Investigating the Effect of Using Blockchain Technology on the Supply Chain Management Performance of Iran Khodro Company

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Abstract

The aim of this study is to introduce the blockchain technology and its advantages and the need to use it in the management of supply chains of automotive companies. Research shows that the use of blockchain technology will improve the process of supply chain management and lower costs in automotive companies. Automakers will be able to focus on increasing the quality of domestic products and reducing the cost of products by using the benefits of using blockchain. To better understand this issue, an operational example in this Iran Khodro company has been studied. For this purpose, after prioritizing the effective factors of supply chain management in Iran Khodro Company based on TOPSIS method, by comparing the identified priorities and advantages of using Blockchain technology, the necessity of using this technology in supply chain management of Irankhodro Company was expressed.

Keywords: blockchain, supply chain, TOPSIS, Irankhodro

1. Introduction and Description of the Problem

1.1 Blockchain

In the past, supply chain simplicity was due to the locality of businesses. But with the development of global marketing issues, the complexity of supply chains is increasing day by day. In the business world, organizations need to improve productivity and innovation to survive. Today, with the development of digital space, emerging technologies such as blockchain have created a good opportunity for businesses to be able to further improve the efficiency of their supply networks (Bocek, T.,& Stiller, B. 2018)[1].

Blockchain technology is widely used in various industries and as a revolutionary technology is making major changes in financial and commercial transactions.

Blockchain technology can be used in both financial and non-financial fields, and in the absence of blockchain technology, the presence of a trusted third party is required to protect transactions (Cai, J et al., 2009)[2]. This technology is divided into two types, private and public. figure 1 presents the types of blockchain technologies, their compliments and benefits (Abeyratne,et al,. 2016)[3].

1.2 Applications of Blockchain in Supply Chain Management

One of the most important applications of blockchain is in supply chain and logistics. Numerous studies have examined the effect of blockchain and supply chain and the need for blockchain development in the supply chain. Table 2 shows the research background of blockchain application in different parts of the supply chain. (Tsung-Ting Kuo,et al,. 2017)[4], (Omran,Y,et al,.2017)[5], (Huertas,J.,et al,. 2018)[6], (Kakavand,H.,et al,. 2017)[7], (Francisco,K., & Swanson, D,. 2018)[8], (Figorilli, S,et al,.2018)[9], (Rejeb, A. 2018)[10], (Tian,F. 2017)[11], (Clark, B., & Burstall, R.., 2018)[12], (Toyoda, K., 2017)[13], (Sermpinis, T.,& Sermpinis,C., 2018)[14],(Glover,D.G.,&Hermans,J.2017)[15],(Madhwal,Y&Panfilov,P.B.,2017)[16],(Korpela,K.,et al.,2017)[17],(Biggs,J.,etal,.2017)[18],(Nakasumi,M.,2017)[19],(Camerinelli,E.2016)[20],(Kumar,M. V&Iyengar,N.C.S.,2017)[21],(O'Marah,K.,2017)[22], (Xia,J.,&Yongjun,L.,2017)[23].

	Public (eg. Bitcoin)	Private	Consortium/ Permissioned (eg. EHRs)
Network type	Decentralized	Partially decentralized	Partially decentralized - hybrid between public and private blockchains
What is it?	Anyone anywhere in the world can read and write on the network. Data is validated by every participant ("node") in the network, thus making it very secure.	Permissions to read and write data onto the Blockchain are controlled by a single "highly trusted" organisation - the owner of the blockchain.	Permissions to verify, read and write on the blockchain controlled by a few predetermined nodes. The choice of predetermined nodes can be different for every entity on the blockchain.
Benefits	-Secure as the entire network verifies transactions -Transparent as all transactions are made public with individual anonymity	-Efficient as verification is done by just owner of the blockchain -Private as the owner can control who has access to read or write on the blockchain	-Efficient as relatively lesser nodes verify transactions -Private as read and write access can be controlled by the predetermined nodes -No consolidation of controlling power
Challenges	Inefficient as all nodes need to verify the transaction	-Controlling power is consolidated to a single organization -Difficult to align many organizations to use the same blockchain	

Figure 1. Comparing the different types of blockchains
(Abeyratne,S. A.,& Monfared, R. P. 2016)

1.3 Applications of blockchain in the supply chain management of the automotive industry

The advent of blockchain technology has led to major changes in the automotive supply chain and business models. This technology has improved the business models of the automotive industry and facilitated the processes of this industry. With the expansion of the use of blockchain, technology-based services and products have increased as a result, supply chain processes have become more difficult to analyze. Benefits such as facilitating supply chain management, immediate tracking of parts and products and improving the process of applying new standards, expecting customers to immediately fix defects in received products and supply chain management of main component factories in different countries, unchangeable data and transparency of the registered reports, encourage some of the largest automotive companies to use this technology in their industry (Faycal Fedouaki.,2020)[24]. Figure 2 schematically shows the evolution of the supply chain by blockchain technology (sara Saberi.,et al.,2018)[25].

Table 1. Applications of blockchain in supply chain management [4-23]

comment	Field
reduce costs by using smart contracts ♣ Reduce risk and increase customer confidence due to accurate information about suppliers and liquidity	**Financial**
Identify the duration, place of storage of products and the quality of the storage environment of products (Especially for frozen products) Provide clear information on shipping status - place of production - delivery status.	**Tracking**
Collecting and processing transactions of various types of supply chain networks	**Network structure issues**
Lower costs, increased efficiency, higher control of information sharing are the benefits of moving from a centralized regulatory system to a Blockchain network.	**Storage and sharing Information**
Achieve new markets Scalability Reduce waiting time flexibility Stability Reduce waste and manpower costs	**other**

(Tsung-Ting Kuo,et al,.2017)[4],(Omran,Y,et al,.2017)[5],(Huertas,J.,et al,.2018)[6], (Kakavand,H.,et al,.2017)[7], (Francisco,K.,&Swanson,D,.2018)[8], (Figorilli, S,et al,.2018)[9],(Rejeb, A. 2018)[10],(Tian,F.2017)[11],(Clark, B.,& Burstall, R..,2018)[12], (Toyoda, K.,2017)[13],(.Sermpinis, T.,& Sermpinis, C.,2018)[14],(Glover, D. G.,& Hermans, J. 2017)[15], (Madhwal,Y&Panfilov,P.B.,2017)[16], (Korpela,K.,etal.,2017)[17],(Biggs,J.,etal,.2017)[18], (Nakasumi,M.,2017)[19], (Camerinelli,E.2016)[20], (Kumar,M.V&Iyengar,N.C.S.,2017)[21], (O'Marah, K.,2017)[22], (Xia, J.,& Yongjun, L., 2017)[23]

Figures 3 and 4 show the traditional, blockchain-based models of the supply chain of automotive companies. Traditional supply chains often lack the control of major component manufacturers over component suppliers at lower levels of the supply chain. Lack of oversight leads to insufficient and transparent information on supply chain such as working capital and levels of financial flows, which disrupts data analysis and undermines the efficiency of businesses in effective planning in all aspects of purchasing and reduces sales of goods and services (sara Saberi.,et al.,2018)[25],(Kotha,Raj.,et al.,2021)[26].

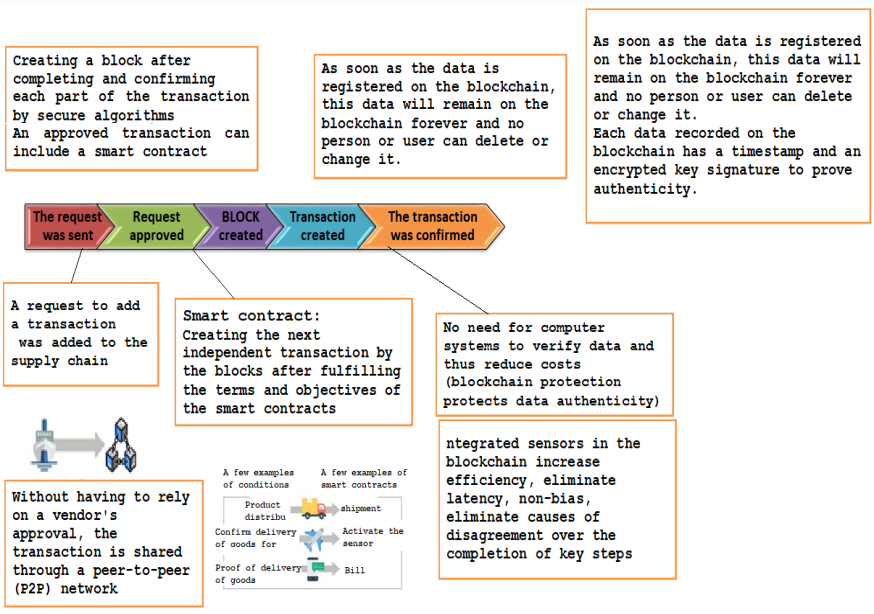

Figure 2. How will blockchain change the supply chain? [25]
(sara Saberi.,et al.,2018)[25]

Blockchain technology makes it possible to access raw material source information at all levels of the supply chain. In addition, it will be possible to monitor the flow of data. The application of blockchain technology in supply chain infrastructure will increase the accuracy of statistical analysis and transparency of business relationships and will facilitate the process of managing suppliers relationships (sara Saberi.,et al.,2018)[25],(Kotha,Raj.,et al.,2021)[26].

According to Figure 3, the flow of information and the selection of suppliers in a blockchain-based automotive supply chain platform is as follows. The manufacturer of the main parts sends the order for the purchase of raw materials. This order contains information such as the desired price, shipping conditions, time and method of delivery, etc.

Figure 3. Traditional supply chain model of automotive companies [26]
(Kotha,Raj.,et al.,2021)[26]

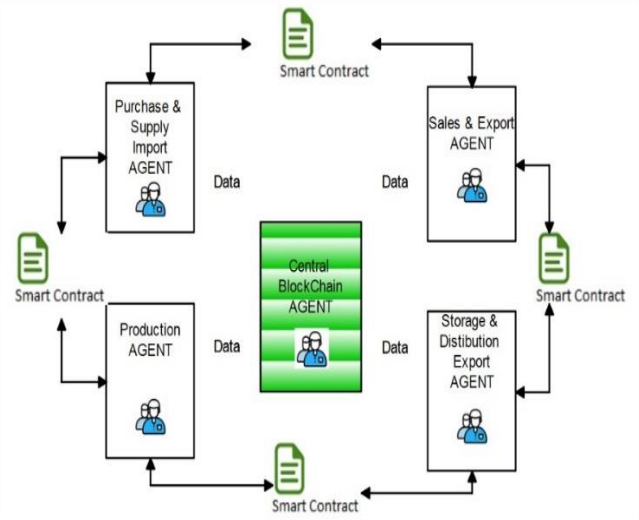

Figure 4. Blockchain-based models of the supply chain of automotive companies [25]
(sara Saberi.,et al.,2018)[25]

Suppliers already connected to the platform will be notified of the terms of the request as soon as the original order is issued, and after reviewing the terms of the request, will announce the terms and conditions of delivery of the raw materials. At this stage, the main manufacturer can select the first offer according to its conditions with the help of smart

contracts. It will also be possible to select manually. Therefore, the most important part of blockchain technology is the use of smart contracts (Mohammad Hossein,Ronaghi.,2021)[27].
In general, the advantages of smart contracts in blockchain technology in the supply chain process are as follows: (GunnarPrause.,2019)[28]

Generating accurate analytical reports to increase transparency and accelerate access to various information such as warehouse volume, current demand. Improving warehouse control, managing financial flows and leading all processes and data in the supply chain, complying with standards, managing delays, facilitating the supply chain, accurately measuring the cost of each component, thereby reducing cost loss and increasing competition through increasing customer satisfaction.

2. Purpose/Objectives

Irankhodro Company is one of the largest industrial companies in the Middle East. Success in supply chain performance will increase production rate, reduce capital loss and employee satisfaction. This study seeks to investigate the effect of using modern blockchain technology on the supply chain performance of Iran Khodro Company, which currently follows the traditional supply chain model. For this purpose, the factors affecting the supply chain management and their prioritization are firstly determined so that the effect of using blockchain would be presented at each priority.

3. Methodology/Approach

In this study, the factors affecting the supply chain have been collected from different sources(table 2) and were divided into concept-dimensions and index according to the Kivi-Kompenhod's structure. (Manoj Hudnurkar .,2018)[29],(Zhu, X., 2011)[30],(Walter A. 2003)[31],(Simatupang, T.M., 2004)[32],(Simatupang T. M.& Sridharan R.,2005)[33],(Zhou H.& Benton Jr W.C.,2007)[34],(Pereira J. V.,2009)[35],(Raymond Quivy.,2007)[36]

In the above structure, dimensions are in fact the outputs created from the effective factors.
A- Concept level: Factors affecting the supply chain management
B- Reliability-Accountability-Flexibility-Information protection-Cost-Asset metrics
C-index level:

1. Variety of products and services
2. Selecting suppliers based on the time and rate of supply and the quality of the product
3. Ordering methods
4. Liquidity cycle time and circulation
5. Deviations from the budget
6. Determining the level of cooperation of suppliers
7. The main production schedule
8. Delivery reliability
9. Scheduling delivery delay
10. Inventory level in circulation
11. Warehousing costs
12. Distribution Scheduling
13. Customer satisfaction

4. Society and Statistical Sample

130 experts of Iran Khodro Company participated in this study and evaluated the 13 factors extracted in six dimensions of supply chain management.

Table 2. Factors affecting the performance of supply chain management

description	Factor	row
Supply chain performance in delivering the right product at the right time to the right place in the packaging situation - the right amount to the right customer	**Reliability**	1
Speed of supply chain in delivering the product to the customer	**Response**	2
Supply chain agility and agility in responding to market changes to gain or maintain a competitive advantage	**flexibility**	3
Supply chain performance in protecting the information of the parties involved in the contract and customers	**Information security**	4
Operating costs	**Cost**	5
Effectiveness of the organization's performance in managing its assets and property in order to support demand response Includes a variety of fixed and current assets	**Assessment of assets**	6

(Manoj Hudnurkar .,2018)[29],(Zhu, X., 2011)[30],(Walter A. 2003)[31],(Simatupang, T.M., 2004)[32], (Simatupang T. M.& Sridharan R.,2005)[33],(Zhou H.& Benton Jr W.C.,2007)[34],(Pereira J. V.,2009)[35]

5. Questionnaire

Questionnaires were prepared in matrix form. The rate of evaluation of the effect of each factor was considered from zero to 100. The measuring instrument was evaluated for reliability using SPSS software and Cronbach's methods. The obtained values were 8 0.839 and 0.897, which indicates the high reliability of the measuring tools.

6. Data Analysis Method

Significance of the effect of each factor was assessed by mean t-test with 95% confidence level. All calculations was performed by SPSS and, TOPSIS method was used to prioritize comments.

6.1 TOPSIS

TOPSIS method is based on the theory that option A has the greatest distance from the negative ideal solution and the greatest distance from the ideal solution. Problem solving by TOPSIS method is based on six steps (M.SocorroGarcía-Cascalesa & M.TeresaLamat., 2012)[37].

Step 1: Using the following formula for transforming the existing decision-making matrix to an observable “unscaled” matrix:

$$(1)\ \text{Nij}=\frac{rij}{\sqrt{\sum_{j}^{m}=1^{rij2}}}$$

Step 2: The input of the algorithm is considered as a vector W and an unscaled matrix is created.

$$w=\{w_1.w_2\,.\cdots w_n\}$$

$$(2)\ \text{Weightless matrix=ND.Wn×m} = \begin{matrix} V_{11} & V_{1j} & V_{1n} \\ \vdots & \vdots & \vdots \\ V_{m1} & V_{mj} & V_{mn} \end{matrix}$$

Step 3: Define the positive and negative ideal solutions as follows:

(3) Positive ideal solution= $A^{+}=\left\{\left(\left(max_i\ V_{ij}\middle|j^{\varepsilon J}\right)\right).\left(min_i\ V_{ij}\ \middle|j^{\varepsilon JJ\blacksquare}\right)|i=1.2\ldots..m\right\}$

$$= \quad \left\{V_1^{+}.V_2^{+}.\ldots V_j^{+}\cdots V_n^{+}\right\}$$

(4) Negative ideal solution= $A^{+}=\left\{\left(\left(min_i\ V_{ij}\middle|j^{\varepsilon J}\right)\right).\left(max_i\ V_{ij}\ \middle|j^{\varepsilon JJ\blacksquare}\right)|i=1.2\ldots..m\right\}$

$$= \quad \left\{V_1^{-}.V_2^{-}.\ldots V_j^{-}\cdots V_n^{-}\right\}$$

Step 4: to calculate the distance from each option to the positive and negative ideals using the Euclidean distance method as follows:

(5) $d_i^{+}=\sqrt{\sum_{j=}^{n}1^{\left(V_{ij}-V_j^{+}\right)^2}.i=1.2\ldots.m}$

(6) $d_i^{-}=\sqrt{\sum_{j=}^{n}1^{\left(V_{ij}-V_j^{-}\right)^2}.i=1.2\ldots.m}$

Step 5: To determine the coefficients of proximity of an option to an ideal solution

(7) $CLi^{*}=\frac{d_i^{-}}{d_i^{-}+d_i^{+}}$

Step 6: ranking options: each option whose CL is higher would be better [24].

7. Data Analysis and Findings

The significance of the research hypothesis has been examined by using the mean test. This examination has been performed by taking accounting the average score of each factor relative to the six factors.

8. Findings/Results

Table 3 has presented the significant levels of different factors. Factors with significance less than 0.05 are rejected.

Table 3. Meaningful amount of effective factors in supply chain management of Iran Khodro Company

95% Confidence Interval of the Difference		Mean Difference	Sig(2-tailed)	df	t	Factors
Upper	Lower					
12/9209	811034	11/01215	0	95	7/516	**Variety of products and services**
1285757	6/5121	9/5429	0	95	6/249	**Selection of suppliers based on the time and price of supply and product quality**
16/4223	10/4033	12/42722	0	95	8/79	**Main production schedule**
9/2992	2/1915	5/79536	0/0002	95	3/192	**Liquidity cycle time and circulation**
12/0148	5/3007	8/65777	0	95	5/12	**Deviation from the budget**
13/1978	5/5388	9/36824	0	95	4/857	**Determining the level of cooperation of suppliers**
2/2275	-4/6029	-1/18772	0/042	95	-0/69	**Ordering methods**
9/6615	3/3101	0/48583	0	95	4/055	**Delivery reliability**
10/057	2/4648	6/26087	0/001	95	3/274	**Delivery delay schedule**
11/8618	4/5913	8/2265	0	95	4/493	**Circulating inventory level**
16/5402	9/3638	12/952	0	95	7/166	**Warehousing costs**
17/161	10/1095	13/63526	0	95	7/628	**Distribution Scheduling**
12/6766	5/7083	9/69244	0	95	4/83	**Customer satisfaction**

According to the derived results, all factors except No. 7 have been confirmed and among the 13 identified factors, the effect of 12 factors on the supply chain management of the automotive industry is significant. The results of the questionnaire data have been presented in Table 4. The average effect of each factor on each related dimension can be seen.

The weight of each dimension has been calculated by the linear weighted-sum method.

W={0.1595, 0.1588, 01/1707, 0.1642, 0.1811, 0.1657}

Then,scoring matrix normalization has been performed using the following relationship (Table 5).

$$(8)\ n_{ij} = \frac{r_{ij}}{\sqrt{\sum_{j=}^{m} 1^{rij^2}}}$$

In the next step, the results of the normalized matrix are multiplied by the weight vectors. The distance of each factor from the positive and negative ideals was also determined by specifying positive and negative solutions. The results have been presented in Table 6. After calculating the distance of each factor from the positive ideal and negative ideal, CLi is also calculated based on the results of Table 6 and the results have been presented in Table 7.

Table 4. Results of evaluating the factors affecting the dimensions of supply chain management

Cost	Information security	Assessment of assets	Responsiveness	Flexibility	Reliability	Dimensions / Factors
68/97	65/04	7075	70/68	73/86	76/77	**Variety of products and services**
64/82	63/99	77/06	61/78	74/84	74/38	**Selection of suppliers based on the time and price of supply and product quality**
82/71	68/92	72/76	71/19	74/84	74/29	**Main production schedule**
62/63	55/46	61/17	69/57	62/14	76/04	**Liquidity cycle time and circulation**
64/64	62/23	72/08	65/84	75/18	73/88	**Deviation from the budget**
70/04	62/25	72/45	67/96	73/47	69/67	**Determining the level of cooperation of suppliers**
55/83	60/45	62/14	46/19	66/75	51/28	**Ordering methods**
64/02	61/28	68/45	67/03	71/45	71/07	**Delivery reliability**
64/17	60/76	66/98	64/583	71/19	8/69	**Delivery delay schedule**
69/25	59/05	68/64	71/61	72/08	70/75	**Circulating inventory level**
72/92	65/72	77/05	74/06	73/94	78/7	**Warehousing costs**
82/84	69/61	69/46	70/97	74/22	75/21	**Distribution Scheduling**
71/2	64/38	66/25	69/41	72/07	69/88	**Customer satisfaction**

Table 5. Normalized matrix The effect of factors affecting the dimensions of the supply chain

Cost	Information security	Assessment of assets	Responsiveness	Flexibility	Reliability	Dimensions / Factors
0/2757	0/2851	0/2812	0/2911	0/2842	0/2959	**Variety of products and services**
0/25191	0/2805	0/03063	0/2545	0/2833	0/286	**Selection of suppliers based on the timeand price of supply and product quality**
0/2306	0/3021	0/288	0/2922	0/288	0/2863	**Main production schedule**
0/2503	0/2431	0/2431	0/2866	0/2391	0/2931	**Liquidity cycle time and circulation**
0/2584	0/2771	0/2865	0/2712	0/2893	0/2847	**Deviation from the budget**
0/28	0/2772	0/2879	0/2799	0/2827	0/2685	**Determining the level of cooperation of suppliers**
0/2222	0/265	0/247	0/1903	0/2569	0/1976	**Ordering methods**
0/2679	0/2686	0/2721	0/2761	0/2749	0/2739	**Delivery reliability**
0/2565	0/2663	0/2662	0/2658	0/2739	0/269	**Delivery delay schedule**
0/2768	0/2588	0/2728	0/295	0/2774	0/2727	**Circulating inventory level**
0/2915	0/2888	0/3062	0/3051	0/2845	0/3033	**Warehousing costs**
0/2312	0/3051	0/2761	0/2923	0/2856	0/2898	**Distribution Scheduling**
0/2846	0/2822	0/2633	0/2859	0/2812	0/2693	**Customer satisfaction**

Table 6. Calculated values of d_i^+ and d_i^- for each of the effective factors of supply chain management

d i -	d i +	Factors
0/027679	0/01106	**Variety of products and services**
0/022666	0/015651	**Selection of suppliers based on the time and price of supply and product quality**
0/032506	0/004478	**Main production schedule**
0/022855	0/022121	**Liquidity cycle time and circulation**
0/022881	0/014963	**Deviation from the budget**
0/024313	0/012523	**Determining the level of cooperation of suppliers**
0/004915	0/034096	**Ordering methods**
0/022229	0/015388	**Delivery reliability**
0/019728	0/018069	**Delivery delay schedule**
0/024714	0/01456	**Circulating inventory level**
0/031971	0/007305	**Warehousing costs**
0/032406	0/005858	**Distribution Scheduling**
0/024628	0/012977	**Customer satisfaction**

Table 7. Calculated CLi* Coefficient for each factor

CL i*	Factors
0/87892	**Main production schedule**
0/846912	**Delivery delay schedule**
0/814	**Variety of products and services**
0/7145	**Distribution Scheduling**
0/660027	**Delivery reliability**
0/654919	**Deviation from the budget**
0/629271	**Customer satisfaction**

CL i*	Factors
0/614793	**Circulating inventory level**
0/601929	**Warehousing costs**
0/590919	**Determining the level of cooperation of suppliers**
0/521942	**Ordering methods**
0/508158	**Selection of suppliers based on the time and price of supply and product quality**
0/1525996	**Liquidity cycle time and circulation**

Acknowledgments

The other field studies indicates that blockchain technology in companies such as IranKhodro, which have just entered this field, requires the following steps:

Internal culture building

- Holding internal brainstorming sessions with the aim of measuring the potential benefits of using Blockchain technology in different parts of the organization.,
- Holding idea generation competitions.,

Training managers and employees

- to encourage employees to study and come up with ideas in this area, buy potential ideas and solutions introduced by them.,
- Invest in the knowledge of this technology in your organization.,
- Ideation by using experts to create a team to determine the applications of the blockchain in the business.
- Develop your Blockchain strategy and prioritize its applications.

Design of the application cases,

Determine the selected applications and create an architecture to implement it in very small dimensions that jeopardize the current business process.

Implementation

- Monitor the progress of priority applications frequently and create an initial version at all times.
- To enter the market and create great business models, make precise plan.

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