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Comparison of the Efficiency of Free Zones of Iran with Window Data Envelopment Analysis

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Abstract: *Today, free zones in Iran are considered as a tool for realizing outward looking development strategies with an emphasis on export development policy. In this study, we tried to investigate the efficiency of free zones in Iran for the years 2012 to 2015 by using window data analysis and sensitivity analysis of indicators. The results showed that Maku free zone is the most effective region and the Aras, Qeshm and Kish regions are inefficient zones. The results of the sensitivity analysis of the indicators also showed that among the output indicators, the export index is the most sensitive indicator of the model and among the input indicators, the registered companies and institutes are considered as the most deficient between inputs. Therefore, in order to improve the efficiency of free zones, these areas need to invest more in sensitive inputs and look for better performance for non-sensitive outputs.*

Keywords: *window analysis, foreign investment, export, free zones*

INTRODUCTION

The facilities available in the world are limited and we should use these limited facilities in an optimized way. The inadequate and inefficient use of existing capital is an obstacle to the promotion of desirable goals. Throughout the history, human beings have always sought to make things simpler and less time-consuming and gain more product with the same amount of resources. By seeing the difference in the level of human life in different societies, there comes a question in mind that which is the reason for this difference? One reason can be the difference in the availability of natural factors and facilities, but with the observation of countries that have a lot of facilities but the level of living and prosperity in them is low (such as developing countries), we can conclude that this cannot be the only reason.

So, we should look for another cause. One of the other reasons can be how communities use resources and facilities. These countries do not use the resources they have at their disposal efficiently (Pourkazemi & Ghazanfari, 2005). As a result, evaluating the efficiency and providing a solution for optimal use of existing resources can help to further economic growth and increase the welfare of communities. Creating a free trade zone is one of the tools for economic growth in countries that can lead to attracting capital, technology transfer, human resource training, academic management education, connecting to the global market and ultimately be a gateway to economic development. Under the present conditions which the world moves towards globalization and full freedom and Iran will inevitably join this trend, free zones are considered as a model for reforming the country's economy to adapt to the emerging developments in the global economy. Considering that the economic structure of the country can be reformed through eliminating administrative barriers and imposing easy regulations while strengthening control and supervision, the free zones can be used as a tool for the design, testing and development of structural reform programs and the exploitation of its results should be considered in order to bring reforms to the mainland.

The history of commercial-industrial free zones is attributed by some to the late 18th century in Russia and some other attribute it to the late 19th century at the harbor of Hamburg in Germany. But the free zones in its present form have become a region for the free exchange of goods and the creation of an area for processing exports since the Second World War.

The history of these regions in Iran goes back to the first program of economic and social development. After communicating the principles of Article 44 of the Constitution, the free zones in the country gained great importance. Right now, 7 free zones are operating in Iran. In these free zones, various objectives include

investing and increasing public incomes, creating healthy and productive employment, regulating the labor and goods markets, active participation in global and regional markets, establishing international trade relations and mobility in the regional economy, the production and processing of goods, the transfer of technology, the production and export of industrial and transformative goods to accelerate the development of infrastructure, development and economic growth are defined. These regions play a major role in promoting the country's macroeconomics and realizing the goals of the 1404 Vision Document. The formation of these zones is one of the important measures of the country to provide the appropriate platform for adopting an export and re-export expansion strategy instead of import substitution.
The concept of free zone created by the modeling of China in Iran aims to develop regional and space development around free zones. Although Iran is the only country with free zones, there is no comprehensive plan for these areas, but for the same purposes improvement in the living standards of the inhabitants of the region were included in the bills on the establishment of free zones. However, these goals have left unaccomplished to a great degree in the wake of the vast activity of dealers in recent years and the purchase of untaxed goods and the transfer of goods in luggage to the mainland which has been the main work of a number of intermediaries. Therefore, evaluating and reviewing the performance of free zones and providing solutions for their optimal performance can significantly contribute to the country's economic growth and development, preventing the loss of resources. One way to evaluate the performance of free zones is to evaluate and review their efficiency and productivity. Therefore, the present study attempts to calculate the efficiency of free zones of Iran by using the Window Data Envelopment Analysis Approach for the years 2012-2015.

Methodology

A) Window Data Envelopment Analysis Approach

The DEA method was first used to analyze the cross-sectional data in which the decision maker unit is compared with all the other units operating in the same time period and the role of time is forgotten. Panel data is preferable to cross-sectional data, since not only one decision maker unit can be compared with another but the efficiency of a particular decision maker can be evaluated over time (Asgharzadeh et al., 2015; Sokhanvar et al., 2011).
The window analysis was initially introduced by Charles, Clarke, Cooper and Glahni (1985). The main idea was to consider each decision maker unit as a decision maker that is different at any given time. Therefore, each decision maker unit is not necessarily compared with the set of all data, but instead it is compared only with alternative sub-categories of panel data (Cullinane et al., 2004). The window analysis increases the number of data in the analysis which is useful in case of a small number of data in the sample. The change in the window width (i.e. the number of time periods) represents a range of simultaneous analyses along with cross-sectional analyzes. The window analysis can be a special case of a sequential analysis. However, in the sequential analysis, it is assumed that what has been practiced in the past remains practicable and therefore includes all the previous observations (Sokhanvar et al., 2011).
The DEA dynamic method (window analysis) is a method that allows calculation of efficiency over time and thus the ability to calculate productivity for managers. The window analysis operates on the basis of moving average and is useful for finding the operation process of a unit over time. The window analysis calculates the average efficiency of fixed efficiency models and models with variable yields and is used to determine the operation process of a decision maker unit over time, but there is no theory for determining the optimal window size (Al-Iraqi et al., 2010). Since this method assumes that the technical efficiency of all units in a window is measured relative to each other, it implicitly assumes that there is no technical change in any of the windows. This is a general issue about the DEA window. By reducing the window's width, this problem is somewhat solved and in order to validate the window analysis, the width of the classes should be chosen in a way that it is logical to ignore technical changes although there is no theoretical basis for determining the size of the window.
The dynamic DEA model allows for the comparison of static technical efficiency, hence the difference between the concept of technical efficiency and the concept of productivity is recognized. The concept of efficiency refers to a time span and productivity refers to a period of time. In performance measurement, it is talked about which firm works efficient, but in concept of productivity, it is said which firms have changed their production factors over time. Firms can increase the productivity of their production factors over time, moving over time to become the most efficient company. Therefore, performance and efficiency measurement methods are not necessarily the same.

The choice of window analysis provides limitations for internal analysis of the structure of firms. On the other hand, the flexibility of the window analysis model is low compared to the models that are capable of measuring the efficiency with the assumption of variable returns versus the scale and are usually estimated by assuming constant returns in relation to the scale. If performance measurement is assumed to be based on constant returns to scale, then performance is not assumed based on the variable returns to scale and it is not measurable based on the performance of the scale and is therefore fixed. The window analysis model provides an opportunity to observe the process of the firm's changing performance over time. This feature can be used to understand whether firms have been working to increase productivity or not. For the formula representation of this, assume that there are N decision making units (DMU) in the time period of t (t = 1, ..., T), and all of them user for production input and s for output. Thus, the sample contains T * N observation and the decision-maker unit n in period t, i.e. DMU_t^n, has a vector of r dimension of the inputs ($X_{1t}^n, X_{2t}^n, ...X_{rt}^n$) and also a s-dimensional vector of the outputs ($Y_{1t}^n, Y_{2t}^n, ...Y_{rt}^n$). The window that starts from K time ($1 \le K \le T$) and has a W width ($1 \le W \le T - W$) is specified by KW and has N * W observation. The matrix of inputs and outputs for window analysis can be seen in the following vectors respectively (Sokhanvar et al., 2011; Snagepta, 1995).

$$X_{KW} = (X_K^1, X_K^2, ...X_K^N, X_K^N + 1, X_K^1 + W, ..., X_K^N + W) \quad (1)$$

$$Y_{KW} = (Y_K^1, Y_K^2, ...Y_K^N, Y_K^N + 1, Y_K^1 + W, ..., Y_K^N + W) \quad (2)$$

The input-oriented DEA window analysis under the assumption of constant output relative to scale is written as follows:

$$\theta'_K = \min_{\theta,\lambda}(\theta)$$

s.t.

$$-X_{KW}\lambda + \theta X'_t \ge 0, \quad t = 1, ..., T \quad (3)$$

$$Y_{KW}\lambda - Y'_t \ge 0, \quad t = 1, ..., T$$

$$\lambda_n \ge 0 \quad n = 1.2.....N \times W$$

Accordingly, the output-oriented window analysis under the assumption of constant returns relative to the scale is written this way (Ali Nezhad, Sarokalani and Afshar Zeidabadi, 2014):

$$\theta'_K = \max_{\theta,\lambda}(\theta)$$

s.t.

$$-X_{KW}\lambda + \theta X'_t \ge 0, \quad t = 1, ..., T \quad (4)$$

$$Y_{KW}\lambda - Y'_t \ge 0, \quad t = 1, ..., T$$

$$\lambda_n \ge 0 \quad n = 1.2.....N \times W$$

B) Input and output indicators

The basis for measuring the efficiency in the data envelopment analysis technique is the input to output ratio. Therefore, it is necessary to specify the input and output variables. By studying studies and consulting with a number of university professors and experts, in the present study 3 inputs and 3 outputs have been used. The list of inputs and outputs is shown in Table (1).

Table 1 - Inputs and outputs of decision units

Outputs	Inputs
Export	Domestic investment
Foreign transit	Registered companies and institutes
Foreign investment	The amount of employment created

Results and Discussion

The present study is a library research type and documentary-based one where non-parametric method by employing DEA-SOLVER-LV8 software has been used. For the purpose of the study, the data from 7 free zones based on the availability of data were used during the period 2012 to 2015 which is provided by telephone and email from the Secretariat of the Supreme Council of the Free Zones. In this part of the article, first the status of free zones is reviewed according to model outputs during the years 2012-2015 and then the results of the window analysis and sensitivity analysis of the indicators are expressed.

A) Status of free zones according to model outputs

Today, free zones have been introduced as a phenomenon in the open economy. Most developing countries have set up one or more free zones. Global surveys and studies have shown that the free zone has brought different results in these countries. To assess the performance of free zones in Iran, the study of some of the key variables related to the missions and objectives considered for these zones can be useful. Three variables of attracting foreign investment, playing the role of export and increasing the amount of transit are among these variables. In Figure 1, the rate of investment attraction in the free zones of Kish, Qeshm, Chabahar, Arvand, Anzali, Aras and Maku is shown in the years 2012 to 2015. According to Figure (1), the largest amount of foreign investment is attracted to the Maku Free Zone in 2015. According to the figure, the statistics indicate that the process of attracting and realizing investments in all free zones is not sufficient to meet the development goals of the regions and the free zones have so far not succeeded in attracting foreign investment. Perhaps the weak performance of the free zones in the above period is attributable to sanctions imposed by the United Nations Security Council, EU sanctions, unilateral sanctions by various countries, including the United States, and US congressional sanctions against the country.

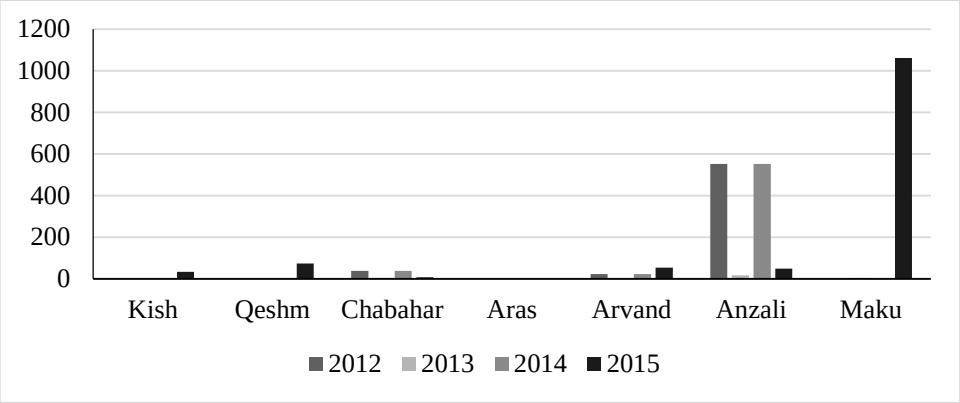

Figure 1. Comparison of foreign investment in free zones

The amount of exports is another variable that is not favorable. In the free zones, unlike the purpose of the export role for their establishment, these areas have turned into the platform of import into the country. Figure 2 shows the export volumes of these areas during the years 2012-2015. According to the figure, the largest export volumes belong to Maku and Arvand free zones and the other regions have had a poor performance.

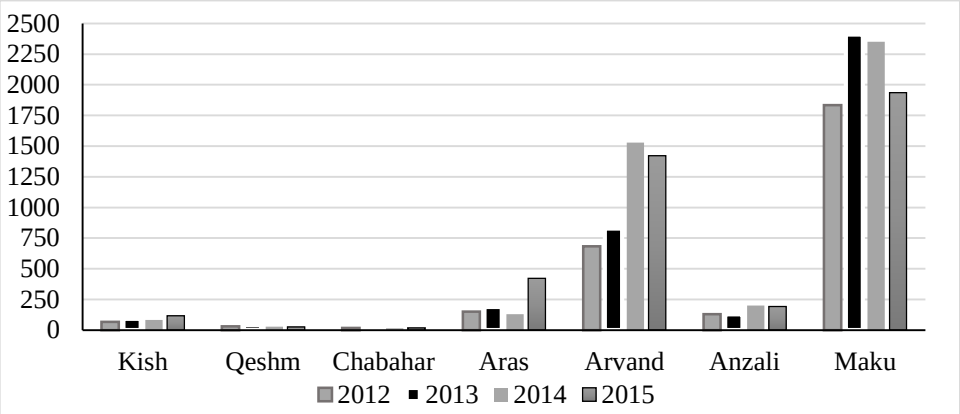

Figure 2. Comparison of export in free zones

Figure 3 shows the amount of foreign transit in Iran's 7 free trade zone during the years 2012-2015. The figure shows that in 2014 and 2015 the Maku Free Zone had had a better performance compared to other areas and other areas had poor performance in this regard.

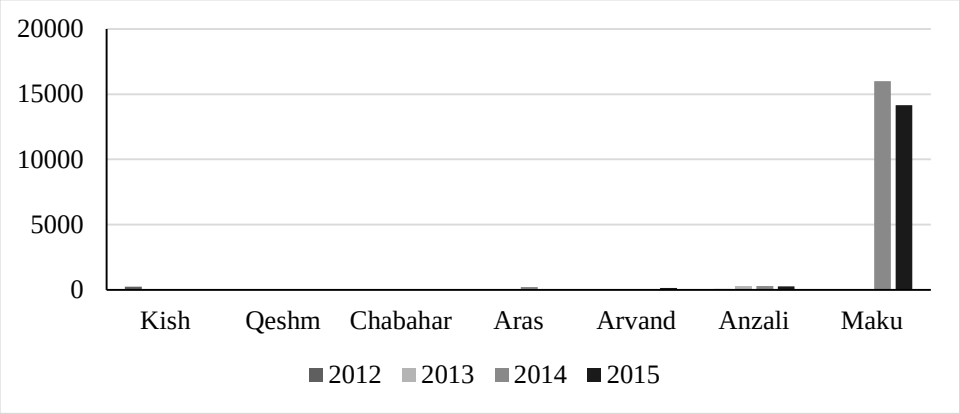

Figure 3. Comparison of foreign transit in free zones

B) The results of the window analysis

In this part of the paper, the efficiency values for the 7 free trade zones with inputs and outputs of Table 1 are obtained based on the window analysis of output data with a 2-year interval for each window. Although theoretically there is no way to determine the optimal size of the window; in most studies, the width of the window is considered 2 or 3 years. So having 4 years of data, 3 windows are formed. To obtain the efficiency values of each window, the linear programming model is solved for 7*2=14 units, and since there are 3 windows in the model, the linear programming model should be solved by 14*3=42 number.

Table 2: Efficiency of Free Zones during 2012-2015					
Kish	**2012**	**2013**	**2014**	**2015**	**The average efficiency of each window**
W1	1	0.076			0.538
W2		0.039	0.035		0.037
W3			0.035	0.055	0.045
Average efficiency each year	1	0.057	0.035	0.055	0.207
Qeshm	**2012**	**2013**	**2014**	**2015**	**The average efficiency of each window**
W1	0.141	0.196			0.168
W2		0.017	0.023		0.020
W3			0.012	1	0.506
Average efficiency each year	0.141	0.106	0.018	1	0.232
Chabahar	**2012**	**2013**	**2014**	**2015**	**The average efficiency of each window**
W1	1	0.091			0.546
W2		1	0.337		0.668
W3			0.058	1	0.529
Average efficiency each year	1	0.546	0.198	1	0.581
Aras	**2012**	**2013**	**2014**	**2015**	**The average efficiency of each window**
W1	0.363	0.557			0.460
W2		0.223	0.054		0.139
W3			0.055	0.180	0.118
Average efficiency each year	0.363	0.390	0.055	0.180	0.239
Arvand	**2012**	**2016**	**2014**	**2015**	**The average efficiency of each window**

W1	1	1			1
W2		1	0.682		0.841
W3			0.654	0.613	0.634
Average efficiency each year	1	1	0.668	0.613	0.825
Anzali	**2012**	**2013**	**2014**	**2015**	**The average efficiency of each window**
W1	1	1			1
W2		0.081	1		0.541
W3			0.520	0.094	0.307
Average efficiency each year	1	0.541	0.760	0.094	0.616
Maku	**2012**	**2013**	**2014**	**2015**	**The average efficiency of each window**
W1	1	1			1
W2		1	1		1
W3			1	1	1
Average efficiency each year	1	1	1	1	1
Source: Research Results					

In the Window Data Envelopment Analysis Approach, the firm's performance values for each period and width of windows are calculated for specific time periods and based on that, the average of the columns of each period is computed and finally the values derived from the average efficiency of each window of firms during the period of evaluation provides a basis for measuring and comparing firms' performance. Therefore, according to the results of Table (2), the free zone of Maku is the most efficient free zone (with full efficiency) among the other during the years 2012 to 2015 which again based on the examination of export, foreign investment and transit status has the best situation among the other regions while the Aras, Qeshm and Kish zones are considered inefficient zones during the same period. In table (3), the rankings of free zones are expressed in terms of the obtained performance values.

Table 3- Free zones ranking in terms of efficiency

Decision making units	Rank
Maku	1
Arvand	2
Anzali	3
Chabahar	4
Aras	5
Qeshm	6
Kish	7
Source: Research Results	

C) Sensitivity analysis of indices

One of the characteristics of the envelopment data analysis approach is sensitivity analysis. In this analysis, each of the indices is deleted from the model and model is re-implemented. Reducing the efficiency after double implementation of the model in each index indicates the sensitivity of the area to the deleted index. In general, the sensitivity among the indices points to the effective and high role of the mentioned index in the efficiency of the area in question and the lack of sensitivity indicates the functional weakness of the region in that indicator relative to other regions and other indices. Two important factors in the sensitivity analysis of indices are first sensitivity and then the nature of the index; whether it is an input or output index. The sensitivity of the region to the input index, indicates the shortage in this input as well as the improper use of the area and among the output indices, it indicates a very good performance of the region relative to other areas and other indices. But the extreme sensitivity of the region will bring about extreme dependence of the region to that indicator which cannot be a good sign for the region, especially the efficient ones. With this approach, the use of sensitivity analysis is very suitable for showing the quality of the

performance digits. The results of the sensitivity analysis are presented in Table (4). In the following, the sensitivity analysis is investigated based on each of the indices.

Table 4. Sensitivity Analysis Based on Output-oriented window analysis

Rank	Zones	Fixed efficiency average	Average efficiency regardless of the index for the years 2012 to 2015					
			Domestic investment	Registered companies and institutes	The amount of employment created	Export	Foreign transit	Foreign investment
1	Maku	1	1	1	1	0.695	1	1
2	Arvand	0.825	0.492	0.492	0.825	0.253	0.825	0.817
3	Anzali	0.616	0.616	0.615	0.616	0.602	0.463	0.366
4	Chabahar	0.581	0.416	0.129	0.537	0.399	0.581	0.510
5	Aras	0.239	0.239	0.100	0.239	0.084	0.180	0.239
6	Qeshm	0.232	0.094	0.223	0.232	0.227	0.184	0.230
7	Kish	0.207	0.207	0.203	0.207	0.178	0.204	0.206

Source: Research Results

1. Domestic investment index: This index showed 2 cases of sensitivities that are related to Chabahar and Qeshm free zones which indicate the lack of this index in these areas and the good performance of Chabahar and Qeshm free zones during 2012-2015.
2. Index of registered companies and institutions: The index shows 6 cases of sensitivities which are ranked first among the input indices and are of particular importance among the input indices. Among free zones, Chabahar region has the highest sensitivity to this index compared to other free zones. These sensitivities show that the free zones of Arvand, Anzali, Chabahar, Aras, Qeshm and Kish have a good performance in relation to this index and that the lack of this indicator in these areas is felt and requires more attention to this indicator for these areas.
3. The rate of employment created: This indicator with one case of sensitivity has the lowest sensitivity among all the indices. In the free zones, Chabahar was sensitive to this variable during the years 2012 to 2015 and there is a shortage of this variable in this region.
4. Exports: As the first indicator of output, this indicator with 7 sensitivities and high sensitivities in the free zones of Maku, Arvand, Chabahar and Aras is of particular importance among output indicators, especially regarding the fact that zones of Maku, Arvand and Chabahar are among the efficient regions and the removal of this variable has stripped these regions of efficiency. In the meantime, Arvand and Maku are very sensitive to this index. This sensitivity in the outlets indicates that these zones have very suitable performance in this index, although the excessive sensitivity of the Arvand zone indicates the dependence of this region on the indicator and the mismatch between the indicators. The high sensitivity of the Maku region to this indicator also shows that performance figures of this area is due to its high values of this indicator rather than the performance fit between the indicators. The sensitivity of all free zones to the elimination of this variable indicates the importance of this indicator among all the regions which makes it much more urgent to consider this index.
5. Foreign transit: This indicator with 4 sensitivities has the least number of sensitivity among outputs. From this perspective, this indicator is the most potent indicator of output indicators for performance in this area for regions so that by improving the region's performance they can improve their efficiency. The highest sensitivity belongs to the Anzali region which indicates the proper performance of this region in this index. The low sensitivity of free zones to this indicator shows less attention to foreign transit in the years 2012 to 2015 and reduction of its effect on the efficiency of outputs.
6. Foreign Investment: This indicator shows 5 sensitivities where the most sensitivity belongs to Anzali Free Zone.

Conclusion

From the point of view of national economic development, free zones can provide the freedom of trade as a gateway to the outside world, helping to attract some of the technical and capital expertise required for the country's industrial development. In the present time when the world moves towards globalization and full freedom and our country will also have to join this trend, free zones are considered as a raw model for

reforming the country's economy to adapt to the changes that have taken place in the global economy. In this study, we tried to investigate the performance of free zones of Iran during 2012-2015 using the window data analysis and sensitivity analysis of indicators. The results of the window analysis of the data show that among the free zones, free zones of the Maku and Arvand are the most efficient free zones in these areas during the years 2012 to 2015 and the Aras, Qeshm and Kish regions have been ranked low and are inefficient. The results of the sensitivity analysis of the indicators also showed that the export indicator was the most sensitive indicator among the output indicators; therefore, it can be concluded that the highest performance of the regions was in this indicator and the external transit indicator had the lowest sensitivity and due to the same reason, considering the opportunities available in the country, it can be the most potent indicator for increasing its ratio to exports. Among the input indicators, registered firms and institutions are considered as the most scarcity of resources which indicates the lack of appropriate infrastructure in these regions and the indicator of the employment created has the best condition among input resources for free zones.

In this regard, in the field of indicators, we can say that more attention is paid to foreign transit as the output with the least sensitivity suggested for planning in these regions and perhaps the modeling of successful free zones will help decision makers of free zones. Among the input indicators the number of companies and institutions registered also requires more attention from planners in these regions.

At the level of free zones, it can be said that:

1) Among the regions, Maku's efficiency is mostly relying to the export index which undermines the functional suitability of other indicators. The lack of sensitivity of the region to the input index indicates that the area is in good standing in terms of resources or inputs. Among the output indicators, the lack of sensitivity to foreign investment and foreign transit indicates a lack of attention to these two factors in the region. While in order to improve the efficiency of this region and reduce the region's dependence on the export index in this region, paying more attention to these two indicators is essential.

2) Among the input indicators, the Arvand area is only sensitive to registered companies and institutions and has not shown any sensitivity to external transit among output indicators. In addition, the region's enormous sensitivity to the export output indicator points out to its high dependent on this index. To improve the efficiency of the area, it is recommended that the policies are planned such that planners in the region pay attention to these two indicators to prevent from unilateral dependence of the region on exports.

3) Anzali Free Zone is also only sensitive to registered companies and institutions indicator among input indicators and has shown good performance vis-à-vis this variable and is also sensitive to all output indicators. Therefore, in order to improve this region's efficiency, it is necessary to pay more attention to registered companies and companies.

4) The Chabahar region has good performance in terms of all 3 input indicators and the lack of these inputs is felt in this region. These deficiencies in the area indicate that the resources of this region do not have good conditions and in order to improve the efficiency, it calls for better planning for these indicators. Among the output indicators, it is necessary to pay more attention to foreign transit to improve the efficiency of the region.

5) In the Aras region, the sensitivity of the region to registered companies and institutions among the input indicators and the lack of sensitivity to foreign investment among the output indicators points to the need to pay more attention to these 2 indicators to improve the efficiency of the region.

6) Qeshm region is also sensitive to domestic investments and registered companies and institutions among the input indicators which makes it necessary to pay more attention to these 2 indicators in order to improve the efficiency of the region.

7) To improve the efficiency of the Kish region, more attention is needed to be paid to the registered companies and companies. Therefore, free zones should invest more in sensitive inputs and look for better performance for non-sensitive outputs.

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