative findings were externally audited and member-checked, and reliability was assessed via test–retest yielding Pearson's  $r = 0.69$ . Qualitative coding was conducted using qualitative data-analysis software, and quantitative procedures (AHP weighting, normalization, reliability testing) were implemented with standard statistical/AHP software. Results indicate a mid-to-high integration of commercial soft technologies in the pilot firm, with relative strengths in technology supply and transfer and gaps in information and human components—findings that have clear implications for SME managers and policy makers in science parks.

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## 1. Introduction

Numerous studies have demonstrated that traditional productive factors, such as labor and capital, explain only a portion of economic output, with the remainder attributable to technological advancements ([Brey, 2017](#); [Oecd, 2025](#)). Technology encompasses a system of practical knowledge primarily rooted in the natural sciences, encompassing skills, tools, systems, and principles that enable individuals to modify, adapt, and manage the natural environment for human sustenance and progress. Contemporary scholarship expands this scope to include knowledge from natural sciences, social sciences, humanities, and even traditional or non-scientific domains as valid forms of technology ([Unctad, 2025](#)). Joseph Pitt posits that social constructs, such as governments, bureaucracies, and legal frameworks—analogue to human-engineered hard technologies—should be recognized as technologies in their own right and incorporated into technological assessments ([Pitt, 2014, 2017](#)). Jin describes soft technology as a system of practical knowledge that originates from social sciences, non-natural sciences, and non-scientific (traditional) knowledge, which aims to solve various practical human problems. A significant application of soft technologies involves the formulation of business regulations and financial instruments attuned to cultural and societal contexts, collectively known as commercial soft technology. This encompasses the processes underpinning creative economic endeavors, enhancing the efficacy of economic operations and amplifying the value of both soft and hard technologies. Examples include exchange mechanisms, monetary systems, accounting practices, marketing strategies, management methodologies, and financial innovations ([Jin, 2002](#); [Unctad, 2025](#)). [Elmeziane et al. \(2011\)](#) examined the sources of technology development and concluded that the rapid development of technology in the 21st century changed the competitive resources of business organizations from tangible resources to intangible resources such as information technology. They considered the focus on soft technology within human resources as the most important factor. [Zhouying \(2004\)](#) examines the historical evolution, developments, and changes of the nature of technology from hard to soft, calling it a kind of revolution, technological innovation, and the reduction of technological gaps.

Recent empirical and review studies strengthen the relevance of intangible and organizational dimensions of technology for SMEs and provide contemporary measurement and governance perspectives that inform our model development. These works document: (a) the centrality of knowledge management and intermediary roles for SME digitalization and organizational routines ([Hafeez et al., 2025](#)); (b) refined IT-governance and measurement approaches relevant to organizational (soft) processes ([Vaya-Arboledas et al., 2025](#)); (c) practical maturity and prioritization frameworks for SME digital/soft capabilities ([Bayat et al., 2025](#); [Cen & Lin, 2025](#)); and (d) leadership, orientation and digital intelligence as drivers of SME soft-technology outcomes ([Bai & Qu, 2025](#); [Maseda et al., 2025](#)). Together, these contemporary sources both justify and operationalize the emphasis on commercial soft technology (organizational/information/human/process dimensions) in SME measurement frameworks.

The nascent character of commercial soft technologies stems from their relatively recent delineation as autonomous entities distinct from hard technologies, with foundational works like [Jin \(2002\)](#) marking a critical evolution in acknowledging their contributions to economic

innovation. In contrast to mature hard technologies, soft technologies remain in flux, with sparse empirical frameworks for quantification, rendering this study a pertinent addition to an emerging domain.

Neglect of commercial soft technologies has fostered a unidimensional perspective on technology assessment, impeding comprehensive evaluations of a firm's technological posture and precipitating systemic inefficiencies. Existing models for technology measurement predominantly emphasize competitive advantages derived from hard technologies and production systems, with minimal attention to commercial soft technologies ([Yee et al., 2025](#)).

Consequently, given the unique attributes of commercial soft technologies—their influence on production processes and their effects on business operations and performance—it is imperative to devise a dedicated model for gauging their levels. This facilitates scrutiny and analysis of such technologies within enterprises. Moreover, this measurement framework bolsters governance by facilitating enhanced regulatory supervision in technology parks, where policies concerning resource distribution, innovation stimuli, and SME assistance can be guided by quantified soft technology metrics, thereby addressing deficiencies in national and corporate governance architectures ([Oecd, 2025](#)). The present inquiry seeks a model or instrument to delineate the status of commercial soft technologies (including strengths and weaknesses) in small and medium-sized enterprises (SMEs), enabling comparisons of gaps relative to optimal benchmarks and quantifying technological disparities.

In the context of the Persian Gulf Science and Technology Park in Bushehr, preliminary documentary review and field evidence indicate the existence of substantive challenges in the domain of commercial soft technologies among tenant firms. Official Park records and internal reports show that a large proportion of SMEs operate with limited formalized soft information systems, rely heavily on experiential and person-dependent managerial practices, and exhibit weak institutionalized mechanisms for technology information management and human capability development. These observations are further corroborated by exploratory interviews with managers and experts affiliated with the park, who repeatedly emphasized deficiencies in structured soft processes—particularly in information handling, specialized human expertise, and process formalization—despite acceptable performance in technology supply and transfer activities. Together, these contextual indicators provide empirical justification for treating the measurement of commercial soft technology as a concrete and relevant problem within the Bushehr Science and Technology Park rather than a purely abstract or theoretical concern.

Thus, the primary research question is: "What are the components for measuring the level of commercial soft technologies, and how can their level be assessed?" Effective decision-making and technological advancement for enterprise growth necessitate a thorough understanding of all extant technologies within the organization. This study examines technologies overlooked in prior evaluations, which have perpetuated a narrow view of technology measurement. The core impetus for this research is to adopt a novel lens on technology and bridge the knowledge void regarding commercial soft technologies in SMEs.

## 2. Literature Review

### 2. 1. Soft technology

[Pitt \(2014\)](#) describes technology as a complex process of humanity at work, believing that all human constructions, such as social tools like governments, administration, and legal systems, are all considered technology. Identified creativity and innovation in soft technologies as the most important factor in achieving long-term economic growth.

Soft technology is characterized by its inherently soft and technological essence. From an ontological perspective, it is rooted in human cognitive constructs and remains entirely subjective. Epistemologically, it posits that technology precedes science. Methodologically, it relies on diverse and integrative approaches, while anthropologically, it embraces an interpretive framework wherein humans hold the authority and capability to shape outcomes ([Jin, 2011](#)). Soft technology exhibits two fundamental characteristics: it must qualify as technology while also being "soft." Specifically, (1) it functions as a cognitive framework equipped to employ processes, tools, rules, and systems for problem-solving; (2) it is defined by softness, which includes:

- Practical objectives contingent upon subjective realities;
- Application scopes encompassing unpredictable mental processes, human social systems, and notable historical achievements;
- Core technical parameters centered on human, social, and cultural elements; and
- Primary modes of delivery that are intangible, such as services, processes, rules, and institutions ([Jin, 2002, 2011](#)).

[Jin and Bai \(2011\)](#) identified the six main criteria of cost, quality, time, service, resource use, and environmental impact (soft technology) as the most important criteria for evaluating and measuring the reproductive technology portfolio. As an emergent field, the distinctiveness of soft technology derives from its divergence from hardware-dominated paradigms, with accelerated evolution in the 21st century to encompass intangible innovation dimensions, and ongoing applications in governance realms including policy design and institutional regulation ([Jin, 2002](#)). [Kanayama et al. \(2010\)](#) examining the factors affecting the development of countries, identified soft technology as a result of technology development in the present century and expressed it as a factor to bridge the technological gap between developed and developing countries. [Lee et al. \(2011\)](#) presented a conceptual model of Japanese-Malaysian soft technology transfer to reduce the technological gap. [Siu and Wong \(2015\)](#) by examining successful and unsuccessful schools, identified soft technologies as a factor in improving the quality and efficiency of educational management.

### 2. 2. Commercial Soft technology

The development of commercial soft technology has begun from ancient Chinese martial arts of "Sun Chi", traditional Chinese medicine, accounting, insurance, equity institutions, public relations, advertising, and banking began," Jin says, "in the years leading up to the Industrial Revolution, this technology became standardized and used during the industrialization period for Western economic and managerial development" ([Dutta et al., 2017](#)). Commercial soft technology

comprises the intangible processes that underpin innovative human economic activities, thereby improving operational efficiency and unlocking the value of both soft and hard technologies. It stems from human, social, and economic interactions, with examples including exchange mechanisms, monetary systems, accounting practices, advertising strategies, and financial innovations ([Jin, 2011](#)). Other forms encompass customer relationship management systems, organizational models, and agile methodologies. Recent studies, such as those by [Siu and Wong \(2015\)](#) and [Fionah \(2024\)](#) have explored the influence of soft technologies on business quality management, demonstrating their direct effects on quality, productivity, and firm profitability.

In contemporary manufacturing and management contexts, commercial soft technologies include total quality management implementation, Kaizen initiatives, Kanban systems, performance management frameworks, just-in-time production, continuous improvement processes, ISO standards adoption, statistical process control, supply chain optimization, efficient marketing strategies, strategic financial management systems, and other quality assurance mechanisms ([Islam & Ahmed, 2024](#)). The evolving nature of commercial soft technologies is apparent in their recent standardization and assimilation into global economic structures following the Industrial Revolution, although their measurement lags behind, presenting avenues for improved governance in small and medium-sized enterprises (SMEs) via enhanced policy coordination and regulatory structures ([Jin, 2011](#)). Evaluating, selecting, and leveraging technologies—whether hard or soft—or even innovating new ones has long posed challenges for organizations. Efforts have focused on comprehensively analyzing technologies in production workflows to boost efficiency and productivity by assessing their current status. Thus, gauging the state of existing technologies and identifying necessary ones are core to technology management.

Insights from hard technology literature can inform the measurement of commercial soft technologies. Technology assessment involves evaluating an organization's technological capabilities to pinpoint strengths, weaknesses, and gaps relative to benchmarks. Applying this, the measurement of commercial soft technology entails assessing capabilities tied to structured economic activities, comparing them against optimal levels to address shortcomings while capitalizing on strengths. Recent research, such as that by [Bailey \(2023\)](#), examines the role of soft technology in organizational design and its contributions to productivity in diverse economies, indicating that soft technology policies enhance performance in advanced markets. Similarly, studies by [Ille \(2009\)](#) examines the role of commercial soft technology in brand transfer in China and suggests that soft technology is the solution to improve brand transfer processes. ([Henry et al., 2009](#)) and have investigated the effects of soft and hard policies on emerging enterprise technologies, revealing that soft technologies lower market exit risks and correlate positively with sales growth. Moreover, the influence of soft processes on firm expansion often surpasses that of hard technologies.

### **3. Methods**

In terms of its purpose, this research is developmental and applied in nature. Philosophically, it aligns with the pragmatist paradigm, as it employs both quantitative and qualitative approaches ([Creswell & Creswell, 2003](#)). From a methodological standpoint, the study adopts a mixed-

methods design, and in accordance with Creswell's classification, it falls within the category of sequential mixed-methods designs. The primary objective of this study is to assess and measure the level of commercial soft technology in small and medium-sized enterprises (SMEs). Additional objectives include the extraction of concepts and components related to measuring the level of commercial soft technology, the identification of components that influence processes associated with commercial soft technologies, and the development of a model for the level of commercial soft technology.

To address governance requirements, the methodology integrates elements that support policy and regulatory decision-making, such as thematic analysis to uncover governance-related themes (e.g., institutional support and policy integration) within the measurement of soft technology.

This research employs a sequential explanatory mixed-methods design of the instrument development type. In the sequential instrument development approach, the research topic is initially explored qualitatively with a limited number of participants, after which the qualitative findings serve as a foundation for formulating questions and developing quantitative survey instruments. Subsequently, the researcher administers and validates these instruments through quantitative methods. In this framework, the qualitative and quantitative approaches are interconnected via the process of instrument question development ([Creswell & Creswell, 2003](#)).

The statistical population for this study was divided into two segments. The first segment comprised experts in the SME domain affiliated with the Organization of Industry, Mine, and Trade in Bushehr Province (Iran), academics specializing in SMEs, managers of units within the Persian Gulf Science and Technology Park, and senior managers of units within the Persian Gulf Science and Technology Park. The second segment consisted of technology units situated in the Persian Gulf Science and Technology Park.

As of March 2010, 2017 SME units were under the park's coverage. Four criteria were applied to define the statistical population in the second phase:

- Technology units must possess more than 5 years of operational experience;
- They must have demonstrated profitability over the last 5 years (2019-2024);
- Their workforce must range between 10 and 50 employees;
- They must be located within the Persian Gulf Science and Technology Park in Bushehr (Iran).

Based on the stated eligibility criteria, 14 technology units qualified for inclusion. For the qualitative phase, purposive (snowball) sampling was used to recruit experts and managers (N = 25) until theoretical saturation was reached. For the quantitative phase, the study employed a pilot implementation approach: a single technology unit was selected by simple random sampling from the 14 eligible units to serve as the pilot for model implementation and feasibility testing. All personnel of the selected pilot unit (N = 15) participated in structured assessments that were subsequently used for standardization, AHP weighting, and computation of component scores. We clarify that the quantitative component reported here is a pilot feasibility study (random selection of one pilot unit) rather than a full-scale probability sample across multiple units; this approach

was chosen due to the limited number of eligible units that met the defined inclusion criteria and the instrument-development aim of the research.

The analysis of qualitative data was conducted using content analysis, with the goal of identifying concepts, categories, and factors that influence the measurement of commercial soft technology. Data analysis in thematic analysis was grounded in the coding process. A "theme or content" represents a significant element in the data that relates to the research questions and seeks to elucidate patterns of meaning within a dataset ([Braun & Clarke, 2006](#)). The theme is a pattern identified in the data that, at minimum, describes and organizes observations and, at maximum, interprets aspects of the phenomenon under study. It encompasses six steps: familiarization with the data, generation of initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the final report.

The thematic analysis method in this research encompasses a broad array of techniques, incorporating the "thematic network technique" ([King et al., 2018](#)). In this technique, the researcher examines the data to identify themes and, following a structured procedure, organizes them into basic themes (codes and key points extracted from the text), organizing themes (categories derived from the synthesis and abstraction of basic themes), and global themes (overarching themes that encapsulate the principles governing the text as a whole). These themes are subsequently visualized as web-like network maps, illustrating the prominent themes at each of the three levels along with the relationships among them.

During the instrument design stage, the SCAPE model was utilized to design and develop a model for measuring the level of commercial soft technology. The SCAPE model is a quantitative approach employed for assessing manufacturing technologies. This model emphasizes various dimensions of technology and is predicated on the assumption that the four core components of technology (machinery, human resources, information, and organization) invariably influence every production process and the conversion of inputs into outputs.

In the quantitative analysis phase, the designed model was implemented in one of the technology units within the Persian Gulf Science and Technology Park in Bushehr (Iran). The results were then analyzed, and the model was finalized. Finally, the research questions are as follows:

- What components are involved in measuring the level of commercial soft technologies?
- What are the characteristics and features of the commercial soft technology measurement model in SMEs?
- What is the status of commercial soft technology in SMEs?

To ensure the validity and reliability of the research procedures and instruments, several complementary measures were applied. Content validity was established through expert review by academic scholars and industry specialists, as well as alignment with documentary analysis and qualitative interview findings. The qualitative coding and theme development process was further strengthened through member checking and external auditing to ensure conceptual consistency between the data and the extracted constructs. Construct validity was supported by the emergence of five coherent core components from the thematic analysis and their structural consistency in the pilot implementation. Regarding reliability, a test–retest procedure was conducted for the

quantitative stage, and the Pearson correlation coefficient between the two testing rounds was  $r = 0.69$ , indicating acceptable reliability for an instrument-development and pilot feasibility study. In addition, qualitative coding was reviewed by independent experts to enhance interpretive stability. Quantitative procedures, including AHP weighting, score normalization, and final coefficient computation, were implemented using standard statistical and AHP software, and the pilot results (including CSTMC values and component-level graphs) demonstrated internal coherence and practical applicability of the proposed measurement model.

## 4. Results

In the first stage, after documentary analysis, reviewing previous studies, and interviewing 25 statistical population, using the thematic analysis and thematic network technique, the concepts, and components that were most frequently repeated in the research documents and in the transcript of the interviews related to measuring the commercial soft technology level were organized into key codes, basic themes, organizing themes, and Global themes. 185 key codes were identified that were classified into 78 basic themes, 25 organizing themes, and 5 Global themes. Table 1 summarizes the organizing themes and their assignment to the five global themes. Fig. 1 visualizes the thematic network and shows the relationships among basic, organizing and global themes.

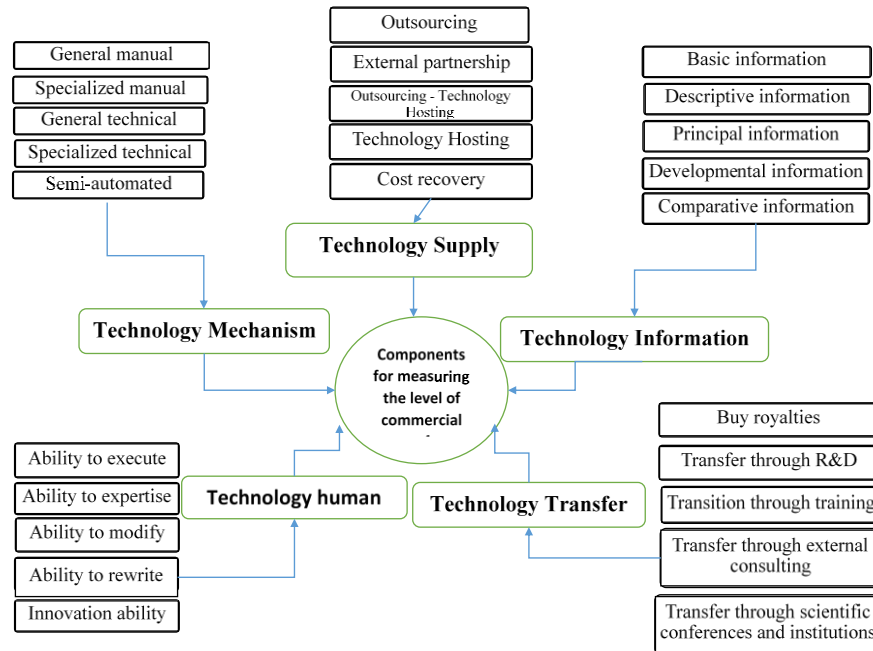
**Table 1.**

Organizing themes and their assignment to five global themes.

Organizing themes	Global themes
General manual	
Specialized manual	
General technical	<b>Technology Mechanism</b>
Specialized technical	
Semi-automated	
Basic information	
Descriptive information	
Principal information	<b>Technology Information</b>
Developmental information	
Comparative information	
Ability to execute	
Ability to expertise	
Ability to modify	<b>Technology human</b>
Ability to rewrite	
Innovation ability	
Outsourcing	<b>Technology Supply</b>

Organizing themes	Global themes
External partnership	
Outsourcing - Technology Hosting	
Technology Hosting	
Cost recovery	
Buy royalties	
Transfer through R&D	
Transfer through scientific conferences and institutions	<b>Technology Transfer</b>
Transition through training	
Transfer through external consulting	

Table 1 provides the organizing themes that guided the operationalization of measurement components. The results of the first stage show that the five components of technology mechanisms, technology human, technology information, technology Supply, and technology transfer are key components in measuring the commercial soft technology level.



**Fig. 1.** Thematic network showing relationships among basic, organizing, and global themes.

After identifying the influential components, at the tool design stage, the Scape approach was used to design the level measurement model. According to the principles of this method, the status of each technology depends on determining the degree of complexity of each technology component in a business unit and their position (distance) relative to the best or highest position of each technology component.

For this purpose, the complexity of each measurement component of the commercial soft technology level must first be calculated. Selecting the degree of complexity largely depends on our expectations of technology and its related factors. Complexity levels were categorized into three classes: high, middle, and low, and are scored from one to nine. The highest complexity score was 9 and the lowest complexity as rated 1. Based on previous studies as well as the opinions of elites and experts, the level and rating of complexity were determined (Table 2).

**Table 2.**

Complexity-class mapping and exemplar indicators for each measurement component.

Complexity limits / measurement components	Technology mechanism	Technology Information	Technology human	Technology Supply	Technology Transfer	Complexity scores
High	Specialized manual	Basic information	Innovation	Technology Hosting	Research and Development	7/8/9
	Technical expertise	Descriptive information				
Middle	General manual	Principal information	Improvement Rewrite	External partnership	Buying royalties	5/6/7
	General technical	Conceptual information	Modification	Outsourcing	External consulting	4/5/6
	Semi-automated	Developmental information	Expertize			3/4/5
Low	All automated	Comparative information	Implementation	Cost recovery	Education Transfer through scientific and workshop institutions	2/3/4

To operationalize complexity for each measurement component we defined explicit indicator sets and numeric bounds. Complexity was treated as an ordinal variable with three classes (Low / Middle / High) and mapped to numeric scoring ranges from 1 to 9. The lower limit (LL) and upper limit (UL) used in Equation (1) refer to the class-specific bounds for each component; these bounds were determined by a small expert panel based on empirical expectations and literature benchmarks. The standardization formula (Equation 1) therefore rescales the mean process score ( $S_i$ ) into a normalized  $N_i$  value within the component-specific LL–UL interval prior to aggregation. Instruments and decision rules for class assignment are as follows: for each component we specified 3–5 observable indicators (e.g., for Technology Information: data collection procedures, frequency of reporting, availability of digital logs), and used a rubric to assign a process to Low/Middle/High complexity.

The SCAPE model (originally developed for manufacturing technology assessment) was adapted here for commercial soft technologies: SCAPE's core idea — that technology status is a function of component complexity and relative position to top-notch benchmarks — was retained, while component definitions and indicators were re-specified for soft/organizational contexts. Key SCAPE parameters used in this study are: complexity class (Low/Middle/High), component upper/lower benchmark (UL/LL), process importance weight ( $w_i$ ), and component impact coefficient ( $\beta$ ).

For multi-criteria weighting and prioritization we used the Analytic Hierarchy Process (AHP). AHP was implemented through pairwise comparisons completed by an expert panel. The AHP outputs supplied include: pairwise comparison matrices, eigenvector-derived weights, and CR diagnostics.

After determining the degree of complexity, it is necessary to compare the position of each component with the best case of each component in the top-notch firms. The general criteria in Table 3 were used to identify the top-notch mode.

**Table 3.**

Criteria used to identify top-notch benchmarks for each component.

<b>Technology Mechanism</b>	<b>Technology Transfer</b>	<b>Technology Supply</b>	<b>Technologist Human</b>	<b>Technology Information</b>
Accuracy required Precision, control, easy operation, flexibility	Interchangeability, the tendency for education, research and development, access to academic institutions, access to training courses	Outsourcing cost, level of external partners, number of external partners in the cluster, being routine, cost,	The initiative, the tendency for success, Cooperation, seriousness, Risk-taking capacity, Punctuality	Accessibility, communication, Being up to date, Ability to update, sharing, Interface

After determining the degree of complexity and identifying the best case for each component, the position of each measurement component of the commercial soft technology level relative to the top-notch for each process should be numerically determined (complexity score). This was done by referring to experts. After scoring the indicators of measurement components of the commercial soft technology level for all soft business processes, a final score must be calculated for each component of the technology level. To this end, the component scores in each process must first be standardized and normalized to continue the measurement process. Equation (1) was used to standardize the scores of the indicators of the measurement components.

$$N_i = \frac{1}{9} \left[ LL + \frac{S_i (UL - LL)}{10} \right] \quad (1)$$

where Ni is the share of technology components for each process, LL is the lower limit of the complexity of commercial soft technology components, Si is the mean score of the indicators set for each component of commercial soft technology, and UL is the higher limit of component complexity. After calculating the score for each of the measurement components of the commercial soft technology level, considering that commercial soft technology processes do not equally affect the overall business process of commercial soft technology of a business unit, it is important to determine the importance of that process (wi) in the overall process. After determining the scores for each process and weighing their importance, the final score of each measurement component of the commercial soft technology level was calculated for the whole firm by using the equation(2). The total weight of all indicators is equal to one.

$$N = \sum N_i w_i \quad (2)$$

After calculating the scores of measurement components of the commercial soft technology level, it should be noted that not all commercial soft technology components affect equally the commercial soft technology levels and each has different impacts on different businesses and even

firms. Therefore, the impact of each measurement component of the commercial soft technology level on the final level of commercial soft technology should be calculated. Therefore, the coefficient or impact factor was used to indicate the intensity of the impact of each technology component (impact factor was denoted by  $\beta$ ). The impact factor or value can be obtained by various methods such as paired comparison methods or AHP. In this section, using the expert opinion, all measurement components of the commercial soft technology level were prioritized based on the intensity of the impact and the impact factor was determined for each of them. The sum of the impact factors is equal to one.

After calculating the final score for the measurement components of the commercial soft technology level and impact factor, a unit value representing the total role of those five components must be estimated to obtain an overall indicator for measuring the level of commercial soft technology. To do this, an exponential function called measurement coefficient function of commercial soft technology level was used. This coefficient shows the status of commercial soft technology in the business unit compared to the highest or best position of competitors' commercial soft technology or similar firms. The mathematical expression of this function is as follows:

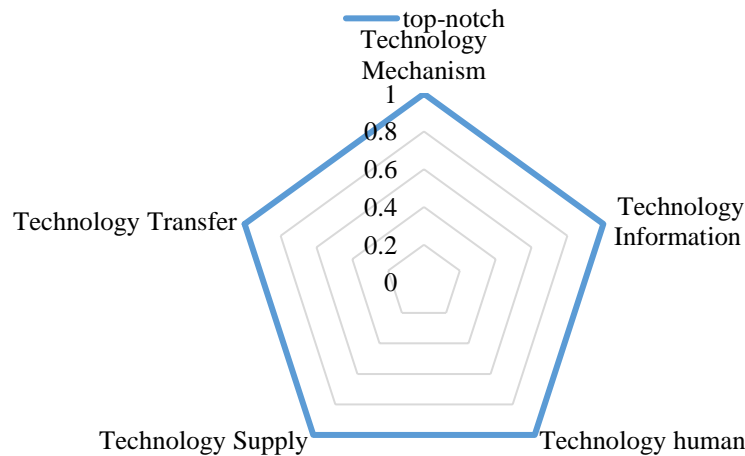
$$CSTMC = M^{\beta_m} \cdot H^{\beta_h} \cdot I^{\beta_i} \cdot A^{\beta_a} \cdot T^{\beta_t} \quad (3)$$

Where the CSTMC is commercial soft technology level measurement coefficient, and M, H, I, A and T are the scores of measurement components of the commercial soft technology related to technology mechanisms, technology human, technology information, technology Supply, and technology transfer, respectively.  $\beta_m$ ,  $\beta_h$ ,  $\beta_i$ ,  $\beta_a$  and  $\beta_t$  are the coefficients of the impact of each of the components of commercial soft technology level measurement. This exponential function indicates that firstly, it is not possible to measure the level of commercial soft technologies without those five components, secondly, implies that each of these components must be greater than zero otherwise the CSTMC value will be zero, and thirdly, CSTMC is never zero and is always positive and its maximum value will be 1.

By approaching this coefficient to 1, the appropriate consistency and combination of commercial soft technology measurement components increase, indicating that the business unit is in good standing in terms of commercial soft technology relative to competitors or similar top-notch firms. As the coefficient approaches zero, the distance with competitors or similar top-notch firms increases. It also shows the importance and impact of commercial soft technology in the overall business process. The higher this factor, the greater the role of commercial soft technologies in the overall business process.

In the final step, for simplicity of analysis, the scores of the level measurement components are shown on the graph the status of the measurement components of the commercial soft technology level. The graph has five axes, each showing a measurement component of commercial soft technology level. This graph shows the difference of each component with its optimal state (i.e. 1), the difference between the components, the gap between the status and the top-notch status of each measurement component of the commercial soft technology level, and the presence or absence of equilibrium between the components. It can also show the way to modify level measurement components in a business unit to reduce the distance to the top-notch status. The

radar chart of component and condition level scores versus the first-order criterion for the experimental unit is shown in Fig. 2.



**Fig. 2.** Radar plot of component-level scores (status vs. top-notch benchmark) for the pilot unit.

Therefore, based on the findings of the research, the steps of the commercial soft technology level measurement model are described below.

- Statistical population identification;
- Identifying all the processes of commercial soft technologies running in the business unit;
- Determining the complexity of commercial soft technology level measurement components and the highest position of commercial soft technology components in competitors or similar top-notch firms;
- Calculating the score of indicators of commercial soft technology level measurement component for each running process of commercial soft technologies;
- Determining the importance (weight) of each of the commercial soft processes in the overall process;
- Calculating the final score for each technology component in the business unit;
- Determining the effect of each measurement component of commercial soft technology level on commercial soft technology level(Intensity of impact)
- Integrating the role of each commercial soft technology level measurement component by calculating the commercial soft technology level coefficient (CSTMC);
- Drawing graph to determine the measurement components of the commercial soft technologies level.

The third step was to evaluate the feasibility of the commercial soft technology level measurement model at one of the companies of the Persian Gulf Science and Technology Park in Bushehr (Iran). 14 technological units operating in the Persian Gulf Science and Technology Park of Bushehr (Iran) were in compliance with the research conditions. One of these companies was selected by probability sampling to implement the model.

The company has been working in the field of commercialization and technology transfer since 2011 by a team of experts in the field of commercialization, marketing, and international trade,

and focusing on SMEs, offers the necessary consulting services to advance into domestic and foreign markets.

**Table 4.**

Commercial soft-technology processes observed in the pilot firm.

Commercial soft processes	Process type	Processes of commercial soft technologies running in the enterprise
Marketing process	The first main process	Efficient product marketing, customer relationship, customer & market, customer orientation, lean service, timely service, continuous improvement
Advertising process	The second main process	Targeted advertising, product introduction, advertising, and conferences, virtual exhibitions
Incubator process (simulation)	The third main process	Simulation of models, simulation laboratory, improvement of the simulation process
The Accounting Process	The first support	Collecting financial data, accounting for revenues and expenses of the company
Management process	The second support	Human resource management, soft information systems management, experience documentation
Financial Management Process	The third support	Cash management, payroll management, financial fluctuation management, working capital management

The company has 15 staff, 3 of whom are female and 12 are male, all holding a master's degree or higher (two Ph.D. students). All individuals were interviewed and entered their assessment scores in the table prepared for this purpose.

After identifying the statistical population, all the soft business processes that are performed at the sample firm should be identified. For this purpose, the classification and instances of commercial soft technologies were used in the two studies of Jin and Mosleh Shirazi. All soft business activities performed in this business unit are shown in Table 4.

After determining the complexity, the superior states of the commercial soft technology components were determined in the competitors or similar top-notch firms. At this stage, based on the above-mentioned general criteria, the highest positions of the measurement components of commercial soft technologies level were selected based on the competitors or similar top-notch firms that are considered by the respondents as the best business units in Iran. The complexity range and first top-notch limits of each technology level measurement component are shown in Table 5.

**Table 5.**

Component-specific complexity ranges and top-notch limits.

The measurement components of commercial soft technology level	Lower limit	Upper limit	Lower class score	Higher class score
Technology Mechanism	Semi-automated	Specialized manual	2	9
Technology Information	Developmental information	Basic information	2	8
Technology Human	Performance	Innovation	2	8
Technology Supply	Outsourcing	Hosting	5	9
Technology Transfer	Education	R&D	4	9

After determining the highest position of the level measurement components, the position of each measurement component must be calculated by determining their index values for each process.

To this end, during a structured interview, all personnel of the sample business unit was asked to enter their measurement score for each process in the chart designed for this purpose. Then the given scores were standardized using relation (1). Interviewers were asked to score the importance of each of the main and support processes in the overall process of the firm while rating the processes. The importance of each sample firm's processes was calculated using the AHP method. After scoring and determining the importance of each process for the whole firm, the final score of level measurement components for the whole firm was calculated using equation (2). The scores of the measurement components of commercial soft technology levels are shown in Table 6.

**Table 6.**  
Final scores of commercial soft technology level measurement components.

Processes / Components	Technology Mechanism	Technology Transfer	Technology Supply	Technology Human	Technology Information	Weight of processes
Marketing process	7	8	8	8	8	0.4
Advertising process	6	6	7	6	6	0.2
Incubator process (simulation)	3	4	5	3	3	0.05
Accounting process	6	5	7	5	5	0.1
Management process	4	5	5	4	4	0.15
Financial management Process	6	4	5	5	4	0.1
Final score of level measurement components	0.677	0.785	0.853	0.627	0.620	1

After scoring and calculating the scores of the level measurement components, the intensity of the impact of each component must be calculated. We used the AHP method to determine the intensity of each component of commercial soft technology. Criteria such as the optimal use of human resources, competitors, customer orientation, service distinctiveness, and quality were used to calculate the impact of each level measurement component of the commercial soft technology on the whole process of commercial soft activities. We used the AHP method to determine the intensity of the component impact. The results are shown in Table 7.

Table 7 shows that in the business processes of the company, human technology has the highest impact and the technology mechanism has the lowest impact. After calculating the scores of each of the components of commercial soft technology as well as determining the intensity of the impact of each component, the sample firm's commercial soft technology level was calculated using the equation (3).

**Table 7.**  
Effectiveness of commercial soft technology level measurement components.

Intensity of impact	$\beta_m$	$\beta_I$	$\beta_H$	$\beta_A$	$\beta_T$
	0.11	0.14	0.39	0.15	0.21

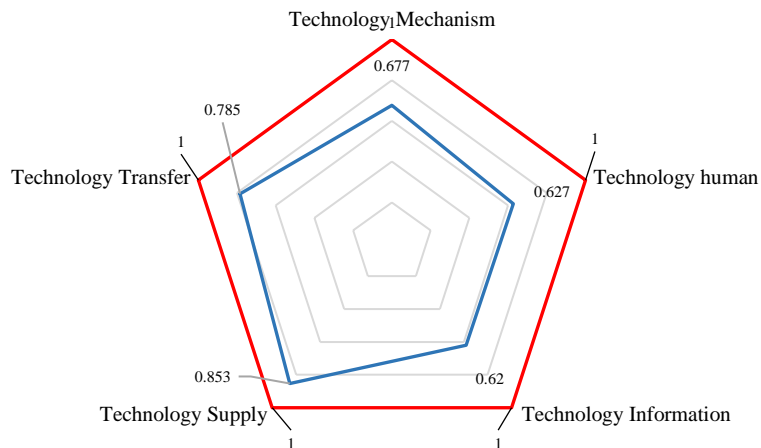
$$CSTMC = M^{\beta_m} \cdot H^{\beta_h} \cdot I^{\beta_i} \cdot A^{\beta_a} \cdot T^{\beta_t}$$

$$CSTMC = 0.677^{.11} \cdot 0.627^{.39} \cdot 0.620^{.14} \cdot 0.853^{.15} \cdot 0.785^{.21}$$

$$CSTMC = 0.957 \cdot 0.833 \cdot 0.935 \cdot 0.976 \cdot 0.950$$

$$CSTM C = 0.691$$

Commercial soft technology level coefficient (0.691) indicates that commercial soft technology processes affect about 69 percent of the overall firms' processes, indicating the importance of this type of technology to business units' performance. The measurement level coefficient for the sample business unit was middle to high. There was good consistency between the measurement components, and the commercial soft technology level of the sample firm was favorable and not too far from the top-notch states considered.



**Fig. 3.** Final Commercial Soft Technology Measurement Coefficient and interpretation.

Fig. 3 shows the technology supply is the least distant from the top-notch level, indicating the proper performance of the company in providing technology. Followed by technology supply, the smallest gap is related to technology transfer, which demonstrates the business unit's high capability in acquiring new techniques and soft skills. Technology information has the highest distance with the ideal state, indicating deficiencies in soft information systems collection, analysis, circulation, and information management. After technology information, the biggest gap is related to the technologist human. The reason for this can be attributed to the shortage of specialist and highly educated postgraduate staff, as the company employs only two PhD students. The technology mechanism also has a gap with the top-notch level. The low technology mechanism indicates that the way processes are conducted is not up-to-date and has executive deficiencies. Therefore, the business unit should use a more specialized workforce, modify, and improve the processes and methods of data collection and analysis in order to improve its status and reduce the technological gap with the top-notch units and its competitors.

The results of the third stage show the level measurement model, the ability to identify strengths and weaknesses, the degree of coherence and equilibrium of the components, and the degree of gap and backwardness of commercial soft technologies from the top-notch states and can pave the way for commercial soft technology development.

In this study, in all three stages of research, the internal-external validation method including external audit, matching, and checking by the participants were used to evaluate the validity. In this way, a number of technology experts who had no relationship with the way the research process was conducted evaluated the process and findings of the research and assessed its accuracy. For the purpose of research reliability, the findings and concepts were provided to a number of academic professors as well as some industry experts in the first and second stages of research (qualitative analysis and tool formulation). In the quantitative step, the reliability of the test was repeated. After performing two test stages, the Pearson correlation coefficient (reliability coefficient) was calculated between the scores of the two stages. The correlation coefficient of the quantitative research stage was 0.69, which indicates a high reliability of the model.

## 5. Discussion

The findings of this study reveal key insights into the measurement of commercial soft technology levels in SMEs, highlighting five core components—technology mechanisms, human technology, information technology, technology supply, and technology transfer—that collectively determine the maturity and effectiveness of these emerging technologies. The thematic analysis identified 185 key codes, distilled into 78 basic themes, 25 organizing themes, and 5 global themes, underscoring the multifaceted nature of commercial soft technologies. The application of the SCAPE model, adapted for soft technologies, yielded a commercial soft technology measurement coefficient (CSTMC) of 0.691 in the sample firm, indicating a moderate-to-high level of integration, with strengths in technology supply and transfer but notable gaps in information and human components.

These results align with prior literature emphasizing the emerging status of soft technologies. As [Jin \(2002\)](#) first delineated, commercial soft technologies represent a novel shift from hard, tangible systems to intangible, human-centered processes, with their measurement lagging behind due to their recent conceptualization ([Zhouying, 2004](#)). Unlike established hard technology models (e.g., Sharif, 1988), which focus on manufacturing efficiency, this study's model addresses the subjective, interpretive aspects of soft technologies, such as cultural and social factors, filling a critical gap in the field. For instance, the identification of human technology as the most impactful component echoes, who highlighted human resources as pivotal in soft technology selection, and [Elmeziane et al. \(2011\)](#), who noted the transition to intangible resources in 21st-century competition. However, the observed deficiencies in information technology diverge from more optimistic views in developed contexts ([Henry et al., 2009](#)), suggesting contextual challenges in developing economies like Iran, where SMEs in science parks may lack robust data management systems.

The emerging nature of these technologies is further evidenced by the model's ability to quantify gaps, such as the distance to "top-notch" states, which prior studies ([Kanayama et al., 2010](#); [Lee et al., 2011](#)) have discussed qualitatively as bridges between developed and developing nations. This novelty positions commercial soft technologies as innovative tools for economic innovation, yet their underdevelopment in measurement frameworks, as noted in the trend analysis, underscores the study's contribution to an evolving domain.

Importantly, the findings have significant implications for governance. By providing a quantifiable metric (CSTMC), the model empowers policy-makers in science and technology parks, such as the Persian Gulf Science and Technology Park, to enhance regulatory governance through targeted interventions—like training programs for human technology or incentives for information system upgrades. This aligns with research that demonstrated that soft policies outperform hard ones in fostering SME growth and reducing market exit risks. In an Iranian context, where governance structures emphasize endogenous development, the model supports national strategies for technological equity, enabling better resource allocation and institutional support to close gaps with global competitors. At the corporate level, it facilitates internal governance by identifying strengths (e.g., technology transfer) and weaknesses, promoting strategic decision-making for sustainable performance ([Zeng et al., 2015](#)).

Despite these strengths, limitations exist, including the study's focus on a single park in Bushehr, limiting generalizability, and reliance on the SCAPE model, which may not fully capture cultural nuances in soft technologies. Future research could extend the model to industry-wide applications or integrate advanced analytics for real-time governance monitoring.

## **6. Conclusions**

The purpose of this study was to present a measurement model for commercial soft technology in small and medium-sized businesses. The subject of commercial soft technology, as an emerging field, has not been thoroughly investigated so far due to its recent emergence from hard technology paradigms ([Jin, 2002](#)), leading to this study being innovative in providing a dedicated measurement framework. The study also sought to measure the level of commercial soft technology in small businesses in science and technology parks, which is also important in environmental terms. This was a mixed research based on a mixed sequential model of tool development, which has been implemented in three stages: qualitative, formulating tools, and quantitative. In the qualitative phase, by the thematic analysis method, 185 key codes related to commercial soft technology level were identified which were classified into 78 basic themes, 25 organizing themes, and 5 Global themes. The results of this step showed that the five components of technology mechanisms, technology information, technology human, technology supply, and technology transfer are key components of commercial soft technology level measurement. In the second stage, using the SCAPE Model, the level measurement pattern was designed in 9 stages. This pattern illustrates how the level is measured, the degree of coherence and coordination of the level measurement components, and their distance to the top-notch states. In the third stage, the model designed to evaluate the feasibility was implemented in the Persian Gulf Science and Technology Park of Bushehr (Iran). The results show that the current technology status of the sample firm was not far from the first level in the country and can minimize this gap by strengthening the human resources. The research findings show that this model can identify the strengths and weaknesses of the firm, identify the distances between each firm's commercial soft technologies and identify the path to correcting and removing them. This research has positive implications for managers in understanding the status of soft business technologies and their impact on the overall process of the firm, and helps managers pay close attention to technological gaps, more precisely identifying the cause of business backwardness, and ways to address them, removing gaps and developing

long-term and short-term technology development plans. Moreover, it strengthens governance linkages by offering tools for policy-makers in technology parks and government bodies to enhance regulatory governance, such as through targeted incentives for soft technology adoption in SMEs, aligning with national strategies for innovation and economic equity (Dutta et al., 2017). External strategy and checking methods were used by the participants (qualitative phase) and test repetition (quantitative phase) for validity and reliability of the model and study. This study was the first of its kind and no other similar study is available, so it is not possible to compare it with the results of other similar studies. Based on the results of the research, it is suggested that the training of managers emphasize the importance of this type of technology for managers to consider commercial soft technologies as well as planning for hard technologies. This study was one of the first studies to consider commercial soft technology separately and as a whole. Therefore, for future research, it may be suggested that the models of dissemination, evaluation or excellence of commercial soft technology be considered by researchers to address the technology gaps identified in business organizations. Future studies could further explore governance dimensions, such as how measurement models inform public policy and corporate governance in emerging economies. This study was for SMEs, and providing a large-scale model at the industry level could be a subject for future research. This study considered an independent nature for commercial soft technology, so it can be explored with other issues such as development, planning, transfer and evaluation of commercial soft technology. In conclusion, this section also addresses the limitations of the research. One of the major limitations of the research was the scarcity of accessible and usable scientific resources due to its pristine and novel nature. Also, due to the use of the SCAPE model and the fact that most of the participants in this study were selected from the Persian Gulf Science and Technology Park in Bushehr (Iran), there are some restrictions on the statistical generalizability of the results. At the end of this section, the limitations of the research are also mentioned. One of the major limitations of the research was the scarcity of accessible and usable scientific resources due to its pristine and novel nature. In addition, due to the use of the SCAPE model and the fact that most of the participants in this study were selected from the Persian Gulf Science and Technology Park in Bushehr (Iran), there are some restrictions on the statistical generalizability of the results.

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## **Conflicts of interest**

The authors declare no conflict of interest.

## Authors contribution statement

Hassan Khalili conceptualized the study, designed the research methodology, conducted the qualitative data collection and analysis, developed the measurement model, and drafted the original manuscript. Mohammad Saadatmand contributed to the theoretical framing and literature review, supported the quantitative analysis and model validation, reviewed and refined the methodological design, and critically revised the manuscript for intellectual content. Both authors discussed the results, contributed to the interpretation of findings, approved the final version of the manuscript, and take full responsibility for its accuracy and integrity.

## Data Availability Statement

Due to ethical and confidentiality considerations, the data are not publicly available but may be obtained from the corresponding author upon reasonable request.

## References

- Bai, J., & Qu, G. (2025). How does digital intelligence drive the SRDI development of SMEs? Evidence from Chinese-style niche enterprises. *Technological Forecasting and Social Change*, 219, 124260. <https://doi.org/10.1016/j.techfore.2025.124260>
- Bailey, M. N. (2023). *Lessons from productivity research: Applying these to a strategy for Japan*.
- Bayat, M., Hassanzadeh, A., Shayan, A., Ostadi, B., & Hassani, H. (2025). Agile digital transformation in SMEs: A hybrid prioritization approach. *Frontiers in Sustainability*, 6, 1618920. <https://doi.org/10.3389/frsus.2025.1618920>
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology*, 3(2), 77–101.
- Brey, P. (2017). Theorizing technology and its role in crime and law enforcement. In *The Routledge Handbook of Technology, Crime and Justice* (pp. 43–60). Routledge.
- Cen, T., & Lin, S. (2025). Digital transformation and corporate innovation in SMEs. *Systems*, 13(7), 551. <https://doi.org/10.3390/systems13070551>
- Creswell, J. W., & Creswell, J. D. (2003). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage Publications.
- Dutta, A., Puvvala, A., Roy, R., & Seetharaman, P. (2017). Technology diffusion: Shift happens—The case of iOS and Android handsets. *Technological Forecasting and Social Change*, 118, 28–43. <https://doi.org/10.1016/j.techfore.2017.01.024>
- Elmeziane, K., Chuanmin, S., & Elmeziane, M. (2011). The importance of critical success factors of enterprise resource planning implementation in China. *Business Management Dynamics*, 1(6), 1–10.
- Fionah, M. J. (2024). Harnessing artificial intelligence in customer relationship management: Transforming customer interactions and business performance. *Research Invention Journal of Current Issues in Arts and Management*, 3(2), 42–48.
- Hafeez, S., Shahzad, K., Helo, P., & Mubarak, M. F. (2025). Knowledge management and SMEs' digital transformation: A systematic literature review and future research agenda. *Journal of Innovation & Knowledge*, 10(3), 100728. <https://doi.org/10.1016/j.jik.2025.100728>

- Henry, M., Kneller, R., & Milner, C. (2009). Trade, technology transfer and national efficiency in developing countries. *European Economic Review*, 53(2), 237–254. <https://doi.org/10.1016/j.euroecorev.2008.05.001>
- Ille, F. R. (2009). Building Chinese global brands through soft technology transfer. *Journal of Chinese Economic and Foreign Trade Studies*, 2(1), 47–61. <https://doi.org/10.1108/17544400910934342>
- Islam, M. S., & Ahmed, S. (2024). Work standardization in lean manufacturing for improvement of production line performance in SME. *Malaysian Journal on Composites Science and Manufacturing*, 13(1), 68–81. <https://doi.org/10.37934/mjcs.13.1.6881>
- Jin, Z. (2002). Soft technology: The essential of innovation. *Futures Research Quarterly*, 18(2), 1–24.
- Jin, Z. (2011). *Global technological change: From hard technology to soft technology*. Intellect Books.
- Jin, Z., & Bai, Y. (2011). Sustainable development and long-term strategic management. *World Future Review*, 3(2), 49–69. <https://doi.org/10.1177/194675671100300208>
- Kanayama, K., Baba, H., Koga, S., & Sugawara, T. (2010). Developing research on a fully passive solar lumber drying apparatus. *Current Applied Physics*, 10(2), S249–S253. <https://doi.org/10.1016/j.cap.2009.11.030>
- King, N., Horrocks, C., & Brooks, J. (2018). *Interviews in qualitative research*. Sage Publications.
- Lee, M. T., Mohayiddin, M. G., & Kanesan, M. (2011). Soft technology transfer for Japanese MNCs in Malaysia: A conceptual model.
- Maseda, A., Iturralde, T., & Arzubiaga, U. (2025). Unpacking the role of entrepreneurial orientation in the digital transformation of family SMEs: The importance of leadership structure and generational involvement. *Technological Forecasting and Social Change*, 219, 124248. <https://doi.org/10.1016/j.techfore.2025.124248>
- Oecd. (2025). *SME Digitalisation for Competitiveness 2025: D4SME Survey*.
- Pitt, J. C. (2014). *On Technology: Foundations of the Philosophy of Technology*.
- Pitt, J. C. (2017). The Role of Technologies in Undermining the Perennial Philosophy. In. [https://doi.org/10.1007/978-3-319-45193-0\\_6](https://doi.org/10.1007/978-3-319-45193-0_6)
- Siu, K. W. M., & Wong, Y. L. (2015). Soft and hard technologies in technology education. In. <https://doi.org/10.4018/978-1-4666-8246-7.ch022>
- Unctad. (2025). *Technology and Innovation Report 2025: Inclusive Artificial Intelligence for Development*.
- Vaya-Arboledas, Á., Ferrer-Oliva, M., & Medina-Merodio, J. A. (2025). Evolution and perspectives in IT governance: A systematic literature review. *Computers*, 14(12), 520. <https://doi.org/10.3390/computers14120520>
- Yee, L., Chui, M., Roberts, R., & Smit, S. (2025). *McKinsey Technology Trends Outlook 2025*.
- Zeng, J., Phan, C. A., & Matsui, Y. (2015). The impact of hard and soft quality management on quality and innovation performance. *International Journal of Production Economics*, 162, 216–226. <https://doi.org/10.1016/j.ijpe.2014.07.006>
- Zhouying, J. (2004). Technological progress in history: A survey of evolution and shift of research emphasis from hard-tech to soft-tech development. *International Journal of Technology Management & Sustainable Development*, 3(2), 133–148. <https://doi.org/10.1386/ijtm.3.2.133/0>