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Validation of the implementation model of the fourth generation industry to achieve sustainable development goals in Iran Khodro Company

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Abstract

The current research was conducted with the aim of validating the implementation model of the fourth generation of the industry in order to achieve the goals of sustainable development in Iran Khodro Company. For this purpose, the initial model of the implementation of the fourth-generation industry was designed to achieve the goals of sustainable development in Iran Khodro Company, and then the designed model was validated. This research is applied-developmental in terms of purpose, and in terms of data collection method, it is non-experimental (descriptive) with a cross-sectional survey approach, and in terms of the nature of the data, it is mixed (qualitative-quantitative). The statistical population in the qualitative section included 8 senior managers of Iran Khodro Company and the targeted sampling method. The statistical population in the quantitative part included 384 experts with experience in Iran Khodro company and a simple random sampling method. The data collection tools in the qualitative part were questionnaires and semi-structured interviews, and in the quantitative part, the structural-interpretive modelling (ISM) questionnaire and a questionnaire with a 5-point Likert scale. In the qualitative part of the research, the content analysis technique and software (MAXQDA) were used to analyze the expert interviews and extract the main and secondary components. In the quantitative part of the research, the structural-interpretive modelling technique and software (MICMAC) were used to identify the causal relationships between the main components of the research and provide the initial model, and the partial least squares technique and software (SMART PLS) were used to validate the initial model. The final model included 10 main components and the results of the partial least squares technique fully confirmed the validity of the model.

Keywords: fourth generation industry, sustainable development, Iran Khodro Company, mixed approach
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1 Introduction

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 analogue, mechanical and electronic technology to digital technology. The fourth industrial revolution is the move towards digitalization. Industry 4.0 uses the Internet of Things and cyber-physical systems such as sensors with the ability to collect data to enable mass production for manufacturers. Smart tools used in this industry improve the quality of factories and their products. The vision expected from Industry 4.0 is fully intelligent factories in which the communication is machine-to-machine (M2M) and in the shortest time, products of the desired quality are offered in the market [8]. It has been called the fourth industrial revolution, and it has fundamentally affected the business model and economic system, in the sense 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 policymaking in developed economies [3].

The fourth generation of the industry is rapidly and widely creating fundamental changes in various industrial fields. In this regard, managers of organizations have no choice but to align with the fourth industrial wave; Because otherwise, they will quickly leave the competition. To realize this, organizations and people involved in the fourth generation of the industry of things must have sufficient knowledge, technological skills and experience in managing the process of IoT-based innovations. One of the problems of management in the fourth era of the industry is unfamiliarity with the elements of innovations based on the Internet of Things [2]. In today's era, when the speed of technology development is increasing day by day, organizations have no other way to survive and grow than to adapt themselves to the changes in their surrounding environment. Therefore, it is necessary for organizations to take advantage of the existing capacities in the field of the Internet of Things to create and develop innovative solutions in order to overcome the technical problems in this field by correctly understanding the developments caused by the fourth generation of the industry [17].

Another issue that entered the field of the industry before the concept of the Internet of Things and has received the attention of many industries as well as government institutions and NGOs is sustainable development. Sustainable development is the intersection of society, economy and environment. Sustainable development is one of the most comprehensive concepts in recent decades. In its broad sense, this word means the correct and efficient management and use of financial resources, human resources, etc., to achieve the optimal consumption pattern, which is achieved by using appropriate technical facilities, structures and organizations. It becomes satisfactorily possible to meet the needs of today and future generations. Sustainable development considers not only the improvement of the current generation but also the future generations [16]. With the introduction of the Internet of Things as a fundamental process in industries, movements have begun to integrate this technology with sustainable development measures in various industries; Although this is still in its infancy. However, it is believed that the integration of the concept of "sustainability" in the fourth generation of the industry can have very beneficial effects for both society and the environment [12].

In fact, the introduction of the new Generations project was held in an exhibition in Germany in 2011, and its output is the production of smart products in a smart factory and for a smart or online market. The basis of the fourth generation is the connection of machines and parts in work systems, which is achieved autonomously with intelligence along the value chain. In fact, the fourth-generation industry is the convergence of physical, cyber and digital systems. In other words, the mentioned industry of supplying customers and producing information are mixed and combined with each other in this generation. A large number of companies are aware of the concept of Industry 4.0, they also know that they need to change company processes, but they do not know how to start their activities with the introduction of the fourth industrial revolution or how to adapt to the fourth industrial revolution. The goal of the Industry 4.0 revolution is the convergence of the physical and digital worlds, creating a world of cyber-physical systems and related processes to understand the great value of the business. In this regard, the first step to entering the field of Industry 4.0 is to get familiar with the components of this industry and to know the importance of each of these components for the success of the industry in the contemporary era. 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 Industry 4.0 in Iran. On the other hand, due to the new nature of the concept of the "4th generation industry", 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 design a model for the implementation of the fourth-generation industry in order to achieve the goals of sustainable development in Iran Khodro Company and then validate the designed model.

2 Theoretical foundations

2.1 The fourth generation of industry

Industry 4.0, which results from the fourth industrial revolution, to fundamental developments in continuous (production line) or discrete production, logistics and supply chain (Logistics 4.0), chemical industries, energy (Energy 4.0), transportation, water and electricity, oil and It pays for gas, mining and metals and other sectors such as resources, health industries, medicine and even smart cities. The term "Industry 4.0" was initially defined for manufacturing fields, but this term has been used for wider fields over time. Therefore, in many documents and writings, Industry 4.0 is only about smart productions, factories and activities, technologies and production and supply processes. To understand Industry 4.0, it is necessary to carefully examine the entire value chain of the organization/industry, which includes suppliers, suppliers of raw materials and required components, physical and digital supply chain partners, all intermediaries providing value and finally the end customer. and analyzed In this analysis, the capacity of people as entrepreneurs, consumers, building owners, retail store owners, workers, citizens, patients, etc. should be considered [10].

2.2 Sustainable development

Sustainable development is one of the most comprehensive concepts in recent decades. This word in its broad sense means the correct and efficient management and exploitation of financial resources, human resources, etc. And suitable formations to meet the needs of today and future generations will be satisfactorily possible. As it was mentioned, the theory of sustainable development was brought up and seriously put on the agenda of governments according to the needs of industrialized societies and in accordance with their cultural, social, economic and political foundations. But it must be said that the phenomenon of the city (which is a reflection of all the social, cultural and economic characteristics of a society) and the urban planning system of Iran have differences and contradictions compared to developed countries, which make the realization of sustainable urban development face many challenges.

Theorists define sustainable development as a synergistic process and transformation among the major subsystems that make up the city (economic, social, physical and environmental) that does not reduce the level of well-being of local people in a long-term period, regardless of Taking development facilities of nearby areas and participation in reducing the destructive effects of development on the biosphere guarantees [6].

Regarding the meaning and concept of sustainable development, Peterhall (1993) states that "a form of today's development that guarantees the continuous development of cities and urban communities for future generations". Also, the European Commission (2006) defines sustainable development as the challenge of solving the problems created for the city and the problems created by the city. In this regard, ecologist experts declare the most important ecological principles governing sustainable urban development on this basis:

1) Compatibility of urban activities with natural conditions
2) Balancing the city with natural resources
3) Minimal interference and encroachment on natural conditions
4) Considering the city system as much as possible

Sustainable development has multiple dimensions and levels that can be applied at the local, national, and international levels. In order to find the objectives of sustainable development, all dimensions should be considered at all three levels. The social dimension is concerned with human-to-human relationship, access to services, health, hygiene, education, security, human valuing, equality and poverty alleviation. The environmental dimension is related to the protection and strengthening of physical, biological, ecosystem resources and the relationship between man and nature, and the political dimension is related to the law, policymaking and setting of policies, planning, budgeting and in short, setting the conditions and conditions necessary for the integration of economic goals. , social and environmental issues in such a way that the realization of sustainable development becomes possible by establishing a relationship between them.

3 Research methodology

3.1 Type of research

From the point of view of the purpose, this research is applied-developmental, and from the point of view of the data collection method, it is non-experimental (descriptive) with a cross-sectional survey approach, and from the point of view of the nature of the data, it is mixed (qualitative-quantitative).

3.2 Statistical population and sampling method and sample size

3.2.1 Statistical population and sampling method and sample size (qualitative part)

The community of participants in the qualitative section includes the senior managers of Iran Khodro Company who have sufficient knowledge in the field of the fourth generation industry.

Nevertheless, expert interviews should be continued until theoretical saturation is achieved. Also, it is better to use non-probability and targeted methods for sampling the qualitative part ([1, 15]. In this study, sampling of the qualitative part was done in a targeted way and theoretical saturation was achieved with 8 interviews.

3.2.2 Statistical population and sampling method and sample size (quantitative part)

The statistical population in the quantitative section included experts with experience in Iran Khodro Company, and Cochran's formula was used to calculate the sample size, and the sample size was estimated to be 384 people. Because the statistical population is homogeneous, the sampling was done by a simple random method so that all the experts of Iran Khodro Company have an equal chance to be selected. The sampling process continued until obtaining 384 correct questionnaires. Cochran's formula for large societies:

$$\begin{cases} d = 0.05 \\ t = 1.96 \\ p = 0.5 \\ q = 0.5 \end{cases} \qquad n = \frac{t^2 pq}{d^2} = \frac{(1.96)^2(0.5)(0.5)}{(0.05)^2} = \frac{0.9604}{0.0025} = 384$$

3.3 Data collection and validation tool

3.3.1 Data collection and validation tool (qualitative part)

The research data collection tools in the qualitative part were questionnaires and semi-structured interviews. The Holstein coefficient was used to measure the validity of the qualitative part (interview results). The value (PAO) of "percentage of observed agreement" in this study is 0.712, which is greater than 0.6, so the reliability of the qualitative part is favorable [9].

$$PAO = \frac{2M}{N1 + N2} = \frac{236}{298 + 365} = 0.712$$

3.3.2 Data collection and validation tools (quantitative part)

The tool for collecting research data in the quantitative part was the structural-interpretive modeling (ISM) questionnaire and a questionnaire with a 5-point Likert scale. Content validity ratio (CVR), content validity index (CVI) and Cronbach's alpha were used to measure the validity of the quantitative part (questionnaire). Because the point of view of 30 people has been used, the value of CVR must be above 33.0, which was met in all cases. Also, the necessary condition for accepting indices based on CVI is that this value must be greater than 79.0. This condition was also valid for all indicators. Finally, a preliminary questionnaire was distributed among 30 people and Cronbach's alpha was calculated as 811.0.

3.4 Data analysis methods

3.4.1 Data analysis methods (qualitative part)

In the qualitative part of the research, the content analysis technique and software (MAXQDA) were used to analyze the expert interviews and extract the main and secondary components.

3.4.2 Data analysis methods (qualitative part)

In the quantitative part of the research, to level the identified indicators and provide the initial model of implementing the fourth generation industry in order to achieve the goals of sustainable development in Iran Khodro Company using the structural-interpretive modeling technique and MICMAC software and to validate the initial model using the partial least squares technique and software. (SMART PLS) was used.

4 Data analysis

In the first step, the views of the managers were gathered using a semi-structured interview in such a way that 9 open questions were used in the interview protocol and during the interview process, new questions were also raised as expected. In order to get to know the depth and scope of the content of the data, repeated reading of the data and active reading of the data (searching for meanings and patterns) were done.

Using content analysis technique and MaxQDA software, expert interviews were analyzed and main and secondary components were extracted. In the current research, by examining and categorizing the descriptive codes from the interview texts, 60 sub-contents were identified, which, according to their semantic similarity and affinity, were divided into 10 main contents: big data collection and analysis, simulation, industrial Internet of Things, horizontal integrated systems and Vertical, network security, additive manufacturing, industrial automatic robots, augmented reality, cloud computing system and sustainable development were categorized. The main components of the design of the implementation model of the fourth generation industry in line with the goals of sustainable development are presented in Table 1.

Table 1: Main and secondary components

1	horizontal and vertical integration systems
2	Big Data Analysis
3	Simulation
4	Industrial automatic robots
5	Industrial Internet of Things
6	Augmented Reality
7	Cloud Computing
8	Sustainable Development
9	Cyber security
10	Additive Manufacturing

The design of the model was done with the structural-interpretive modeling method, and for this purpose, the structural self-interaction matrix (SSIM) was first formed. The relationships of comprehensive structures are characterized by four symbols V (variable i affects j), A (variable j affects i), X (two-way relationship), and O (absence of relationship) [4]. The structural autocorrelation matrix is presented in Table 2.

Table 2: Structural self-interaction matrix of the fourth generation industry in line with the goals of sustainable development in Iran Khodro Company

AM	CS	SD	CC	AR	IIOT	IAR	SIM	BDI	HVSI	SSIM
V	V	V	O	V	V	A	A	A		Integrated Systems (HVSI)
O	V	V	V	V	V	V	V			Big data collection and analysis (BDI)
V	O	V	V	V	V	X				simulation (SIM)
V	V	V	V	V	V					Automated Robots (IAR)
V	X	O	V	V						Industrial Internet of Things (IIOT)
V	X	V	V							augmented reality (AR)
V	A	V								Cloud computing system (CC)
A	A									sustainable development (SD)
V										Network Security (CS)
										additive manufacturing (AM)

By transforming the structural self-interaction matrix into a two-valued matrix of zero and one, the received matrix (RM) is obtained. In the received matrix, the dimensions of the main diameter are equal to one. Also, secondary relationships should be checked to be sure. That is, if A leads to B and B leads to C, then A must lead to C. That is, if direct effects should be considered based on secondary relationships, but this did not happen in practice, the table should be corrected and the secondary relationship should also be considered [4]. The final access matrix is presented in Table 3.

Table 3: Matrix of the final achievement of the fourth generation of industry in line with sustainable development in Iran Khodro Company

AM	CS	SD	CC	AR	IIOT	IAR	SIM	BDI	HVSI	SSIM
1	1	1	1*	1	1	0	0	0	1	Integrated Systems (HVSI)
1*	1	1	1	1	1	1	1	1	1	Big data collection and analysis (BDI)
1	1*	1	1	1	1	1	1	0	1	simulation (SIM)
1	1	1	1	1	1	1	1	0	1	Automated Robots (IAR)
1	1	1*	1	1	1	0	0	0	0	Industrial Internet of Things (IIOT)
1	1	1	1	1	1	0	0	0	0	augmented reality (AR)
1	0	1	1	1	0	0	0	0	0	Cloud computing system (CC)
0	0	1	0	0	0	0	0	0	0	sustainable development (SD)
1	1	1	1	1	1	0	0	0	0	Network Security (CS)
1	0	1	0	0	0	0	0	0	0	additive manufacturing (AM)

After forming the achievement matrix to determine the relationships and stratification of the fourth generation industry in line with sustainable development in Iran Khodro Company, "achievement set" and "prerequisite set" should be identified. For the C_i variable, the access set (output or effects) includes the variables that can be reached through the C_i variable. The 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 achievements and prerequisites of the fourth generation of the automotive industry in line with sustainable development in Iran Khodro Company

Subscribe	Input: Effectiveness	Output: effect	Variables
HVSI	HVSI,BDI,SIM,IAR	HVSI,IIOT,AR,CC,SD,CS,AM	Integrated Systems
BDI	BDI	HVSI,BDI,SIM,IAR,IIOT,AR,CC,SD,CS,AM	Big data collection and analysis
SIM,IAR	BDI,SIM,IAR	HVSI,SIM,IAR,IIOT,AR,CC,SD,CS,AM	simulation
SIM,IAR	BDI,SIM,IAR	HVSI,SIM,IAR,IIOT,AR,CC,SD,CS,AM	Automated Robots
IIOT,AR,CS	HVSI,BDI,SIM,IAR,IIOT,AR,CS	IIOT,AR,CC,SD,CS,AM	Industrial Internet of Things
IIOT,AR,CS	HVSI,BDI,SIM,IAR,IIOT,AR,CS	IIOT,AR,CC,SD,CS,AM	augmented reality
CC	HVSI,BDI,SIM,IAR,IIOT,AR,CC,CS	CC,SD,AM	Cloud computing system
SD	HVSI,BDI,SIM,IAR,IIOT,AR,CC,SD,CS,AM	SD	sustainable development
IIOT,AR,CS	HVSI,BDI,SIM,IAR,IIOT,AR,CS	IIOT,AR,CC,SD,CS,AM	Network Security
AM	HVSI,BDI,SIM,IAR,IIOT,AR,CC,CS,AM	SD,AM	additive manufacturing

Therefore, sustainable development (SD) is at the first level. According to the output of ISM calculations, the incremental production variable (AM) is at level two. Augmented reality (AR) and cloud computing (CC) variables are the third level. Network Security (CS) and Industrial Internet of Things (IIOT) variables are at the fourth level, and the horizontal and vertical integrated systems (HVSI) variable is at the fifth level. Simulated Variables (SIM) and Automated Robots (IAR) are the sixth level, and finally, Big Data Collection and Analysis (BDI) is the most underlying element of the model. Also, the outputs and inputs of each variable show the power of influence and dependence of that variable, respectively.

After determining the relationships and 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 initial model of the implementation of the fourth generation industry to achieve sustainable development goals in Iran Khodro Company is shown in Figure 1.

5 Validation of the model with partial least squares method

The partial least squares technique has been used to validate the model. The results of running the model in the standard estimation mode show the direction and intensity of the relationship between the variables. The output of Smart PLS software for standard estimation is presented in Figure 2.

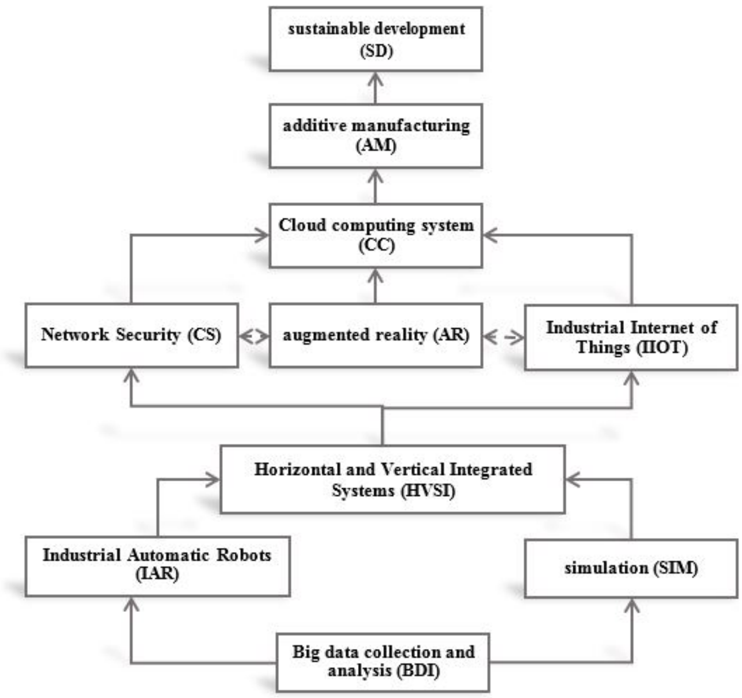

Figure 1: The implementation model of the fourth generation of industry to achieve sustainable development goals in Iran Khodro Company

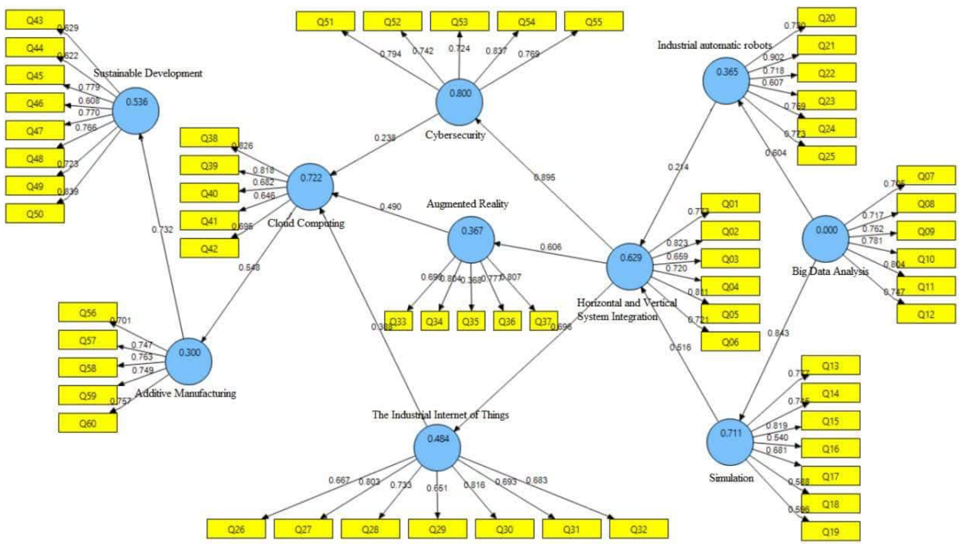

Figure 2: Model validation output with partial least squares method

To check the significance of the relationships of the variables of the model, the bootstrap method has been used, which gives the t statistic. At the 5% error level, if the value of the bootstrapping statistic is greater than 96.1, the observed correlations are significant. The t-statistic and bootstrapping value to measure the significance of relationships are also shown in Figure 3.

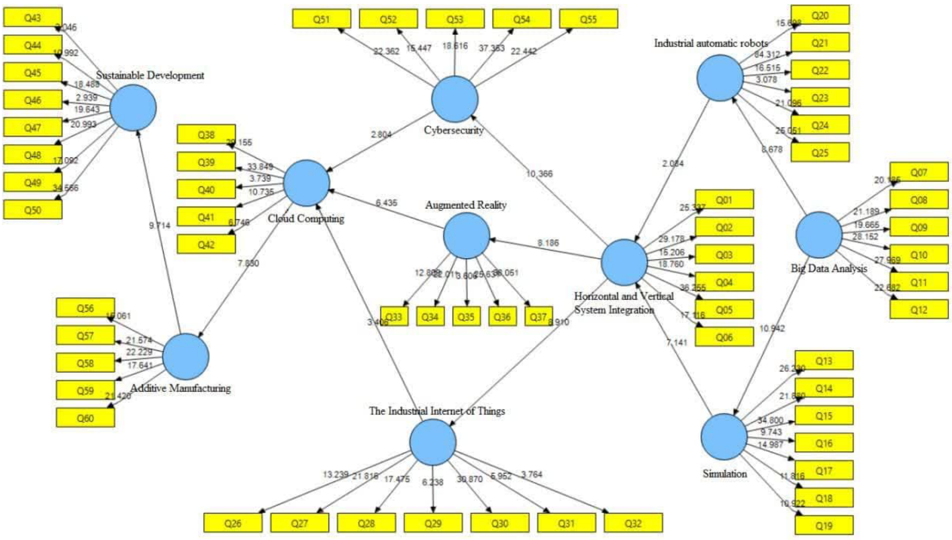

Figure 3: Significance of relationships of variables with partial least squares method (bootstrapping)

5.1 External model (measurement model)

External model or measurement model is equivalent to confirmatory factor analysis in Lisrel or Emos software. This part of the model shows that the items intended to measure each of the main factors have sufficient validity. The strength of the relationship between the items and the factors related to their effectiveness and significance is measured by the t-statistic. It should be noted that in the partial least squares method, the value of the t statistic is calculated by the resampling method, and in the present study, the bootstrapping method was used for resampling. The results of the external model (measurement model) are presented in Table 5.

Table 5: The results of the external model (measurement model)

t statistic	operational burden	objects	The main components
25.337	0.773	Creating an integrated global data network and mechanized value chain collaboration with stakeholders along the value chain (Q01)	Horizontal and vertical integrated systems
29.178	0.823	Mass production of customized and exclusive goods (Q02)	
15.206	0.659	Transforming traditional supply chains into a digital supply network and integrating customers and products into it (Q03)	
18.76	0.720	Sharing data and applying advanced and predictive analytics (Q04)	
36.255	0.811	Integration by Internet service and Internet of people (Q05)	
17.116	0.721	Development of product as service business model (Q06)	
20.185	0.705	Supply Chain Planning (Q07)	
21.189	0.717	Organization resource planning systems (Q08)	Big data collection and analysis
19.665	0.762	Customer relationship management (Q09)	
28.152	0.781	Logistics management (Q10)	
27.969	0.804	Research and development (Q11)	
22.682	0.747	Company asset management (Q12)	
26.23	0.777	Virtual simulation of machines, products, processes based on real data (Q13)	

21.88	0.745	Intelligent repair and maintenance system of machines and intelligent maintenance of products (Q14)	simulation
34.8	0.819	Machine settings before applying in the real environment, testing and optimizing it in the virtual environment (Q15)	
9.743	0.540	Reducing machine downtime (Q16)	
14.987	0.681	Creating innovative business models (Q17)	
11.816	0.588	Improving consumer experience and increasing customer lifetime value (Q18)	
10.922	0.596	Improving health and safety and product quality (Q19)	
15.698	0.730	Doing dangerous work and being in tight and hard-to-reach places (Q20)	Industrial automatic robots
84.312	0.902	Using robots in ergonomically unfavorable workstations (Q21)	
16.515	0.718	Performing monotonous and repetitive tasks (Q22)	
3.078	0.607	Industrial automation and reduction of human errors (Q23)	
21.096	0.759	Maintaining the health and productivity of employees in the long term (Q24)	
25.051	0.773	Increasing employee satisfaction and motivation (Q25)	
13.239	0.667	Management of employees' work processes through smart devices (Q26)	Industrial Internet of Things
21.816	0.803	Sensors and control equipment using artificial intelligence to control production processes (Q27)	
17.475	0.733	Energy recovery from waste/residues and production waste (Q28)	
6.238	0.651	Optimizing business processes with advanced technologies (Q29)	
30.87	0.816	Creating a more flexible work environment for employees (Q30)	
5.952	0.693	Monitoring the health of employees continuously by devices (Q31)	
3.764	0.683	Reducing production costs (Q32)	
12.809	0.698	Simultaneous combination of real world and virtual images (Q33)	Augmented Reality
22.011	0.804	Addition of live physical appearance, directly or indirectly, to real-world elements (Q34)	
3.606	0.668	Providing the most effective industrial training methods (Q35)	
25.631	0.777	Providing more affordable, safer, faster and more productive learning (Q36)	
38.051	0.807	Carrying out dangerous or sensitive repairs and increasing the readiness of manpower (Q37)	
29.155	0.826	Having access to applications and documents (Q38)	Cloud computing system
33.849	0.818	Order execution by enabling access to real-time information (Q39)	
3.739	0.682	Increasing communication and interactions throughout the supply chain (Q40)	
10.735	0.646	Access to information in real time (Q41)	
6.746	0.695	Increasing responsiveness and reducing inefficiency by eliminating the whiplash effect (Q42)	
2.046	0.629	Increasing productivity and production efficiency (Q43)	Sustainable Development
10.992	0.622	Reducing production costs and achieving profitability (Q44)	
18.488	0.779	Improving production competitiveness (Q45)	
2.939	0.608	Continuous and stable increase in the country's economic growth (Q46)	
19.643	0.770	Creating environmental, social and economic opportunities (Q47)	
20.993	0.766	Environmental sustainability through sustainable energy (Q48)	
17.092	0.723	Reducing environmental damage (Q49)	
34.566	0.839	Reducing toxic and greenhouse gas emissions (Q50)	
22.362	0.794	Establishing strict laws to prevent illegal activities (Q51)	
15.447	0.742	Protecting people's information against possible abuses (Q52)	

18.616	0.724	Increasing security in cyberspace and privacy (Q53)	Network Security
37.353	0.837	Protection of sensitive industrial systems and important production lines against cyber attacks (Q54)	
22.442	0.769	Evaluating the effects of cyber attacks (Q55)	
15.061	0.701	Modifying products before physical production digitally (Q56)	incremental production
21.574	0.747	Reducing processing time, resources and required tools (Q57)	
22.229	0.763	Increase product innovation and help coding activities (Q58)	
17.641	0.749	Promote more customized products (Q59)	
21.42	0.757	Reducing production waste and physical transportation and logistics processes (Q60)	

The values of observed factor loadings are greater than 5.0 and the t statistic is greater than 96.1. Therefore, the external model (measurement) is approved.

5.2 Internal model (structural part)

The relationships between the main structures of the research have been investigated in the structural section. The summary of the results of the structural part of the model (relationships of model variables) is presented in Table 6:

Table 6: Summary of the results of the structural part of the model (relationships of model variables)

Result	t statistic	Path coefficient	Relation
non-rejection	10.942	0.843	Big data collection and analysis → simulation
non-rejection	8.678	0.604	Collection and analysis of big data → industrial automatic robots
non-rejection	7.141	0.516	Simulation of horizontal and vertical integrated systems
non-rejection	2.084	0.214	Automatic industrial robots → horizontal and vertical integrated systems
non-rejection	8.910	0.695	Horizontal and vertical integrated systems → Industrial Internet of Things
non-rejection	8.186	0.606	Integrated systems → Augmented reality
non-rejection	10.366	0.895	Cloud computing system → network security
non-rejection	3.406	0.388	Industrial Internet of Things → Cloud computing system
non-rejection	6.435	0.490	Augmented reality → cloud computing system
non-rejection	2.804	0.238	Network security → cloud computing system
non-rejection	7.850	0.548	Cloud computing system → additive manufacturing
non-rejection	9.714	0.732	Incremental production → sustainable development

Considering that in all cases the value of t statistic is greater than 96.1, therefore the relationships between the variables of the model are confirmed.

6 Conclusions and suggestions

6.1 Conclusion

The current research was conducted with the aim of validating the implementation model of the fourth generation of the industry in order to achieve the goals of sustainable development in Iran Khodro Company. For this purpose, the initial model of implementation of the fourth generation industry was designed to achieve the goals of sustainable development in Iran Khodro Company and then it was validated. The final model included 10 main components and the results of the model showed that the collection and analysis of big data, automatic industrial robots and simulation have the greatest impact on the implementation of the fourth generation industry to achieve the goals of sustainable development in the automobile industry. Based on the results obtained from the partial least squares technique, the validation of the model can be interpreted as follows:

The path coefficient for the collection and analysis of big data was obtained on the simulation of 843.0. Also, the value of t statistic is 942.10. Therefore, it can be claimed with 95% certainty: the collection and analysis of big data has a positive and significant effect on simulation.

The path coefficient of big data collection and analysis on industrial automatic robots is 604.0. Also, the value of t statistic is 678.8. Therefore, it can be claimed with 95% certainty: Big data collection and analysis has a positive and significant effect on industrial automatic robots.

In the results of Nara et al.'s [14] study, "implementation of big data" is recognized as one of the main drivers of sustainable development, and from this point of view, it is consistent with the results of the present study.

The simulation path coefficient on horizontal and vertical integrated systems has been obtained as 516.0. Also, the value of t statistic is 141.7. Therefore, it can be claimed with 95% certainty: simulation has a positive and significant effect on horizontal and vertical integrated systems.

In the results of Qabakhlo's [7] study, the effectiveness of "simulation" as a factor to achieve sustainable development is also mentioned, and from this point of view, it is consistent with the results of the present study.

The path coefficient of industrial automatic robots on horizontal and vertical integrated systems is 214.0. Also, the value of t statistic is 084.2. Therefore, it can be claimed with 95% certainty: Industrial automatic robots have a positive and significant impact on horizontal and vertical integrated systems.

In the results of Asadi's study [3], "automatic industrial robots" are mentioned as one of the physical drivers of sustainable economic growth, and from this point of view, it is in line with the results of the present study.

The path coefficient of horizontal and vertical integrated systems on the Internet of Industrial Objects has been obtained as 695.0. Also, the value of t statistic is 910.8. Therefore, it can be claimed with 95% certainty: Horizontal and vertical integrated systems have a positive and significant impact on the Internet of Industrial Objects.

The path coefficient of horizontal and vertical integrated systems on augmented reality is 606.0. Also, the value of t statistic is 186.8. Therefore, it can be claimed with 95% certainty: horizontal and vertical integrated systems have a positive and significant impact on augmented reality.

The path coefficient of horizontal and vertical integrated systems on network security has been obtained as 895.0. Also, the value of t statistic is 366.10. Therefore, it can be claimed with 95% certainty: horizontal and vertical integrated systems have a positive and significant impact on network security.

In the results of Bagh et al.'s [5] study, "horizontal integration and vertical integration" is one of the main drivers of Industry 4.0, which plays an important role in the stability of the supply chain, and from this point of view, it is compatible with the results of the present study.

The path factor of industrial internet of things on cloud computing system has been obtained as 388.0. Also, the value of t statistic is 406.3. Therefore, it can be claimed with 95% certainty: Industrial Internet of Things has a positive and significant impact on the cloud computing system.

In the results of Nara et al.'s [14] study, "Internet of Things" is known as one of the main drivers of sustainable development, and from this point of view, it is consistent with the results of the present study.

The path coefficient of augmented reality on the cloud computing system has been obtained as 490.0. Also, the value of t statistic is 435.6. Therefore, it can be claimed with 95% certainty: Augmented reality has a positive and significant impact on the cloud computing system.

In the results of Qabakhlo's [7] study, the effectiveness of "augmented and virtual reality" is also mentioned as a factor to achieve sustainable development, and from this point of view, it is consistent with the results of the present study.

The coefficient of network security path on cloud computing system is 238.0. Also, the value of t statistic is 804.2. Therefore, it can be claimed with 95% certainty: network security has a positive and significant effect on the cloud computing system.

In the results of Bagh et al.'s [5] study, "Improving security and information technology standards" is one of the main drivers of Industry 4.0, which plays an important role in the stability of the supply chain, and from this point of view, it is compatible with the results of the present study.

The path coefficient of the cloud computing system on incremental production has been obtained as 548.0. Also, the value of t statistic is 850.7. Therefore, it can be claimed with 95% certainty: the cloud computing system has a positive and significant effect on incremental production.

In the results of the study by Kiani Bakhtiari et al. [11], "cloud computing system" is known as one of the fundamental components of the fourth industrial revolution, and from this point of view, it is consistent with the results of the present study.

The coefficient of incremental production path on sustainable development has been obtained as 732.0. Also, the value of t statistic is 714.9. Therefore, it can be claimed with 95% certainty: increased production has a positive and significant effect on sustainable development.

In the results of the study by Muller et al. [13], "incremental production" is also mentioned as one of the opportunities to achieve sustainability, and from this point of view, it is in line with the results of the current research.

It was also found that the index (GOF) equal to 401.0 was obtained and it indicates that the model has a good fit.

6.2 Offers

Regarding the collection and analysis of big data, Iran Khodro company managers are suggested to collect and analyze data from sources such as factory equipment, Internet of Things systems, enterprise resource planning systems (ERP), customer relationship management (CRM) and in all Use parts of supply chain management such as supply chain planning, logistics management, research and development (R&D), enterprise asset management (EAM). Also, use data collection and analysis by artificial intelligence and professional algorithms to predict future events and problems.

It is suggested to use simulation in product design to reduce production costs, in machine settings in the virtual environment to reduce machine downtime, and also in the layout design of production lines in order to determine the number of machines, cycle time, line balance, and belt speed. Use conveyors.

It is suggested to use collaborative robots in production lines to perform dangerous tasks and in ergonomically unfavorable workstations for the health of employees. Also, use autonomous mobile robots in the intelligent warehouse management system to monitor inventory and select and locate items.

It is suggested that horizontal and vertical integrated systems be used to transform traditional supply chains into a digital supply network (DSN) and also to mass produce customized and exclusive products. Regarding the Internet of Industrial Objects, 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.

Regarding incremental production, 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 sustainable development, it is suggested that if all the identified components are implemented, achieving the goals of sustainable development and increasing productivity and production efficiency, reducing production costs and achieving profitability and improving the competitiveness of production for Iran Khodro Company will not be far from expected. Also, continuous and sustainable increase in the country's economic growth, creation of environmental, social and economic opportunities and environmental sustainability through sustainable energy, reduction of environmental damage and reduction of toxic and greenhouse gas emissions can also be achieved. Because sustainable development, which is one of the main topics discussed in development and planning circles today, is itself the result of different concepts of development.

Regarding the security of the network, it is suggested to the managers of Iran Khodro Company to increase security in cyberspace and protect personal privacy by establishing strict rules to prevent illegal activities and increase the protection of people's information against possible abuses.

It is suggested that memorandums regarding the creation and access to the cloud computing system be concluded with the companies that provide this system so that they can access all the applications and documents from any place. Also, increase communication and interactions throughout the supply chain and provide access to real-time information through this system.

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