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Ranking the Dimensions of Research and Development Capabilities Through New Product Development Approach in the Car Industry

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Abstract

This paper first reviewed the relevant literature and several R&D evaluation models in various industries. Then, a suitable model for the evaluation of R&D capabilities was selected through a New Product Development (NPD) approach within the Iranian automotive industry in 9 main dimensions and 29 indicators, validated based on the structural equations proposed in another paper. In the first stage, the coefficient matrix of criteria was identified according to the pairwise comparison matrix. Then, the VIKOR values S, R, and Q were calculated. The ranking involved smaller Q values. The criteria were ranked as follows: 1) research and design capabilities, 2) customer and market, 3) technological capabilities, 4) financial capabilities resources, 5) organizational structure, 6) intellectual capital capabilities, 7) NPD process, 8) management capabilities and, 9) strategic capabilities. Finally, there were suggestions about the capabilities falling under the lowest ranks.

Keywords: R&D, New product development, Evaluation, VIKOR.

1 | Introduction

In the final days of the industrial revolution, science and knowledge were extremely limited. The New Product Development (NPD) only covered the idea behind production and prototype manufacturing. Since there were only one or two individuals involved in production, physics, and chemistry somewhat combined at the end of the nineteenth century when it seemed beneficial to utilize the available science and methodologies within several systematic methods. This came true first by the composition of industry and chemistry in

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Germany and the US. The Research and Development (R&D) laboratories were established. With the help of their assistants, scientists developed new technologies and adopted new scientific methods to achieve new products with a variety of qualities. The NPD process gradually expanded through scientific exploitation and acquisition, propelling modern science [1]. In such a complex and competitive environment, it is crucial to utilize the NPD so as to fulfill the corporate requirements in global business successfully. In today's economic world, most companies are looking for sources of competitive advantage. Undoubtedly, the NPD is an introductory stage into that realm.

Most leading companies around the world are well aware of the fact that the most important factor contributing to success and excellence in the competitive global market is the continuous capability to design new products offered to the market faster and more effectively than competitors. The NPD and improvement play vital roles in the survival of many successful manufacturers. NPD is a very important process to ensure the survival of the company, securing the welfare and expansions of any national economy. Nowadays, new product quality, customer responsiveness and process control are the most important factors turning into the criteria for the availability and competence of global products.

In a world progressing toward the zero-waste concept and high reliability in its agenda, production needs to shift from science to practice. Therefore, it is essential to pay careful attention to creating a favorable environment for R&D, innovation, successful production design, marketing, and NPD. What elements will eventually design the product? R&D? Engineering? Production? Marketing? No. All these elements should be integrated with the help of the customers [2]. NPD covers the complete process of bringing a new product to market, renewing an existing product, or presenting a product in a new market. Hence, there are different "degrees of newness" of a new product [3] and by resources spent by project type [4] The financial victory of most firms depends on their ability to distinguish the needs of customers and to quickly create products that meet these needs and can be produced at low cost. Accomplishing these objectives is not solely a marketing problem, nor is it solely a design problem or a manufacturing problem, it is a product development problem involving all of these functions.

From the perspective of the investors in a for-profit enterprise, successful product development results in products that can be produced and sold profitably, yet profitability is often difficult to assess quickly and directly. Five more specific dimensions, all of which ultimately relate to profit, are commonly used to assess the performance of a product development effort. The first one is the product quality that is the resulting from the development effort. Second one is the product cost. This cost includes spending on capital equipment and tooling as well as the incremental cost of producing each unit of the product. Development time is the third factor, that it means, how quickly did the team complete the product development effort. Development time determines how responsive the firm can be to competitive forces and to technological developments, as well as how quickly the firm receives the economic returns from the team's efforts. Development cost is the other factor that is important. Development cost is usually a significant fraction of the investment required to achieve the profits. Final factor is the development capability which means that the team and the firm better able to develop future products as a result of their experience with a product development project. Development capability is an asset the firm can use to develop products more effectively and financially within the future [5].

One of these financial ventures is the car fabricating companies, which need the R&D centers of these companies to constantly implement NPD projects by receiving the needs of their customers. But since product development is a multi-dimensional category and requires various factors, and due to the high cost, it is not possible to focus on all factors equally, so to reduce development costs and also reduce time development, it is necessary to be rank the factors affecting the development of new products in the automobile industry. Therefore, in the current research, using the literature review, these R&D capabilities with the NPD approach are first extracted and then ranked using the VIKOR method.The results of this research, if used in NPD projects of Iran Khodro Company (IKCO), can probably reduce cost and time, as

well as better management of product development projects from the stage of identifying customer needs to product commercialization.

2 | Literature Review

A product is something sold by an enterprise to its customers. Product development is the set of activities beginning with the perception of a market opportunity and ending in the production, sale, and delivery of a product. A process is a sequence of steps that transforms a set of inputs into a set of outputs. Most people are familiar with the idea of physical processes, such as those used to bake a cake or to assemble an automobile. A product development process is the sequence of steps or activities that an enterprise employs to conceive, design, and commercialize a product. Many of these steps and activities are intellectual and organizational rather than physical. Some organizations define and follow a precise and detailed development process, while others may not even be able to describe their process. Furthermore, every organization employs a process at least slightly different from that of every other organization. In fact, the same enterprise may follow different processes for each of several different types of development projects [5].

Various researches have been conducted on the factors affecting product development in the R&D centers of various organizations. For example, in a research, the factors contributing to the efficiency of NPD were ranked in 1989 at the University of Massachusetts among 600 American companies through interviews with senior executives and middle management and product efficiency teams. The ranking was as follows:

I. Integration in different parts of the design team (40.6%).
II. Capability of the management control system (17.7%).
III. Appropriate product and market strategy (11.5%).
IV. Focus on R&D (11.5%).
V. design for manufacturing (7.3%).
VI. Design tools (6.3%).
VII. Simultaneous performance of engineers (5.3%) [6].

Maria Cristina Hernandez et al. [7] wrote an article titled "The development of a model for NPD in Small to medium companies". In this study, 26 variables were selected from the literature review. These candidate variables included financial performance, customer satisfaction, market attractiveness, the performance of the development process, strategy and leadership, technology acquisition, knowledge management and project management, business performance, market access, development team communications, space and culture of expressing ideas, cooperation and involvement of senior management, productivity and efficiency of design, evaluation of ideas and generation of ideas, cost of product development, percentage of sales from new products, strategy, and development of new products. Finally, with regard to the methodology, a model was extracted in four phases: exploratory studies, basic model structuring, development, and validation.

This evaluation model for NPD involves four stages: planning, early identification, final deeper identification, adoption of SWOT, and conclusion, in all of which learning takes place in parallel [7] Of course, in the aforementioned research, the identified factors were not consistently selected and tested in a model.

In the research conducted by Talebi in 2011 [8], using the factor analysis method, it covered the shortcomings of other researches in this regard. At the Entrepreneurship School, University of Tehran, conducted a study in 2011 to identify and prioritize the critical success factors in NPD in small to medium businesses based in science and technology parks across Tehran. The research methodology involved semi-structured interviews, open interviews, and review of relevant documents in the qualitative phase, while a questionnaire was employed in the quantitative phase to collect data. Moreover, the data were processed through factor analysis. The results showed that in the first stage, technological factors are more important while emerging technologies are critical. At this stage, concentration on technology does not necessarily imply that the other

four factors are trivial but rather signifies the importance of technology over others. In the later stages, the importance of marketing, business, and management grows. Finally, the proposed framework obtained in this study classified the key success factors of NPD into eight critical categories, including market sensitivity and capacity, competitiveness capabilities, marketing and revenue, products and innovations, financial and management capabilities, inventor's expertise, technological advantages, costs and profitability [8].

In another research conducted [9], titled R&D intensity, knowledge creation process and new product performance: the mediating role of international R&D teams, used data from Ghana, a sub-Saharan African emerging economy, to show that R&D investments and utilization of international R&D teams can serve as an enabler for new product performance in emerging markets' firms that lack critical resources in their home markets. Accordingly, the study contributes to research on emerging-market firms in uncertain institutional setting [10] by examining firms' R&D investments in Ghana and demonstrating how emerging country-based firms are likely to spur new product performance when R&D investments are greater. This is an important addition to the strategy and international business literature because very little effort has been devoted to investigating how R&D investments in an emerging country drive a new product performance via international R&D teams and how knowledge creation processes condition the effect of international R&D teams on NPP. This addition offers a rich emerging market perspective for theory building [11].

On the other hand, a long time afterward, there was a more extensive and more comprehensive research regarding the development of new product. One of these researches conducted, was a research entitled the drivers of success in the development of new products three categories of success drivers have been defined. First, success drivers, that explain the success of individual new-product projects, are more tactical: they capture the characteristics of new product projects, such as certain executional best practices (building in voice-of-customer; doing the front-end homework; and adopting a global orientation for the project), and well as the nature of the product itself (a compelling value proposition, for example).

A second category is drivers of success at the business level: they include organizational and strategic factors, such as the business's innovation strategy and how the firm makes its R&D investment decisions; how it organizes for NPD; climate and culture; and leadership The third category of success divers identified is the systems and methods the firm has in place for managing NPD, for example gating systems, Agile development approaches, and ideation methods. The details of each of these 20 success drivers, along with their managerial implications, are outlined in the article [4]. Of course, having all the drivers of NPD usually has a high cost, and it is better to choose a few of the most important drivers according to the conditions of the relevant organization do that you can better focus on them. A research titled the impact of R&D sources on NPD: sources of funds and the diversity versus control of knowledge debate conducted in which it is stated that alternative sources of finance moderate the relationships: internal funds strengthen the impact of R&D sources with more diversity of knowledge on the sale of new products, while external funds strengthen the impact of R&D sources with more control of knowledge on the sale of new products [10]. The results of a study indicate that innovative small enterprises need to secure the number of R&D human resource members for maintaining sustainable competitiveness and securing market share. Therefore, a strategy is needed that would enable employing and raising excellent human resource in the quantitative and qualitative aspects. However, in the circumstances that small enterprises suffer difficulty in securing professional human resource for R&D compared to large enterprises, as there is a limitation for securing human resource for R&D from only the dimension of enterprises, governmental and political support is thought to be necessary for securing good-quality human resource for R&D [12]. The analysis shows how the organization of the NPD projects, alignment strategies, approaches to reward structure, supplier integration willingness and absorptive capacity were all formative in the firms' abilities to achieve ambidexterity in the NPD processes [13].

Therefore, by conducting the literature review, it was determined that despite the various researches conducted in the field of NPD in different industries, and the identification of the capabilities of R&D centers with the approach of developing new products, however, no coherent research was found that ranked these capabilities by MADM techniques.

So, in this research, the question is how the dimensions and factors contributing to R&D capabilities are ranked through the NPD approach in IKCO.

3 | Research Method

The present research in the first layer, which is the research philosophy and the type of researcher's worldview towards the world, considering that the research topic is about ranking the dimensions of R&D capabilities through NPD approach in the car industry. Since these factors can be different according to technological, economic, cultural, and social conditions in countries, as well as different organizations, and of course, to some extent, the topic in question has standards. On the other hand, in terms of value, because during the research, the researchers were not involved in completing the answers to the questionnaires, and also, the subject of the research was an almost standard reality in terms of the nature of the reality. Finally, according to the situation of the present research subject based on the epistemology and ontology of the research explained above, It can be concluded that, the subject of research is within the scope of realism. Therefore, the research approach is quantitative. In the second layer of the research, considering that in the first layer, the philosophy of the research was realism, therefore, in the quantitative part, the researcher's reasoning is hypothetical, which builds a general model based on this detailed information. In the third layer of the present research, it can be stated that the ranking of NPD capabilities has been done using the multi-index ranking method. In the fourth layer, it is also can stated that the research data has been used by using the questionnaire tool to complete the matrices required by the VIKOR[1] method.

To conduct this research, in the first step, the data of the decision matrix was obtained from the information obtained from 20 experts of the Iranian automobile industry in Iran Khodro, who are in the specialized departments of R&D, NPD, engineering, quality, production and technical teams related to NPD was completed. Then, the S, R, and Q were determined. In next step, the values of S, R, and Q were obtained. In next step,the dimensions of R&D capabilities were ranked. How to do it as well as the results of the different steps are explained in full detail in the findings section. *Table 1* displays the model parameters used in this study:

Table 1. R&D Capability Assessment Model with a View to Developing New Products in the Automotive Industry [14].

Question	Dimensions	Effective Factors or Indexes
1	Research and design capability	R&D organizations should have the ability of basic and applied research to design a new product.
2		R&D organizations should constantly make innovations from the beginning until reaching the completion of the product and work on designing new ideas and producing new products.
3		R&D organizations should apply CAD and CAM to design and develop the sample of new products.
4	Customer and market	R&D organizations should initially receive the ideas of customers, competitors and other sources, then sift them and use their most feasible and most appropriate. They should consider financial and non-financial incentives for the customers who give ideas.
5		The quality and performance analysis is done by the R&D organization After supplying new products to customers.
6		R&D organizations should evaluate the power, volume, market share, and profit prediction before introducing a new product to the market.
7		New products must fit the price and have good quality in terms of customers.

[1] VIKOR is a compromise ranking method that is used in Multi-Criteria Decision-Making (MCDM)

Table 1. Continued.

Question	Dimensions	Effective Factors or Indexes
8	Technology capability	R&D organizations should be able to conduct technical changes and improve on imported technologies from anywhere in the world in order to convert imitation into innovation.
9		R&D organizations should be able to increase science level and technological knowledge and take a step to manage these three fields, especially technology management.
10		Organization R&D should have the technical capability and the knowledge to transfer older technologies to other organizations or countries.
11	Financial resources capability	R&D organizations should be able to invest without returning the capital in a short time.
12		R&D organizations should have the financial capability to send employees to research trips, seminars, conferences and academic courses.
13		R&D organizations should have the financial capability to import appropriate and required technologies for developing new products.
14	Organizational Chart	The research unit should be separated from the development unit.
15		R&D organizations should use an appropriate matrix structure to perform better for NPD.
16		New product design and development should be done jointly by the units of R&D, engineering, production, marketing, and the units relevant to project sectional activities; resources and facilities should also be used in the form of multi-functional teams in developing new products.
17	Intellectual capital capability	There should be different professions in R&D organizations, including statistics, marketing, finance and human resources, to analyze the current situation with favorable conditions.
18		R&D organizations should ask their human resources (tacit and explicit knowledge) to help correctly in order to develop new products.
19		R&D organizations should use the organization's structural capital (tactic knowledge related to the organization's internal processes such as hardware-software capital and databases...) in order to support productivity.
20	NPD process capability	The process of developing a new product should be flexible so that it has the possibility to change the method, product, strategy, or any improvement possibility at any time.
21		Remaining problems from design phases and primary production, such as operational problems and product appearance, training forces for mass production, technical and equipment difficulties, and... related to mass production within the process of developing a new product, should be reviewed, and its' weaknesses should be determined and resolved.
22		R&D organizations should perform activities of NPD in accordance with a proper process. (such processes respectively: identify customer demand, determine product characteristics, target specifications, concept generation, concept testing, determine the product final specifications, project planning, economic analysis, benchmarking of competitive products, modeling, and prototyping)
23	Management capability	Management of R&D organization should constantly use stimuli that employees respond to positively in order to stay on the spot that employees' motivation remains at an optimal level, such as financial stimulus (cash, cash bonuses, etc.) and spiritual (job promotion, etc.), identification (verbal encouragement, praise and thanks, etc.).
24		R&D organization should have a professional and experienced manager who is aware of most matters related to the project of NPD, such as Cost management, financial management, quality management, risk management, human resources management, project management, etc., and evaluate the performance of selling percent and a number of productions, profit percent and …
25		R&D organization management should be a model and sample (in terms of reliability, honesty, etc.).

Table 1. Continued.

Question	Dimensions	Effective Factors or Indexes
26	Strategy capability	R&D organization originally should specify the overall objectives and partial goals for the programs of NPD, such as, what it is going to sell, how much profit it has, etc.
27		R&D organizations should adopt different and appropriate strategies during the lifetime of organization products, such as new product platforms, some derivatives from product platforms, and consider innovation and customer-oriented strategies.
28		There should be a balance between the organization's business objectives and the capability of the R&D organization; the role of new products in achieving the organization's business objectives should be defined all clearly.
29		NPD should be aimed at international markets in addition to domestic markets.

4 | Findings

Firstly, the pairwise comparison matrix was formed using the expert opinions (presented in Appendix 1). Then, the criteria coefficient table was obtained by dividing each previous number by the total columns of the same column (specified in Appendix 2).

4.1 | Decision-Making Matrix

After forming the pairwise comparison matrix and data importance coefficient, a combined matrix was constructed based on the expert opinion concerning all 29 criteria according to 9 dimensions displayed in *Table 2*.

Table 2. Decision-making matrix.

Alternatives	Indicators																											
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29
A1	3.98	3.15	4.03	3.41	3.36	3.42	3.14	3.81	3.75	3.24	3.58	3.74	3.84	3.78	3.57	3.85	3.70	3.60	3.45	3.67	3.36	4.12	3.28	3.87	3.65	3.50	3.73	3.40	3.95
A2	4.02	3.96	3.86	3.10	2.40	3.10	3.25	3.98	3.70	3.84	4.03	3.82	3.90	3.93	3.89	3.84	3.8	3.69	3.73	3.84	4.02	3.82	3.49	3.83	3.79	3.82	4.00	3.8	4.23
A3	3.85	3.75	3.96	2.80	3.10	3.20	3.30	4.05	4.10	4.08	3.89	3.54	3.85	3.65	4.11	3.75	3.80	3.87	2.95	3.52	3.25	3.76	3.70	3.87	4.12	3.85	3.95	4.00	3.90
A4	4.02	4.12	3.94	3.02	4.10	3.82	3.60	3.57	3.80	3.80	4.15	4.13	4.03	3.47	3.28	3.46	3.40	3.52	3.82	3.54	3.93	3.74	3.54	3.62	3.25	3.74	3.25	3.6	3.36
A5	3.10	2.80	2.90	3.20	2.80	2.80	2.80	3.20	2.70	2.70	3.80	3.94	3.71	4.18	4.43	4.38	4.1	4.23	4.31	4.26	4.30	3.95	3.90	3.79	3.58	3.74	3.93	3.9	3.45
A6	3.80	3.40	3.70	3.40	3.50	3.90	3.70	3.90	3.80	3.70	3.70	3.80	3.96	3.85	3.69	3.79	3.50	4.05	3.85	3.82	4.05	4.19	4.10	3.97	3.92	4.06	4.16	4.3	4.06
A7	3.76	2.90	3.21	3.74	2.84	3.78	3.73	2.76	3.64	3.71	3.47	3.65	3.82	2.74	3.54	3.64	3.5	3.70	3.27	3.53	4.13	4.55	3.74	3.46	3.86	3.46	3.43	3.6	3.28
A8	3.50	3.52	3.40	3.24	3.12	2.97	3.12	3.41	2.95	3.50	3.47	3.68	3.45	3.98	3.58	3.28	3.4	3.96	3.47	3.97	4.02	3.93	3.45	3.20	3.65	3.27	3.14	3.6	3.75
A9	3.85	3.97	3.85	3.98	3.94	3.64	3.74	3.54	3.76	3.65	3.58	3.56	3.62	3.75	3.85	3.64	3.9	3.45	3.69	4.12	4.06	4.24	3.56	3.69	3.64	3.68	3.30	3.60	3.35

Table 3. Dividing the weighted matrix by maximum values.

Alternatives	Indicators																											
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29
A1	0.000	0.004	0.000	0.002	0.003	0.002	0.002	0.001	0.001	0.003	0.002	0.001	0.001	0.001	0.002	0.002	0.002	0.003	0.004	0.002	0.004	0.002	0.001	0.000	0.001	0.001	0.001	0.002	0.001
A2	0.00	0.001	0.001	0.003	0.006	0.003	0.002	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.001	0.002	0.001	0.002	0.003	0.001	0.001	0.003	0.001	0.000	0.001	0.000	0.000	0.001	0.000
A3	0.001	0.002	0.000	0.005	0.003	0.003	0.002	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.002	0.007	0.003	0.004	0.004	0.001	0.000	0.000	0.000	0.000	0.001	0.001
A4	0.000	0.000	0.000	0.004	0.000	0.000	0.001	0.002	0.001	0.001	0.000	0.000	0.000	0.001	0.003	0.003	0.003	0.003	0.002	0.003	0.002	0.004	0.001	0.001	0.001	0.001	0.002	0.001	0.002
A5	0.003	0.006	0.004	0.003	0.004	0.004	0.003	0.004	0.005	0.005	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.001	0.001	0.000	0.001	0.001
A6	0.001	0.003	0.001	0.002	0.002	0.000	0.000	0.001	0.001	0.001	0.002	0.000	0.000	0.001	0.002	0.002	0.002	0.001	0.002	0.002	0.001	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A7	0.001	0.005	0.003	0.001	0.004	0.000	0.000	0.006	0.002	0.001	0.002	0.001	0.001	0.003	0.002	0.002	0.002	0.002	0.005	0.003	0.001	0.000	0.001	0.001	0.000	0.001	0.001	0.001	0.002
A8	0.002	0.003	0.002	0.003	0.003	0.003	0.002	0.003	0.004	0.002	0.002	0.000	0.002	0.000	0.002	0.003	0.003	0.001	0.004	0.001	0.001	0.003	0.001	0.001	0.000	0.002	0.002	0.001	0.001
A9	0.001	0.001	0.001	0.000	0.001	0.001	0.000	0.002	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.002	0.001	0.003	0.003	0.000	0.001	0.001	0.001	0000	0.001	0.001	0.002	0.001	0.002

Table 4. Values of Sj and Rj.

Alternatives	Indicators																											
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29
A1	0.002	0.033	0.000	0.019	0.015	0.017	0.023	0.009	0.010	0.022	0.033	0.011	0.011	0.006	0.021	0.017	0.024	0.039	0.034	0.032	0.044	0.030	0.019	0.002	0.010	0.015	0.009	0.021	0.006
A2	0.000	0.006	0.006	0.029	0.034	0.028	0.019	0.003	0.011	0.006	0.007	0.009	0.008	0.004	0.013	0.017	0.019	0.034	0.023	0.023	0.013	0.051	0.014	0.003	0.007	0.007	0.003	0.012	0.000
A3	0.008	0.013	0.002	0.039	0.020	0.024	0.017	0.000	0.000	0.000	0.015	0.017	0.011	0.008	0.008	0.020	0.018	0.022	0.053	0.040	0.049	0.055	0.009	0.002	0.00	0.006	0.005	0.007	0.007
A4	0.000	0.000	0.003	0.032	0.000	0.003	0.005	0.018	0.009	0.007	0.000	0.000	0.000	0.010	0.028	0.029	0.041	0.044	0.019	0.039	0.017	0.057	0.013	0.008	0.018	0.009	0.020	0.016	0.019
A5	0.041	0.045	0.032	0.026	0.026	0.038	0.037	0.032	0.040	0.036	0.020	0.005	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.042	0.005	0.004	0.011	0.009	0.005	0.008	0.017
A6	0.010	0.025	0.011	0.019	0.012	0.000	0.002	0.006	0.009	0.010	0.026	0.009	0.004	0.005	0.018	0.019	0.035	0.011	0.018	0.024	0.012	0.025	0.000	0.000	0.004	0.000	0.000	0.000	0.004
A7	0.012	0.042	0.028	0.008	0.025	0.004	0.000	0.049	0.013	0.010	0.039	0.014	0.013	0.021	0.022	0.024	0.038	0.033	0.041	0.040	0.008	0.000	0.008	0.012	0.005	0.016	0.016	0.017	0.021
A8	0.023	0.021	0.021	0.025	0.019	0.032	0.024	0.024	0.033	0.015	0.039	0.013	0.035	0.003	0.021	0.035	0.041	0.017	0.033	0.016	0.013	0.043	0.015	0.018	0.010	0.022	0.022	0.015	0.010
A9	0.008	0.005	0.006	0.000	0.003	0.009	0.000	0.019	0.010	0.011	0.033	0.016	0.025	0.006	0.014	0.024	0.014	0.048	0.024	0.008	0.013	0.022	0.012	0.008	0.010	0.011	0.011	0.016	0.019

4.2 | Obtaining S, R, and Q

All matrix numbers were divided by the maximum f *Table 3*, and the formula was used to calculate the values of Sj and Rj *Table 4*. Finally, the values of -S, S*, -R, and R* were determined according to the formula in *Table 5*.

$$s_j = \sum_{i=1}^{n} w_i \cdot \frac{f_i^* - f_{ij}}{f_i^* - f_i^-};\ R_j = \max_i \left[w_i \cdot \frac{f_i^* - f_{ij}}{f_i^* - f_i^-} \right].$$

Table 5. Value of -S, S*, -R and R*.

-S	S*	-R	R*
0.658	0.317	0.057	0.035

4.3 | Obtaining the Values of S, R, and Q

Finally, the formula and the values of the previous phase were used to obtain S, R, and Q while ranking the criteria through Q. Each criterion with a lower Q will be considered more important, as specified in *Table 6*.

Table 6. Values of S, R, and Q.

S	R	Q
0.533	0.044	0.965
0.407	0.051	0.997
0.475	0.055	0.601
0.465	0.057	0.564
0.504	0.045	0.987
0.317	0.035	2.000
0.576	0.049	0.615
0.658	0.043	0.624
0.409	0.048	1.120

4.4 | Ranking by VIKOR

In response to the survey questions, the dimensions of R&D capabilities were ranked through a NPD approach within the Iranian automotive industry at Iran Khodro, shown in *Table 7*.

Table 7. Dimensions and factors contributing to R&D capabilities ranked through NPD Approach in Iran Khodro Corporation (IKCO).

No	Capabilities	Factor	Ranking by VIKOR
1	Financial resources capability	0.564	A4
2	Technology capability	0.601	A3
3	NPD process capability	0.615	A7
4	Management capability	0.624	A8
5	Research and design capability	0.965	A1
6	Organizational chart	0.987	A5
7	Customer and market	0.997	A2
8	Strategy capability	1.120	A9
9	Intellectual capital capability	2.000	A6

4.5 | Final Ranking

According to the results obtained in this study, the R&D department of Iran Khodro, with a NPD approach, ranked first to third, respectively, in financial capability, technology, and NPD. Moreover, customer capability, market strategy, and intellectual capital ranked seventh to ninth, respectively. The fourth to sixth was occupied by management capability, research and design, and organizational structure. The results were compared with the literature review and research model, finding that IKCO was performing better in financial and

technological capabilities. In contrast, it performed poorly in research and design capabilities, and customer and market and intellectual capital. Furthermore, the strategic capabilities and organizational structure were identical compared to the original model and the model. The output of this study was compared against the literature, as shown in *Table 8*.

Table 8. Comparing the output of this study through a literature review.

Capabilities ranking based on literature review		Capabilities ranking based on the current article	
Final	**Capabilities**	**Final Ranking**	**Capabilities**
1	Research and design capability	1	Financial resources capability
2	Customer and market	2	Technology capability
3	Technology capability	3	NPD process capability
4	Financial resources capability	4	Management capability
5	Organizational Chart	5	Research and design capability
6	Intellectual capital capability	6	Organizational Chart
7	NPD process capability	7	Customer and market
8	Management capability	8	Strategy capability
9	Strategy capability	9	Intellectual capital capability

5 | Conclusion

Given the importance of research and design capabilities, customer and market, intellectual capital, and rank lower than the original model, it is suggested that IKCO take the necessary actions in this regard. For example, the above capabilities can be increased through the following measures:

I. According to the new conditions in Iran forward and requests from a number of industrialized countries for a joint venture in Iran, it is suggested that such contracts be signed to gain the tacit knowledge of the industrialized countries, especially in the automotive industry, so as to acquire the new technical knowledge trough projects gradually. By acquiring this knowledge, the R&D departments are empowered, which in turn sets in motion the development of new products.

II. In signing contracts of participation with advanced industrial countries, however, it should be noted that the best technologies match several dimensions, such as technology life, sophistication, the pace of technology evolution, and its resulting value. For example, great care should be exercised in the technology life so that the technology is imported during the introduction and growth, i.e., when the research risks have been tackled and it is the right time to be utilized. As for the sophistication, the technology transfer should fit the technical capacity of the Iranian economy or at least one step ahead. Concerning the pace of technology, the Iranian infrastructure should provide the new transfer with survival conditions. Finally, on the aspect of added value, the new technology transfer to the country should bring about the greatest possible amount of added value. For example, the highest value-added in software systems can be found in engineering design, and the highest value-added for biotechnology lies in applied R&D.

III. It is suggested that R&D departments enhance their capacities through the development of new products from technology transfer to innovation in the products, which will then be transferred to target countries, generating a great deal of wealth.

IV. It is suggested that the R&D capacities be enhanced through joint R&D t contracts in the automotive industry with advanced countries so that the two parties engage in a particular technology, thereby sharing new research findings.

V. It is suggested that the automotive industry adopt the spin-off technique. In addition to good universities and research centers established, technological innovations should be utilized in the auto parts business. Thus, the relationships between universities and industry will be established to enhance the research potential.

VI. The intellectual capital can be enhanced by seriously building on knowledge management, thereby acquiring the tacit knowledge for all employees. Due to their specialized training over the years, the intellectual capital

in the automotive industry is one of the most valuable assets in the country. Knowledge management can be implemented to make the utmost use of the valuable capital.

VII. Given the great capacity of intellectual capital in the Iranian automotive industry, it is suggested that employee conditions be promoted in order to retain the workforce. Particularly, the R&D personnel who have valuable experiences regarding various business projects should be esteemed. Moreover, their ideas and suggestions should be taken more seriously.

VIII. One of the most important measures to enhance the capability of the market and customers in the automotive industry involves after-sales services. In fact, customer and market influence the mechanism and type of future R&D teams. Thus, it is suggested that IKCO provide customer-oriented after-sales services through the new model. In addition to after-sales service, customers will be able to directly contact the designers and experts in the R&D departments while leaving their ideas and suggestions about the new products. Such joint activities will ultimately lead to customer satisfaction with customers. This good feeling in customers will, in turn, promote customer loyalty while tackling the real defects in the products as expressed by the consumers.

Author Contributions

Hamid Hanifi was responsible for the conceptualization, methodology, and initial drafting of the study. Adel Azar contributed to the development of the structural equations, analysis, and final revisions of the manuscript. Both authors were involved in the literature review and the selection of the evaluation model for R&D capabilities.

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Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

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

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Appendices

Appendix 1. Pairwise Comparison Matrix.

Indicators	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29
C1	1	1	1	0.5	0.5	0.5	0.5	1	1	1	0.5	3	2	3	2	1	1	1	1	2	1	1	3	3	2	2	2	2	3
C2	1	1	1	0.5	0.5	0.33	0.5	1	1	1	0.5	3	2	3	3	2	2	1	1	2	2	2	2	2	2	2	2	2	2
C3	1	1	1	0.5	0.5	0.5	0.33	1	1	1	0.5	2	2	3	2	2	1	1	1	1	1	1	2	2	2	2	2	2	2
C4	2	2	2	1	0.5	0.5	2	2	2	1	1	1	1	3	2	1	0.5	0.33	0.33	1	0.33	0.33	2	2	2	2	2	2	2
C5	2	2	2	2	1	1	1	0.5	0.5	1	0.5	2	1	1	1	1	1	1	1	1	1	1	0.5	2	0.5	0.5	0.5	1	1
C6	2	3	2	2	1	1	2	2	2	2	2	1	0.33	2	0.5	0.5	0.5	0.33	0.33	0.5	0.33	0.33	2	2	2	1	1	1	1
C7	2	2	3	0.5	1	0.5	1	3	3	2	2	0.5	0.5	0.5	0.5	0.33	0.5	0.33	0.33	0.5	0.33	0.33	2	2	2	1	1	1	1
C8	1	1	1	0.5	2	0.5	0.33	1	1	1	1	2	2	2	3	2	2	2	2	2	1	1	3	2	3	3	3	2	2
C9	1	1	1	0.5	2	0.5	0.3	1	1	1	0.5	2	2	2	3	2	1	1	1	1	1	1	2	2	2	2	2	2	2
C10	1	1	1	1	1	0.5	0.5	1	1	1	0.5	2	2	2	2	1	1	0.5	0.5	1	1	1	2	2	2	2	2	2	2
C11	2	2	2	1	2	0.5	0.5	1	2	2	1	1	2	2	1	1	0.5	0.33	0.5	0.5	0.5	0.33	2	2	2	2	2	2	2
C12	0.33	0.33	0.5	1	0.5	1	2	0.5	0.5	0.5	1	1	0.33	0.5	0.5	0.5	0.5	0.33	0.33	0.5	0.33	0.33	0.5	0.5	0.5	0.5	0.5	0.5	0.5
C13	0.5	0.5	0.5	1	1	3	2	0.5	0.5	0.5	0.5	3	1	2	2	1	1	1	1	0.5	0.5	0.5	3	2	2	2	2	2	2
C14	0.33	0.33	0.33	0.33	1	0.5	2	0.5	0.5	0.5	0.5	2	0.5	1	0.5	0.33	0.5	0.33	0.33	0.5	0.33	0.33	2	2	2	1	1	1	1
C15	0.5	0.33	0.5	0.5	1	2	2	0.33	0.33	0.5	1	2	0.5	2	1	0.5	0.5	0.33	0.33	0.5	0.5	0.55	2	2	3	2	2	2	2
C16	1	0.5	0.5	1	1	2	3	0.5	0.5	1	1	2	1	3	2	1	1	0.5	0.5	0.5	0.5	0.5	2	2	3	2	2	2	2
C17	1	0.5	1	2	1	2	2	0.5	1	1	2	2	1	2	2	1	1	0.5	0.5	1	1	2	2	2	3	2	2	2	2
C18	1	1	1	3	1	3	3	0.5	1	2	3	3	1	3	3	2	2	1	0.5	0.5	0.5	0.33	3	3	2	2	2	2	2
C19	1	1	1	3	1	3	3	0.5	1	2	2	3	1	3	3	2	2	2	1	1	1	1	3	2	2	3	2	3	2
C20	0.5	0.5	1	1	1	2	2	0.5	1	1	2	2	2	2	2	2	1	2	1	1	0.5	0.33	2	2	2	2	2	2	2
C21	1	0.5	1	3	1	3	3	1	1	1	2	3	2	3	2	2	1	2	1	2	1	0.5	2	2	2	2	2	2	2
C22	1	0.5	1	3	1	3	3	1	1	1	3	3	2	3	2	2	0.5	3	1	3	2	1	3	2	2	2	2	3	3
C23	0.33	0.5	0.5	0.5	2	0.5	0.5	0.33	0.5	0.5	0.5	2	0.33	0.5	0.5	0.5	0.5	0.33	0.33	0.5	0.5	0.33	1	1	1	1	1	1	1
C24	0.33	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	2	0.5	0.5	0.5	0.5	0.5	0.33	0.5	0.5	0.5	0.5	1	1	1	1	1	1	1
C25	0.5	0.5	0.5	0.5	2	0.5	0.5	0.33	0.5	0.5	0.5	2	0.5	0.5	0.33	0.33	0.33	0.5	0.5	0.5	0.5	0.5	1	1	1	0.5	0.5	0.5	0.5
C26	0.5	0.5	0.5	0.5	2	1	1	0.33	0.5	0.5	0.5	2	0.5	1	0.5	0.5	0.5	0.5	0.33	0.5	0.5	0.5	1	1	2	1	1	1	1
C27	0.5	0.5	0.5	0.5	2	1	1	0.33	0.5	0.5	0.5	2	0.5	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	1	2	1	1	1	1
C28	0.5	0.5	0.5	0.5	1	1	1	0.5	0.5	0.5	0.5	2	0.5	1	0.5	0.5	0.5	0.5	0.33	0.5	0.5	0.33	1	1	2	1	1	1	1
C29	0.33	0.50	0.50	0.50	1.00	1.00	1.00	0.50	0.50	0.50	0.50	2.00	0.50	1.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.33	1.00	1.00	2.00	1.00	1.00	1.00	1
Total	27.15	26.49	28.83	32.33	33	36.33	41.46	23.65	27.33	28.5	31.5	59.5	32.49	53.5	43.33	31.49	25.33	24.97	19.47	27	21.15	19.68	54	51.5	56	46.5	45.5	47	47

Appendix 2. Importance coefficient matrix.

Weights	Components	0.041			0.037				0.041			0.030			0.028			0.048			0.049			0.018			0.021			
	Factors																													
	Indicators	0.041	0.045	0.039	0.039	0.034	0.038	0.037	0.049	0.040	0.036	0.039	0.017	0.035	0.021	0.028	0.053	0.041	0.048	0.057	0.040	0.049	0.057	0.019	0.018	0.018	0.022	0.022	0.021	0.021
	factors																													

Appendix 3. Normal matrix.

Alternatives	Indicators																										
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	29
A1	15.8	9.9	16.2	11.6	11.3	11.7	9.9	14.5	14.1	10.5	12.8	14.0	14.7	14.3	12.7	14.8	13.7	13.0	11.9	13.5	11.3	17.0	10.8	15.0	13.3	12.3	13.9	11.6	15.6
A2	16.2	15.7	14.9	9.6	5.8	9.6	10.6	15.8	13.7	14.7	16.2	14.6	15.2	15.4	15.1	14.7	14.4	13.6	13.9	14.7	16.2	14.6	12.2	14.7	14.4	14.6	16.0	14.1	17.9
A3	14.8	14.1	15.7	7.8	9.6	10.2	10.9	16.4	16.8	16.6	15.1	12.5	14.8	13.3	16.9	14.1	14.4	15.0	8.7	12.4	10.6	14.1	13.7	15.0	17.0	14.8	15.6	16.0	15.2
A4	16.2	17.0	15.5	9.1	16.8	14.6	13.0	12.7	14.4	14.4	17.2	17.1	16.2	12.0	10.8	12.0	11.6	12.4	14.6	12.5	15.4	14.0	12.5	13.1	10.6	14.0	10.6	12.8	11.3
A5	9.6	7.8	8.4	10.2	7.8	7.8	7.8	10.2	7.3	7.3	14.4	15.5	13.8	17.4	19.6	19.1	17.0	17.9	18.6	18.1	18.5	15.6	15.2	14.4	12.8	14.0	15.4	15.5	11.9
A6	14.4	11.6	13.7	11.6	12.3	15.2	13.7	15.2	14.4	13.7	13.7	14.4	15.7	14.8	13.6	14.4	12.3	16.4	14.8	14.6	16.4	17.6	16.8	15.8	15.4	16.5	17.3	18.3	16.5
A7	14.1	8.4	10.3	14.0	8.1	14.3	13.9	7.6	13.2	13.8	12.0	13.3	14.6	7.5	12.5	13.2	12.0	13.7	10.7	12.4	17.0	20.7	14.0	12.0	14.9	12.0	11.8	12.7	10.8
A8	12.3	12.4	11.6	10.5	9.7	8.8	9.7	11.6	8.7	12.3	12.0	13.5	11.9	15.8	12.8	10.8	11.6	15.7	12.0	15.8	16.2	15.4	11.9	10.2	13.3	10.7	9.9	13.1	14.1
A9	14.8	15.8	14.8	15.8	14.0	13.2	14.0	12.5	14.1	13.3	12.8	12.7	13.1	14.1	14.8	13.2	15.0	11.9	13.6	17.0	16.5	18.0	12.7	13.6	13.2	13.5	10.9	13.0	11.2
SUM	128.2	112.6	121.1	100.3	96.9	105.5	103.4	116.7	116.8	116.6	126.4	127.7	130.1	124.8	128.9	126.4	121.6	129.5	118.9	121.0	138.0	147.0	119.7	123.7	124.9	122.3	121.3	127.2	124.4

Appendix4. Normal matrix square root.

Alternatives	Indicators																												
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29
A1	0.351	0.297	0.366	0.340	0.341	0.333	0.309	0.353	0.347	0.300	0.318	0.331	0.337	0.338	0.314	0.342	0.335	0.316	0.316	0.321	0.286	0.340	0.300	0.348	0.327	0.316	0.339	0.302	0.354
A2	0.355	0.373	0.351	0.309	0.244	0.302	0.320	0.368	0.342	0.356	0.358	0.338	0.342	0.352	0.343	0.342	0.343	0.324	0.342	0.335	0.342	0.315	0.319	0.344	0.339	0.345	0.363	0.333	0.379
A3	0.340	0.353	0.360	0.280	0.315	0.311	0.324	0.375	0.379	0.377	0.3460	0.313	0.338	0.327	0.362	0.334	0.344	0.340	0.271	0.307	0.277	0.310	0.338	0.348	0.369	0.348	0.359	0.355	0.350
A4	0.355	0.388	0.358	0.302	0.417	0.372	0.354	0.330	0.352	0.352	0.369	0.366	0.353	0.311	0.289	0.308	0.308	0.309	0.350	0.309	0.335	0.308	0.324	0.326	0.291	0.338	0.295	0.317	0.301
A5	0.274	0.264	0.263	0.319	0.284	0.273	0.275	0.296	0.250	0.250	0.338	0.349	0.325	0.374	0.390	0.389	0.373	0.372	0.395	0.372	0.366	0.326	0.356	0.341	0.320	0.338	0.357	0.349	0.305
A6	0.336	0.320	0.336	0.339	0.356	0.380	0.364	0.361	0.352	0.343	0.329	0.336	0.347	0.345	0.325	0.337	0.317	0.356	0.353	0.334	0.345	0.346	0.375	0.357	0.351	0.367	0.378	0.380	0.364
A7	0.332	0.273	0.292	0.373	0.289	0.368	0.367	0.255	0.337	0.344	0.309	0.323	0.335	0.245	0.312	0.324	0.313	0.325	0.300	0.308	0.351	0.375	0.342	0.311	0.345	0.313	0.311	0.317	0.294
A8	0.309	0.332	0.309	0.323	0.317	0.289	0.307	0.316	0.273	0.324	0.309	0.326	0.303	0.356	0.315	0.292	0.309	0.348	0.318	0.347	0.342	0.324	0.315	0.288	0.327	0.296	0.285	0.321	0.33
A9	0.340	0.374	0.350	0.397	0.400	0.354	0.368	0.328	0.348	0.338	0.318	0.315	0.317	0.336	0.339	0.324	0.351	0.303	0.338	0.360	0.346	0.350	0.325	0.332	0.326	0.332	0.300	0.319	0.300

Appendix 5. Normal Weighted Matrix.

Alternatives	Indicators																												
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29
A1	0.014	0.013	0.014	0.013	0.012	0.013	0.011	0.017	0.014	0.011	0.012	0.006	0.012	0.007	0.009	0.012	0.014	0.015	0.017	0.013	0.014	0.019	0.006	0.006	0.006	0.007	0.007	0.006	0.007
A2	0.015	0.017	0.013	0.012	0.008	0.012	0.012	0.018	0.014	0.013	0.014	0.006	0.012	0.007	0.010	0.012	0.014	0.016	0.018	0.014	0.017	0.018	0.006	0.006	0.006	0.007	0.008	0.007	0.008
A3	0.014	0.016	0.014	0.011	0.011	0.012	0.012	0.018	0.015	0.014	0.013	0.005	0.012	0.007	0.010	0.012	0.014	0.016	0.014	0.012	0.014	0.018	0.006	0.006	0.007	0.008	0.008	0.007	0.007
A4	0.015	0.018	0.014	0.012	0.014	0.014	0.013	0.016	0.014	0.013	0.014	0.006	0.012	0.006	0.008	0.011	0.013	0.015	0.019	0.012	0.016	0.018	0.006	0.006	0.005	0.007	0.006	0.007	0.006
A5	0.011	0.012	0.010	0.013	0.010	0.010	0.010	0.014	0.010	0.009	0.013	0.006	0.011	0.008	0.011	0.014	0.015	0.018	0.021	0.015	0.018	0.019	0.007	0.006	0.006	0.007	0.008	0.007	0.006
A6	0.014	0.015	0.013	0.013	0.012	0.014	0.013	0.018	0.014	0.012	0.013	0.006	0.012	0.007	0.009	0.012	0.013	0.017	0.019	0.013	0.017	0.020	0.007	0.007	0.006	0.008	0.008	0.008	0.008
A7	0.014	0.012	0.011	0.015	0.010	0.014	0.013	0.012	0.013	0.012	0.012	0.005	0.012	0.005	0.009	0.011	0.013	0.016	0.016	0.012	0.017	0.021	0.006	0.006	0.006	0.007	0.007	0.006	0.006
A8	0.013	0.015	0.012	0.013	0.011	0.011	0.011	0.015	0.011	0.012	0.012	0.005	0.011	0.007	0.009	0.010	0.013	0.017	0.017	0.014	0.017	0.018	0.006	0.005	0.006	0.006	0.006	0.007	0.007
A9	0.014	0.017	0.013	0.016	0.013	0.014	0.013	0.016	0.014	0.012	0.012	0.005	0.011	0.007	0.010	0.011	0.014	0.015	0.018	0.014	0.017	0.020	0.006	0.006	0.006	0.007	0.007	0.007	0.006