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Subsidy Allocation using ZSG-DEA Model: Evidence from Manufacturing Industries in Iran

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Abstract
Industrial subsidy is an important tool that encourages national production and plays a crucial role in the realization of a resilient -economy. Due to limited financial resources, it is important to determine how these subsidies can be distributed efficiently. Accordingly, the purpose of this study is to provide a model for allocating industrial subsidy among 22 manufacturing industries at the level of 2-digit ISIC codes using the Zero Sum Gain -Data Envelopment Analysis (ZSG-DEA) model based on merging of the concepts of game theory with the DEA. The model also utilizes four effective criteria in allocating public resources, namely industrial added value, the number of industrial employees, the amount of direct export, and the amount of industrial taxes and duties. The results of the study show that the food and beverage industry should receive the highest proportion of optimum subsidy, whereas industries related to manufacturing office machines, accounting and computing machinery, radio, television, communication devices, wearing apparel, tanning and polishing, leather and leather goods, fur, and tobacco products should receive the lowest proportion of industrial subsidies.

1. Introduction

Industrial manufacturing has been one of the main channels for accelerating economic growth throughout the twentieth and twenty-first centuries. Evidence based on the experience of developed countries emphasizes its role as a driver of economic growth. Today, due to the continuity and connection between economic sectors, the development of industry has also stimulated other sectors and caused an increase in employment, production, and national income (Shahabadi and Rahmani, 2008). Therefore, any factor affecting industry will affect other sectors as a result of these connections. The implementation of industrial policies in the form of giving subsidies to industry

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is considered as one of the factors which affect not only the manufacturing sector but also changes other sectors due to their connections to it.

Historically, Adam Smith was the first to focus on industrial subsidy as a bounty for domestic industry in his book *The Wealth of Nations* (Wren, 1996). In Iran, the first payment of industrial subsidy dates back to the Qajar dynasty. This was in the form of grants to train industrialists and tax exemptions to the manufacturing and mining sectors (Sadeghi, 2009). This kind of support expanded during the Pahlavi dynasty and was continued after the Islamic Revolution as an industrial policy. The most serious operational and developmental changes in the payment of industrial subsidies have been performed by the approbation of the targeted subsidies law and the allocation of 30% proportion of the resources obtained from the liberalization of the price of energy carriers for the production sector. However, reviewing the report of the performance of the Islamic Parliament of Iran on the targeted subsidies law shows that targeted subsidies were not provided to manufacturing since the implementation of the law as stipulated in the law. Apparently, just a small portion (almost 1%) had been paid to the manufacturing industries by the end of 2014. Reasons for non-payment of a proportion to the manufacturing and industrial sector should be sought in Article 7, the targeted subsidies law referring to cash payments to the heads of households. Therefore, by comparing the statistics of the subsidy to the industrial sector before and after the targeted subsidy law, it can be concluded that subsidy to the industrial sector has been eliminated after the implementation of this law and, contrary to what is stipulated in the law, the 30% proportion to the manufacturing and subsequently the industrial sector has not been realized.

Providing subsidy to the industry sector is not the only issue to cope with: how to allocate these subsidies to different industries should also be taken into consideration separately as an important issue. In the case of inappropriate performance in the allocation of industrial subsidies, the expected outcomes of implementing this supportive policy will be undermined and the expected objectives will not be achieved. In other words, industrial subsidies require coherent planning: according to Lee (2002), this planning needs to be properly designed, well-controlled, and carefully evaluated in order to achieve its positive intentions. Designing a model for allocating subsidies to various industries as part of this program is of great importance and is considered a step in realizing the desirable distribution of scarce resources.

In this respect, the present study aims to provide a model to allocate subsidy to the industrial sector (in the case of providing it from the sources of the targeted subsidies scheme) to different manufacturing industries. The study will submit some practical solutions by applying a cross-sectoral approach using criteria affecting allocation of subsidy to the industry sector, and ZSG- DEA model. Given the importance of the subject, this study is divided into five parts. After the Introduction, the theoretical foundations and different views on industrial subsidy are reviewed. The third part introduces the study model, while the fourth part involves the main findings. Lastly, the fifth part presents the conclusions and practical recommendations.

2. Literature Review

Firstly, in order to determine the effects of industrial subsidy, the adverse and respondent viewpoints towards supporting policies will be analyzed in all their various aspects. According to the classic and neo-classic schools, in cases such as complete competition and automatic adoption system of market, the payment of subsidy to the manufacturing sector can be considered as government interference in the market. This leads to tribulation in the optimum allocation system and inefficient allocation of resources.

On the other hand, according to the Keynesian model and the proponents of the market failure theory, due to the existence of externalities, incomplete competition, lack of sufficient demand, the existence of public goods, and economies of scales, the interference of the government in the market is not justifiable. For example, according to this viewpoint, if there are positive externalities for a specific firm, the payment of subsidy leads to increase in production and development of benefits for society. In this respect, the interference of government by paying subsidy is a way that can lead to increase in production to the optimum level. In addition to this fundamental viewpoint about industrial subsidy, some researchers have considered this subject from the other aspects as well.

According to the political economics perspective and the computable general equilibrium (CGE) theory advocated by Behboodi (1994) and Peacock (1997), providing subsidy to manufacturing industries can be considered as a political and social. It allows policy makers to solicit the satisfaction of the citizens and specific groups, and their votes in political selections. However, even as paying subsidy to manufacturing industries increases the amount of production, the emission of pollution and destruction of environment also increase due to this (Kelly, 2009).

There are some problems, such as practical expenditure, opportunity costs, and the costs of funding industrial subsidy, that cause doubts about paying industrial subsidy (Moor, 1999). Indeed, in recent years, the subject of industrial subsidy has been discussed as the most important issue in the interviews and periodical sessions of international commercial and financial organizations such as the World Bank, the International Monetary Fund, and the World Trade Organization (WTO). They have always emphasized on decreasing and eliminating industrial subsidy. However, practical evidence and statistical information show that the direct and indirect paying of industrial subsidy has been followed as an industrial policy not only in developing countries but also in developed countries. For instance, according to a WTO report of 2006, the shares of industrial subsidy in all subsidy payments in Australia, USA, and 15 members of the Europe Union were 51, 8, and 19 % respectively during the period 1999–2002. In addition, Lim (1991) showed that supporting policies in

Singapore, Taiwan, and Japan in the form of financial funds, tax exemptions, and export subsidies have played a basic role in industrialization of these countries. Also, according to the Carlsson (1983), the Swedish government has used industrial subsidies as an instrument to create economic stability.

Santarelli and Vivarelli (2002) analyzed the effects of paying subsidy to encourage energy production in Italia. Kehtels (2007) reported the payment of subsidies to the tune of more than 40 billion dollars to R&D firms in USA. Also, Haley and Haley (2013) reported the growth of industrial subsidy at 23% in China (13.8 billion dollars) in 2013. In addition, Cin et al. (2017) highlighted the role of industrial subsidy in improving productivity of small and medium manufacturing enterprises in Korea.

Laird and Rinehart (1967) were the first to investigate the issue of industrial subsidy in a research entitled "Neglected aspects of industrial subsidy". They regarded this supportive policy a facilitator of market problems which can accelerate market adjustment by reducing the time needed to resolve problems in areas with unemployment and low income. From their viewpoint, these subsidies can also play an important role in economic development by facilitating the organization of surplus supply capacity outside the economy. They believed that clever use of local subsidies (national) could reduce unemployment more quickly than the normal market adjustment process. On the other hand, in their view, a significant reduction in the risk of corporate profits leads to a positive contribution to investment decision making, which enables firms to provide liquidity to expand as quickly as possible. They also believed that subsidies could increase both competitiveness and industry capacity.

Ford and Suyker (1990) investigated the amount of industrial subsidy in OECD countries during the 1980s. The results of this study indicate that most of the OECD countries had subsidy rates in the 2 to 3.5 % range. Also, industrial subsidies are less distortive than agricultural subsidies. On the other hand, industrial subsidies represent a large drain on government finances and therefore generate greater social costs indirectly through the deadweight costs of taxes. The success of international negotiation in reducing tariff barriers has increased the relative importance of subsidies and this improved competitiveness in high technology industries.

Giebe et al. (2006) identified the position of allocation of industrial subsidy in Germany. They analyzed the allocation of R&D subsidy and presented two sources of inefficiency: selection based on a ranking of individual projects, rather than complete allocations; and the failure to induce competition among applicants. In order to correct these inefficiencies, they proposed some mechanisms that include some form of an auction in which applicants bid for subsidies. The results indicated that their mechanism might considerably improve allocation efficiency.

Kwan and Molana (2010) analyzed social welfare and other effects related to industrial subsidy of government by designing the CGE model with imperfect competition. They considered both forms of paid subsidy—lump sum transfers and the proportion of variable cost component—and found that the optimal proportion of subsidy leads to Pareto improvement. The results indicated that performing a cost-reducing subsidy policy leads to improvement of welfare.

Haley and Haley (2013) indicated that industrial subsidy played a main role in transforming China from being a country with an agriculture-oriented economy to becoming the biggest exporter and producer in the world. They also noted that paying subsidies lead to development business and increase in production instead of disrupting the Chinese economy.

Kalouptsidi (2014) investigated the impact of subsidy to the global shipbuilding industry using a dynamic model. The results of this study showed that the Chinese government had decreased the cost of shipbuilding by 15 to 20 % using subsidy worth approximately 5 billion dollars from 2006 to 2012. Mohamed and Bekhet (2016) indicated the effect of removal of fuel subsidy on energy consumption in Malaysian manufacturing industries. Using the CGE, they found that this policy reduced total energy consumption by 3.56%. Moreover, the remove of energy subsidy encouraged industries to use alternative sources of energy. Cin et al. (2017) analyzed the impact of paying subsidy for R&D in Korean manufacturing firms (SMEs) using a dynamic panel data. They concluded that industrial subsidy is related positively to R&D expenditure and productivity of Korean SMEs.

The evaluation of the methods and models engaged by previous studies indicates that the focus of these researches has been on the effects of industrial subsidies. The innovative aspect of this study is its focus on answering this question: how to allocate subsidy to manufacturing industries. To do so, this study uses a new model based on the combination of game theory and data envelopment analysis.

3. The Basic Model

DEA is a mathematical programming method designed for analyzing the efficiency of Decision Making Units (DMUs). Farrell (1957) calculated the efficiency of manufacturing firms using a method that was similar to the estimation of efficiency in engineering issues. After that, Charnes, Cooper, and Rhodes developed the Farrell method and presented a model that was capable of estimating efficiency by using a different level of inputs to achieve a different level of outputs. This method was named DEA. The applied DEA model assumes that there is complete output independence, i.e. the output of any given DMU does not affect the output of others. But, in some situations, there is no independency: for example, in a competitive situation where one output represents the total of scores, the higher score for each competitor leads to reduction of scores of others (Lins et al, 2003). Again, supposing that a specific producer supplies a specific product with constant demand. If this unit increases its supply, the production of other units will decrease as well. In these situations, the ZSG-DEA is needed. This is similar to a zero sum game in which whatever is won by a player is lost by one or more of the others. This model was presented for the first time by Lins et al. (2003) in order to rank the countries in

Sidney 2000 Olympic Games, and then developed by Gomes and Da Silva (2010) and Dlouhy (2014) in other fields.

DMUs in ZSG-DEA are able to change their efficiency frontier. To do this, Lins et al. (2003) presented a proportional output reduction strategy. The idea is that the total amount of an input (output) is fixed so that a decrease in the input (output) for one decision-making unit can lead to an increase in the input (output) for another DMU. It suggests that resource allocation is highly effective in the ZSG-DEA model. After the reallocation of resources by using the ZSG-DEA model, the DMUs with lower technical efficiency scores can reach the frontier of best practice. In other words, a specific unit with lower technical efficiency in the constant return to scale (CCR) model can improve its efficiency by increasing the output level. The output oriented ZSG-DEA model can finally be formulated in Equation 1 below.

$$
\begin{aligned}
&Max\ z = h_{R0} \\
&\text{s.t} \\
&\sum_{j=1}^{n} \lambda_j x_{ij} \le x_{i0} \\
&\sum_{j=1}^{n} \lambda_j y_{rj} \left(1 - \frac{y_{ro}(h_{Ro} - 1)}{\sum_{j\neq 0} y_{rj}}\right) \ge h_{Ro} y_{ro} \qquad r = 1,2,\dots,s \\
&\lambda_j \ge 0 \qquad\qquad j = 1,2,\dots,n
\end{aligned}
\tag{1}
$$

Assuming that there are n DMUs that convert inputs into s outputs. The h_{R0} variable denotes the efficiency factor of DMUs evaluated by the ZSG-DEA. Let x_{ij} denote the i^{th} input for j^{th} DMU and y_{rj} indicates the r^{th} output for j^{th} DMU. λ_j is an auxiliary variable. It should be noted that to achieve the variable returns to scale in the DEA model (BCC ZSG-DEA model), $\sum \lambda_j = 1$ should also be considered.

To present a better description of the ZSG-DEA model, it is compared below in Figure 1 to the classic DEA model.

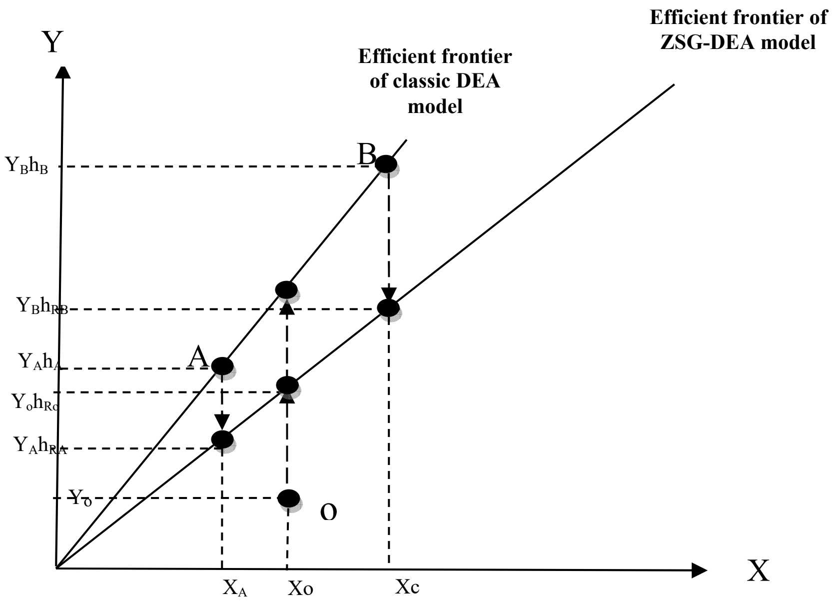

Figure 1: Comparison of the ZSG-DEA model and the classic DEA model (output oriented with constant return to scale)
Source: the authors' findings

Supposing DMU_A and DMU_B are efficient units and DMU_o is an inefficient unit. The unit O attempts to increase the output in order to achieve the efficient frontier of the classic DEA model. Due to lack of independency between outputs of units, the outputs of other units will not change. But, if we suppose that the total of all outputs is constant, the unit O attempts to locate on the efficient frontier of the ZSG-DEA model by increasing the output. This means that the output of other units will decrease. Therefore, the output of O will increase from Y_o to Y_oh_{Ro} and the outputs of A and B will decrease into Y_Ah_{RA} and Y_Ah_{RB} respectively. Finally, all the units will get located on the efficient frontier of the ZSG-DEA. It is possible that more than one of the unit will decide to achieve efficient level. In this case, the problem is a little complex and the model can change to a non-linear programming problem. To simplify this problem, the proportional output reduction strategy with the assumption of equality of λj is used subsequently (Gomes and Souza, 2010).

Therefore, the efficient outputs of units can be indicated as Equation 2 below:

$$h_{Ri} = h_i\left(1 - \frac{\sum_{j\epsilon w}[y_j((\frac{h_i}{h_j})h_{Ri}-1)]}{\sum_{j\notin w} y_j}\right) \quad (2)$$

In Equation 2, h_{Ri} denotes the efficiency of i[th] DMU in the ZSG-DEA model. h_i indicates the efficiency of i[th] DMU and w shows all the inefficient DMUs in the classic DEA model. Also, y_j is the output of the DMUs, while the efficiency in the input oriented ZSG-DEA model can be presented as below:

$$h_{Ri} = h_i\left(1 + \frac{\sum_{j\epsilon w}[x_j(1-(\frac{h_i}{h_j})h_{Ri})]}{\sum_{j\notin w} x_j}\right) \quad (3)$$

where, x_j denotes the inputs of DMUs.

3.1 ZSG-DEA model and efficient allocation of resources

The ZSG-DEA model can be used in order to allocate subsidy between specific units so that all them enjoy from technical efficient allocation. In other words, because of the budget, the subsidy is constant and limited, so by increasing the subsidy of a specific unit the allocated subsidy to other units decreases. In this case, the subsidies allocated to all of the units are not independent from each other. Due to this, the ZSG-DEA model can be used to indicate the efficient level of allocated subsidies. To do this, suppose that an amount of B subsidy should be allocated to n units. So, the share of each unit will be equal to $\frac{B}{n}$. After the allocation of this share between the intended units, the equations 4 and 5 can be presented with some difference as:

$$h_{Ri} = \frac{1}{h_i}\left(\frac{1}{n} - \frac{\sum_{j\epsilon w}[y_j(\left(\frac{h_i}{h_j}\right)h_{Ri} - \frac{1}{n})]}{\sum_{j\notin w} y_j}\right) \quad (4)$$

$$h_{Ri} = \frac{1}{h_i}\left(\frac{1}{n} + \frac{\sum_{j\epsilon w}[x_j(\frac{1}{n} - (\frac{h_i}{h_j})h_{Ri})]}{\sum_{j\notin w} x_j}\right) \quad (5)$$

Equations 4 and 5 are input oriented and output oriented ZSG-DEA models respectively. The estimated shares by these equations show the amount of efficiency and the efficient share of each unit from the total allocated subsidy. If the actual share of every unit is replaced with estimated efficient shares and the efficiency of intended units is calculated again using the classic DEA model, the amount of efficiency for each unit will be equal to one. Therefore, the calculated efficient share of subsidy for each unit can be considered as an index for reallocation of subsidy resources in order to achieve efficient distribution between all units.

In this study, the output oriented ZSG-DEA with constant returns to scale is used for efficient allocation of industrial subsidy between 22 industries of Iran. This is because the total subsidy is constant and the increase in the share of each industry will decrease the shares of others. According to the targeted subsidy law, the targeted subsidy organization has the main responsibility of allocating the financial resources of industrial subsidies. This organization pays subsidy (output) to manufacturing industries based on four criteria (as input): these are industrial value added, the number of industrial employers, the amounts of direct exports, and industrial taxes and duties. In the other words, the purpose of each industry is to maximize the output (industrial subsidy) according to the specific input: the output-oriented model is selected accordingly. Also, due to the heterogeneity of industries, the Constant Return of Scale model (CCR) is considered as well.

Significantly, the number of DMUs in this model should be more than or equal to three times the total inputs and outputs. Deviance from this condition will decrease the power of model (Mehregan, 2013).

3.2 Data

After the introduction of the research model, the research indices and the selected units should be indicated in order to indicate the efficient level of subsidy. To do so, 22 industries were selected by two digit ISIC codes as per the existent data. Also, four criteria were selected as effective factors on industrial subsidy: industrial value added the number of industrial employers, the amounts of direct exports, and industrial taxes and duties. This data is provided by the results of the survey of industrial workshops in 10 workers and more in the country and statistical yearbook of Iran in 2014. But, due to lack of awareness about the amount of funding of industrial subsidy in Iran (the output of the model), the amount of the total budget is considered as 100 units and the share of every industry from the total budget is calculated in percent.

4. Empirical Results

After the selection of input and output of the presented model, the optimum share of 22 manufacturing industries was calculated using the ZSG-DEA allocation model. This optimum share is presented in Table 1. The Roa software calculated the results of the estimation of this model.

According to the Table 1, the manufacture of food products and beverages industry enjoys the highest share of subsidy, equaling 17.27%. The following industries should receive the lowest proportion of total industrial subsidy, i.e. 0.51%: manufacture of office, accounting and computing machinery; manufacture of radio, television, and communication equipment and apparatus; manufacture of wearing apparel, dressing and dyeing of fur; tanning and dressing of leather; manufacture of luggage, handbags, saddler, harness, and footwear; and manufacture of tobacco products. Using the presented shares by percent, the government can calculate the efficient amount of subsidy for each industry.

Table 1. Optimal allocation of industrial subsidies to manufacturing industries based on the ZSG-DEA model

ISIC	Manufacturing Activities	Effective Share	Proportional Efficiency (Equal Distribution)	Proportional Efficiency (ZSG-DEA)
15	Manufacture of food products and beverages	17.27	0.03	1
16	Manufacture of tobacco products	0.51	1	1
17	Manufacture of textiles	4.84	0.11	1
18	Manufacture of wearing apparel; dressing and dyeing of fur	0.51	1	1
19	Tanning and dressing of leather; manufacture of luggage, handbags, …	0.51	1	1
20	Manufacture of wood and of products of wood and cork, except furniture; …	0.70	0.73	1
21	Manufacture of paper and paper products	1.04	0.50	1
22	Publishing, printing, and reproduction of recorded media	0.55	0.93	1
23	Manufacture of coke, refined petroleum products, and nuclear fuel	2.10	0.25	1
24	Manufacture of chemicals and chemical products	10.89	0.05	1
25	Manufacture of rubber and plastics products	4.96	0.10	1
26	Manufacture of other non - metallic mineral Products	13.58	0.04	1
27	Manufacture of basic Metals	10.77	0.05	1
28	Manufacture of fabricated metal products, except machinery and …	5.63	0.09	1
29	Manufacture of machinery and equipment	6.40	0.08	1
30	Manufacture of office, accounting and computing machinery	0.51	1	1
31	Manufacture of electrical machinery and apparatus n.e.c.	3.87	0.13	1
32	Manufacture of radio, television, and communication equipment and …	0.51	1	1
33	Manufacture of medical, precision and optical instruments, watches and clocks	0.99	0.52	1
34	Manufacture of motor vehicles, trailers, and semi–trailers	11.91	0.04	1
35	Manufacture of other transport equipment	1.14	0.45	1
36	Manufacture of furniture; manufacturing	0.78	0.66	1

Source: Researchers Computations

Also, according to the estimated proportional efficiency column, if the subsidy is divided equally between all industries, only the following five groups of industries should receive the lowest proportion of the total industrial subsidies and enjoy from efficient subsidy: manufacture of office, accounting and computing machinery; manufacture of radio, television and communication equipment and apparatus; manufacture of wearing apparel, dressing and dyeing of fur; tanning and dressing of leather and manufacture of luggage, handbags, saddler, harness and footwear; and manufacture of tobacco products. However, other industries are inefficient according to the equal distribution model. It should be noted that in both the selected models, the industries that have lower proportional efficiency near to zero are more inefficient consequently. For example, the manufacture of food and beverages industry with proportional efficiency of 0.03 has the highest inefficiency. Therefore, the equal allocation of subsidy between intended industries according to the evaluated equal distribution model is inefficient. Therefore, the allocation of subsidy using the proportional efficiency index leads to inefficient allocation between 17 industries and is not an ideal solution.

As mentioned in the methodology section, if subsidy is reallocated amongst industries according to the shares estimated by the ZSG-DEA model, the efficient shares for all industries will be equal to one. In other words, if the estimated shares in column 3 are considered as the output in the model and the efficiency of industries is calculated again using the classic DEA model, the efficiency of allocation for all of industries will be one. In addition, a comparison of the results in columns 4 and 5 indicates that the allocation of subsidy between intended industries using the ZSG-DEA model is more ideal than equal allocation of the subsidy between them. This is because the estimated level of subsidy for all the 22 industries is efficient using the ZSG-DEA model.

Additionally, paying industrial subsidy based on optimal proportion leads to increase in production and employment in this sector, and other sectors that are connected to it. The increase of export as well as national production is another result of subsidy allocation as emergent from the model presented in this study (ZSG-DEA).

5. Conclusion and Policy Recommendations

In this study, using a systematic model, the allocation of subsidy between 22 industries is considered subject to four effective indices, namely industrial value-added, the number of industrial employers, the amounts of direct exports, and industrial taxes and duties. To do this, the ZSG-DEA model is used to determine the efficient shares of selected industries from subsidy resources. According to the results of this study, the allocation of subsidy as per the ZSG-DEA model helps in efficient distribution amongst all the intended industries in comparison to equal distribution of subsidies. On the other hand, since the estimated share of subsidy is based on the role of each industry in industrial production of the country, so the payment of subsidy according to this model helps to increase national production, power, and employment, encourages industrial export, and increases tax incomes. In addition, another emergent finding from this study is that this model is the flexible and can be used in various regions and cases. It has a simple structure and calculation and the possibility of estimation within its framework relies on the Roa software. It allows increase in the utility level of producer's consequent to the distribution of subsidy, and thus improves the industrial situation of the nation. This study also provides a useful model and framework for efficient distribution of resources from the subsidy-targeting plan for industries. It should be noted that although subsidy has not been paid to the industrial sector by the government until now, this model will help in effective and fair allocation of financial resources should the government decide to give subsidies. Accordingly, it is recommended that the government use systematic and effective models such as this ZSG-DEA model in order to allocate public resources through industrial subsidy.

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