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Monitoring The Photovoltaic Industry Financing Challenge in Iran

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Abstract: The global energy crisis has increased the need to use renewable energy such as solar energy instead of fossil fuels. The present study aims to model the financing of the photovoltaic industry which is one of the most fundamental challenges that this industry is facing. To fulfill this aim, this study proposed a model based on the opinions of industry experts collected through interviews in the period from January 2021 to August 2021 and validated it by the structural equation modeling method. Based on the results of the research, issues related to the financing challenge of the photovoltaic industry can be examined in 8 clusters, which are; challenging factors, mediating conditions, consequences, government financing strategies, government incentives for the private sector, personal financing strategies, public financing strategies, guarantees, and insurance. The relationship between each of these variables has also been confirmed as research hypotheses.

Keywords: Photovoltaic, financing, structural equation modeling, self-organizing maps

1. Introduction

Energy as the driving power of production activities is considered the foundation of the economic and social activities of any country. Today, it has become clear that the effects and consequences of inappropriate use of natural resources and disregard for the rights of current and future generations can be irreparable. (Mohammadi et al., 2012)

In addition to the fact that renewable energy sources have a great potential to meet the increase in energy demand, realize social justice and fight against the risks caused by the increase in the price of fossil fuels, they are also considered a solution to reduce the effects of climate change and greenhouse gas emissions. (Karimi et al., 2020) On the other hand, studies show that the production and consumption of renewable energy cause economic growth, and economic growth can influence the increase in the production and consumption of renewable energy. (Baseri et al. 2019)

At present, considering the prospect of the end of fossil energy sources, climate warming, and climate change, many countries are seriously pursuing the development of renewable energies due to diversification policies in the energy portfolio. (Torabi and Payam, 2018). In this regard, renewable energies are finding a more prominent place in the perspective of the global energy portfolio day by day (Kazemi, 2017).

According to statistics published by the International Renewable Energy Agency, in 2019, at least 11.5 million people were employed in the renewable energy sector worldwide, and 3.75 million of these jobs were in the photovoltaic industry. (IRENA, 2020) The development process of renewable energy industries has been such that in Europe, the share of energy produced from renewable sources compared to the final gross energy consumption in 2018, with an increase of almost two times since 2004, has reached 18.9% and according to European Union resolution of 2018, the strategy is to increase this share to 32% in 2030 (Eurostat, 2020).

The development of Iran's renewable energy industries has been slow compared to the global growth trend of these industries. So that the share of renewable energies in Iran's electricity production is a quarter of the world average (Enerdata, 2021).

According to the research findings, high initial capital costs are one of the most important obstacles to the development of renewable energy industries, including photovoltaics (Esmailzadeh et al., 2021), because in many cases, the investment costs to start a new photovoltaic project are far higher than the costs of fossil fuels (Karimi et al., 2020). Therefore, several studies have been conducted worldwide to find suitable financing methods in this industry, and many successful projects have been implemented worldwide (Yang and Liu, 2020), which shows that the high initial costs could not question the necessity of renewable energy development. Rather, this issue has led developed countries to plan for the use of appropriate financing methods, and the result of their efforts indicates that crossing the barrier of high costs and being on the path of development in these industries is possible.

The important point in project financing is that the laws and conditions of each country are effective in the usefulness of any financing method. In other words, a financing method may not be effective in one country, but it may be useful in another country. Therefore, to choose the appropriate financing method, it is necessary to pay attention to the conditions of each project and the host country of the project (Emami Meibodi, 2019). So in the present research, considering the conditions and laws of Iran, using the opinions of financial experts and photovoltaic industry activists, the financing challenges of this industry will be examined and monitored.

2. Literature Review

One of the best alternatives to fossil fuels is solar energy, which is an inexhaustible source of energy (Irfan et al., 2021). One of the types of the solar power plant is the photovoltaic solar power plant that directly converts sunlight into electricity. A photovoltaic system consists of a set of semiconductor solar cells. Therefore, in these power plants, electricity is produced with a direct method without the need for complex equipment and with a relatively suitable efficiency. To design a photovoltaic system, sunshine duration is considered an influential factor, such that with the increase of hours of sunshine, fewer solar panels will be needed (Kazemi, 2017). The very important advantage of these power plants is that they can be installed in small dimensions and on the roof of any residential house. But due to the reasons, the most important of which is the high initial cost, they are not welcomed by the public. Because it is not easily possible to provide the required capital to install this equipment (Karimi et al., 2020). Considering the necessity of developing the photovoltaic industry, it is necessary to solve the issue of its financing through the proper management of financial resources. Financing is the science of managing financial resources. In developing countries with financial crises, choosing the appropriate financing method becomes more important (Ebrahimi et al., 2017). The survey of large photovoltaic projects in the world shows that the financing of these projects has been done through a combination of financing tools. In this regard, Lem and Lau (2018) examined and analyzed the combined financing tools used in photovoltaic projects in different countries to help make decisions in the field of financing renewable energy industries.

The monitoring of studies in the field of renewable energy financing showed that some of these studies have investigated different methods of financing. For example, Arifin (2021) compared 11 different financing models by examining some economic indicators and finally introduced a special type of hybrid financing method as the optimal solution for financing the photovoltaic industry in Indonesia. To investigate crowdfunding and its conditions, Linhart et al. (2021) compared crowdfunding with individual financing under different conditions using economic indicators and concluded that in crowdfunding even with a higher interest rate loan, the payback period is lower. Also, Yang and Liu (2020), to investigate leasing financing in China's photovoltaic industry, conducted a case study on the cash flows of photovoltaic projects using leasing and concluded that the leasing method is a suitable method for active companies in China's photovoltaic industry and the longer the lease term, the lower the interest rate. Yang et al. (2019) also conducted a case study on China's photovoltaic projects using the net present value index to investigate loan and leasing financing and concluded that low-interest loans and long repayment periods along with leasing increase the rate of investment return and to implement this method of financing, they suggested that the government implement policies to improve the trust of financial institutions that provide loans to the photovoltaic industry. Also, Isa (2019), to analyze the financing challenges of renewable energy industries in Nigeria, using descriptive analysis, investigated and compared the financing situation of renewable energy projects in Nigeria and Brazil and concluded that Nigeria has been unsuccessful in comparison to Brazil in this field due to weak political will and the lack of a specific financing framework and model for renewable energy industries. Liu and Chu (2018) also aimed to diagnose and find solutions for the financing of China's renewable energy industries, through SWOT analysis concluded that private capital is a

good incentive for the development of renewable energy, which is necessary to benefit from appropriate policies for attracting this capital.

Some studies have analyzed the situation of the renewable energy industry in Iran. For example, Khayyatian et al. (2020) analyzed the historical development of the photovoltaic industry using the grounded theory approach and concluded that since 1991, the authorities have been familiar with renewable energies for 15 years, and after that, for 10 years, there was a focus on supporting the development of the industry, and since 2015, the direction has been towards creating a renewable energy industry market in Iran.

Some studies have investigated the relationship between the development of renewable energy and the country's economic growth; Baseri et al. (2019) using the Autoregressive Distributed Lag model, concluded that the production and consumption of renewable energy and Iran's economic growth have a mutual effect on each other. Also, Ghaed et al (2019) using the Vector Auto-regression model, Johansen-Juselius method, and error correction method, concluded that in the long term, private sector investment in renewable energy causes economic growth.

Some of the studies have examined the challenges of renewable energy development; Sarlaki and Hasanbeigi (2019), Using descriptive analysis, introduced the main obstacles to the development of renewable energies in Iran: very high initial costs and lack of financial resources, technological problems, and the existence of rich oil resources in the country. Aghaei et al. (2019) used the Tobit panel model to explain that the development of renewable energy in developed countries is most affected by the development of the stock market and in developing countries by the development of the entire financial markets.

Therefore, based on the studies conducted in Iran, the development of renewable energy industries is effective on the country's economic growth, and the photovoltaic industry has gone through its historical evolution towards creating a market for this industry in the country. The main obstacles to the development of the industry are high initial costs and a lack of financial resources. But studies have not addressed the issue of financing the photovoltaic industry and there is a research gap in this field. Nevertheless, the issue of financing the photovoltaic industry has been taken into consideration in several studies from other countries, especially the European Union and China. So that they have passed the examination of the necessity of developing this industry and have largely moved towards pathology and finding solutions for financing this industry. Therefore, the current research analyzes the challenges of financing the photovoltaic industry in the path of its historical evolution in Iran.

3. Methodology

This research is considered applied research because the results of this research are directly used in the development of the photovoltaic industry. The research community included technical or financial experts active in this industry. Targeted sampling was used by combining the maximum variation method and the snowball method.

Research Steps:

1- Create a database: this step was done in two phases. In the first phase, a collection of the results of the experiences of successful photovoltaic projects, the results of the researches conducted in the field of financing the photovoltaic industry, and related laws and regulations in the country were collected. In the second phase, a list of public and private companies active in the photovoltaic industry was prepared and after making the necessary arrangements, interviews were held in a semi-structured interview manner. By using these interviews, the opinions of photovoltaic experts were collected between January 2019 and August 2019, and the content of the interview was recorded as an audio file.

2- Pre-processing of the text: the data obtained from the interviews were implemented and the text was carefully examined word by word and line by line. In such a way that the text was divided into separate meaningful parts and the additional parts that had no meaningful role in the main topic were removed.

3- Text analysis: after data preprocessing, repeated words and phrases with the same meaning were determined and the most important factors in the texts were determined and analyzed.

4- Expertise: At this step, through a questionnaire, experts' opinions were determined regarding the degree of relationship between the most important and frequent expressions and general concepts.

5- Clustering: After determining the important factors of experts' opinions about the financing of the photovoltaic industry, we clustered them using the clustering method of self-organizing maps.

Self-organizing networks have been developed based on certain characteristics of the human brain. The inputs of different sensory areas are associated with a meaningful geometric arrangement of human brain cells. In self-organizing maps, which are composed of two separate input and output layers, each neuron in the output layer is related to an information vector with the dimensions of the analyzed space. The location of each unit of a self-organizing map corresponds to the inherent characteristics of the input patterns. To train self-organizing networks, without the need for a predetermined output, a random weight is assigned to each node, and if the node's weight matches the weight of the input layer, it is selected. Then, during repeated steps, the weight of the node and the nodes around it are slowly changed to achieve the maximum similarity between the node and the input layer. (Nakhaei et al., 1400)

Since self-organizing maps do not need a predetermined output, they are classified in the category of unsupervised neural networks. These neural networks, by forming a system of relationships between the

variables affecting clustering, based on the initial classification of the input patterns, can provide an appropriate classification of new patterns with the least error. Therefore, they have a great ability to analyze complex spaces and cluster data into homogeneous groups. (Bayanloo and Ahmadabadi, 2016) For this reason, in this research, this method was used to monitor and cluster the collected information.

6- Relationships: At this stage, the theoretical links between the clusters have become clearer and we create a visual diagram of the connections and relationships between the clusters.

7- Validating: At this stage, the diagram of the previous stage was subjected to the judgment of the statistical community of stakeholders, and the validation of the model was done with a sample size of 99 using structural equations.

4. Findings

After the pre-processing and analysis of the text, which led to the identification of words and phrases with the same semantic load and the determination of the most frequent phrases, the resulting data were clustered. For clustering, SoMine software and a hierarchical cluster analysis called SOM-Ward Clusters were used. The inputs of the network consisted of 43 (number of key phrases), 64-dimensional vectors (features obtained from the questionnaires completed by experts), and the key phrases of the interviews were divided into 8 clusters. In SoMine software, a structure with 150 neurons was used in the output layer. The speed of training was set so that the software used the most accuracy for training the network automatically. To train the network, the stretch value was also chosen to be 0.5. During training, SoMine software automatically selects the best dimensions for the network according to the number of neurons in the output layer. After training the network, the training background shows that the software has chosen 6×7 dimensions for the network after testing different dimensions, which shows the characteristics and structure of the self-organizing map used in this research. Figure 1 shows the final clustering of key phrases, which shows homogeneous combinations of keywords, in 8 clusters.
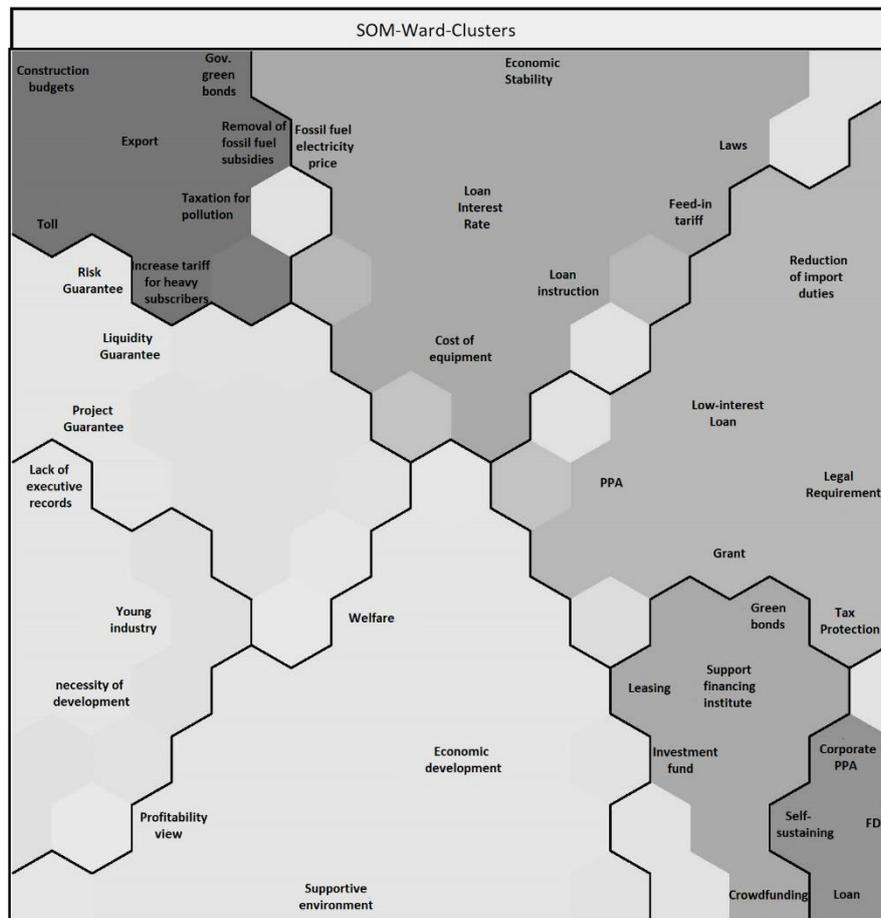

Fig. 1 - Graphical diagram of clustering

After determining the clustering presented in Table 1, it is possible to analyze the characteristics of phrases and keywords placed in each cluster based on the literature on financing the photovoltaic industry.

Table 1 - Clustering of key phrases of the texts

Guarantees and insurances	Causes of the challenge
• Risk guarantee • Project guarantee or system performance insurance • Liquidity guarantee	• Young industry in the country • Lack of executive records for many financing methods • Economic and environmental necessity of industry development in the country
Government incentives for the private sector	**Government financing strategies**
• Power purchase agreement • Low-interest and long-term loan with a rest period • Grant • Reduction of equipment import duties • Tax protection and purchase from domestic producers • Legal requirements for large companies	• Electricity toll • Electricity export • Construction budgets • Removal of fossil fuel subsidies • Increase in electricity tariff for heavy subscribers • Taxation of companies that pollute the environment • Government green bonds
Public financing strategies	**Personal financing strategies**
• Leasing • Support investment fund • Crowdfunding • Green bonds	• Bank loan • Foreign direct investment • self-sustaining investment • Corporate power purchase agreement • Long-term stocks
Achievable results	**Influencing conditions**
• Economic development • Public Welfare • Profitability view of the industry • Supportive environment of the industry	• Fossil fuel electricity price • Loan interest rate • Economic stability • Bank loan instructions • Relevant government laws • Feed in tariff • Prime cost of equipment

Based on the clustering of opinions, the challenges of financing the photovoltaic industry in the country, from the perspective of the causes of the challenge, the influencing conditions, the achievable results, government financing strategies, government incentives for the private sector, personal financing strategies, financing strategies, public financing strategies, guarantees, and insurances can be reviewed.

The first cluster (causes of the challenge): one of the most important reasons that have been identified for creating challenges in the financing of the photovoltaic industry is the short history of this industry in the country and it's not so much development. The need for high initial capital is the underlying issue for this slow growth. Another important cause is the lack of executive records for many financing methods. In fact, the lack of development of the industry leads to financing methods with no implementation and, consequently, the lack of experience in this field. The third causal condition is the economic and environmental necessity of industrial development for the country because of the need to limit the consumption of fossil fuels to reduce the dependence of the country's economy on fuels that are not only non-renewable but also cause pollution and climate warming and climate change.

The second cluster (influencing conditions): In explaining the most important conditions affecting the financing of the photovoltaic industry, we can refer to the country's economic stability which affects the number of private sector investments, and related government laws that can be cumbersome and an obstacle to investment, and the price of fossil electricity whose cheapness can question the profitability of the photovoltaic industry, and bank loan instructions and interest rates that can become an obstacle to the growth of the industry instead of facilitating investment, and the amount of the feed-in tariff of electricity produced by solar power plants which greatly affects the attractiveness of this industry for investment, and the prime cost of the equipment that if there is no development of their manufacturing technology inside the country and there are import problems, they can greatly reduce the profitability of this industry.

The third cluster (achievable results) : The four titles are the most important components that can be achieved through financing strategies of the photovoltaic industry; One is the rule of the industry support environment which is created due to the existence of government policies in creating incentives for the private sector. The other is to expand

the view of profitability in the industry, which is achieved with the success of using different financing methods. By solving the problems of power outage and electricity export, the welfare level in society will improve. And finally, by reducing the dependence of the country's economy on non-renewable fuels, economic development occurs.

The fourth cluster (government financing strategies): The government plays a key role in the development of the industry because it owns two clusters and can not only use solutions to finance the industry, but it can also play a role in motivating private sector investment. The government can collect tolls on electricity bills, construction budgets, and electricity exports, remove or reduce fossil fuel subsidies, increase heavy subscribers' electricity tariffs, collect taxes from polluting companies and issue green bonds to finance the construction and operation of large solar power plants.

The fifth cluster (government incentives for the private sector): By providing incentives for private sector investment, the government can play an effective role in overcoming the challenge of financing the photovoltaic industry. The most important government incentives in this research are power purchase agreement, grants, tax reliefs, low-interest and long-term loans with a rest period, reduction of photovoltaic equipment import duties, purchase of equipment from domestic manufacturers, and the legal obligation of large companies to produce their electricity from renewable sources was recognized.

The sixth cluster (personal financing strategies): Foreign direct investment, bank loans, and long-term stocks have been identified as the most effective personal financing strategies. Long-term shares mean that capitalists, in exchange for holding shares in the production company, provide capital to that company and support it for long-term growth and continuous development; But the requirement for people to invest in this company is that the company has a good history and high quality of work. Self-sustaining investment, which means financing by one's own capital and without the help of other sources, is another identified strategy if the investor is financially capable. For foreign direct investment, international companies finance the project in a country where there is a suitable return to the capital for the foreign investor. In addition, if large companies face high costs of supplying fossil electricity due to the existence of legal requirements to reduce electricity consumption, they can produce electricity through a power purchase agreement for photovoltaic.

The seventh cluster (public financing strategies): Leasing, solar investment funds, green bonds, and crowdfunding are the most effective public financing strategies in this cluster. Solar Fund invests specifically in solar energy infrastructure by using an experienced and expert team and helps the development of the photovoltaic industry in a scientific and targeted manner. The efficiency of leasing will be greater when there is a solid and sustainable marketing and financing infrastructure. The supporting financial institution itself may not have enough credit for financing, but it is supported through various financial sources to promote basic investments in the industry. Crowdfunding is for collecting relatively small amounts of capital from a large number of people, without financial intermediaries, which is done through public invitations and the publication of visual descriptions of projects. By issuing green bonds, the initial capital of the project is provided, and the buyers of the bonds receive their interest from the project's income at maturity dates, and at the end of the bond's life, the principal amount is returned to them; But the important point for the publication of these papers is that the need to go through numerous legal procedures and spending certain costs makes most of the small companies unable to benefit from this possibility.

The eighth cluster (guarantees and insurances): risk guarantees, which are important in international contracts, have been identified in this cluster to cover political or regulatory risks related to renewable energy. The Project guarantee, which guarantees the success of the project in the installed capacity for production, and the Liquidity guarantee, which guarantees the repayment of project debts, are among the components identified in this cluster to overcome the financing challenge of the photovoltaic industry. Due to the attention paid to these components by the photovoltaic industry activists, it has been determined that guarantees and insurances play an important role in financing the industry by creating confidence and increasing the motivation of investors despite the increase in project costs.

Based on the theoretical foundations and the findings obtained from the interviews described above, the following structure was obtained.
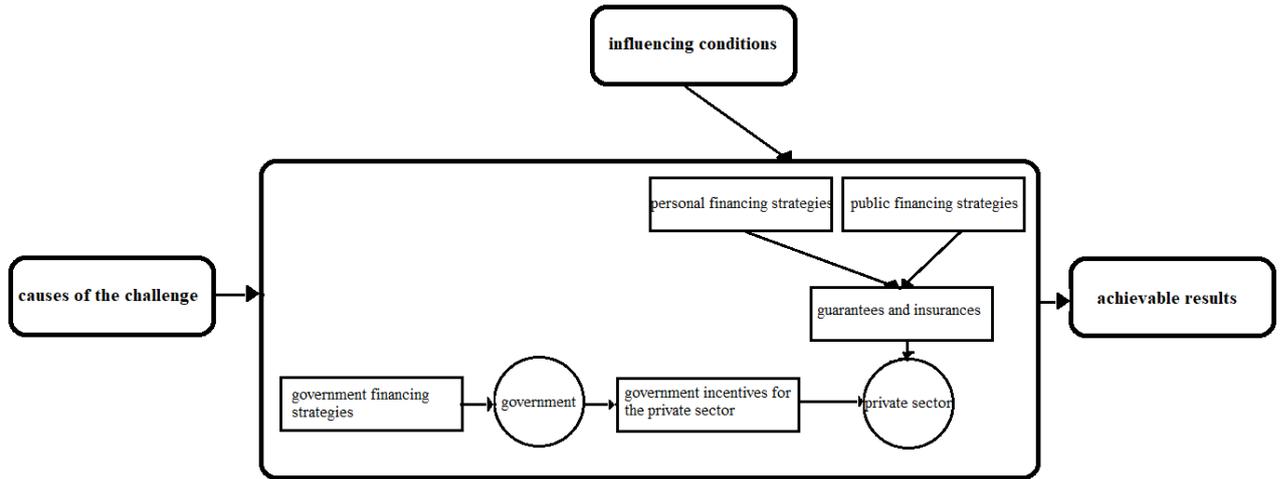
Fig. 2 - Visual diagram of relationships between clusters

To validate our model, we performed structural equation modeling (SEM). We evaluated the coefficients of determination (R2) and the size and relevance of the path coefficients. Figure 3 shows the resulting structural model with all the path coefficients. Since the results reported in this figure are all greater than 2.58, it can be concluded that all the relationships of the model are confirmed at the significance level of 99%. To measure the overall performance of the model by the goodness of fit (GOF) index, the following table and formula have been used, in which the resulting value indicates the strong desirability of the model.
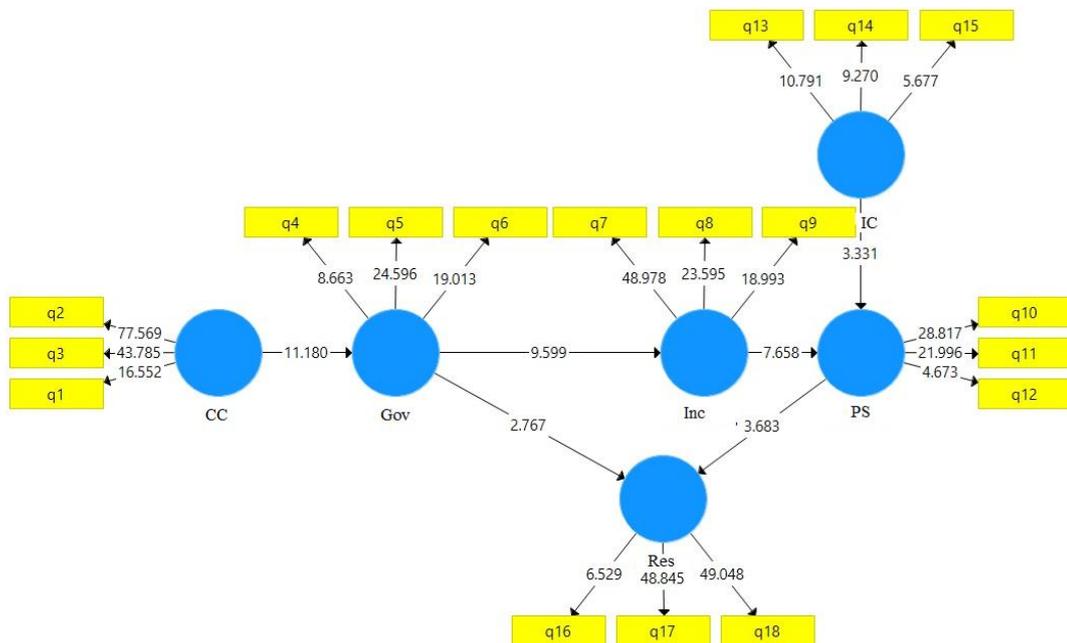

Fig. 3 - The structural model

Table 2 - Calculating GOF of the model

	Communality	R^2
Causes of the challenge	0.600	
Government Financing strategies	0.295	0.498
Government incentives for the private sector	0.476	0.407
Private sector financing strategies	0.332	0.540
Influencing conditions	0.332	
Achievable results	0.438	0.396
Average	0.412	0.307

$$GOF = \sqrt{\overline{Communality} \times \overline{R^2}} = \sqrt{0.412 \times 0.307} = 0.356 \qquad (1)$$

5. Conclusion

Considering the historical development of the photovoltaic industry in the country, with the transition from familiarization, support, and market creation stages, it is now necessary to monitor and find solutions to the challenges that are placed in the development of this industry. Since in studying the challenges of the development of the photovoltaic industry, high initial costs and lack of financial resources have been identified as the main obstacles, in this research, we tried to study this challenge based on all available texts about photovoltaic financing and opinions of industry experts in the country. The results of the research showed that all the issues raised in the challenge of financing the photovoltaic industry can be analyzed in 8 clusters, which are the causes of the challenge, influencing conditions, achievable results, government financing strategies, government incentives for the private sector, personal financing strategies, public financing strategies, guarantees and insurances.

Considering the role of the government in the four clusters of government financing strategies, government incentives for the private sector, causes of the challenge, and influencing conditions, it is concluded that the plans and policies of the government in the field of financing the photovoltaic industry, are of particular importance and considering that the goals set for this industry in the previous programs have not yet been realized and there is backwardness in this field, it is suggested that a comprehensive review of these policies and programs be done. One of the cases that need to be fundamentally reviewed for these policies is non-principal subsidies allocated to fossil electricity, which is in the cluster of influencing conditions. The corporate power purchase agreements in the cluster of personal financing strategies also require the use of government mandatory methods such as taxes to prevent the increase in fossil electricity consumption. It is also suggested that to achieve the supportive atmosphere identified in the third cluster, by using strong media methods, the incentives used by the government from the fifth cluster should be noticed throughout the country so that the incentives can play their role in the most complete way. In addition, considering the identification of the prime cost of equipment in the cluster of influencing conditions, it is suggested that the government strengthen its supporting role of knowledge enterprises in the photovoltaic industry from this point of view. In order to increase the efficiency of investment funds in the cluster of public financing strategies, it is suggested to use appropriate advertising methods for the entry of small and large investors into the specialized field of these funds, by diversifying their financing methods and using the experiences of successful projects in the world.

Acknowledgement

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