

# Linking Competitors' Knowledge and Developing Innovative Products Using Data Mining Techniques

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**How to cite this paper:** Saesi, N. and Taleghani, M. (2023) Linking Competitors' Knowledge and Developing Innovative Products Using Data Mining Techniques. *Journal of Computer and Communications*, 11, 37-57. <https://doi.org/10.4236/jcc.2023.117004>

**Received:** June 22, 2023

**Accepted:** July 24, 2023

**Published:** July 27, 2023

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## Abstract

In this article, the relationship between the knowledge of competitors and the development of new products in the field of capital medical equipment has been investigated. In order to identify the criteria for measuring competitors' knowledge and developing new capital medical equipment products, marketing experts were interviewed and then a researcher-made questionnaire was compiled and distributed among the statistical sample of the research. Also, in order to achieve the goals of the research, a questionnaire among 100 members of the statistical community was selected, distributed and collected. To analyze the gathered data, the structural equation modeling (SEM) method was used in the SMART PLS 2 software to estimate the model and then the K-MEAN approach was used to cluster the capital medical equipment market based on the knowledge of actual and potential competitors. The results have shown that the knowledge of potential and actual competitors has a positive and significant effect on the development of new products in the capital medical equipment market. From the point of view of the knowledge of actual competitors, the market of "MRI", "Ultrasound" and "SPECT" is grouped in the low knowledge cluster; "Pet MRI", "CT Scan", "Mammography", "Radiography, Fluoroscopy and CRM", "Pet CT", "SPECT CT" and "Gamma Camera" markets are clustered in the medium knowledge. Finally, "Angiography" and "CBCT" markets are located in the knowledge cluster. From the perspective of knowledge of potential competitors, the market of "angiography", "mammography", "SPECT" and "SPECT CT" in the low knowledge cluster, "CT scan", "radiography, fluoroscopy and CRM", "pet CT", "CBCT" markets in the medium knowledge cluster and "MRI", "pet MRI", "ultrasound" and "gamma camera" markets in the high knowledge cluster are located.

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## Keywords

Knowledge of Competitors, Development of Products, Innovative Products, Data Mining, Data Mining Techniques, Medical Capital Goods, Medical Capital Goods Market

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## 1. Introduction

Today, manufacturing companies around the world are facing many challenges, including the rapid development of technologies, rapid changes in market conditions, constant demands of customers/users for high-quality products, and global competition. Under such conditions, innovation is one of the strategies that companies follow to achieve competitive advantage and increase company performance and profitability [1]. In fact, innovation is a valuable tool for organizations to adapt to environmental dynamics [2] and achieve competitive advantage by providing new products or services for current and new customers [3]. Previous studies claim that innovation through reducing the cost of existing products or services, improving their quality, and inventing new products and services for which there is sufficient demand, leads to the creation of competitive advantage and competitiveness of companies. To increase profit and competitive power, the product development process is considered one of the most important processes of the organization [4].

Many researchers have introduced the development of new products as a knowledge-based process that urgently needs effective knowledge management with the increasing complexity of products and technologies. Capability in the process of developing new products is one of the advantages for organizations. Product development is an information and knowledge-oriented subject, and organizations need sufficient knowledge and information to succeed. One of the product development capabilities of successful and superior organizations is their ability to use knowledge throughout the product development process, which itself leads to success in new product development projects [5].

The development of innovative products relies on knowledge management and external knowledge, such as customer and competitor knowledge. Because the knowledge management of the organization's external environment leads to the analysis of the external environment and making appropriate strategic decisions. Successful companies continuously discover or create new knowledge to solve new and unfamiliar problems; then, they develop this knowledge in a purposeful and systematic manner and in accordance with specialized and strategic goals in all layers and different departments of the organization and seek to transform it into new technologies and products [6].

Considering the importance of external knowledge in the development of new products and gaining a competitive advantage, in this article, the link between the knowledge of competitors and the development of innovative and new prod-

ucts in the market of medical capital goods is investigated using data mining techniques.

## 2. Literature Review

### 2.1. Development of New Products

The development of new products is a set of activities that begins with the understanding of market opportunities and ends with the creation, sale and delivery of a product [7]. The new product development process is a process in which an organization uses all its resources, facilities and abilities in the form of multipurpose groups to create a new and innovative product or to develop and improve an existing product; so that the development of a new product is a fundamental process and is considered as a kind of progress and revival of the organization [8]. In other words, the process of production and development of new products should respond positively to the needs of customers and create a suitable competitive arena for the organization by relying on the superiority of technology and the appropriate allocated budget [9]. New product development is an important part of any business. New products provide growth opportunities and competitive advantage for companies. According to the mentioned cases, the management of the development process of new products will also require the use of new management approaches [10].

In fact, the development of new products is a process that for its proper implementation, the whole company must be motivated and sensitive [8]. This includes creating or discovering opportunities, choosing and creating and transforming them into artifacts and activities (services) offered to customers and institutionalizing various improvements in new product development activities [11].

The purpose of new product development is to respond to customer needs, adapt to market conditions and environmental changes, increase profits and customer satisfaction and deal with competitors' policies. The ever-increasing flood of development and production of new products and their commercial and successful supply to the market will shorten the life curve of products and move from mass production to customized production [9].

### 2.2. Competitors' Knowledge

Competitors' knowledge refers to the internal awareness and understanding of competitors that exists throughout an organization. Many of these are either temporary, informal, or difficult to use. Either they lack structure or they exist only implicitly. Competitor information includes all data about competing products, while companies often use competitors as sources of knowledge to test and transfer best practices [12]. Therefore, competitors' knowledge is one of the key capabilities of rival companies, which if used effectively, will lead to a win-win situation for both companies and their customers [13]. In addition to quantity, the timeliness and accuracy of competitor intelligence determine a com-

pany's ability to respond to competitors' actions on a global scale. Competitors' knowledge is one of the skills required to achieve success in the market and it is expected to have a positive relationship with the organization's performance [14].

García-Murillo and Annabi (2002) stated that the knowledge of competitors is a part of the company's knowledge. According to them, the components of competitors' knowledge are: competitors as partners, knowledge about competitors' customers, competitors' market knowledge, competitors' suppliers' knowledge, and competitors' products or services. The ability to understand the competitive environment is the basic premise of extra-organizational knowledge [15]. If the organization has the ability to understand the strengths, weaknesses, abilities, current and potential strategies of its competitors, it will be better able to develop a counter strategy [14].

### **2.3. The Effect of External Knowledge on Developing of New Products**

Today, few companies have the capacity to develop technology and design new products using only internal resources [4] and due to the high failure rate of new products, they are looking for new solutions to increase product innovation and accelerate the product development process [16]. For this reason, the operations management community has deeply investigated the cooperation models in the development of new products Such as partnerships with suppliers and customers in recent decades [17]. Therefore, one of the important mechanisms for innovative business models is to carry out and establish joint development relationships [18]. But both groups of small and medium and multinational companies are not able to sustain innovation costs by themselves, and in order to be innovative and gain a competitive advantage, they rely more on external information and research collaborations and knowing competitors [19].

Zhang *et al.* (2008) defines knowledge integration capability as a dynamic capability to combine and apply existing knowledge with respect to external knowledge in the process of knowledge management. They argued that most product innovation failures are caused by the lack of knowledge integration capability, because a significant amount of knowledge is implicit in the product development process [20].

Organizational capability is the company's ability to repeatedly perform a productive task, which is directly or indirectly related to the company's capacity to create value through influencing and changing input to output [9]. The ability of knowledge integration refers to the combined ability of the organization in analyzing and combining the knowledge that comes from outside the organization or the knowledge that is accumulated by using the experiences of people inside the organization [21]. Therefore, according to the view of the dynamic ability of knowledge integration, it refers to the company's ability to manage knowledge bases by reconfiguring the knowledge management process inside and outside the organization [22].

New product development is a way to integrate knowledge published in different natures in an innovative way [22]. Yang stated that knowledge integration has a significant effect on new product performance and new product development depends on integrating specialized capabilities [23]. Berends *et al.* (2007) claim that during joint new product development, knowledge management should focus on knowledge integration instead of focusing on knowledge transfer. It is argued here that product development requires a partner to transform specific knowledge into specialized knowledge. Regardless of this issue, partners will not have fresh ideas or distinctive expertise for joint product development [4].

#### 2.4. Research Background

Chang and Taylor (2016) investigated the role of customer participation in new product development projects. According to the findings of this research, customer participation in the stages of ideation and new product launch strengthens the economic performance of new product expansion projects and indirectly improves the duration of the new product presentation to the market. Also, customer participation in new product expansion projects that take place in emerging countries, in industries with a lower technology level, and relatively smaller companies is more effective. Bouncken *et al.* (2017) introduced the issue of cooperation between competitors and its impact on new product development projects. There are two types of new product expansion. The first one is the gradual expansion of the product in which a model of the product is transformed into a more up-to-date model. According to the findings of this research, cooperation between competitors is effective both in the stage before the launch of a new product and during the launch stage. The second is radical product expansion, in which a completely different product from the specifications of the old products is launched. According to the findings of this research, cooperation between competitors in the case of radical product expansion is only effective at the new product launch stage and not before.

Chauhan *et al.* (2017) designed a comprehensive risk management model in the discussion of new product development. This comprehensive model includes three stages of risk recognition, risk assessment and analysis, and risk reduction. In the identification phase, a set of risks involved in the new product development process was prepared. In a research, Robert Cooper (2018) identified and categorized the success factors of new product development projects. In this process, three categories of important success factors were identified. The first category was related to individual aspects of new product development, such as creating the voice of the customer, etc. The second category was related to the level of business and organization and management, and the third category was related to the methods that companies use to manage new product development.

Zhan *et al.* (2019) investigated the link between customer knowledge and innovative product development with a data mining approach. Their study pro-

vides a unique method for linking customer knowledge with innovative product development in a data-driven environment. In addition to the communication law and decision tree methods, this study provides a systematic method for managers to extract knowledge “from” and “about” the customer to identify their preferences. This allows companies to produce the right products and gain a competitive advantage. The findings show that the knowledge-based approach is effective and the extracted knowledge as a set of rules can be used to identify useful patterns for innovative product development. López-Cabarcos *et al.* (2020) investigated the role of product innovation and customer orientation in transforming tacit and explicit knowledge into profitability. Their research investigated the topic of this research by combining knowledge base theory, organizational learning theory, and dynamic capability theory, on one hand, and the relationship between exploration and measurement of tacit knowledge, on the other hand. In this research, the conceptual model was investigated with a study sample of 153 industrial organizations using the structural equation modeling approach. The results showed that implicit and explicit knowledge are effective in achieving sustainable competitive advantages. Furthermore, tacit and explicit knowledge both translate directly into profitability through product innovation and customer orientation, which play a partial mediating role.

Medase and Abdul-Basit (2020) investigated the relationship between the company’s external knowledge and innovation performance. This article includes types of external sourcing strategies, internal company competencies, and industry characteristics in a unique analytical framework in predicting the innovative capabilities of companies in developing countries to highlight the importance of external knowledge sources as influential factors. The data sets from the databases of manufacturing, service and retail companies in 11 countries in Sub-Saharan Africa were used to evaluate the extent to which companies use external sources of information (customers, competitors, consultants, new employees and workshops). The results of their research showed that although internal sources are necessary, external sources of information are also necessary to achieve the desired level of innovation. These findings confirm that companies that open their innovation process and use separate knowledge sources have a superior ability to introduce their innovations.

Işik-Tosun (2020) investigated the role of human-centered design in a multinational company through the development of innovative products. The results showed that the designer plays six diverse and contemporary roles during the new product development process. Gao *et al.* (2021) investigated the strategy of global design thinking in the development of innovative products and showed that global design as an important concept in product development has been gradually implemented in various industries and companies. The universal umbrella base has significantly improved the evaluation of universal design principles. In the future design, innovative architectural products with incorrect design factors can also use this process to complete the design and development of

the intended product and significantly increase the global evaluation of product design.

Gómez-Prado *et al.* (2022) investigated product innovation, market intelligence and pricing capability as a competitive advantage in the international performance of start-ups. The results of their research showed that competitive advantage does not act as a mediator between pricing capabilities and international performance of startups. Furthermore, competitive advantage was found to act as a mediator between two of the three capabilities assessed: market intelligence capabilities and product innovation capabilities. Bratianu *et al.* (2022) investigated the mediating role of customer knowledge management in the relationship between innovative work behavior and product innovation. The findings show positive relationships between innovative work behavior and the product innovation process with a Pearson correlation coefficient of 0.42, which means that 42% of the changes in perceived product innovation are due to changes in innovative work behavior. Also, knowledge management, which is supported by other determining factors (such as cooperation in exploring ideas, supporting ideas and encouraging participation in the implementation of ideas), significantly contributes to the product innovation process. The bootstrapping method also showed that innovative work behavior about product innovation is supported through the mediation of customer knowledge management.

As can be seen in the research background section, a lot of research has been done in the field of developing new and innovative products. The impact of external knowledge (customers and competitors) on innovation, the development of new and innovative products has been investigated with statistical methods [6]. Also, the use of data mining techniques to link customer knowledge with innovative product development has also been studied by some researchers such as Zhan *et al.* (2019). But what has not been investigated so far and the reason for distinguishing the current research from the previous research is “linking competitors’ knowledge and developing innovative products using data mining techniques”.

## 2.5. Conceptual Model

In the era of open innovation, external knowledge and technology play an important role in the company’s innovation performance and the development of innovative products. Chesbrough (2003) claimed that the knowledge produced inside the companies may be used across the boundaries of the companies and basically it is used to absorb external knowledge capabilities. Thematic literature shows how companies use internal and external knowledge sources to develop new innovative products (Medase and Abdul-Basit, 2020).

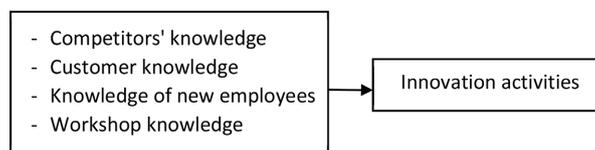
Knowledge is often closely related to the person who develops the particular knowledge and is often considered as a type of tacit knowledge. It is commonly believed that tacit knowledge requires interaction. A company cannot rely only on internal knowledge to develop the innovation process. Hence, for internal

innovation efforts, companies are increasingly looking for external knowledge sources as well as external partners, so in this direction, the option of external knowledge becomes absolutely necessary for companies. In this regard, the study of Medase and Abdul-Basit (2020) clarifies the importance of open innovation and explains that external sources of knowledge and external networks should be integrated with internal knowledge to create additional benefits. Medase and Abdul-Basit (2020) considered the external knowledge of the company in the form of knowledge of customers, competitors, consultants, new employees and workshops in their model and showed that external knowledge affects innovation performance and R&D activities. In the study of Zhan *et al.* (2019), the impact of customer knowledge in the development of innovative products has been investigated with a data mining approach.

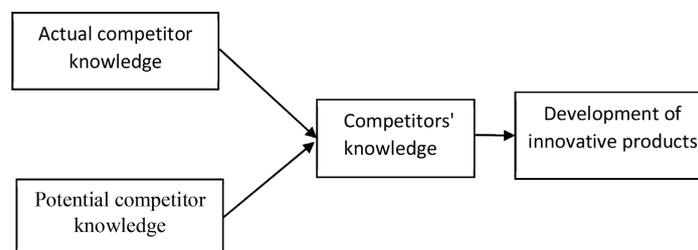
The conceptual model of the current research is drawn based on the study of Zhan *et al.* (2019) as well as the article of Medase and Abdul-Basit (2020) as follows to investigate the impact of competitors' knowledge on the development of innovative products. In the article of Medase and Abdul-Basit (2020), the impact of foreign knowledge on innovation activities was investigated using the structural equation modeling approach and their conceptual model is presented in **Figure 1**.

In the study of Zhan *et al.* (2019), the impact of customer knowledge on the development of innovative products was investigated using data-mining techniques, but in their study, a conceptual model was not presented.

In this research, the effect of the knowledge of actual and potential competitors on the development of innovative products has been investigated using structural equation modeling and data mining. Considering that in the first step, the significance of the impact of the knowledge of actual and potential competitors on the development of innovative products, as well as the significance of the components of the competitor's knowledge, is examined using the structural equation modeling approach, the current research needs a conceptual model which is in accordance with **Figure 2**.



**Figure 1.** Conceptual model of Medase and Abdul-Basit (2020).



**Figure 2.** The Conceptual model of the current research (created by the researchers).

### 3. Research Methodology

Until now, the use of static models for grouping has been common, but factors such as technological changes, the entry of new customers, the entry of competitors, and the increase in the variety of products over several periods of time, have changed the competitive conditions. In this research, structural equation modeling method and clustering approach such as k-MEAN have been used to cluster competitors and examine the dynamic behavior of competitors and the impact of their behavior and knowledge on the company's position in the competitive market.

Based on the type of data and its collection method, this research is a mixed qualitative-quantitative research project. In this research, competitor data is collected using questionnaires, existing databases (if access is possible) and competitor clustering is used to analyze their behavior and the company's position in the competitive market. Analyzing the behavior of competitors and the position of the company in the competitive market is an analysis for deciding which markets or market segments capital medical equipment companies should enter or exit from. On the other hand, it will determine and estimate the competitive position of capital medical equipment companies by examining their capabilities or deficiencies in relation to market needs and competencies of existing competitors.

#### Research Variables

This research has no hypothesis in terms of being exploratory, but the research variables include the development of innovative products and the knowledge of competitors, which are dependent and independent variables, respectively. Also, competitors' knowledge includes "potential competitor's knowledge" and "actual competitor's knowledge", each of these two sections includes the items in **Table 1**.

The medical equipment markets that are considered in this research are listed in **Table 2**.

The variable of development of new and innovative products, based on the model of Martti Lindman *et al.* (2008), includes 8 dimensions as described in **Table 3**. This questionnaire is a reference type and was designed by Martti

**Table 1.** Components of potential and actual competitor's knowledge.

Row	Component
1	Market share
2	Market capacity
3	Different advantages
4	State of technology
5	Conditions of prices
6	Quality of products
7	Quality of services and distributors

**Table 2.** Capital medical equipment markets (diagnostic imaging).

Row	Market
1	MRI (magnetic resonance imaging, MRI)
2	PET-MRI
3	CT Scan (computed tomography, CT Scan)
4	Angiography
5	Ultrasound
6	Mammography
7	Radiography, fluoroscopy & C-Arm
8	PET-CT
9	CBCT
10	SPECT
11	SPECT CT (SPECT-CT)
12	Gamma camera

**Table 3.** Dimension of development of new and innovative products.

Row	Dimension
1	Being systematic
2	Technology tendency
3	Design tendency
4	Market tendency
5	Resource consumption
6	The basis of the effort made for new goods
7	New product conceptualization
8	New product management

Lindman *et al.* in 2008 for the development of new products and has 51 questions in 8 dimensions. Also, this questionnaire is based on a 5-point Likert scale.

The questionnaire related to the knowledge of actual and potential competitors includes 14 questions corresponding to the components presented in **Table 1**. Also, the new product development questionnaire is as described in the following **Table 4**.

#### 4. Data Analysis

At this stage, competitors were grouped into three groups of low knowledge, medium knowledge, and high knowledge based on current potential and actual knowledge. Then, by using the opinion of experts, the future position of competitors has been predicted based on their knowledge components. Also, in order to achieve the objectives of the research, a questionnaire was distributed and

collected among 100 members of the statistical sample.

#### 4.1. Reliability of the Questionnaire

Validity and reliability in structural equation modeling method includes convergent validity, diagnostic validity and construct reliability. In this research, the aforementioned methods and Cronbach's alpha were used to calculate the internal consistency (reliability) of the questionnaire.

As can be seen in **Table 5**, the value of Cronbach's alpha for all three variables of potential competitor knowledge, actual competitor knowledge and new product development is greater than 0.7, so the questionnaire for each of the mentioned variables, according to this index has reliability and can be used to collect data and measure research variables.

AVE means average extracted variances and its value should be greater than 0.5, as can be seen in **Table 5**, the value of this index is greater than 0.5 for all three variables, and therefore, the data collection tool from the perspective of this index is also a reliable asset.

The rho-A index is also used for diagnostic validity, which is equal to the amount of average variance extracted (AVE) and its value is greater than 0.5 and indicates the diagnostic validity of research variables.

Also, the CR index is used to check the composite reliability (structural reliability) and its value should be more than 0.7. As can be seen in **Table 5**, the target structure has composite reliability according to the values of this index.

**Table 4.** New product development questionnaire.

Row	Questionnaire components	Number of questions
1	Being systematic	1 to 6
2	Technology tendency	7 to 11
3	Design tendency	12 to 17
4	Market tendency	18 to 28
5	Resource consumption	29 to 32
6	The basis of the effort made for new goods	33 to 38
7	New product conceptualization	39 to 44
8	New product management	45 to 51

**Table 5.** Reliability check of the entire questionnaire.

Variable	Number of questions	Cronbach's alpha	Rho-A	CR	AVE
Actual competitor knowledge	7	0.933	0.933	0.953	0.911
Potential competitor knowledge	7	0.924	0.925	0.980	0.942
Development of new and innovative products	51	0.768	0.981	0.920	0.902

### 4.2. Structural Equation Modeling

In this research, structural equation modeling method was used in SMART PLS software environment. The fitted model is shown in Figure 3, and in this research, various indices were used to estimate the overall goodness of fit of the model with the observed data, which are shown in Table 6. The dimensions and components of knowledge of actual and potential competitors have been determined based on the opinion of experts of capital equipment companies and their significance has been investigated using the structural equation modeling approach.

Figure 3 shows the estimated model in SMART PLS2 software. As can be seen in this model, among the components of “actual competitive knowledge”, the different advantages are the most important and the state of technology is the least important. Among the components of “potential competitor knowledge”, the component of marketing ability and capacity is the most important and product quality is the least important. On the words, among the components of the development of new and innovative products, the component of being systematic

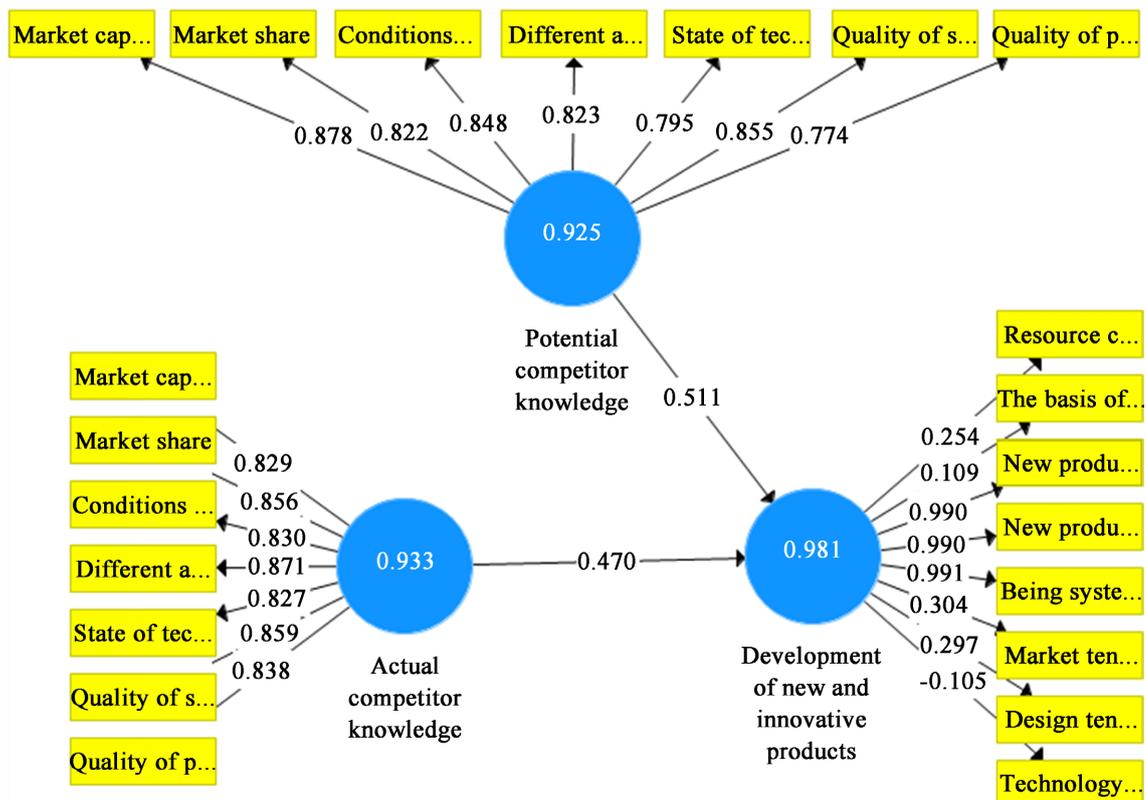


Figure 3. Model fitting based on structural equation modeling method.

Table 6. Structural model goodness of fit indices.

Indicator	RMSEA	CFI	GFI	AGFI	NFI
Acceptable value	<0.1	>0.9	>0.9	>0.9	>0.9
Calculated value	0.031	0.94	0.97	0.93	0.95

with weight of 0.991 has the first rank and the components of new product management and new product conceptualization with weight 0.990 are located in the second rank. The component of technology tendency has the least importance.

After fitting the model, the goodness of fit of the model has been investigated based on the indicators available in the literature.

It can be seen in **Table 6** that the values of the indicators are within the permissible range, so it can be said that all the suitability indicators of the research model are in the acceptable range. In addition, according to the value of P-VALUE, which is greater than 0.05, the fit of the model is confirmed (**Figure 4**).

In **Figure 4**, the numbers on each path indicate the value of the T statistic, and the P-VALUE calculated for each of them is 0.000. In examining the significance of the path coefficients, if the calculated values for each path are greater than 1.96, the coefficient in the model fit is significant at the level of 0.05, and if the values are greater than 2.58, the path coefficients are significant at the error level of 0.01. As seen in **Figure 4**, all the calculated values are greater than 2.58, so it can be said that the path coefficients in the fitted model are significant at the 0.01 error level.

In the next step, to determine the degree of influence of exogenous variables on endogenous variables, standardized regression coefficients related to the paths in the model were examined. These coefficients express how much (percentage) the

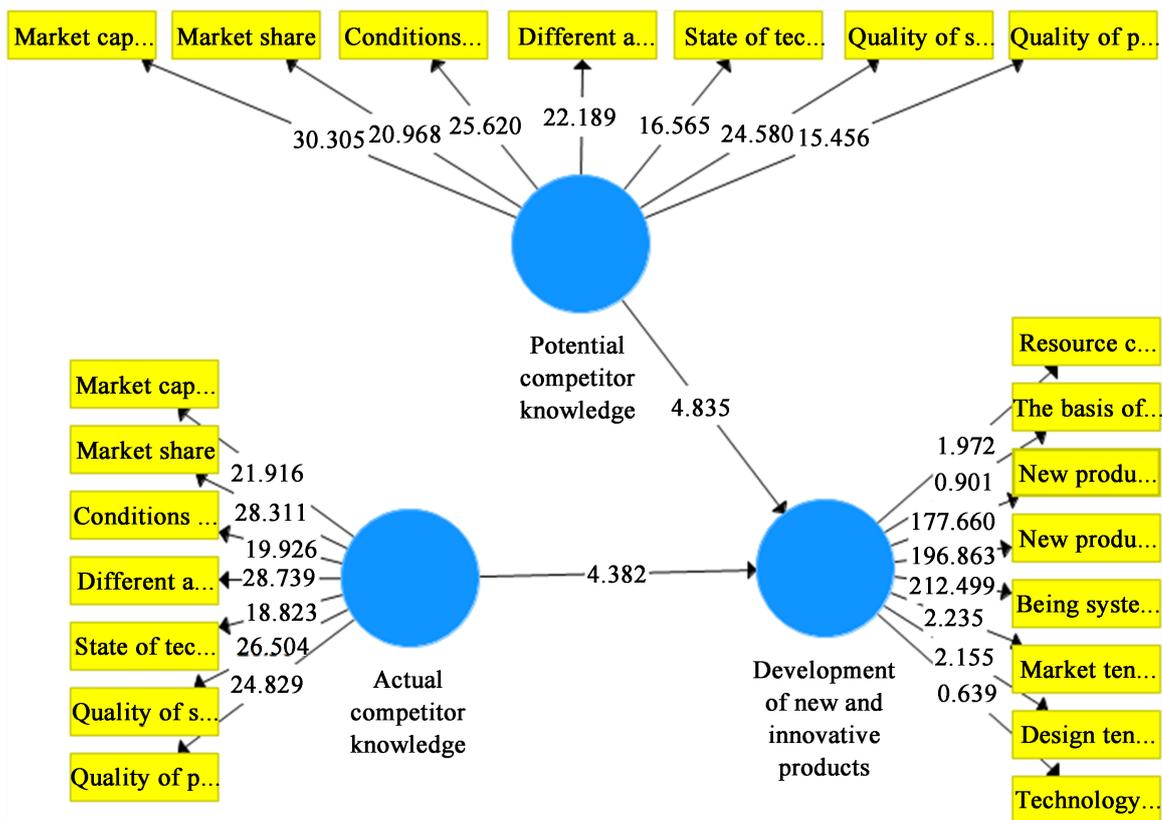


Figure 4. Significance of path coefficients.

changes of the dependent variables are explained by the independent variables presented in the model. This level of influence can be seen in **Figure 4** and **Table 7**.

As can be seen in **Table 7**, the value of T statistic calculated for each of the routes is greater than 2.58 and the coefficients of the routes are significant at the error level of 0.01. Therefore, the statistical null hypothesis that there is no significant relationship or no significant effect among the variables on the sides of each path is rejected and the statistical hypothesis that there is a significant effect or relationship among the variables on the path is accepted. Therefore, we can say:

- The potential competitor's knowledge has a positive and significant effect on the development of new products.
- Actual competitor knowledge has a positive and significant effect on the development of new products.

### 4.3. Clustering Competitors Based on Their Level of Knowledge

As mentioned earlier, the K-MEAN approach has been used to group competitors into three categories: low knowledge, medium knowledge, and high knowledge. In the following, capital medical equipment markets are grouped based on the knowledge of their actual and potential competitors and the results of this clustering are presented.

#### 4.3.1. Clustering Capital Medical Equipment Markets Based on Knowledge of Actual Competitors

The results of the K-MEAN clustering method with a maximum of 10 repetitions show that the capital medical equipment markets are grouped into three clusters, and the minimum distance between the centers of the clusters is calculated as 9.539.

**Table 8** shows the information of the clusters in the final clustering of capital medical equipment markets based on the level of knowledge of actual competitors.

As can be seen in **Table 9**, from the point of view of the knowledge of the actual competitors, the market of "MRI", "Ultrasound" and "SPECT" has a higher degree of membership in the low knowledge cluster. Also, "Pet MRI", "CT Scan", "Mammography", "Radiography, Fluoroscopy and CRM", "Pet CT",

**Table 7.** The paths of the model with the method of structural equations.

Path	Coefficient	The standard deviation	T statistics	P-value	The result
Actual competitor knowledge-new product development	0.470	0.084	4.427	0.000	Actual competitor knowledge has a positive and significant effect on the development of new products.
Knowledge of potential competitors-new product development	0.511	0.008	4.903	0.000	Knowledge of potential competitors has a positive and significant effect on the development of new products.

**Table 8.** Centers of the final clusters of the K-MEAN algorithm of actual competitors.

Market	Cluster 1 (low knowledge)	Cluster 2 (medium knowledge)	Cluster 3 (high knowledge)
MRI (magnetic resonance imaging, MRI)	3.90	2.48	2.69
PET-MRI	2.82	3.54	2.78
CT Scan (computed tomography, CT Scan)	3.16	3.28	2.71
Angiography	2.67	3.25	3.42
Ultrasound	3.59	3.07	2.48
Mammography	2.98	3.76	2.38
Radiography, fluoroscopy & C-Arm	3.29	3.52	2.43
PET-CT	2.85	3.25	2.91
CBCT	2.92	2.70	3.29
SPECT	3.44	2.76	2.53
SPECT CT (SPECT-CT)	2.70	3.77	2.67
Gamma camera	3.13	3.27	2.83

**Table 9.** Final clusters of markets of actual competitors.

Market	Cluster
MRI (magnetic resonance imaging, MRI)	Low knowledge
PET-MRI	Medium knowledge
CT Scan (computed tomography, CT Scan)	Medium knowledge
Angiography	High knowledge
Ultrasound	Low knowledge
Mammography	Medium knowledge
Radiography, fluoroscopy & C-Arm	Medium knowledge
PET-CT	Medium knowledge
CBCT	High knowledge
SPECT	Low knowledge
SPECT CT (SPECT-CT)	Medium knowledge
Gamma camera	Medium knowledge

“Aspect CT” and “Gamma Camera” markets have a higher degree of membership in the average knowledge cluster. On the other hand, “angiography” and “CBCT” markets have a higher degree of membership in the knowledge cluster.

### 4.3.2. Clustering Capital Medical Equipment Markets Based on Knowledge of Potential Competitors

The results of the K-MEAN clustering method with a maximum of 10 repetitions show that the capital medical equipment markets are grouped into three clusters, and the minimum distance between the centers of the clusters is calculated as 9.592.

**Table 10** shows the information of the clusters in the final clustering of capital medical equipment markets based on the level of knowledge of potential competitors.

As can be seen in **Table 11**, from the perspective of knowledge of potential competitors, the market of “angiography”, “mammography”, “SPECT” and “SPECT CT” has a higher degree of membership in the low knowledge cluster. Also, the markets of “CT Scan”, “Radiography, Fluoroscopy and CRM”, “Pet CT”, “CBCT” have a higher degree of membership in the average knowledge cluster. On the other hand, the “MRI”, “Pet MRI”, “Ultrasound” and “Gamma camera” markets have a higher degree of membership in the knowledge cluster.

### 4.3.3. Forecasting the Future Position of the Markets

In order to predict the future of the markets, the possible trend of changes in the attractiveness of the market for the next three years should be determined by managers and experts based on the knowledge of competitors and their strategies. Then managers should analyze how to change the company’s competitive position in the market.

**Table 10.** Centers of the final clusters of the K-MEAN algorithm of potential competitors.

Market	Cluster 1 (low knowledge)	Cluster 2 (medium knowledge)	Cluster 3 (high knowledge)
MRI (magnetic resonance imaging, MRI)	2.90	2.93	3.25
PET-MRI	2.51	2.20	3.86
CT Scan (computed tomography, CT Scan)	2.94	3.39	2.44
Angiography	3.45	2.20	3.13
Ultrasound	2.93	2.62	3.54
Mammography	3.34	3.12	2.74
Radiography, fluoroscopy & C-Arm	2.79	3.42	2.85
PET-CT	2.64	3.61	3.40
CBCT	2.74	3.43	2.65
SPECT	3.34	3.11	2.73
SPECT CT (SPECT-CT)	3.09	2.48	2.97
Gamma camera	3.01	2.56	3.25

In this section, the experts were requested, based on the knowledge of the competitors and their strategies, to evaluate the position of the markets in relation to the knowledge of the actual and potential competitors with numbers 1 to 5, and then the average opinion of the experts was calculated and after normalization, through the calculation The average of comments for each market, the corresponding weight for each market was calculated (**Table 12**).

As can be seen in **Table 12**, among the markets according to the evaluation of the future conditions, the “PET-CT” market with a weight of 0.684 has the first

**Table 11.** Final clusters of markets of potential competitors.

Market	Cluster
MRI (magnetic resonance imaging, MRI)	High knowledge
PET-MRI	High knowledge
CT Scan (computed tomography, CT Scan)	Medium knowledge
Angiography	Low knowledge
Ultrasound	High knowledge
Mammography	Low knowledge
Radiography, fluoroscopy & C-Arm	Medium knowledge
PET-CT	Medium knowledge
CBCT	Medium knowledge
SPECT	Low knowledge
SPECT CT (SPECT-CT)	Low knowledge
Gamma camera	High knowledge

**Table 12.** Ranking table of preference prioritization method based on expert opinion.

Market	Weight	Priority
MRI (magnetic resonance imaging, MRI)	0.5951	6
PET-MRI	0.5391	11
CT Scan (computed tomography, CT Scan)	0.6799	2
Angiography	0.5835	8
Ultrasound	0.6420	4
Mammography	0.6254	5
Radiography, fluoroscopy & C-Arm	0.6733	3
PET-CT	0.6840	1
CBCT	0.5554	10
SPECT	0.5807	9
SPECT CT (SPECT-CT)	0.5874	7
Gamma camera	0.5334	12

rank and according to the knowledge of the actual and potential competitors, it is an attractive target market among the medical equipment markets. Also, the Gamma Camera market with a weight of 0.5334 will be the least attractive in the future.

## 5. Conclusions

As it was said, the present article was formed with the aim of “investigating the relationship between competitors’ knowledge and new product development in the field of capital medical equipment using data mining”. Structural modeling tool and K-MEAN clustering method were used to analyze the data. The questionnaire was distributed and collected among 100 members of the statistical community who were selected from the top 50 companies, and then the reliability of the questionnaire was checked. In the next step, the research model was estimated using the structural equation modeling method in the SMART PLS software environment. After analyzing the results of structural equation modeling and checking the significance of the research model, the K-MEAN approach was used to cluster the capital medical equipment market based on the knowledge of actual and potential competitors in order to continue the analysis. Also, at the end of the work, the future status of these markets was presented.

The results of the research showed that the knowledge of the competitors in the two groups of Bagoeh has a positive and significant effect on the development of new and innovative products. Today, the main source of success in gaining a competitive advantage for companies in the future is the successful and continuous development of new and improved products. With the increase in the variety of products and the volume of orders, the life curve of the products also decreases, so the variability of the competitive rules in the business world has made the process of presenting a new product to the market particularly important. Today, more than ever, most organizations have realized that relying on traditional competitive levers, such as increasing quality, reducing costs, and differentiation in providing products and services, is not enough, and instead concepts, such as speed and flexibility can be used in competition, have gained attention and the trend towards providing new products and services to their market is the justified reason for this change of attitude. But the new product development process is a costly and risky process. More acceptance of new products by customers compared to competitors’ products is one of the risk-taking factors in new product development projects, which requires us to fully understand the needs and expectations of customers from products as well as the knowledge of competitors in order to reduce this risk. Managing competitors’ knowledge to gain information about their products and their position in the market creates competitive advantages for companies, and knowledge of competitors’ knowledge reduces the risk of new product failure.

The evaluation of the future conditions of the markets shows that the “PET-CT” market with a weight of 0.684 has the first rank and according to the knowledge

of actual and potential competitors, it is an attractive target market among the medical equipment markets. Therefore, it seems that capital equipment companies can plan on product development in this market.

## 6. Suggestions

The results of this research along with practical suggestions are as follows:

- Actual competitor knowledge has a positive effect on innovative product development and it is suggested to pay more attention to the different advantage components in order to increase this knowledge. In order to increase the mentioned component and as a result to increase the knowledge of the actual competitor, by conducting extensive and appropriate research in the field of new products, designing and producing a product that has a high distinction and superiority over the competitors.
- The potential competitor's knowledge has a positive and significant effect on the development of innovative products, and it is suggested to pay more attention to the component of marketing ability and capacity in order to increase this knowledge. In order to increase the mentioned component and as a result to increase the knowledge of the potential competitor, new marketing approaches can be used to impress the customers and the important thing is to allocate more resources in the field of marketing and increase the capacity and ability of marketing.
- Among the components of the development of innovative products, the component of being systematic has the highest importance and it is suggested to pay attention to this component more than other components in order to succeed in the development of new products. Therefore, the organization must have long-term plans for new products; the goals and roles of new products should be defined according to the business goals and image and brand of the company; the scope of business and the development path of new products are defined in the long term; the organization should increase its ability to continuously invest in the production of new products; and finally, the meaning and importance of new products should be clarified for all the employees of the organization.
- The results show that from the point of view of the knowledge of the actual competitors, the "MRI", "Ultrasound" and "SPECT" markets are in the low knowledge cluster, so it is suggested to increase the knowledge of the actual competitors of these markets with regard to the different advantage components, planning be made.
- The results show that from the perspective of knowledge of potential competitors, "angiography", "mammography", "SPECT" and "SPECT CT" market are grouped in the low knowledge cluster. Therefore, it is suggested that in these markets, in order to increase the knowledge of potential competitors, attention should be paid to the component of marketing ability and capacity, and with proper planning, it is possible to increase the marketing ability and

capacity in these markets.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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