Journal of System Management (JSM)
Online ISSN: 2538-1571, Print ISSN: 2322-2301
Doi: 10.30495/JSM.2022.1964456.1671
9(1), 2023, pp. 37-52

Received: 30/07/2022
Accepted: 10/10/2022

RESEARCH ARTICLE **Open Access**

Designing a Model for Implementing the Fourth Generation Industry to Achieve Sustainable Development Goals in the Automotive Industry (Case Study: Iran Khodro Company)

Amir Ardehi [1], Habibollah Javanmard [2*], Nazanin Pilevari [3]

Abstract
The automotive industry, as a job-creating and infrastructure industry, needs an executive model for success in the domestic and international markets. In this regard, the present study has been conducted with the aim of designing a model for implementing the fourth generation industry to achieve sustainable development goals in Iran KhodroCompany. The study is an applied-developmental study in terms of purpose and cross-sectional survey research. Also, in this study, a mixed research method (qualitative-quantitative) was used. Content analysis method and MaxQDA software were used for data analysis in the qualitative section. Then, using Interpretive Structural Modeling (ISM) with MICMAC software, the initial pattern was drawn. In the quantitative section, one-sample t-test and SPSS software were used to measure the current situation. The research findings showed that the Collection and Analysis of Big Data affects the Simulation and Automatic Robots. These factors affect horizontally and vertically integration systems and thus lead to the Internet of Industrial Things, Augmented Reality and Cyber Security. Further, through the Cloud Computing system, Additive Manufacturing is affected and this Additive Manufacturing leads to Sustainable Development.
Keywords: *Industry 4.0, Sustainable development, Automotive industry, Mixed approach, Big Data Analytics*

Introduction

The modern world is faced with the emergence and application of a new generation of industrial revolution known as 4.0 industries. Modern production system using information technology and achieving social sustainability is one of the main pillars of this industry. Industries 4.0 bring new technologies to maximize output with optimal use of raw materials in production (Kamble et al., 2018). The fourth industrial revolution can be seen as a revolutionary change that occurred simultaneously with the development of information technology in all revolutions, the second and the third. In other words, Industries 4.0 is the result of the horizontal expansion of information technology. Therefore, these

[1]. Department of Industrial Management, Science and Research Branch, Islamic Azad University, Tehran, Iran
[2*]. Department of Industrial Management, Arak Branch, Islamic Azad University, Arak, Iran (Corresponding author: h-javanmard@iau-arak.ac.ir)
[3]. Health & Industry Research Center, West Tehran Branch, Islamic Azad University, Tehran, Iran

industries create a creative connection between technology and the market in all industries based on information technology, which is actually an open and creative combination of technology and the market in the context of open innovation or growth based on the open business model. (Koushan&Ebrahimi, 2021).

The fourth generation industrial revolution includes all developments that have fundamentally changed the traditional production environment (Dinçeret al., 2022). The fourth industrial revolution is not an unmanned factory. With more use of information technology, creating a human centered organization which has value for all stakeholders it's too important. In this structure there are concepts like Internet, connected products, machines, people, organizations, and virtualization. With the fourth industrial revolution, modern automation systems, data exchange and technology are widely used. (Monazzemi, 2021).

One of the industries in which the use of the fourth generation of the industry can be transformative is the automotive industry. Application and development of innovation and new technologies in automobile production is one of the factors of competitive automobile production (Neyshabouriet al., 2019). Automotive companies and industries related to this field are moving towards the fourth generation of industry by using the facilities provided by technology (Lin et al, 2018). The fourth industrial revolution has brought many changes in the automotive industry. Companies that have adapted themselves to new industrial developments earlier have been able to enjoy more competitiveness (Chandriah&Raghavendra., 2019). Applying and developing the requirements related to the fourth generation industrial revolution in the automotive industries requires extensive strategic planning and this development requires a detailed understanding of the necessary infrastructure. This issue should be done with more considerations, especially in developing countries (Verma&Venkatesan, 2021).

On the other hand, sustainability is the core of 4.0 industries and is based on three economic, social and environmental pillars. In order to achieve sustainability goals, major changes in the existing economic system are required, which is referred to as circular economyand its executive lever is the changes in the current business model (Khan et al., 2021). Sustainability is an important issue which is also emphasized in the country's automobile industry. One of the strategic goals of the automotive industry is to improve sustainability. Companies active in this industry have adopted new management strategies to achieve sustainability in the production supply chain (Eizadyer et al., 2021). The automotive industry, as an old and important industry that accounts for a large share of the country's GDP, in all parts of its life cycle, from the exploitation of natural resources to the manufacture, production, consumption and then direct and indirect consumption.(Alahyari&Pilevari, 2020).In general, the sustainable developmentof the country based on the local criteria and priorities contained in the upstream documents, including the vision document for the economic, social and cultural development of the Islamic Republic of Iran 1404 in all economic fields, including the automotive industry is desired (Azimi et al., 2021). achieving sustainable development or promoting it are of the most important concerns of societies, since the sustainable development leads to providing basic needs and improving living standards for all, better preserving and managing ecosystems and, in general, providing a safer and more prosperous future for humankind (Ghahremani&Ardestani, 2019).

Finally, the statistics show the importance of the automotive industry in Iran and the current business world. If the automobile industry is considered as a country, it will be equivalent to

the seventh largest economy in the world. 30% growth in the last 10 years, financial turnover of more than 2790 billion dollars and direct and indirect employment of more than 48 million people indicate the importance of this industry in the world (Jamali, 2016). Since the country of Iran is far away from the advanced industrial countries and many technologies enter this country late, so far no significant measures have been taken to enter the 4.0 industry in the country's automobile industry. On the other hand, due to the new nature of the fourth generation industry concept, not much academic research has been done in this field and there is a very large research gap in this field. With regard to the above, the current research as a pioneering study seeks to designing a model for implementation of the fourth generation industry in order to achieve the goals of sustainable development in the automobile industry (case study: Iran Khodro Company). In this research, the main question is addressed, what are the indicators of the fourth generation of industry in Iran Khodro Company and what is the pattern of causal relationships between them?

Literature Review

The fourth generation of the industry

The term fourth industrial revolution is the Latin translation of "Industries 4.0" in the German language, which was introduced in 2011 during a hi-tech project in the state industries of Germany in the city of Hanover. This term expressed a new generation of industry based on intelligentization and the use of technology, which emerged after the previous three periods of the industrial revolution (Xu et al., 2021). The first industrial revolution caused a change in the production process from agriculture to factory products. The second revolution was during the First World War when steel and electrical installations and mass production entered the field of industry, finally the third industrial revolution led to the change of analog technology, mechanics and electronics to digital technology. The fourth industrial revolution is the move towards digitalization (Nara et al., 2021). The fourth industrial revolution has fundamentally affected the business model and the economic system to the concept of determining the relations of economic and productive life of man. The most important economic effect of this revolution is the establishment and spread of the digital economy with the direction of sustainable economic growth, which is the main focus of policy in developed economies (Asadi, 2019).

After the first industrial revolution, almost a century later, we see that the world has entered the second stage of the industrial revolution. The second stage from the end of the 19th century and with the development of science by scientists such as Niels Bohr, Nikola Tesla and Albert Einstein led to the emergence of new sources of energy such as electricity, gas and gasoline. The result of this industrial revolution was the production of internal combustion engines, whose technology was improved in a short period of time, another important point of this stage was the increase in demand for steel and the expansion of communication methods such as telegraph and telephone. Finally, at the beginning of the 20th century, inventions such as airplanes and automobiles led to the second industrial revolution being referred to as the most important industrial revolution today (Akbari et al., 2019).In the second half of the 20th century, we saw the emergence of another source of energy that was unusable before, nuclear energy! Also, the third industrial revolution brought the emergence of electronics, remote communication and computers, and through these new technologies, the possibility of space travel and biotechnology was realized in this period, and it caused significant progress in the field of research. Also, the third industrial revolution brought the emergence of

electronics, remote communication and computers, and through these new technologies, the possibility of space travel and biotechnology was realized in this period, and it caused significant progress in the field of research. In this period, two important inventions, PLC and robots, caused a significant development in the field of industrial automation, as a result of which, due to the limitations that no longer existed, machines were preferred over humans, machines that could produce similar products within a few hours and produce perfectly (Bagheri et al., 2016).

The fourth industrial revolution is a revolution that is expanding every day. The term 4.0 originates from an ultra-advanced project that was being carried out by the German government in 2011, which was publicly introduced at the Hanover Fair in the same year. Now this revolution has provided the necessary grounds to achieve the goals of sustainability and social responsibility of companies (Grybauskas et al., 2022). This revolution is expanding virtual reality, by means of which we can control everything that have been produced in previous industrial revolutions automatically and remotely. The Internet, artificial intelligence, human-machine interfaces, robotics and cyber-physical systems that enable autonomy and communication between machines independently of humans by combining real and virtual technologies are the most important features of this industrial revolution. In this period, the size of companies does not guarantee survival, but their agility in responding to changes is the key to the success of companies; in this period, it is no longer big companies that swallow small companies, but fast companies (quick response to changes) that swallow slow companies. With a general look at the industrial revolutions, we realize that man is always looking for the simplest solution to carry out his activities, that all these stages have been created in the same direction and in acceleration of the previous stages (Devezas&Sarygulov, 2017).

Automotive Industry

Automotive industry includes all aspects of design, development, production, market and sale of motor vehicles. A collection of companies and factories that are involved in the design, manufacture, marketing and sale of motor vehicles are part of this industry. In 2008, more than 70 million motor vehicles, which include regular cars and commercial vehicles, have been produced worldwide. In 2018, a total of (91.9 million) car were sold in the world, 32.9 million in Europe, 26.4 million in Asia-Pacific, 24.4 million in the US and Canada, 4.4 million in Latin America. 2.4 million Were sold in the Middle East and 1.4 million in Africa. While the market was stagnant in America and Japan, Asia and South America grew and became strong. It also seems that the big markets of Russia, Brazil, India and China have grown very fast (Lee & Tan, 2019).

The automotive strategic industry is the world's largest industry and the second major economic activity after banking. This industry has become the foundation of national industries and can reflect the overall production level of the country's industries. Adopting efficient and operational policies and policies is the first step to achieve the goals of this industry (Koushan&Ebrahimi, 2021). From this point of view, the automobile industry and the two largest automobile manufacturers of the country, namely Saipa and Iran Khodro, have always been the special attention of the government and parliament. The governing regulatory bodies are trying to lead this industry to success by adopting appropriate policies (Karimpour et al, 2018). Nevertheless, Iran's failure in the field of automobile industry is evident and various reasons have been proposed for this. One of the main reasons is the weakness of planning and coherent policies and efficient policies in the

field of automobile manufacturing (Hoseini&Saee, 2017).

Iran's automotive industry has always suffered from problems that appear more prominently at certain times. Each of the policymakers and officials in different governments have made different analyzes about this industry and have proposed different solutions, but despite all the efforts, today we see that not only the problems have not been solved, but they have also intensified (Fartoukzadeh&Tahmasabi, 2020). Establishing a temporary monopoly, tariff support, and helping to finance some of the rents provided to the automobile industry in order to push the country's economy forward as a driving industry. However, this industry in our country has not been able to progress as it should and get closer to global competitors. Therefore, it is necessary to review the policy of the automobile industry (Nadiri et al, 2020).

However, domestic car manufacturers have been able to market their products by using government support and various and attractive sales methods. In this situation, however, the general experts and even some activists of the automobile industry believe that in order to change the current conditions and satisfy the domestic customers and of course to be present in the global markets, this industry should go for new patterns and models and through them is updated slowly. There is no doubt that improving the quality level of cars requires the absorption of global technology and modern technical knowledge, just as reducing production costs and providing standard after-sales services also requires modeling successful global methods. In this situation, different methods are proposed to change the direction of Iran's automobile industry and absorb modern technical knowledge and, as a result, provide products with appropriate price and quality levels and standard services (Esmaeilpour et al, 2017).

Research Methodology

The purpose of this research is to design the implementation model of the fourth generation of the industry in order to achieve the goals of sustainable development in Iran KhodroCompany. From the point of view of the purpose of this research, it is an applied-developmental research, and based on the method of data collection, it is a non-experimental (descriptive) study of the cross-sectional research type. In terms of the nature of the data, it is a mixed research (qualitative-quantitative).

The statistical population of the research includes managers of information technology and research and development of Iran Khodro. The sample size in qualitative studies is usually between 5 and 20 people. Nevertheless, expert interviews should continue until theoretical saturation is achieved. Also, for sampling the qualitative part, it is better to use non-probability and purposive methods. (Paripour et al., 202١; Azizzadeh et al., 2021). In this study, sampling of the qualitative part was done in a targeted way and theoretical saturation was achieved with 8 interviews.

The tool for collecting research data in the qualitative part is a semi-structured interview and in the quantitative part is the ISM standard questionnaire.Holsti coefficient was used to assess the validity of the interview results. The "percentage of observed agreement" or PAO was obtained by calculating the Holsti coefficient of 0.719, which is an acceptable value (Holsti, 1969).

To analyze the data in the qualitative section, the content analysis method and MaxQDA software were used. Finally, quantitative analysis was done to measure the current situation with one-sample t-test and SPSS software.

Research Findings

In the qualitative part, the point of view of 8 IT and R&D managers of Iran Khodro was used. In terms of gender, 6 people were male and 2 were female. In terms of age, 1 person was less than 40 years old, 5 people were between 40 and 50 years old, and 2 people were over 50 years old. In terms of education, 1 of the experts had a master's degree and 7 had a doctorate. Finally, 3 people have between 10 and 20 years of work experience and 5 people have more than 20 years of work experience.

In the first step, using the qualitative content analysis method, it was attempted to identify the underlying factors of the implementation model of the fourth generation of the industry in order to achieve the goals of sustainable development. Since the aim was to present a local model, therefore, the perspective of the information technology and research and development managers of Iran Khodro Company was used to identify the factors.The views of the managers were collected through a semi-structured interview in such a way that 5 open questions were considered in the interview protocol and new questions were asked during the interview process as expected. To get acquainted with the depth and scope of the data content, the data was read repeatedly and actively (searching for meanings and patterns).

Content analysis was done with the method proposed by (Krippendorff, 2018) including main categories and basic codes. The results of the interviews were analyzed using the content analysis method. For this purpose, the text of the interviews was read and reviewed several times. The data was then broken down into semantic units in the form of sentences and paragraphs related to the main meaning. The semantic units were reviewed several times and then the appropriate codes of each semantic unit were written and the codes were classified based on the semantic similarity. The analysis process was repeated in the same way with the addition of each interview. The text of the interviews, which was previously entered into the software as a text file, was studied many times, and their key points were entered into MaxQDA software as code. In the open coding stage, 521 codes were identified. Finally, 10 main categories and 60 basic contents were obtained through axial coding. The basic categories of the implementation model of the fourth generation of the automotive industry are presented in Table 1.

Table 1

Categories of the implementation model of the fourth generation of the automotive industry in line with sustainable development

Main categories	Basic codes
Big Data Analysis	1. Supply chain planning
	2. Enterprise resource planning (ERP)
	3. Customer relationship management (CRM)
	4. Logistics management
	5. Research and development (R&D)
	6. Enterprise asset management (EAM)
Simulation	7. Virtual simulation of machines, products, processes based on real data
	8. Intelligent maintenance system of machines and intelligent maintenance of products
	9. Testing and optimizing machine settings in the virtual environment before applying them in the real environment
	10. reducing machine downtime
	11. Creating innovative business models

Main categories	Basic codes
	12. Improving consumer experience and increasing customer lifetime value
	13. Improving product quality and safety
The Industrial Internet of Things	14. Managing the work process of employees through smart devices
	15. Sensors and control equipment using artificial intelligence to control production processes
	16. Energy recovery from waste/residues and production waste
	17. Optimizing business processes with advanced technologies
	18. Creating a more flexible workplace for employees
	19. Monitoring employee health continuously by devices
	20. Reducing production costs
horizontal and vertical integration systems	21. Creating an integrated global data network and mechanized value chain, collaborating with stakeholders (producers, suppliers and consumers) along the value chain.
	22. Mass production of customized and exclusive products
	23. Transforming traditional supply chains into a digital supply network (DSN) and integrating customers and products into it
	24. Sharing data and applying advanced and predictive analytics
	25. Integration by Internet of Service (IoS) and Internet of People (IoP)
	26. Product as a Service (PaaS) business model development
Cyber security	27. Enact strict laws to prevent illegal activities
	28. Protecting people's information against possible abuse
	29. Increasing security in cyberspace and privacy
	30. Protection of sensitive industrial systems and important production lines against cyber attacks
	31. Evaluating the effects of cyber attacks
Additive Manufacturing	32. Digital modification of products before physical production
	33. reducing the processing times, resources and tools needed
	34. accelerate product innovation and assists co-design activities
	35. Promote more customized products
	36. Reducing production waste and physical transportation and logistics processes
Industrial automatic robots	37. Doing dangerous work and being in tight and hard-to-reach places
	38. Using robots in ergonomically unfavorable workstations
	39. Carrying out monotonous and repetitive tasks
	40. Industrial automation and reduction of human errors
	41. preserve employees' health and productivity in the long view
	42. Increase employee satisfaction and motivation
Augmented Reality	43. Simultaneous combination of real world and virtual images
	44. Adding live physical appearance, directly or indirectly to real-world elements
	45. AVR offers one the most effective ways of industrial training
	46. AVR offers more affordable, safer, faster and more productive learning
	47. Practice dangerous or sensitive repairs and increasing the readiness of personnel

Main categories	Basic codes
Cloud Computing	48. Having access to applications and documents
	49. Improve order fulfillment process by enabling real-time information
	50. Enhancing communication and responsiveness throughout the supply chain
	51. Access to information in real time
	52. Enhancing responsiveness and reduced inefficiencies through eliminating bullwhip effect
Sustainable Development	53. Increasing production efficiency and productivity
	54. Reducing production costs and achieving profitability
	55. Improving the competitiveness of production
	56. Continuous and sustainable increase in the country's economic growth
	57. Creating environmental, social and economic opportunities
	58. Environmental sustainability via sustainable energy
	59. Reducing environmental damage
	60. Reducing toxic and greenhouse gas emissions

The main categories of the fourth generation of the automotive industry are: Horizontal and Vertical System Integration (HVSI), Big data collection and analysis (BDI), simulation(SIM), Automatic robots(IAR), Industrial Internet of Things (IIOT), Augmented Reality (AR), Cloud computing system (CC), sustainable development (SD), Cyber security (CS), Additive manufacturing (AM). These factors were used to design the initial model of the fourth generation of the automotive industry in line with sustainable development.Interpretive Structural Modeling (ISM) method was used to design the model and for this purpose, the structural self-interaction matrix (SSIM) was first developed.

Establishing contextual relationships

To establish and identify the direction of the relationship among each pair of variables, the ISM technique uses the following symbols:

V: Function i determines function j;

A: Function i is determined by function j;

X: Functions i and j determine each other;

O: Functions i and j are unrelated

The structural self-interaction matrix (SSIM) is presented in Table 2.

Table 2

The structural self-interaction matrix (SSIM) of the fourth generation automotive industry in line with sustainable development

SSIM	HVSI	BDI	SIM	IAR	IIOT	AR	CC	SD	CS	AM
Integrated Systems(HVSI)		A	A	A	V	V	O	V	V	V
Big Data Collection and Analysis (BDI)			V	V	V	V	V	V	V	O
Simulation (SIM)				X	V	V	V	V	O	V
Automatic Robots (IAR)					V	V	V	V	V	V
Industrial Internet of Things (IIOT)						V	V	O	X	V
Augmented Reality (AR)							V	V	X	V
Cloud Computing System (CC)								V	A	V
Sustainable Development (SD)									A	A
Cyber Security (CS)										V
Additive Manufacturing (AM)										

Establishing the Initial reachability matrix

Initial reachability matrix (IRM) is a binary matrix that is established by replacing V, A, X, O symbols in the SSIM with 1 or 0 values under the following replacement rules(Govindan et al., 2015; Kaswan and Rathi, 2019):

-If the (i,j) entry in the SSIM is V, then entry (i,j) in the reachability matrix is set to 1, while entry (j,i) is set to 0.

-If the (i,j) entry in the SSIM is A, then entry (i,j) in the reachability matrix is set to 0, while entry (j,i) is set to 1.

-If the (i,j) entry in the SSIM is X, then both (i,j) and (j,i) entries in the reachability matrix are set to 1.

-If the (i,j) entry in the SSIM is 0, then in the reachability matrix both entry (i,j) and (j,i) are set to 0.

Establishing the final reachability matrix

The Final Reachability Matrix (FRM) is developed by subjecting the interrelationships within the IRM to the transitivity property (Dev and Shankar, 2016; Thirupathi and Vinodh, 2016). The transitivity of contextual relations is an underlying assumption of the ISM technique, whichassumes that if function A determines function B and function Bdetermines function C, then function A necessarily determinesfunction C (Fathi et al., 2019).The Final Reachability Matrix (FRM) is presented in Table 3.

Table 3.

The Final Reachability Matrix (FRM) of the fourth generation of the automotive industry in line with sustainable development

TM	HVSI	BDI	SIM	IAR	IIOT	AR	CC	SD	CS	AM
Integrated Systems(HVSI)	1	0	0	0	1	1	1*	1	1	1
Big Data Collection and Analysis (BDI)	1	1	1	1	1	1	1	1	1	1*
Simulation (SIM)	1	0	1	1	1	1	1	1	1*	1
Automatic Robots (IAR)	1	0	1	1	1	1	1	1	1	1
Industrial Internet of Things (IIOT)	0	0	0	0	1	1	1	1*	1	1
Augmented Reality (AR)	0	0	0	0	1	1	1	1	1	1
Cloud Computing System (CC)	0	0	0	0	0	1	1	1	0	1
Sustainable Development (SD)	0	0	0	0	0	0	0	1	0	0
Cyber Security (CS)	0	0	0	0	1	1	1	1	1	1
Additive Manufacturing (AM)	0	0	0	0	0	0	0	1	0	1

After forming the reachability matrix, to determine the relationships and leveling of the fourth generation of the automotive industry in line with sustainable development, "reachability set" and "prerequisite set" should be identified. Reachability set (output or impacts) for the C_i variable, includes the variables that can be reached through the variableC_i. Prerequisite set (inputs or effects) includes the variables through which the variable C_i can be reached. The set of inputs and outputs to determine the level is presented in Table 4.

Table 4.

The set of reachabilitiesand prerequisites of the fourth generation of the automotive industry in line with sustainable development

Variables	Output: Impacts	Inputs: Effects	Common Collection
Integrated Systems(HVSI)	HVSI,IIOT,AR,CC,SD,CS,AM	HVSI,BDI,SIM,IAR	HVSI
Big Data Collection and Analysis (BDI)	HVSI,BDI,SIM,IAR,IIOT,AR, CC,SD,CS,AM	BDI	BDI

Variables	Output: Impacts	Inputs: Effects	Common Collection
Simulation (SIM)	HVSI,SIM,IAR,IIOT,AR,CC,SD,CS,AM	BDI,SIM,IAR	SIM,IAR
Automatic Robots (IAR)	HVSI,SIM,IAR,IIOT,AR,CC,SD,CS,AM	BDI,SIM,IAR	SIM,IAR
Industrial Internet of Things (IIOT)	IIOT,AR,CC,SD,CS,AM	HVSI,BDI,SIM,IAR,IIOT,AR,CS	IIOT,AR,CS
Augmented Reality (AR)	IIOT,AR,CC,SD,CS,AM	HVSI,BDI,SIM,IAR,IIOT,AR,CS	IIOT,AR,CS
Cloud Computing System (CC)	CC,SD,AM	HVSI,BDI,SIM,IAR,IIOT,AR,CC,CS	CC
Sustainable Development (SD)	SD	HVSI,BDI,SIM,IAR,IIOT,AR,CC,SD,CS,AM	SD
Cyber Security (CS)	IIOT,AR,CC,SD,CS,AM	HVSI,BDI,SIM,IAR,IIOT,AR,CS	IIOT,AR,CS
Additive Manufacturing (AM)	SD,AM	HVSI,BDI,SIM,IAR,IIOT,AR,CC,CS,AM	AM

Therefore, Sustainable development variable (SD) is at the first level. According to the output of ISM calculations, the Additive manufacturing variable (AM) is at level two.Augmented reality (AR) and cloud computing (CC) variables are at the third level. Cyber security (CS) and Industrial Internet of Things (IIOT) variables are at the fourth level, and the horizontal and vertical integration systems (HVSI) variable is at the fifth level. Simulated (SIM) and Automated Robots (IAR) variables are the sixth level and finally, the Big data collection and analysis (BDI) is the most basic element of the model. Also, the outputs and inputs of each variable show the Drive Power and Dependence Power of that variable, respectively. The Drive-dependence power of the studied variables is presented in Table 5.

Table 5

The Drive Power and the Dependence Power of the fourth generation of the automotive industry in line with sustainable development

Research variables	Dependence Power	Drive Power
Integrated Systems(HVSI)	4	7
Big Data Collection and Analysis (BDI)	1	10
Simulation (SIM)	3	9
Automatic Robots (IAR)	3	9
Industrial Internet of Things (IIOT)	7	6
Augmented Reality (AR)	7	6
Cloud Computing System (CC)	8	3
Sustainable Development (SD)	10	1
Cyber Security (CS)	7	6
Additive Manufacturing (AM)	9	2

Based on the Drive-dependence power diagram, The variables of “Big Data Collection and Analysis (BDI)”, “Simulation (SIM)”, “Industrial Automatic Robots (IAR)” and “Horizontal and Vertical Integrated Systems (HVSI)” have a high drive power and have little dependence power and are placed in the area of independent variables. The variables of “Cloud Computing system (CC)”, “Sustainable Development (SD)” and “Additive Manufacturing (AM)” also have a high dependence power but little drive power,

so they are considered dependent variables. “Augmented Reality (AR)”, “Cyber Security (CS)” and “Industrial Internet of Things (IIOT)” variables have strongDrive power and dependence power, so they are linkage variables. After determining the relationships and the level of the mentioned indicators, they can be designed as a model. For this purpose, the indicators are first adjusted according to their level from top to bottom. The basic model of the fourth generation of the automotive industry in line with sustainable development is presented in Figure 1.

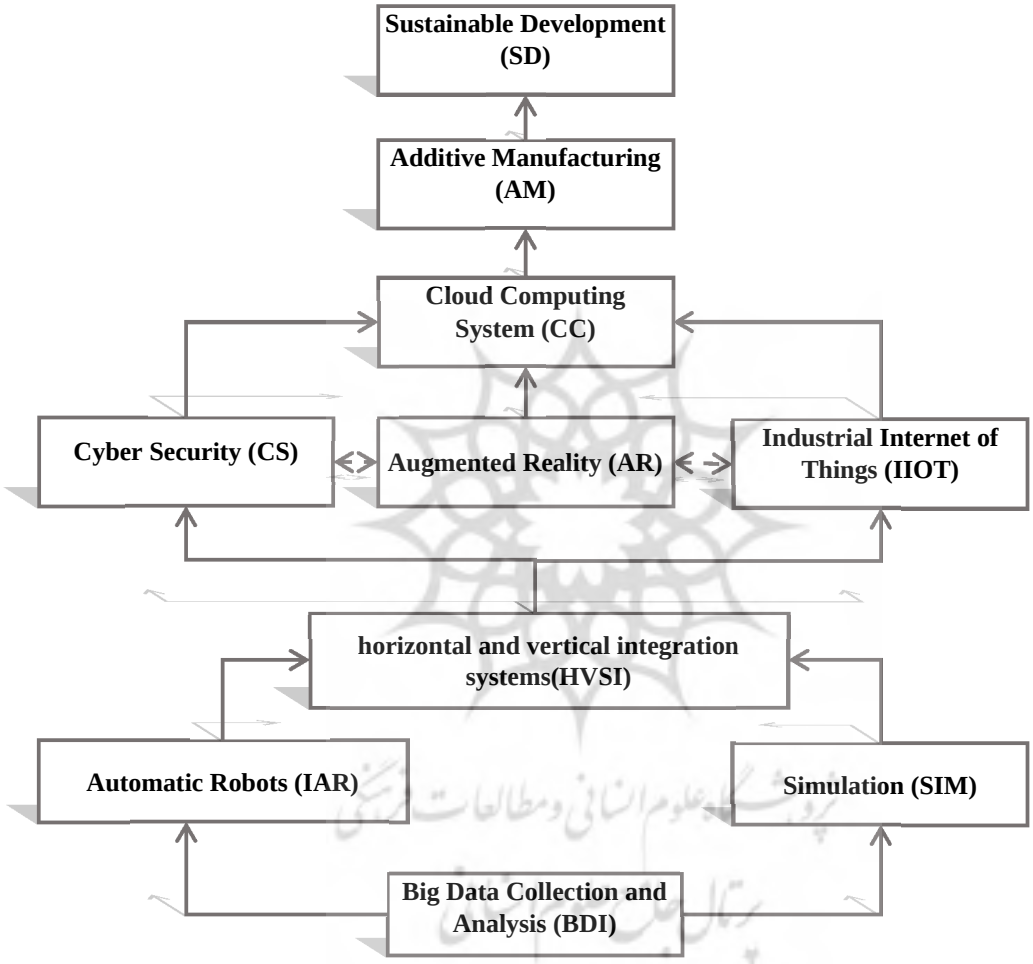

Figure 1. *Open the model of the fourth generation of the automotive industry in line with sustainability*

Finally, in the case and functional review of the existing situation, each of the identified dimensions was examined from the perspective of the employees of Iran Khodro Company. The opinion of the employees was collected with a Likert scale questionnaire and analyzed with a one-sample t-test. In this test, the null hypothesis (H_0) is based on the fact that the investigated variable is not in a favorable state, and the alternative hypothesis (H_a) is also the claim of the test. The summary of the results of the one-sample t-test is presented in Table 6.

Table 6
Summary of one-sample t-test results for research variables

Research variables	Mean	t value	Sig	95% Confidence Interval of the Difference	
				Lower	Upper
Integrated Systems(HVSI)	3.371	9.685	۰/۰۰۰	.295	.446
Big Data Collection and Analysis (BDI)	3.474	12.401	۰/۰۰۰	.398	.549
Simulation (SIM)	3.199	5.83	۰/۰۰۰	.122	.276
Automatic Robots (IAR)	4.244	44/780	۰/۰۰۰	1.189	1.299
Industrial Internet of Things (IIOT)	3.810	26.114	۰/۰۰۰	.749	.870
Augmented Reality (AR)	3.186	4.592	۰/۰۰۰	.106	.266
Cloud Computing System (CC)	3.566	14.307	۰/۰۰۰	.488	.643
Sustainable Development (SD)	3.318	8.914	۰/۰۰۰	.248	.389
Cyber Security (CS)	3.870	24.791	۰/۰۰۰	.801	.939
Additive Manufacturing (AM)	3.621	16.328	۰/۰۰۰	.547	.696

The average opinion of the respondents was greater than the middle of the Likert scale (number 3) in all cases. The significance value was also calculated as 0.000 and smaller than the error level of 0.05 and the value of t statistic was larger than the critical value of 1.96. Also, both upper and lower limits of the confidence interval are slightly greater than zero (positive) and the claim of the test is confirmed. Based on each of these statistical findings, it can be said with 95% certainty: the factors identified in Iran Khodro Company are in a favorable situation.

Conclusions and Suggestions

The current research was conducted with the aim of designing a Model for Implementing the Fourth Generation Industry to Achieve Sustainable Development Goals in the Automotive Industry (Case Study: Iran Khodro Company) .Based on the results, it was found that the big data collection and analysis (BDI) component, as the most influential component in the model, affect the simulation (SIM) and automatic robots (IAR) components and are consistent with the results of studies by (Asadi, 2019) and (Grybauskaset al., 2022).

Based on the results, it was found that the mentioned factors affect the horizontal and vertical integrated systems (HVSI).Also, the results of the research showed that the mentioned factors affect the industrial Internet of Things (IIOT), augmented reality (AR) and Cyber security (CS). In the results of the studies of (Fartoukzadeh&Tahmasabi, 2020) and (Nara et al., 2021), the industrial Internet of Things (IIOT) and Augmented Reality (AR) are also mentioned and are consistent with the results of the present study.

The results of the research showed that additive manufacturing (AM) is affected through the cloud computing system (CC) and this additive manufacturing (AM) leads to sustainable development (SD) and is consistent with the results of study by (Salami et al., 2019).

In the following, based on the results of the research, practical suggestions are presented to the managers of Iran Khodro Company:

In order to collect and analyze big data, it is suggested to pave the way for the implementation of the fourth generation industry in order to achieve the goals of sustainable development in the automobile industry by developing coherent plans for the

supply chain and using enterprise resource planning (ERP) systems. In this regard, it is important to pay attention to customer relationship management (CRM) and understand the needs of customers.Because today, customer relationship management is very important for the reasons of globalization, increased competition, market maturity and rapid development of technology in businesses. Customer relationship management is considered a key business strategy, so a company needs to focus on the needs of its customers to survive. The trend of increasing competition and decreasing customer loyalty made companies move from product-oriented to customer-oriented.

In terms of the simulation, it is suggested to start virtual simulation of machines, products, processes based on real data. The intelligent maintenance and repair system of machines and intelligent maintenance of products is mandatory in the company and helps to solve the failures and defects in the products. Another application of simulation is to test and optimize machine settings in the virtual environment before applying them in the real environment, which leads to a reduction in machine downtime. In this regard, executives and managers of Iran Khodro Company can achieve their ultimate goal of improving consumer experience and increasing customer lifetime value by creating innovative business models and improving health and safety and product quality.

In terms of the industrial internet of things, it is suggested to implement the management of employees' working process through smart devices in the mentioned company. Among other purposes of using the Internet of Industrial Things, we can mention energy recovery from waste/residues and production waste. What is important in the meantime and should be implemented is creating a more flexible work environment for employees and continuously controlling the health of employees by devices, which should be the priority of the company's management decisions.

In terms of the horizontal and vertical system integration, it is suggested by creating a global integrated network of data and a mechanized value chain of cooperation with stakeholders (producers, suppliers and consumers) along the value chain and the mass production of customized and exclusive goods, take a big step towards the implementation of the fourth generation industry to achieve the goals of sustainable development in the automobile industry. In this regard, the transformation of traditional supply chains into a digital supply network (DSN) and the integration of customers and products in it and the sharing of data and the use of advanced and predictive analytics will also help. Also, the recommendation of the current research on the integration of Internet of Service (IoS) and Internet of People (IoP) to develop the product as a service (PaaS) business model is also worth considering for relevant managers.

Regarding the cyber security, it is suggested to increase security in the cyber space and protect personal privacy by establishing strict laws to prevent illegal activities and increasing the protection of people's information against possible abuses. One of the important elements in cyber security is the protection of sensitive industrial systems and important production lines against cyber attacks, and of course the evaluation of the effects of cyber attacks by relevant specialists and experts.

Regarding additive manufacturing, it is suggested to modify products digitally before physical production in order to save processing time, resources and required tools. Also, increasing product innovation and helping coding activities, and of course promoting more customized products for customers will also lead to increased production for the company. Reducing production waste and physical transportation and logistics processes will also have a direct impact on increasing production in the company.

Regarding automatic industrial robots, it is suggested to prevent employees from performing monotonous and repetitive tasks by using the mentioned robots in performing dangerous tasks and placing them in tight places with difficult access and workstations that are ergonomically unfavorable. The use of automatic industrial robots in some lines of Iran Khodro will lead to industrial automation and reduce human errors, maintain the health and productivity of employees in the long term, and increase employee satisfaction and motivation.

Regarding augmented reality, it is suggested that in this field, with the possibility of combining the real world and virtual images at the same time and adding live physical view directly or indirectly to the elements of the real world, they are able to produce new and safe products. Therefore, it is recommended to provide the most effective industrial training methods and provide more affordable, safer, faster and productive learning by AVR for the implementation of virtual reality in the mentioned company. In addition to the mentioned cases, carrying out dangerous or sensitive repairs and increasing the readiness of human resources is also possible with augmented reality, and this will lead to the reduction of many life and financial risks in the company.

Regarding the cloud computing system, it is suggested that if the system is used, it will be possible for the company to have access to applications and documents and make orders by enabling access to information in real time. The role of the intrusion detection system in the security of the cloud computing system is very important because it acts as an additional preventive security layer and apart from detecting known attacks, it can detect many types of known and unknown attacks. Also, by providing increased communication and interactions throughout the supply chain and access to information in real time, it will lead to increased responsiveness and reduced inefficiency by eliminating the bullwhip effect.

Finally, it can be acknowledged that by implementing the mentioned results and suggestions, sustainable development can be achieved in Iran Khodro Company.

Reference

Akbari, Raziyeh; Pourjalili, Ali; Rezazadeh, Masoumeh. (2019). The leading industry with the fourth look; How the fourth industrial revolution was formed in industries. Smart Industry, 22(213), 1-30. [in Persian]. http://iimag.ir/archive/product/no-213-214-y1398/

Alahyari, M., Pilevari, N. (2020). CO-Active Neuro- Fuzzy Inference System Application in Supply Chain Sustainability Assessment Based on Economic, Social, Environmental, and Governance Pillars. Journal of System Management, 6(3), 265-287.https://dx.doi.org/10.30495/jsm.2021.678904

Asadi, Marzieh. (2019). Fourth industrial revolution and digital economy: drivers of sustainable economic growth. Applied Studies in Management and Development Sciences, 4 (17), 11-33. [in Persian]. http://www.asmd.ir/post.aspx?id=608#

Azimi, Ali; Ghari, Mohammad; Niavarani, Saber. (2021). Government intervention in the automotive industry with e System Management mphasis on the components of sustainable development management. Geography and Planning, 11(3), 714-731. [in Persian].https://dorl.net/dor/20.1001.1.22286462.1400.11.3.40.2

Azizzadeh, Nadereh; Aghamousa, Reza; Azad, Naser. (2021). Presenting the dynamic growth model of Iran's market share of regional gas trade from a strategic point of view. Strategic Studies of Public Policy, 11(38), 257-275. [in Persian]. http://sspp.iranjournals.ir/article_245351.html

Bagheri, Ruholah; Abbasi, Mohammad; Salehi, Ibrahim. (2016). University in the process of sustainable development of resistance economy. Strategy, 25 (81), 529-541. [in Persian]. https://www.sid.ir/fa/journal/ViewPaper.aspx?id=345854

Chandriah, K. K., &Raghavendra, N. V. (2019). Architectural framework for industry 4.0 compliance supply chain system for automotive industry. In Computer Science On-line Conference Springer Cham, 11(2), 107-116.DOI: 10.1007/978-3-030-19813-8_12

Devezas, T., &Sarygulov, A. (2017).Industry 4.0. Basel: Springer.DOI: 10.1007/978-3-319-49604-7

Dinçer, F. I., Bayram, G. E., &Altunoz, O. (2022). Fourth generation of rights and their reflections on human resources practices in tourism businesses. In Research Anthology on Human Resource Practices for the Modern Workforce (pp. 1390-1411).IGI Global.DOI: 10.4018/978-1-6684-3873-2.ch073

Eizadyer, Mehdi; Toloui, Abbas; Mehri, Zahra (2021).The application of system dynamics in evaluating the sustainability performance of a large supply chain in the automotive industry. Management Research in Iran, 25(1), 1-24. [in Persian]. https://dorl.net/dor/20.1001.1.2322200.1400.25.1.1.1

Fartoukzadeh, Hamid; Tahmasebi, Siamak. (2020). The missing link of industrial policy in Iran's automotive industry. Management Improvement, 14(3), 149-164. [in Persian]. https://dx.doi.org/10.22034/jmi.2020.119658

Fathi, M., Ghobakhloo, M., Syberfeldt, A., 2019.An interpretive structural modelingof teamwork training in higher education.Education Sciences.9 (1), 1e18. https://doi.org/10.3390/educsci9010016

Ghahremani, Z., Ardestani, A.(2019). Ranking the Information Technology Dimensions Using Sustainable Development Criteria. Journal of System Management, 5(2), 133-146. https://dorl.net/dor/20.1001.1.23222301.2019.5.2.6.9

Grybauskas, A., Stefanini, A., &Ghobakhloo, M. (2022). Social sustainability in the age of digitalization: A systematic literature review on the social implications of industry 4.0. Technology in Society, 70(101997), 2-15. https://doi.org/10.1016/j.techsoc.2022.101997

Holsti, O. R. (1969). Book Reviews :Content analysis for the social sciences and humanities.SAGE Journals.https://doi.org/10.1177/000169937001300209

Hoseini, Ismail; Saei, Ahmed (2017).A comparative study of Iran and South Korea's policies in the field of automobile industry.Studies of International Relations, 10 (39), 29-9. [in Persian].http://prb.iauctb.ac.ir/article_535764.html

Esmaeilpour, Reza; Akbari, Mohsen; Masoudi, Meisam. (2017). Investigating the role of corporate social responsibility in brand equity through the mediation of brand personality and goodwill. Business Management Research, 9(18), 83-106. [in Persian].https://dorl.net/dor/20.1001.1.2645386.1396.9.18.5.5

Jamali, Mehdi. (2016). Automotive industry in the world.The world of economics. [in Persian]. https://www.donya-e-eqtesad.com/fa/tiny/news-1008135

Kamble, S. S., Gunasekaran, A., &Gawankar, S. A. (2018). Sustainable Industry 4.0 framework: A systematic literature review identifying the current trends and future perspectives. Process Safety and Environmental Protection, 117, 408-425.https://doi.org/10.1016/j.psep.2018.05.009

Karimpour, Ahmad; Arasti, Mohammadreza; Akbari, Mohammadreza.(2018). Macro Policy for Product Architecture in Automotive Industry a Means for Integrated Design.public management researches, 11(40), 137-162. [in Persian]. https://dx.doi.org/10.22111/jmr.2018.4297

Khan, I. S., Ahmad, M. O., &Majava, J. (2021). Industry 4.0 and sustainable development: A systematic mapping of triple bottom line, Circular Economy and Sustainable Business Models perspectives. Journal of Cleaner Production, 12(1), 66-75.https://doi.org/10.1016/j.jclepro.2021.126655

Koushan, Amir Hossein; Ebrahimi, Abbas.(2021). A comparative study of success factors in localization policies of the automobile industry. International Business Management, 4(2), 1-20. [in Persian]. DOI: 10.22034/JIBA.2021.40624.1476

Krippendorff, klaus. (2018). Content analysis: an introduction to its methodology. SAGE Publications, Inc. https://us.sagepub.com/en-us/nam/content-analysis/book258450

Lee, J. W., & Tan, W. N. (2019). Global Corporate Citizenship: Cross-cultural Comparison of Best Practices in the Global Automotive Industry. The Journal of Asian Finance, Economics and Business (JAFEB), 6(1), 261-271.https://doi.org/10.13106/jafeb.2019.vol6.no1.261

Lin, D., Lee, C.K.M., Lau, H. and Yang, Y. (2018), "Strategic response to Industry 4.0: an empirical investigation on the Chinese automotive industry", Industrial Management & Data Systems, 118(3), 589-605.https://doi.org/10.1108/IMDS-09-2017-0403

Monazzemi, Homayoun. (2021), Solutions of the fourth industrial revolution and blockchain technology for effective management of employees, Brandafarin, 2(20), 110-123. [in Persian]. https://www.brandafarin.org.ir/article_141831.html

Nadiri, Mahshid; Mortazavi, Negar; Haghighat, Fatemeh. (2020). An Analysis of Production Support Policies in the Iranian Automotive Industry. Public Policy Quarterly, 5 (4), 211-240. [in Persian]. https://dx.doi.org/10.22059/jppolicy.2020.75203

Nara, E. O. B., da Costa, M. B., Baierle, I. C., Schaefer, J. L., Benitez, G. B., do Santos, L. M. A. L., & Benitez, L. B. (2021). Expected impact of industry 4.0 technologies on sustainable development: A study in the context of Brazil's plastic industry. Sustainable Production and Consumption, 2(5), 102-122.https://doi.org/10.1016/j.spc.2020.07.018

Neyshabouri, R., Saeidi, P., Didekhani, H., Hoseini, R. H. (2019). Identifying the Factors Affecting Government Support for Iranian Automotive Industry.Journal of System Management, 5(3), 139-158. https://dorl.net/dor/20.1001.1.23222301.2019.5.3.9.4

Paripour, A.,Natagi, F., Mohammadi, M. (2021).Presenting a model for evaluating the quality of combined education in higher education based on the CIP evaluation approach. Research in educational systems, 14 (51), 7-22.https://dorl.net/dor/20.1001.1.23831324.1399.14.51.1.4

Salami, Robab; Kordi, Masoumeh; Farrokhi, Naser; Khan, Faranak. (2019). Examining the necessity and various applications of Internet of things in the field of agriculture in Iran and the world. The 7th National Congress of Biology and Natural Sciences of Iran. [in Persian].https://civilica.com/doc/1028997/

Verma, A., &Venkatesan, M. (2021). Industry 4.0 workforce implications and strategies for organizational effectiveness in Indian automotive industry: a review. Technology Analysis & Strategic Management, 1-9.https://doi.org/10.1080/09537325.2021.2007875

Xu, X., Lu, Y., Vogel-Heuser, B., & Wang, L. (2021).Industry 4.0 and Industry 5.0—Inception, conception and perception. Journal of Manufacturing Systems, 61, 530-535.https://doi.org/10.1016/j.jmsy.2021.10.006