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Strategic Technology Selection for Oil Production: An Application of Attractiveness–Capability Matrix of Technology

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Highlights

- The processes and challenges in the production field were examined;
- For the key challenges, existing and new technologies were identified and assessed, and the technology portfolio was designed using the attractiveness–capability matrix;
- All the technologies in the first area of the matrix, which have high attractiveness and capability, and the technologies of the third area of the matrix, which gain an attractiveness score of above 3.5, have been introduced as the strategic options for selection and investment.

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Abstract

The rapid development of technologies and their increasing complexity and variety together with limited organizational resources and efforts for survival in industrial competitions have made the task of appropriate technology selection a major challenge. The present research is aimed at the formulation of a technology strategy related to oil production in one of the west Karoon oil fields in Iran. At first, the processes and challenges of production in the studied oil field are recognized by an experts' survey. Then, the priority of the challenges is evaluated, and four key challenges of the considered field are recognized by using a paired comparison questionnaire and Chang fuzzy analytic hierarchy process (AHP). In the next step, the existing and new technologies of oil production in the four recognized key challenges are determined. For each of the recognized technologies, the attractiveness assessment and capability assessment questionnaires are designed based on Jolly indices and distributed in a sample composed of production engineering experts. Sampling is done by the nonrandom and purposive–judgmental method. Based on the results of the questionnaires, the attractiveness–capability matrix is designed by Morin's model, and then based on the obtained technology portfolio, the strategies for each of the four areas are formulated and discussed.

Keywords: Attractiveness–Capability Portfolio, Oil Field, Production Engineering, Technology Strategy

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1. Introduction

Technology plays a pivotal role in developing countries. In today's competitive environments, the high speed of environmental changes and the increasing complexity and compactness of competitive environments among businesses have doubled the importance of technology as the most important tool for organizations and countries. For a number of decades, technological changes and the innovation driven by research and development have been the most important sources of productivity growth and prosperity enhancement. However, the competitive conditions of global markets and the short life cycle of technologies necessitate the management of technological competencies, the amount of investment, the technology supply, and competition based on a strategic perspective. Accordingly, developing a long-term strategic plan called technology strategy (TS) and determining the investment priorities and preferences of a firm in the technology development are the first steps in the technology management (Ebrahimi et al. 2013).

The technology strategy is used as a strategic decision to invest in technologies embodied in a firm. It means that all technological changes can affect firm performance, but not all of them have an identical influence on competitive advantages. Thus, among all technologies which are incorporated in business processes, some of the critical technologies should be selected to invest in (Vernet et al. 1997). On the other hand, maintaining a sustainable competitive advantage in a high-tech industry requires updating the existing technologies and developing new technologies constantly. In addition, the right choice and development of technology helps companies and countries to create competitive advantages in today's turbulent world (Akhundzadeh et al. 2015). The technology selection is defined as the process of prioritizing technological investment options. Therefore, the business and technological risks associated with the processes of achieving organizational goals should be considered in selecting technology (Stacey et al. 1990) since technology allocates more than one-third of the company's capital expenditures, and the selection of an inappropriate technology has irreparable financial and strategic consequences for the company (Aliakbari Nouri et al. 2015). Therefore, the use of specific tools and methods with the desired operational efficiency is inevitable due to the abundance of technological options, organizational complexity of the technology-receiving company, and dynamics of the business environment (Shehabudeen et al. 2006).

The petroleum industry is considered to be one of the most important technology-oriented industries, and all the stages of exploration, development, production, and operation of the tanks are closely linked to the used technologies. According to the value chain of oil and gas industry, new dynamic technologies in the areas of detailed petrophysical assessment of exploration wells, planning for development wells, updated and detailed data acquired from reservoirs, preserved production, and security of the data acquisition of oil and gas fields are extremely important and failure to use an appropriate technology to obtain this information can waste huge costs and deprive the country of access to new resources (Daghaieghi et al. 2018). Also, by increasing the life of reservoirs and discussing the enhanced oil recovery (EOR) issues, the technological link has become critical, especially in the production field, and selecting the most appropriate technological options has become an urgent and challenging topic.

The studied oil field is one of the largest oilfields in Iran with over 30 billion barrels of oil storage, and it has almost heavy oil with an API of around 24. Considering the importance of the field as one of the developmental priorities of the oil industry, the Ministry of Oil is trying to maximize the secondary recovery mainly by engineered water injection and lifting using advanced technologies and implementing extraction-rising techniques. Accordingly, the extraction coefficient of the field is expected to increase by about 20% over 20 years, and the daily production of the field can reach more than half a million barrels per day. Therefore, it is important to pay attention to the many economic impacts of increasing oil extraction and consequently the risks associated with this process. Although it costs a few billion dollars to operate on the ground level, and the costs and risks of the project increase significantly, a 1% increase in the extraction coefficient leads to billions of dollars in revenue; this indicates the sensitivity and importance of the work, especially in the western Karun fields with high reservoir complexity and a high activity risk since successful project implementation requires the use of advanced and efficient technologies. Thus, the present study aims to identify the technology strategy in the oil field exploitation area. Consequently, their processes and challenges are identified and prioritized using the Chang fuzzy analytic hierarchy process (AHP) method, and four key operational challenges are determined. The existing and new technologies are then identified and evaluated in each of the key challenges. Finally, the attractiveness–capability matrix of the technology is plotted using the obtained results, and the strategies for each of the four areas are formulated and described based on the resulting technology portfolio.

2. Literature review

Technology is a vital part in the life of business organizations, industry, individuals, and communities. Regardless of whether we are talking about a materialist society or an information society, technology is at the heart of wealth production. The technology is used to collect, store, and transfer information for improving or worsening. The technology management propels the balance toward improvement (Braun 2001) and relates the disciplines focusing on the technology creation to the ones converting it to the wealth. This specialized area examines how technology is created, how technology strategy is integrated with the business strategy, and how technology is used to gain competitive advantage (Khalil 2000). The real importance of technology strategy was acknowledged in the early 1980s, and many technology-related tasks were discussed as a strategic variable (Chiesa 2001). Accordingly, organizations typically develop operational strategies to formulate a firm strategy at the parent company and business level. The operational strategies, namely the translation and interpretation of the overall strategy of the organization, are in a particular part of the intended organization. In other words, the operational strategy in each part of the organization is considered as the method of realizing the overall strategy of the organization in that unit (Khalil 2000). According to Danila, the technology strategy is one of the most important operational strategies of the organization. He considers the technology strategy as a task strategy, which is superior to other task strategies such as financial strategy, marketing strategy, research and development strategy, production strategy, etc. (Danila 1989). The technology strategy is defined as a mechanism used by the firm to acquire and utilize technology to create new competitive advantage and defend its technology-based competitive advantage (Braun 2001). Given that executing a strategic plan without taking the right steps to access the right technologies is almost impossible, the output of the technology strategy is to determine the investment priorities in the area of technology selection. Chiesa (2001) examined the technology strategy as positioning and resource-based approaches. Some researchers proposed different models for formulating technology strategies based on these approaches. Some proposed their models based on the positioning approach (Porter 1998; 1985; Little 1981; Booz-Allen and Hamilton 1981; Morin 1985; Foster 1986; Hax and Majluf 1996). Further, some modeled their technology strategy formulation based on the resource-based approach (Itami and Numagami 1992; Prahalad and Hamel 1990; D'Aveni 1994; Chiesa 2001; Burgelman 2009). The various models of technology strategy formulation and the importance of employing the most appropriate method and consequently selecting the most appropriate technological options have motivated many researchers to focus on this area. Pakniyat et al. (2005) examined various models of technology strategy formulation and their placement in a spectrum with positioning and resource-based approaches in its both sides. Arasti et al. (2010) evaluated different models and frameworks of technology strategy formulation based on a process approach. Arasti et al. (2013)

presented an integrated model using research design method for formulating a technology strategy based on the positioning approach. Arasti et al. (2016) considered the necessity of linking technology strategy and macro strategy of the companies based on the deductive approach by using the content analysis approach and provided an initial framework in this regard. Based on the results of the models available in the literature of technology strategy, Ebrahimi et al. (2013) presented a new model of technology strategy formulation in the Iran's petrochemical industry. In another study, Jafar Nezhad et al. (2013) proposed a seven-step model for technology strategy formulation based on the model of Hax and Little and the positioning approach in the auto part manufacturing industry. Given the several studies conducted on the technology selection, Shehabudeen et al. (2006) provided a framework for the technology selection with an emphasis on operational experience and examined the considerations of the technology selection in the real-world. Alvarado et al. (2016) presented a technology selection and operation (TSO) model. This comprehensive and economical model enables decision makers to optimally select a technology among the available options and simultaneously optimize the selection and utilization of the technology.

3. Methodology

In the present applied and descriptive study, the statistical population included oil industry experts such as managers, engineers, and technicians in the field of operation. The statistical samples were the experts in the oil fields in west Karun, who were selected based on nonrandom and purposive (judgmental) sampling. Judgmental sampling, also known as purposive sampling or authoritative sampling, is a nonprobability sampling technique in which the sample members are chosen only based on the researcher's knowledge and judgment. As the researcher's knowledge is instrumental in creating a sample in this sampling technique, there are chances that the results obtained will be highly accurate with a minimum margin of error. The process of selecting a sample using judgmental sampling involves the researchers in carefully picking and choosing each individual to be a part of the sample. Judgmental sampling is most effective in situations where there are only a restricted number of people in a population who own qualities that a researcher expects from the target population (Danaeefard et al. 2014). As a result, the sample size in this method is limited and small. Judgmental or expert sampling is usually used in situations where the target population is comprised of highly intellectual individuals who cannot be chosen by using any other probability or nonprobability sampling technique.

After determining the processes and identifying the challenges in each process, the developmental analysis method of Chang, as a type of fuzzy AHP, was used to analyze the obtained data so as to prioritize the key challenges. For this purpose, a paired comparison questionnaire was designed, and the following steps were taken to calculate the results:

Considering the fuzzy pair comparison matrix $P = \left[\tilde{a}_{ij}\right]_{n\times n}$, a fuzzy size index, ($S_k$) is calculated for each row of this matrix as follows (Razavi et al. 2014):

$$\tilde{S}_k = \sum_{j=1}^{n} \tilde{a}_{kj} \left(\sum_{i=1}^{n} \sum_{j=1}^{n} \tilde{a}_{ij} \right)^{-1} \tag{1}$$

In the next step, each of the values obtained for the fuzzy size index is compared in pairs. If $\tilde{S}_1 = (l_1, m_1, u_1)$ and $\tilde{S}_2 = (l_2, m_2, u_2)$ are two fuzzy sizes, the probability of $\tilde{S}_1 \geq \tilde{S}_2$ is defined based on the following equation (Razavi et al. 2014):

$$\begin{cases} V(\tilde{S}_1 \geq \tilde{S}_2) = 1 & if \quad m_1 \geq m_2 \\ V(\tilde{S}_1 \geq \tilde{S}_2) = hgt(\tilde{S}_1 \cap \tilde{S}_2) = d & if \quad m_1 < m_2 \end{cases} \tag{2}$$

where d indicates the height of the highest common point of μm_1 and μm_2 and is calculated for the triangular fuzzy numbers based on the following equation (Razavi et al. 2014):

$$d = \frac{(l_2 - u_1)}{[(l_2 - m_2) - (u_1 - m_1)]} \tag{3}$$

Accordingly, $n - 1$ degrees of possibility are obtained for every option or element of A_i compared in the paired matrix. Now, for each option, we define (Razavi et al. 2014):

$$V(\tilde{S}_i \geq \tilde{S}_k)\,.\,k = 1.2.\cdots.n \quad k \neq 1 \tag{4}$$

$$d'(A_i) = \min\{V(\tilde{S}_i \geq \tilde{S}_k)\} \\ k = 1.2.\cdots.n \quad k \neq i \tag{5}$$

Finally, the weight vector is calculated as $W = (w_1.w_2.\cdots.w_n)$, i.e. $w_i = d'(A_i)$. By scaling these weights (dividing each weight by the sum of the weights), the final weight vector is obtained as the sum of the weights is equal to one (Razavi et al. 2014). After determining the key challenges, a process-based approach is used to identify the technologies for each challenge. The technology management literature presented various models of identifying technology such as Porter's value chain model (Porter 1985), quality function deployment (QFD) model (Revelle et al. 1998), map of technology (Porter et al. 1991), and process-based approach (Vernet et al. 1997). Based on the process-based approach, each organization is identified based on its value chain of processes; since each process consists of multiple activities, it identifies the activities in each process, and, given that each activity relies on one or more technologies, the relevant technology is identified in this way (Arasti et al. 2002). Accordingly, after identifying the existing and new technologies in the operation area, the questionnaires related to the attractiveness assessment and technology capacity assessment were designed using 16 indices of Jolly (Jolly 2003) to evaluate the identified technologies. For the reliability of the questionnaires, the Cronbach's alpha coefficient was determined using SPSS software; it was 0.875 and 0.949 for the attractiveness assessment questionnaire and the technology capability questionnaire respectively. Furthermore, the validity of the research questionnaires was confirmed using the content method and considering that the questionnaires were designed based on the subject literature and approved by academic experts. Finally, the technology portfolio was plotted using the scores obtained from the questionnaires, and the related strategies were presented. Figure 1 displays the research design.

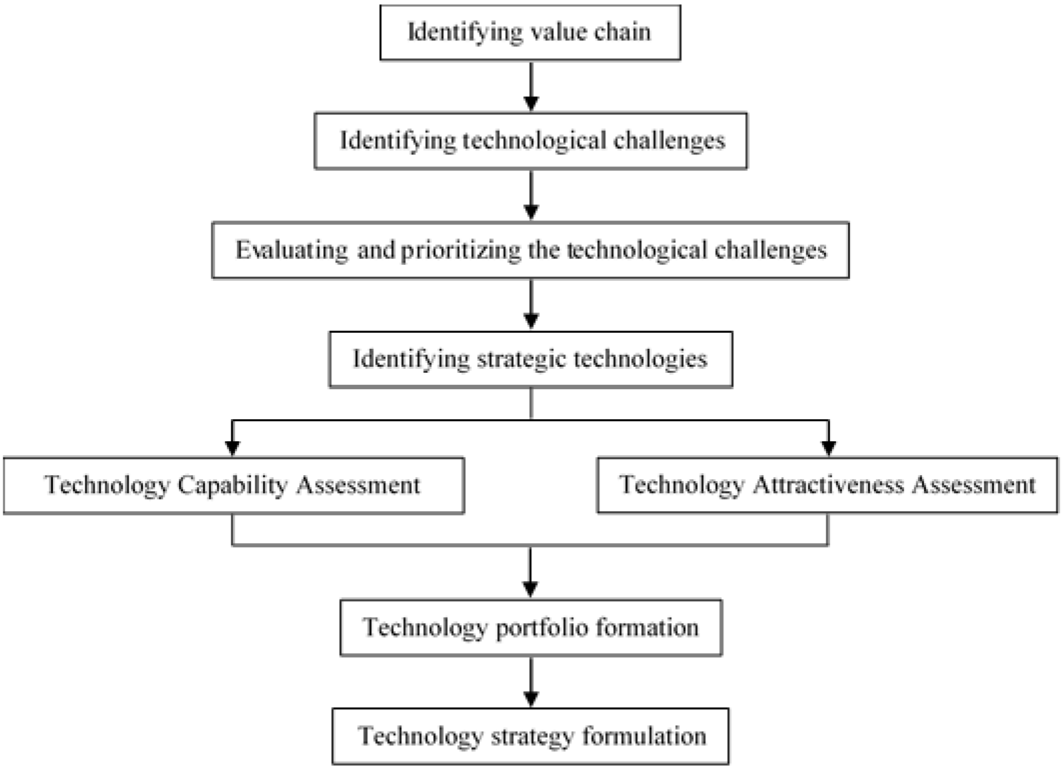

Figure 1

A schematic of the research design.

4. Results and discussion

The results of implementing the steps outlined in the research project in the operation of the studied oil field are presented in the following. The considered field is a giant carbonate undersaturated oil reservoir. Tight rock nature, low solution gas, relatively high viscous oil, and limited aquifer support all make the reservoir show a rapid pressure decline and a recovery factor by natural depletion of around just 5%. The combination of improved oil recovery (IOR) (stimulation, fracturing, lifting) and EOR (near miscible gas injection, chemical EOR, and smart water injection) methods are proposed to boost the production rate and recovery factor of this reservoir.

4.1. Identifying value chain

The processes of the operation area were identified through the interview with specialists and senior managers in the area. Table 1 presents the processes identified.

Table 1

The processes of the production field.

Code	Processes	Category
P_1	Well completion design with relevant software such as Prosper	Well
P_2	Running the completion string and installation of X-mass tree	Well
P_3	Design and installation of optimal production pipelines to surface facility unit	Surface facility
P_4	Designing wellhead control panel and examining low/high pilot values of pipelines based on well production capacity and emergency shutdown	Surface facility

Code	Processes	Category
P_5	Design and installation of a chemical injection valve to prevent wax and asphaltene deposition or pipeline corrosion	Well
P_6	Burning pit installation	Surface facility
P_7	Matric acidization of carbonate reservoirs or acid wash of sandstone reservoirs	Well
P_8	Well testing to estimate reservoir properties	Reservoir
P_9	Processing the produced fluids to separate oil, gas, and water	Surface facility
P_{10}	Reinjection of produced gas for oil production improvement	Reservoir
P_{11}	Design and installation of compressor for section 10	Surface facility
P_{12}	Injecting produced water into disposal wells	Reservoir
P_{13}	Monitoring wellhead pressure and online production (SCADA) and conducting periodic rigless tests such as BHP and T, PI test, etc.	Surface facility
P_{14}	Collecting processed oil from all wells and sending it to oil terminal for export or refining	Surface facility

4.2. Identifying technological challenges

Through interviews with a group of experts, the main challenges related to the production field in the studied oil field were identified. Table 2 lists the major challenges in the processes.

Table 2

The identified technological challenges.

Code	Challenge	Code	Challenge
C_1	Artificial lift	C_4	Water production
C_2	Hydraulic fracturing	C_5	Flaring of associated gases and pollutions
C_3	Organic and inorganic precipitation and their control	C_6	Perforation

4.3. Assessing and prioritizing technological challenges

In order to evaluate and prioritize the challenges in relation to each other, a paired comparison questionnaire was developed and distributed among a six-person statistical population of the experts in the field of exploitation. Based on the model, the statistical population of this questionnaire is three to six people, and six people were selected in the present study to obtain the maximum reliability of the results. Then, the challenges were weighted using Chang’s developmental analysis method, and the weights of the importance of each challenge were determined as described in Table 3.

Table 3

The weights of the importance of technological challenges.

Code	Challenge	Weight	Code	Challenge	Weight
C_1	Artificial lift	0.114	C_4	Water production	0.180
C_2	Hydraulic fracturing	0.242	C_5	Flaring of associated gases and pollutions	0.075
C_3	Organic and inorganic precipitation and their control	0.088	C_6	Perforation	0.302

Finally, the challenges the importance weights of which scored above 0.1 were identified as the key challenges in the order of importance:

C_6: Perforation C_2: Hydraulic fracturing C_4: Water production C_1: Artificial lift

4.4. Identifying strategic technologies

Technology identification involves developing a list of technologies which are or can be used and incorporated into the company's products or processes. According to Hax and Majluf (1996), technology identification contains a preliminary filtering. This indicates that the technologies embodied in the company's products or processes are not completely identified, so some existing and new technologies are identified, evaluated, and selected according to the firm's particular requirements (objectives). There are a number of approaches to technology identification discussed in the related literature (Arasti et al. 2002). In this research, a process-based analysis approach was used to identify the existing and new technologies, called strategic technology units (Hax et al. 1996) or major technologies (Little 1981). According to the process-based approach, each organization is identified based on its value chain of processes; since each process consists of multiple activities, it identifies the activities in each process, and given that each activity relies on one or more technologies, the relevant technology is identified in this way (Arasti et al. 2002). Accordingly, after identifying the key processes and challenges, based on the opinions of industry experts, by exploring the sites and articles of different companies, and by studying documents of recent innovations and patents in related areas, a list of existing and new technologies was extracted to meet each of the challenges. A code was then assigned to each of the identified technologies: the existing technologies were introduced with an ET code, and the new technologies with an NT code. Table 4 presents the results. It should be noted that at this stage, the technologies are identified regardless of cost, risk, or other factors, and the purpose is only to provide a list of options.

Table 4

Existing and new technologies identified in the production filed.

New technologies		Existing technologies	
Code	**Technology name**	**Code**	**Technology name**
NT_1	Dual electrical submersible pump (ESP)	**ET_1**	Electrical submersible pump
NT_2	Hydraulic submersible pump (HSP)	**ET_2**	Gas lift pump
NT_3	Vortex meters	**ET_3**	Coriolis meter measuring
NT_4	Two-phase digital Coriolis meters	**ET_4**	CT tractor
NT_5	Hydraulic tractor	**ET_5**	Mechanical solution (cement, squeeze, packer, plug)
NT_6	Jet acidizing	**ET_6**	Chemical solution
NT_7	Biopolymers, synthetic polymers	**ET_7**	Shaped charge (Jet)
NT_8	PosiSET mechanical plugback tool	**ET_8**	Perforating gun
NT_9	PatchFlex sleeve		
NT_{10}	Annular chemical packer		
NT_{11}	Electronic firing system		

4.5. Technology attractiveness assessment and technology capability assessment

The identified technologies were assessed after identifying the key technologies. The technology assessment is a framework and tool for better understanding and identifying the state of technology and predicting the results of applying a particular technology (Tran et al. 2008). Based on the research model, the process of the technology assessment simultaneously was conducted in two dimensions of attractiveness and capability assessment. The process of technology attractiveness assessment is the relative determination of the attractiveness of the technologies of the product, process, and system, which is used by the firm or is intended to be used in the near future (Tran et al. 2008). On the other hand, the technological strengths and weaknesses of a firm compared to its competitors, the technological leader of the market, or the progress border of an emerging technology in the research and development centers are assessed in the technology capability assessment level (Arasti et al. 2013). Consequently, the questionnaires of technology capability assessment and technology attractiveness assessment were designed based on Jolly's indices to analyze the attractiveness assessment and capability assessment of each identified technology. Based on the purposive (judgmental) sampling method, the questionnaires were then distributed in a 10-person statistical population of experts in the operation area. Table 5 tabulates the results.

Table 5

Score of technology attractiveness assessment and technology capability assessment.

Technology capability assessment			Technology attractiveness assessment		
Code	**Technology name**	**Result**	**Code**	**Technology name**	**Result**
ET_1	ESP	3.02	**ET_1**	ESP	2.94
ET_2	Gas lift pump	3.58	**ET_2**	Gas lift pump	3.45
ET_3	Coriolis meter measuring	2.55	**ET_3**	Coriolis meter measuring	2.37
ET_4	CT tractor	4.50	**ET_4**	CT tractor	4.22
ET_5	Mechanical solution	4.03	**ET_5**	Mechanical solution	3.87
ET_6	Chemical solution	3.10	**ET_6**	Chemical solution	3.05
ET_7	Shaped charge (Jet)	2.77	**ET_7**	Shaped charge (Jet)	2.07
ET_8	Perforating gun	4.73	**ET_8**	Perforating gun	4.27
NT_1	Dual ESP	1.52	**NT_1**	Dual ESP	1.97
NT_2	HSP	2.07	**NT_2**	HSP	3.68
NT_3	Vortex meters	1.78	**NT_3**	Vortex meters	3.25
NT_4	Two-phase digital Coriolis meters	1.53	**NT_4**	Two-phase digital Coriolis meters	3.10
NT_5	Hydraulic tractor	2.30	**NT_5**	Hydraulic tractor	4.04
NT_6	Jet acidizing	2.10	**NT_6**	Jet acidizing	3.85
NT_7	Biopolymers, synthetic polymers	1.62	**NT_7**	Biopolymers, synthetic polymers	3.28
NT_8	PosiSET mechanical plugback tool	1.02	**NT_8**	PosiSET mechanical plugback tool	3.75
NT_9	PatchFlex sleeve	1.06	**NT_9**	PatchFlex sleeve	3.96
NT_{10}	Annular chemical packer	1.12	**NT_{10}**	Annular chemical packer	3.98
NT_{11}	Electronic firing system	1.11	**NT_{11}**	Electronic firing system	4.57

4.6. Technology portfolio formation

The technology portfolio analysis is considered as one of the key techniques used from the beginning of the technology planning school to develop a strategy in the field of technology. The components of the technology portfolio indicate the product technologies and the processes emphasized by the organization (Zahra 1996). Based on the research model, the technology portfolio and the technology strategy codification were designed based on the technology attractiveness–capacity matrix. For this purpose, the attractiveness–capacity matrix (Figure 2) was plotted using the scores obtained from the attractiveness and capacity assessment of each technology. This matrix consists of four areas, and situating each technology in four areas results in a specific strategy.

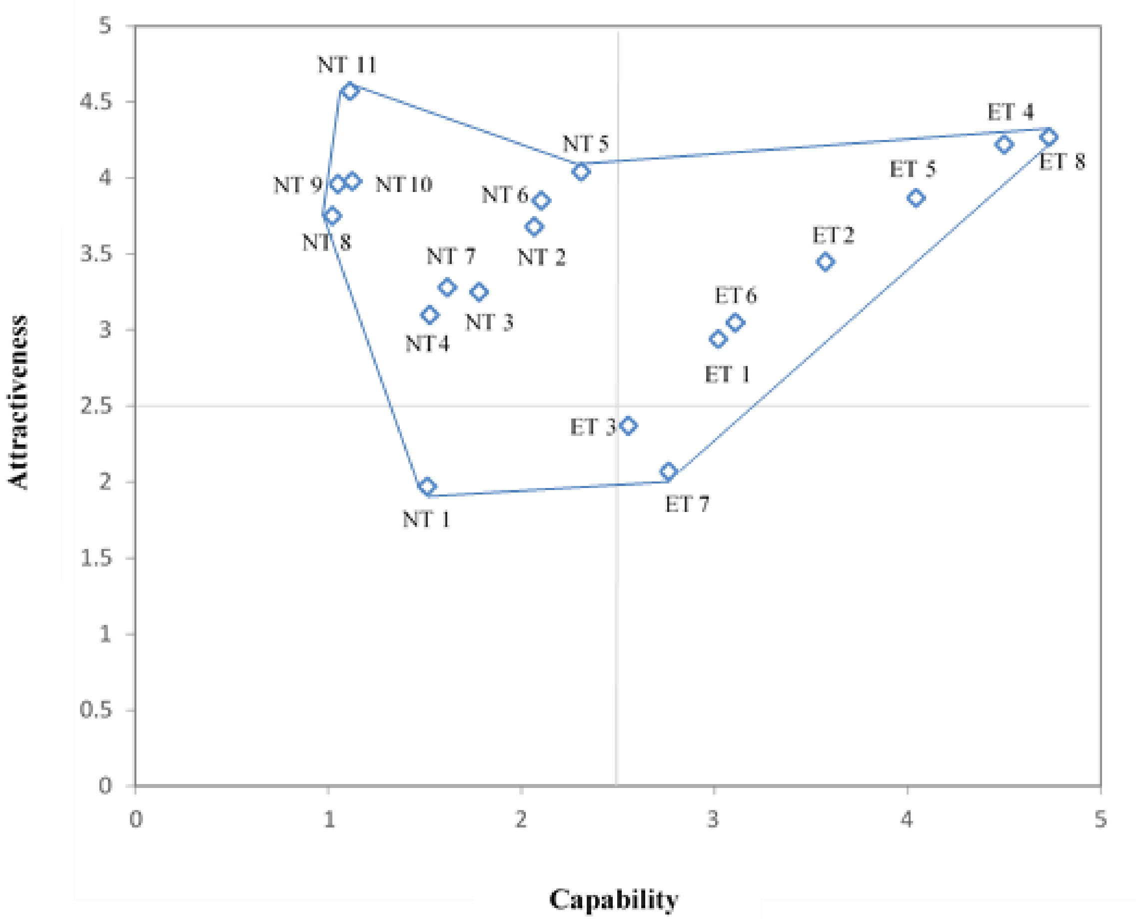

Figure 2

Attractiveness–capability matrix.

4.7. Formulating technology strategy

After the technology portfolio formation, the strategy for the four areas of the matrix was formulated. The strategies for each area of the matrix were explained in the following.

Technologies ET_1, ET_2, ET_4, ET_5, ET_6, and ET_8 are in the first area of the matrix. The capacity of the operation area of these technologies is good, and the attractiveness of these technologies is high as well. Given that the technologies in this area significantly influence the predetermined goal achievement, authorities should pay special attention to maximize the operation of these technologies for better realization of the desired strategic objectives as well as protecting the position of the operation area by maintaining greater readiness and dominance. On the other hand, given that the technologies in this area are at risk of replacement, the relevant authorities should be alert to the technological developments and maintain their readiness to keep pace with these developments. Accordingly, the emergence of new technologies and their application by other countries may undermine the position of this field within the country. Thus, the proposed strategy for this area is a “positioning” or “development” strategy.

Technologies ET_3 and ET_7 are in the second area. As the technologies in this area are not very attractive, the significant investment in the technologies in this area is not justifiable, and they should be replaced with new technologies with a higher strategic value (attractiveness) as much as possible. On the other hand, given the high capability of using these technologies, their effective operation obtained over time and by expenditure is essential. Consequently, this capability is utilized in other units of the operation field if necessary except the unit to which the technology belongs. Therefore, the “replacement” or “sale” strategy is suggested for the technologies in this area.

Technologies NT_2, NT_3, NT_4, NT_5, NT_6, NT_7, NT_8, NT_9, NT_{10}, and NT_{11} are situated in the third area. Although the technologies in this area are very attractive, the industry’s capability to operate them is not appropriate. The specialists in the operation field should try to increase the capability of the aforementioned technologies due to their strategic importance. Since there are many technologies in this area and the constraints on the resources prevent investment in all of these technologies, the general strategy for the technologies in this area is “selective improvement”, indicating that the investment is made selectively. To this end, identifying the causes of and the factors in the technological weakness of the relevant field in relation to each of the remaining technologies affects the improvement in the method selection.

NT_1 is the only technology in the fourth area of the matrix. The operation field capacity is weak, and the attractiveness of technology is low in this area. Therefore, the strategy for the operation field in this area is “ignoring” or “disregarding” the technology. Since the technology in this area is considered as one of the new technologies which is not currently used in operation activities, investment in it should be avoided. It is worth mentioning that the decision to abandon investing in a technology is only appropriate if there is no dependency between this technology and the technologies with high attractiveness.

Finally, given the fact that investing in all identified technologies is impossible due to the constraints on time and resources, the technological options should be selected carefully.

Based on the obtained technology portfolio, investment in technologies ET_1, ET_2, ET_4, ET_5, ET_6, and ET_8 situated in the first area is justifiable due to their high capability and attractiveness as well as the high degree of their importance in achieving the predetermined goals of the industry. Furthermore, technologies NT_2, NT_5, NT_6, NT_8, NT_9, NT_{10}, and NT_{11} placed in the third area with an attractiveness score of higher than 3.5 are justifiable. Therefore, investment in these technologies, as technological options, is recommended.

5. Conclusions

Oil industry is one of the main manifestations of the application of technical knowledge and various technologies in the fields of engineering, management, and economics. The awareness of its different sectors and the effective and appropriate use of technologies in every field are considered as the keys to the success and progress in the different downstream, midstream, and upstream sectors of oil industry. Understanding the current situation and moving toward a desirable one by overcoming the challenges, as well as identifying, selecting, and using new industry technologies at the right time and at the right place, allow for increased productivity and increased oil and gas recovery from reservoirs with a lower cost. While gas reservoirs are somehow easier to control and manage by fixing the challenges related to undesired water production and/or prevention/removal of condensate blockage, oil reservoirs are much more demanding in terms of innovative solutions and proper technologies. Therefore, the present study attempted to identify the existing and emerging strategic technologies in each of the key challenges by identifying and prioritizing the key challenges existing in the process of the projects in the field of operation. Each technology was then assessed from the perspective of the attractiveness and the capability. Based on the obtained results and the attractiveness–capacity matrix, the technology portfolio was formed, and a specific strategy was designed for each area. Finally, the obtained data indicated the strategic options for investment. Accordingly, investment in the technologies situated in the first area of the attractiveness–capacity matrix was justifiable due to the high degree of their importance in achieving the predetermined objectives of the industry and owing to the high ability of specialists to utilize them. Also, the technologies available in the third area of the attractiveness–capacity matrix, which achieved an attractiveness score of larger than 3.5, were justifiable due to their strategic importance for the industry. Therefore, these technologies, as technological options, are recommended for investment.

There were some limitations in conducting the present study such as the difficulty of accessing technical experts and in identifying new technologies completely; also, the inability to conduct in-depth interviews with senior managers of the industry to identify and prioritize challenges was another issue. In line with the results of the research, it is recommended that the specialized process of identifying, evaluating, and selecting technology in National Iranian Oil Company should be performed, formulated, and presented as a comprehensive plan to reduce the risks occurring in oil fields. It is worth noting that the present study is an early step in using knowledge management to identify technologies in one particular upstream sector; it can also be used as an example to further apply this knowledge to other sectors of oil industry.

Nomenclature

API	American Petroleum Institute
ESP	Electrical Submersible Pump
EOR	Enhanced Oil Recovery
HSP	Hydraulic Submersible Pump
IOR	Improved Oil Recovery

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