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Analysis on the effects of China's fiscal and taxation policy on exporting products of photovoltaic and high-end equipment manufacturing industries

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China's fiscal and taxation subsidy policy plays a positive role in promoting the international market development of emerging industries, which also brought about many problems. In this paper, countries with large overseas investment from China and those along the "One Belt One Road" project were specially selected and divided into different types of international markets according to parameters of political risk, relations with China, geographical locations, etc. The computable general equilibrium model was then used to analyze the change in the export volume to different types of countries influenced by the change in export tax rebate ratios and research and development (R&D) subsidies. Simulation results showed that the change in export tax rebate policy has a greater impact on the photovoltaic industry and a relatively low impact on the high-end equipment manufacturing industry. The change in the export tax rebate rate has different effects on the export volume of countries in different regions and has the greatest effect on the high risk region and the partnership region. Additionally, R&D subsidy has different effects on the export volume of countries in different regions and has the greatest effect on the low risk region and the poorer relation region. Therefore, suitable subsidy policy should be decided, based on the characteristics of foreign markets in different regions. Contributions of this study are expected to be used in governmental policy designing and company development strategy optimization. *Published by AIP Publishing.* <https://doi.org/10.1063/1.5003232>

NOMENCLATURES

b	Index at the second level
B	Index at the first level
c	Weight of index at the second level
D	Direct government subsidy
EE_a	Product capacity
L	Tax
PA_a	Price of product a
P_d	Domestic price of product receiving subsidy
PDA	Price of the product produced and sailed domestically
PE	Price of export commodity
PE_a	Export price of product a
PKE_a	Capital for producing product a
PM_c	Price of import commodity
$PSE_{Percentage}$	Ratio of subsidy to product value

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PSE_{Total}	Total government subsidy to industry
PSE_{Unit}	Government subsidy to unit product
PVA_a	Price of added value
P_w	International price of product receiving subsidy
pwm	Dutiable value
QA	Product quantity
QA_a	Domestic production of the product
QE_a	Foreign production of the product
QKD_a	Capital demand
QKE_a	Integration of capital and product
QKE_a^{vn}	Integration of capital and products
Q_p	Domestic production of industry receiving subsidy
QVA_a	Integrated producing capacity of the capital-labor-product
t_e	Export tax
WK	Capital price
x'	Value of index corresponding to the lowest risk
ρ_a^{ke}	Elasticity of substitution of price
δ_a^{vn}	Elasticity of substitution of price of integration of labor and capital-product

I. INTRODUCTION

To grasp the development trend of new industrial revolution and based on the sustainable development of economy and society, cultivation and development of emerging industries (EIs) is a major strategic project for China.^{1,2} Demanding of market plays an important role in driving the development of new industries. In addition to the domestic market, attention should be paid to the international market for the development of new industries.³⁻⁵ As the growth rates of global economic integration and domestic economic decrease, actively expanding the international markets for EIs has become an inevitable choice for the development of China's EIs in the process, for example, high-end equipment manufacturing industry (HEMI),⁶ solar photovoltaic (PV) industry,^{7,8} advanced energy materials,⁹ and intelligent electric power systems.¹⁰

For a new EI technology or product, development conditions and mature commercial outside the domestic market usually cost a lot of time. When the developing EIs competed with traditional and mature ones, tax policy support becomes a widely used policy for each country to promote the development of EI, due to its few advantages.^{11,12} In recent years, China has implemented a series of tax subsidy policies, such as export tax rebates and research and development (R&D) subsidy, which played a positive role in the cultivation of international market and EIs.¹³ However, it also led to many problems, such as international trade disputes and anti-dumping litigation.^{14,15}

The role of fiscal and taxation policies in export trade attracted widespread attention from global researchers, and many relative studies and models were carried out and reported.¹⁶ Pavcnik analyzed the data of the export tax rebate and related industries in 1979–1986 in Chile. As concluded, the export tax rebate is beneficial to the improvement of production efficiency of export oriented industries.¹⁷ Using the B-S model, Bagwell and Staige demonstrated that innovation subsidy is a more robust innovation incentive policy, but there are some negative effects for export subsidies.¹⁸ Mi analyzed the relationship between export tax rebate and competitiveness of enterprises by using the data from 2000 to 2006 in China and reported that the export tax rebate helps enterprises in the processing trade and increases their profit rate and production efficiency.¹⁹ Shao and Wu investigated the relationship between import openness and international competitiveness of China's manufacturing industries. As indicated, increasing the export tax rebate plays a positive role in improving the company competitiveness for low tech industries, and increasing R&D subsidy is conducive to enhancing the competitiveness of high tech industries.²⁰ Based on the computable general equilibrium (CGE) model, Chen *et al.* found that the export tax rebate plays a significant positive role for the export of most manufacturing departments. But the promoting effect is very slight for the export of high-tech products, which

even is changed to adverse.^{21,22} Fan also found that the export tax rebate policy is very significant for the primary product industry in China's export commodity structure and labor intensive export industries but has few significant effects on the high-tech industry.²³

On the role of government subsidies, some scholars emphasized the incentive effects of government subsidies.²⁴ Clausen demonstrated that the increase in public investments for government will help enterprises to get more resources, which can effectively increase the inputs of independent innovation.²⁵ Furthermore, Wang and Feng believed that government subsidies could not only encourage enterprises to increase innovation investment but also increase enterprise innovation results and thus promote the rapid development of high-tech enterprises.²⁶ Li and Zhang indicated that governmental investments in science and technology projects would have both positive and negative effects on the efficiency of enterprise innovation.²⁷

On the other hand, government subsidies may reduce the enterprise R&D investment.^{4,8} For example, Zhu and Xu found that there are crowding out effects between government subsidy on innovation and the investment of enterprises prepared by themselves.²⁸ This means that when government innovation subsidy increases, enterprises would decrease their self-prepared R&D investment. The main reason is that when the government subsidy program is implemented, enterprises will only apply these subsidy programs included in the government program.²⁹ This would decrease the enterprises' self-prepared R&D investment and thus has negative effects on the development of relevant technology which is not listed in the government program. It has also been proved by some previous empirical analysis.³⁰

Although a great number of research studies have been carried out on the effects of different tax and subsidy policies, most of them are related to traditional industries. In addition, international market is generally investigated as a whole market. However, EIs in China are totally different. First, China has a small scale of EIs, with a low industry concentration and a low international market price control level.³¹ Second, as a typical developing country, China makes more governmental subsidy policies for EIs than traditional ones. These fields always meet trade sanctions from developed countries. Third, Chinese EIs might face many "structure blockade" and/or "political containment" from some developed countries.³² Consequently, in view of previously mentioned differences, it is necessary to optimize the design of Chinese EIs according to their characteristics as well as the characteristics of different international markets.

In this study, countries with large overseas investment from China and those along the "One Belt One Road" project will be specially selected. These international markets will be classified by parameters of political risk, relationship with China, and geographical factor. In addition, the assessments of country risk factors given by international rating agencies are considered.³³ By using the simulation tool of the CGE model,^{17,18} the export changes of different types of countries will be qualitatively and quantitatively analyzed, when the export tax rebate rates and government R&D subsidies of EIs changed. Moreover, based on the simulation results, government fiscal and tax subsidy (FTS) policies for different types of international markets will be further explored. Contributions of this study will guide the steady development of China's EIs in the international market. Also, these results are expected to be used in governmental policy designing and company development strategy optimization.

II. CURRENT INTERNATIONAL MARKETS OF EIs

A. Fiscal and taxation policies and their defects

Currently, there are two types of government subsidies for the development of China EIs entering the international market: export tax rebates and R&D subsidies. Among China's EIs, the HEMI is an important support for other strategic EIs and the PV industry is the representative of new energy industry. Both of them need massive government subsidies because of their characteristics of large capital investment, high R&D risk, strong dependence of technology on foreign countries, etc. Therefore, this study focuses on analyzing these two industries. For HEMIs and new energy industries, a number of export tax rebate policies were made in China. The export tax rebate rates of two EIs were kept at 17%, with about 2%–3% higher than that of the traditional industry. Besides, the government investment to R&D is increasing

continuously year by year. In 2015, China R&D investments were at about 40 billion RMB for large civil aircraft and about 200 billion RMB for large military transport aircraft. In the field of marine engineering equipment, China R&D investment became more than 25 billion RMB.³⁴ Government R&D subsidy policies were also made in the PV industry, the Solar Roof Plan, and the Golden Sun Project.³⁵ The types of FTSs to EIs and relevant measures and policies in China are listed in Table I.

At present, the current FTS policies are facing series of problems while promoting the development of international markets. First, Chinese subsidy policy always focuses on export tax rebate. This can easily lead to anti-dumping lawsuits in some countries. The Chinese high export tax rebate rate for some of the EIs caused some countries anti-dumping litigation. Numbers of trade disputes and anti-dumping investigations about China from 2006 to 2010 are shown in Fig. 1.³⁶ From 2004 to date, 70% of World Trade Organization (WTO) litigations are related to China. It should be noticed that Chinese trade litigation mainly concentrated in few developed countries, such as the European Union, United States, and Australia. 75% of litigations are from developed countries of Europe. There are few trade disputes from Central Asia, Southeast Asia, Africa, and other countries.³⁷ Clearly, most of them are developing countries.

Second, few analyses were carried out on the effectiveness of government subsidy to determine the appropriate subsidy rate in China. As recently reported by Kuenzel, the relationship between government subsidy rates and their effectiveness seems like an “inverted U.” Government subsidies’ effects will increase with the increasing government subsidy. When the curve reaches a peak, their relationship will change to opposite.³⁸ Therefore, the government should regularly review the actual effect of subsidies and thus to determine the most optimal subsidy rate. However, at present, Chinese government has not been able to regularly review the effectiveness of subsidies to determine the appropriate rate of subsidies.

Third, Chinese government subsidies are not classified according to their types and regions. At present, Chinese export subsidy policy is mainly based on the industry division of the enterprise but not the region division of the enterprise export country. In fact, the optimal number and quantity of subsidies are different in different regions and types of countries. Currently, more than 70% of Chinese financial subsidy trade litigations come from North America and Western Europe countries. Most of them are related to the export tax rebate. In accordance with the provisions of the WTO, this type of subsidy is actionable subsidy. It will be exempt

TABLE I. Types of FTSs to EIs and relevant measures and policies in China.

EIs	Types of FTSs	Measures taken	Government policies
HEMI	Export tax rebates	The export tax rebate rate of mechanical and electrical products with a high technical content and high added value has been increased from 14% to 17% since January 1, 2009.	“Notice on improving the export tax rebate rate of some mechanical and electrical products,” from China Ministry of Finance and the State Administration of Taxation (FT No. [2008]177).
HEMI	R&D investment	The export tax rebate rates of ship, vehicle and its key components, aeronautics and space facilities, numerical control machines, and other goods listed were kept at 17% since January 1, 2004.	“Notice of adjusting the tax refund rate of export goods by the Ministry of Finance and the State Administration of Taxation,” from the China Ministry of Finance and the State Administration of Taxation (FT No. [2003]222).
New energy industries	Export tax rebates	Export tax rebates of polysilicon products with their purities higher than 99.99% were increased from 13% to 17%.	“12th Five-Year Plan of Renewable energy development” from Energy Department of China National Development and Reform Commission, (NDRC-E No. [2012]610).
New energy industries	R&D investment	The R&D costs of new technologies, products, technology in new energy enterprises, and new energy vehicles and key parts enterprises can be deducted in income taxable calculations.	Notice of the temporary management policy of enterprise R&D cost deduction, from the China State Administration of Taxation, (NFD No. [2006]166).

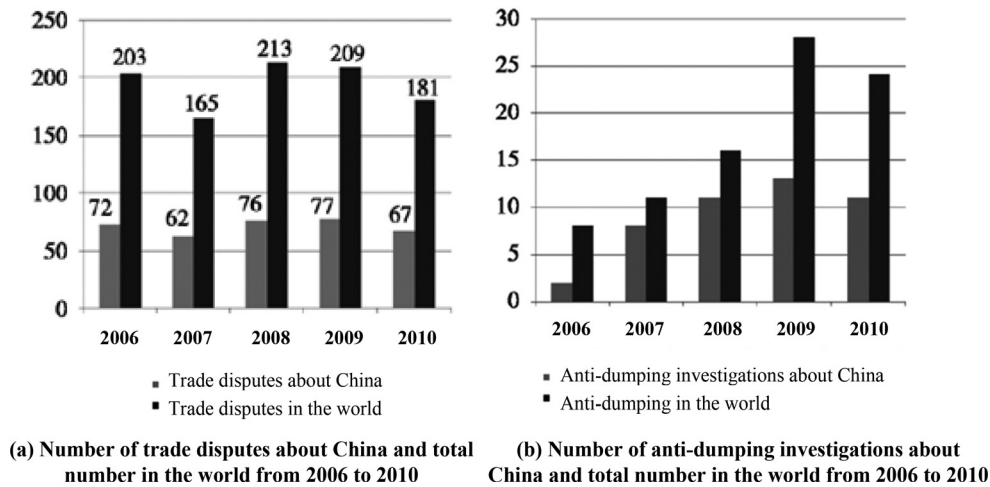


FIG. 1. Numbers of trade disputes and anti-dumping investigations about China from 2006 to 2010.

from prosecution, as long as no harmful consequences are in the export country.³⁹ For Chinese friendly diplomatic relation countries in Northeast Asia, Central Asia, and Africa, export tax rebate policy can be continued. In contrast, in Europe and other countries, China government should weaken or even cancel this type of subsidy policy. By using the same subsidy policy for countries in different regions, the international trade disputes cannot be avoided. Meanwhile, the best effect of subsidy was hard to be achieved.

B. Optimization direction of FTS for EIs entering the international market

In view of the existing defects of FTS policy for EIs entering the international market, there are two aspects of optimization, as follows:

First, countries and regions should be distinguished, and different FTSs should be given. Thus, international trade disputes were expected to be effectively avoided. Currently, China subsidy policy for EIs entering foreign markets was made based on their enterprise scale, characteristic, and location, as shown in Fig. 2. However, the region or location of the investment country of an enterprise was not considered. In fact, for international markets, different policies should be considered for different countries or regions. For example, developed countries are more sensitive to the property of government subsidy, and many trade disputes with Chinese

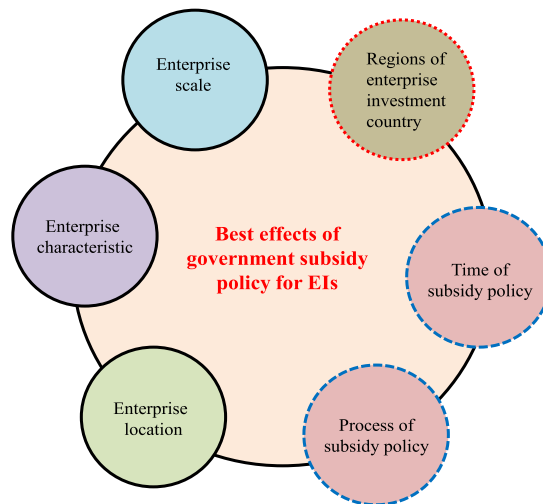


FIG. 2. Optimization direction of FTS for EIs entering the international market.

existed, such as the United States and European Union. It is easy to cause trade disputes by direct government subsidies, such as export tax rebate. However, for countries with better relations with China, such as Southeast Asia and Central Asia, increasing the export tax rebate will not lead to trade disputes but can greatly increase the export volume. For some developing countries in Africa, most Chinese investments resulted from political consideration. Some financial support can be replaced by export enterprise subsidies. Therefore, China government should consider the regions of export countries to make different subsidy policies.

Second, as shown in Fig. 2, the time and process of subsidy policy should be timely analyzed, thus improving the accuracy of FTS. Government subsidy has the effect of diminishing marginal utility. There is not a simple linear relationship between the export tax rebate rate, R&D subsidy, and export volume. There exists the greatest effect of subsidy. Therefore, the subsidy rates should be timely reviewed, and their effects should always be analyzed. The optimal combination and the appropriate proportion for export tax rebate and R&D subsidy should be considered for making suitable subsidy policies.

III. RESEARCH METHODS AND RESULT ANALYSIS

To decide the best type of financial and tax policy, the study was carried out following the schematic shown in Fig. 3. As shown, first, the target countries were selected and divided based on the geographical locations. Second, the indexes used to evaluate these countries were selected based on previous studies. Third, the countries were evaluated using these indexes, and the grades and ranking were obtained. Based on the rankings, the levels of these countries were given. Finally, aiming at different levels of countries, the effects of FTS on export to different countries were evaluated using the CGE model.^{17,18}

A. Evaluation of the international market of EIs and the corresponding FTS

As the first step of this study, the countries where China exports EI products were evaluated. The evaluation procedure was summarized as shown in Fig. 4. As seen, first, three types of indexes were specified: political, economic indexes, and relation with China. Second, the importance of indexes was given using the expert grading method (EGM), and the weights of index were given using the analytic hierarchy process (AHP) method. Third, based on the importance and weight, the values were given for each index for different countries and the final total values were calculated. Finally, the ranking was obtained based on the total values, and the levels for each country were decided.

1. Introduction of EIs

There are mainly seven strategic EIs: energy saving and environment protection, new information technology, bio-industry, new energy, alternative fuel vehicles, HEMI, and advanced

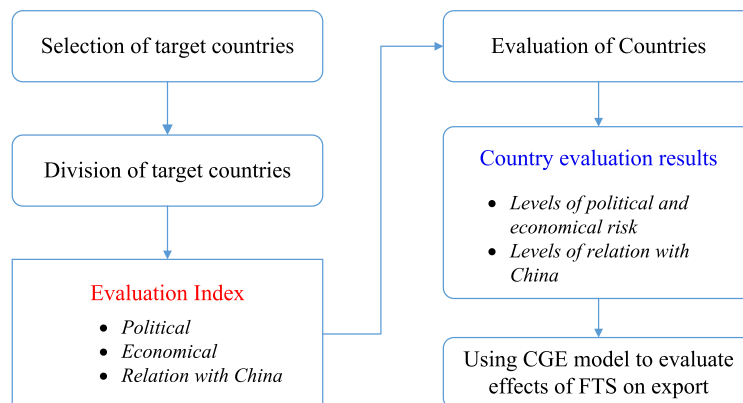


FIG. 3. Schematic of evaluated effects of FTS on export in China.

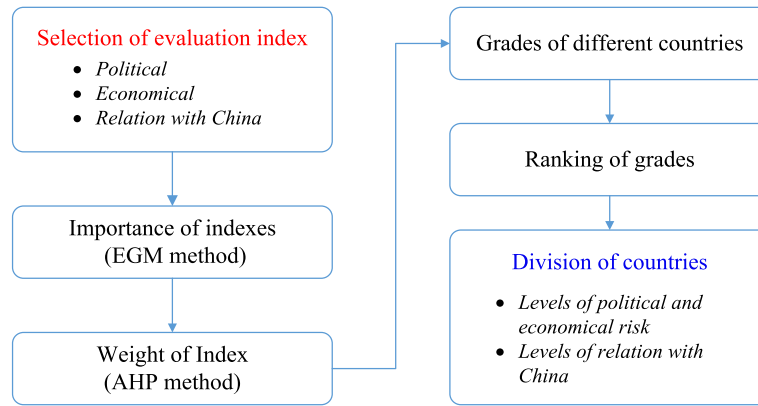


FIG. 4. Flow chart of the evaluation system in this study.

material industry. Therein, the HEMI is the core element and supports other strategic EIs. Therefore, the focus on the development of the HEMI is necessary to enhance the key competitiveness of industries in our country and hold the opportunity to lead the advanced scientific development. However, the very high investment cost and research risk result in the excessively high governmental subsidies. Besides, the capacity of the PV industry and the productivity of the PV cell in China take the first place for a long time. According to the existing data, the fast development of the PV industry in China depends on the large amount of governmental subsidies, which in return causes the anti-dumping and anti-subsidy activities of European and American countries.⁴⁰ Therefore, for these two industries, it is necessary to understand the method of providing subsidies to avoid the international trade disputes and bring about positive effects. In this study, the PV and high-end equipment manufacturing industries were analyzed numerically.

2. Target countries and division

The countries that China exports high-end equipment manufacturing industries to are mainly Central and Southeast Asian countries, while the target countries of exporting PV products to are European and American countries. Considering the investment policy “One Belt One Road” of China government, parts of the related countries along the “Silk Road Economic Belt” and “the 21st Century Maritime Silk Road” are selected for analysis because the investment to which is very large. These countries include Pakistan, Russia, Philippines, Kazakhstan, Cambodia, Laos, Malaysia, Mongolia, Burma, Thailand, Turkey, Iran, India, Singapore, Indonesia, Vietnam, USA, Japan, Canada, German, Australia, New Zealand, France, and Britain. The total investment of China to these countries accounts for 70% of the total investment abroad of China. Therefore, these countries can represent the international market and are selected for analysis.

According to the division of the geographic location, economic region, and geopolitics, these 25 selected countries were divided into four regions: Northeast Asia (Russia, South Korea, Mongolia, and Japan), Central Asia (Pakistan, Kazakhstan, Turkey, and Iran), Southeast Asia (Philippines, Kampuchea, Laos, Malaysia, Burma, Thailand, Singapore, India, Indonesia, and Vietnam), and Europe and America (Germany, France, Australia, Canada, America, New Zealand, and UK), as shown in Fig. 5. It should be noted that Australia and New Zealand were seen to belong to Europe and America due to the geopolitical reasons. Thereafter, the analysis would be conducted in two aspects: (1) political and economic risks and (2) relation with China.

3. Evaluation index

After selecting the analyzed countries, the most important procedure is to evaluate these countries. There are several types of indexes used for the evaluation of countries. The

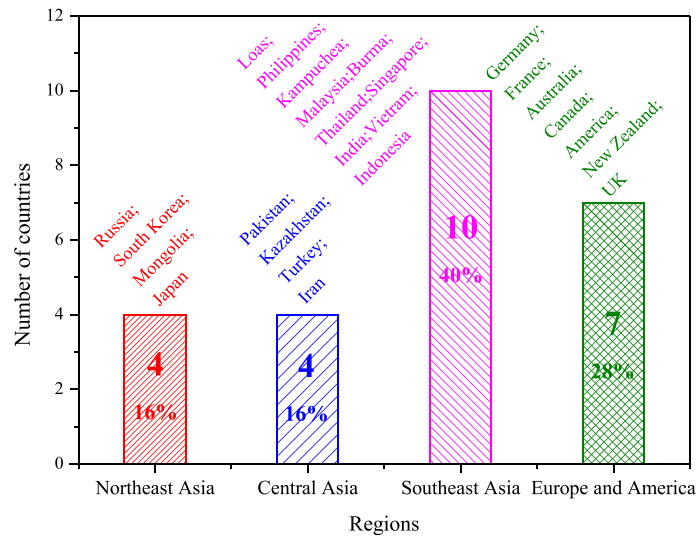


FIG. 5. Regions' classification and their countries in this study.

Economist Intelligence Unit (EIU) proposed an index considering the market size, natural endowment, domestic politics, and financial risk to analyze the government operation risk and credit risk of countries which were mentioned in China's "One Belt and One Road" policy.^{41,42} ICRG (International Country Risk Guide) established an evaluation system to evaluate one country. The system includes the public security which affects the investment environment. Chinese Academy of Social Sciences established an evaluating system named Country-risk Rating of Overseas Investment from China (CROIC) which considered the risk of Debt Investments and Direct Investment. Although these evaluation indexes are different, the main elements contained lie in two aspects: politics and economy, which are main risk types of one country. To evaluate the politics of one country, the stability of the politics, establishment of law, and effectiveness of government operation are important factors. To evaluate the economic risk of one country, factors such as per-capita income, Gross Domestic Product (GDP), percentage of total external debt to import and export, and percentage of revenue deficit to GDP are used.

Through a review on those evaluation indexes, it was found out that the state relations were not considered in the index. However, a good state relation plays a critical role in the international business, which can protect the foreign investment, even one of the countries having political or economic risk.⁴³ Hence, the evaluation in this study was carried out in three aspects: economy, politics, and state relation. Therein, the economic aspect involves total GDP in three years, GDP per capital, non-performing loan ratio, and debt ratio, while the political aspect involves the stability of government and domestic and abroad conflicts. The state relation involves diplomatic relations, degree of dependence on trade, degree of dependence on investment, etc. According to the study on the risk of foreign investment of China, the relation of one country with China was evaluated considering trade agreement, trade dependence on China, investment dependence on China, and visa exemption with China.

In the procedure of evaluation based on multi-index, the weight assignment for each index is important for the final results. Currently, the most widely used method by the risk rating organization is the Expert Grading Method (EGM). Therein, the most acceptable one is that adopted by the ICRG. Therefore, in this study, first, the importance of each index was given by using the EGM method; second, the weight values were given using the analytic hierarchy process (AHP) method. These experts are mainly working at consulting company for abroad investment, principal of abroad investment department in large companies, and government officials in charge of investment invitation. The selection of these experts can reflect the different views on the importance of each index from different people. There are totally 10

questionnaires issued, and all returned. Based on these questionnaires, the weights for each index were obtained.

The rating for each country can be calculated using the following equation:

$$R = a_1B_1 + a_2B_2 + a_3B_3, \quad (1)$$

where $B_1 = \sum_{i=1}^4 b_i c_i$; $B_2 = \sum_{i=5}^6 b_i c_i$; and $B_3 = \sum_{i=7}^{10} b_i c_i$

The EGM method was used to rate the first level and second level indexes. The results are shown in Table II. The AHP method was used to obtain the weights for a_i and b_i . For the first level, the expert grade shows that the importance order is economic indexes > political indexes > state relation indexes. The finally obtained weight vector $b = (0.54, 0.30, 0.16)$. Hence, the weights for economic, politic, and state relation indexes are 54%, 30%, and 16%, respectively. For the second level indexes, the experts give grades through comparison between two indexes. Based on these grades, the weights of each second level index are given as follows:

4. Evaluation of the countries in different regions

First, the political and economic risks were evaluated. The rates of each index for different countries are shown in Table II. Based on these rates and the weights in Table III, the total grades of political and economic risks for each country were calculated and are shown in Fig. 6. The grade values were divided into 3 levels: top 30% of the ranking list, which can be seen as the High Risk region; middle 40% which can be seen as the Medium Risk region; and bottom 30% which can be seen as the Low Risk region.

Second, the relation of these countries with China was evaluated. According to the index of evaluating relation with China, the grades of the relation are summarized in Table IV.

The rates of each index for different countries are shown in Table IV. Based on these rates and the weights in Table III, the total grades of relation of each country with China were calculated and are shown in Fig. 7. The grade values were divided into 3 levels: top 30% of the ranking list, which can be seen as the Partnership region; middle 40% which can be seen as the Normal relation region; and bottom 30% which can be seen as the Poor relation region.

Based on the grades of relation with China, the relation of these countries with China can be divided into 3 levels: Partnership (Top 30%); Normal (Middle 40%); Poor (Bottom 30%). Based on the results in Tables II–IV, the grades on the countries in different regions are shown in Fig. 8. It can be found that European and American countries have low risks of politics and economics, but they have a poor relation with China; Northeast Asian countries have medium risks and have a normal relation with China; Southeast Asian countries and Central Asian countries have high risks but have a good relation with China.

B. Design of financial and tax subsidies for Els

1. Methodology to evaluate the government FTS's effects on EI export

The Computable General Equilibrium (CGE) model was used to study the variation of macroeconomy and the industrial structure affected by one index. It can be used to analyze the effects of the variation of tax, public consumption, tariff, and foreign trade policy on welfare, industrial structure, and financial value of international trade. The CGE model is mainly used to analyze effects of tax policy in the fossil energy area on macroeconomy and international trade. Therefore, it can be used to analyze effects of variation in FTS policy.⁴⁴ Although there are many other models to analyze the effects of part of the economy society to the other part, including (1) Partial Equilibrium model, (2) Input-Output model, (3) Linear Programming model, and (4) Macroeconometric model, the CGE model has its distinguished advantages. The CGE mode can estimate both the marketing activities and the non-marketing activities, and it can better estimate the effect of government activities. Consequently, in this study, the CGE

TABLE II. Grade of political and economic risks.

Country	Region	GDP in recent 3 years			GDP/capital (2015)	Total debit/GDP	Non-performing loans/GDP	Stability of governments	External conflict	Risk
		2013	2014	2015						
Australia	Europe and America	1498.5	1555.3	1505.2	64 863.2	0.86	0.85	6.5	11	Low
Pakistan	Central Asia	213.7	225.6	238.7	1307.5	0.61	N/A	6	805	High
Germany	Europe and America	3631.4	3427.9	3635.9	45 000	0.66	0.57	8.5	10.5	Low
Russia	Northeast Asia	1893.8	2004.3	2118	14 818.6	0.55	0.88	7	9	Medium
France	Europe and America	2784.8	2612.7	27 37.4	43 000	0.57	0.31	6.5	10	Medium
Philippines	Southeast Asia	224.1	250.2	272	2790.4	0.66	0.56	7.5	11	Medium
Kazakhstan	Central Asia	188	203.5	220.3	12 843.2	0.01	0.24	9	11	Medium
South Korea	Northeast Asia	1114.5	1129.6	1221.8	24 329	1	0.98	7.5	8	Medium
Canada	Europe and America	1778.6	1821.4	1825.1	51 989.5	0.91	1	9	11	Low
Cambodia	Southeast Asia	12.9	14.1	15.7	1016.4	0.41	0.3	N/A	N/A	High
Laos	Southeast Asia	8.2	9.2	10	1476.9	0.46	0.3	N/A	N/A	High
Malaysia	Southeast Asia	289	304.7	312.4	10 548	0.51	0.78	5	10.5	Medium
America	Europe and America	15 533.8	16 244.6	16 799.7	53 101	0.85	0.52	8.5	10.5	Low
Mongolia	Northeast Asia	8.8	10.3	11.5	3971.9	0.28	0.3	6	11.5	High
Myanmar	Southeast Asia	56.2	55.8	56.4	868.7	0.49	0.3	10	9.5	High
Japan	Northeast Asia	5905.6	5937.8	4901.5	38 941.4	0.96	0.69	5.5	9	Medium
Thailand	Southeast Asia	345.7	366	387.2	5674.4	0.48	0.69	6	9	Medium
Turkey	Central Asia	774.7	788	827.2	10 815.5	0.38	0.63	7	7.5	Medium
Singapore	Southeast Asia	272.3	284.3	295.7	54 775.5	0.88	0.94	9.5	10.5	Low
New Zealand	Europe and America	162.7	170.4	181.3	40 481.4	0.79	0.89	8	10.5	Low
Iran	Central Asia	541.1	398	366.3	4750.7	1	0.3	5	5.5	High
India	Southeast Asia	1880.1	1858.7	1870.7	1504.5	0.77	0.41	6	9.5	Medium
Indonesia	Southeast Asia	845.6	877.8	870.3	3509.8	0.59	0.8	5	10.5	Medium
UK	Europe and America	2464.6	2484.4	2535.8	39 567.4	0.11	0.26	7	9.5	Low
Vietnam	Southeast Asia	134.6	155.6	170.6	1901.7	0.46	0.4	7.5	11.5	High

TABLE III. Evaluation index of the international market of EIs and the corresponding FT subsidies.

First level index	Second level index	Illustration of indexes	Ratio
Economic (54%)	GDP (in recent 3 years)	Total GDP in 2012, 2013 and 2014	35%
	GDP per capital	Natural resource considered	35%
	Non-performing loan ratio and debt ratio	Innovation and protection on intellectual property	20%
	Debt ratio	Total debit/GDP	10%
Political (30%)	Stability of government	Government capacity in implementation of the policy and operation (Scale: 0–12) (Higher value means stable government) based ICGR	50%
	Domestic and abroad conflicts	Risk of external and internal conflicts on one country (Scale: 0–12) (Higher value means serious conflict)	50%
State relation (16%)	Signing free trade agreement or not	Scale: 0/0.5/1 (0.5: signed)	35%
	Trade dependence	Total value of export and import/GDP	35%
	Investment dependence	Total investment/GDP	20%
	Visa exemption or not	Scale: 0/0.5/1 (0.5: signed but not executed)	10%

model was used to analyze the effects of different government FTSs on the export of EI of China, which is further illustrated in Fig. 9.

The original data were standardized using the following equation:

$$x^* = 1 - \left| \frac{x - x'}{\max - \min} \right|, \tag{2}$$

where x' is the value of the index corresponding to the lowest risk, the total GDP in the past 3 years and GDP per capital are the maximum value of x' , and the ratio of non-performing loan and loan level is the minimum value of x' .

Currently, although, there are many methods to compute the amount of government subsidy: (1) Price Difference (PD) method,⁴⁵ (2) producer subsidy equivalent method (PSE) method,⁴⁶ (3) Consumer Subsidy Equivalent (CSE) method,^{47,48} (4) Specific Object (SO) method,⁴⁹ and (5) Effective Subsidy Rate (ESA) method.⁵⁰ The fundamental of the PD method is to calculate the price of the product with no subsidy and the actual consumer price of the energy product in order to estimate the scale of the subsidy. However, this method can only be used to estimate the subsidy of the consuming side. It is not suitable to estimate the subsidy of the producing side. On the other hand, the PD method is not effective for the subsidy which

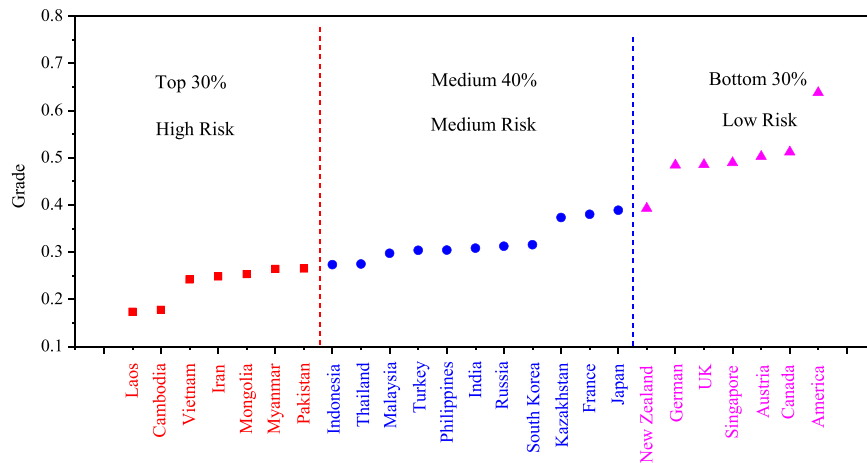


FIG. 6. Grades on political and economic risks of the selected countries.

TABLE IV. Relation with China.

Country	Region	Signing BIT	Trade dependence (Total import and export value/GDP)		Investment dependence (Investment/GDP)	Visa free or not	Grade
Australia	Europe and America	1	0.48	0.65	0.5	Normal	
Pakistan	Central Asia	1	0.41	1	1	Partnership	
Germany	Europe and America	1	0.1	0.13	0.5	Normal	
Russia	Northeast Asia	1	0.18	0.29	0.5	Normal	
France	Europe and America	1	0.07	0.13	0	Poor	
Philippines	Southeast Asia	1	0.51	0.25	1	Normal	
Kazakhstan	Central Asia	1	0.42	0.73	1	Partnership	
South Korea	Northeast Asia	1	0.47	0.17	0.5	Normal	
Canada	Europe and America	0.5	0.1	0.22	0.5	Poor	
Cambodia	Southeast Asia	1	0.46	1	1	Partnership	
Laos	Southeast Asia	1	0.7	1	1	Partnership	
Malaysia	Southeast Asia	1	0.48	0.16	1	Normal	
America	Europe and America	0.5	0.23	0.45	0	Poor	
Mongolia	Northeast Asia	1	1	1	0	Normal	
Myanmar	Southeast Asia	1	0.8	1	1	Partnership	
Japan	Northeast Asia	1	0.36	0.16	0.5	Poor	
Thailand	Southeast Asia	1	0.28	0.2	1	Normal	
Turkey	Central Asia	1	0.1	0.06	0.5	Poor	
Singapore	Southeast Asia	1	0.16	0.47	0.5	Normal	
New Zealand	Europe and America	1	0.25	0.08	0.5	Normal	
Iran	Central Asia	1	0.44	0.84	1	Partnership	
India	Southeast Asia	1	0.14	0.17	0	Poor	
Indonesia	Southeast Asia	1	0.35	0.31	1	Partnership	
UK	Europe and America	1	0.25	0.3	0.5	Poor	
Vietnam	Southeast Asia	1	0.53	0.34	1	Normal	

has no effect on the actual price, such as market transfer and implicit subsidy. Therefore, this method cannot be used for the R&D subsidy in this paper. The SO method is used to select a specific project to estimate the scale of subsidy. It considers the following subsidies: subsidy of government, tax exemption, complementary subsidy, compensation, government revenue, and

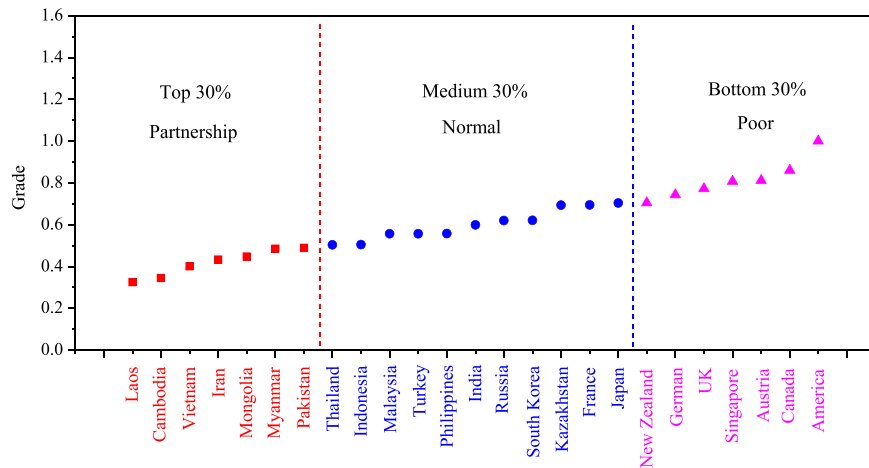


FIG. 7. Grades on the relation of the selected countries with China.

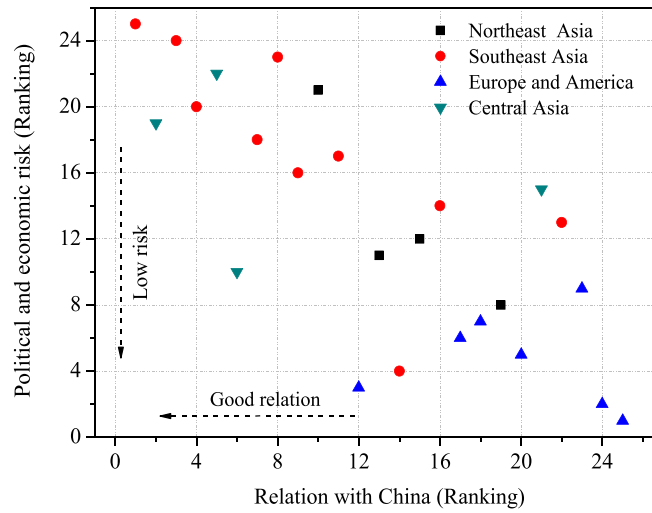


FIG. 8. Risk-Relation map in different regions.

government tax policy. This method can be used to estimate the producing and consuming side subsidy. However, this method cannot be used to tackle the price distortion. The ESA method was used to estimate the things that influence the price of the energy product. The advantage of this method lies in that all the price information of the energy product includes upstream and downstream products. However, this method needs the input-output coefficient and the investment cost which are difficult to be collected. Considering the disadvantages of the above methods, the PSE (CSE) method was used in this study.^{47,48}

PSE (Producer subsidy equivalent method) is used by Organization for Economic Cooperation and Development (OECD) to calculate the subsidy amount to energy industries. The concept of PSE is to calculate the loss of producer of energy industries if the subsidy was cancelled. PSE can be calculated as follows:

$$PSE_{Total} = Q_p(P_d - P_w) + D - L + B, \tag{3}$$

$$PSE_{Unit} = PSE_{Total}/Q_p, \tag{4}$$

$$PSE_{Percentage} = 100(PSE_{Total})/[Q_p * P_d + D - L]. \tag{5}$$

The amount of subsidy to EIs calculated according to the above equations can be seen as a variable of the evaluation model. Afterwards, the evaluation model can be divided into two

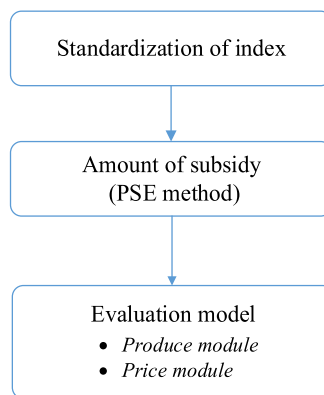


FIG. 9. Flowchart of the CGE model in this study.

modules: produce module and price module. Then, the influence of different ratios of financial subsidy to tax subsidy on China's export of EI products to different countries was investigated.

First, according to the CGE model, the produce module was established using multi-layer nested constant elasticity of the substitution (CES) production function to build relationship between the input and output of EIs. First, the products and the capital were integrated to be hybrid capital, and then, the hybrid capital was integrated with the labor capital. Afterwards, the integration of capital-energy-labor was added with the inputs using the Leontief production function to get the total outputs of the EI.

Integration of capital and products

$$QKE_{\alpha} = \alpha_{\alpha}^{kn} \left(\delta_{\alpha}^{kn} QKD_{\alpha}^{kn} + (1 - \delta_{\alpha}^{kn}) EE_{\alpha}^{kn} \right) \frac{1}{\rho_{\alpha}^{ke}}, \quad (6)$$

$$\frac{QEE_{\alpha}}{WK} = \frac{\delta_{\alpha}^{kn}}{1 - \delta_{\alpha}^{kn}} \left(\frac{QKD}{EE_{\alpha}} \right)^{1-} \rho_{\alpha}^{ke}, \quad (7)$$

$$PKE_{\alpha} * QKE = PEE_{\alpha} * EE_{\alpha} + WK * QKD_{\alpha}, \quad (8)$$

where EE_{α} represents the product capacity and ρ_{α}^{ke} represents the elasticity of substitution of price between the capital and products of EI.

Integration of capital, product, and labor

$$QVA_{\alpha} = \alpha_{\alpha}^{vn} \left(\delta_{\alpha}^{vn} QLD_{\alpha}^{vn} + (1 - \delta_{\alpha}^{vn}) QKE_{\alpha}^{vn} \right) \frac{1}{\rho_{\alpha}^{ve}}, \quad (9)$$

$$\frac{WL * (1 + tval)}{PKE_{\alpha} * (1 + tvak)} = \frac{\delta_{\alpha}^{vn}}{1 - \delta_{\alpha}^{vn}} \left(\frac{QKE_{\alpha}}{QLD_{\alpha}} \right)^{1-} \rho_{\alpha}^{ve}, \quad (10)$$

$$PVA_{\alpha} * QVA_{\alpha} = (1 + tral) * WL * QLD_{\alpha} + (1 + tval) * PKE_{\alpha} * QKE_{\alpha}, \quad (11)$$

where QVA_{α} represents the integrated producing capacity of the capital-labor-product in company a, QLD_{α} represents the quantity of labor force in company a, and QKE_{α}^{vn} represents the integration of capital and products. $\rho_{\alpha}^{ve} = 1 - \frac{1}{\delta_{\alpha}^{vn}}$, and δ_{α}^{vn} represents the elasticity of substitution of price of integration of labor and capital-product.

The production of i th EI was calculated using Eq. (12). Z_{ni} represents the intermediate input of the n th company in the i th industry and a_{ni} represents the coefficient of direct consumption

$$QA_a = \min \left(\frac{Z_{3a}}{ica_{3a}}, \frac{Z_{4a}}{ica_{4a}} \dots \frac{Z_{na}}{ica_{na}}, QVA_a \right). \quad (12)$$

Second, the price module was established. In the CGE model, the price reflects the commodity circulation. Therefore, it is a very important and critical module. The price of the products produced domestically is named PE

$$QA_{\alpha} = \alpha'_{\alpha} \left(\delta'_{\alpha} QDA_{\alpha}^{p0} + (1 - \delta'_{\alpha}) QE_{\alpha}^{p0} \right) \frac{1}{\rho'_{\alpha}}, \quad (13)$$

$$\frac{PDA}{PE} = \frac{\delta'_{\alpha}}{1 - \delta'_{\alpha}} \left(\frac{QE_{\alpha}}{QDA_{\alpha}} \right)^{1-} \rho'_{\alpha}, \quad (14)$$

$$PA_{\alpha} * QA = PDA_{\alpha} * PDA_{\alpha} + PE_{\alpha} * QE_{\alpha}, \quad (15)$$

$$PM_c = pwm_c (1 - t_e) * EXR, \quad (16)$$

where EXR is the exogenous exchange rate, t_e is the export tax, and pwm is the dutiable value.

TABLE V. PV export to different countries with the variation of financial subsidy.

	Political and economic risks			Relation with China		
	High risk	Medium risk	Low risk	Partnership	Normal	Poor
Export tax rebates 0%	85%	82%	79%	83%	80%	87%
Export tax rebates 20%	114%	110%	107%	109%	107%	109%
Export tax rebates 30%	125%	113%	109%	115%	109%	111%
R&D subsidy 0%	99%	94%	95%	99%	100%	97%
R&D subsidy 10%	101%	103%	102%	102%	101%	104%
R&D subsidy 15%	102%	105%	108%	105%	101%	110%

2. Analysis on the EIs using the CGE model

The computation of the FTS effects on the EIs by the CGE model indicates that the export tax rebates in HEMI account for around 15%, close to the limitation of 17% in China's policy. According to the report on the HEMI and PV industry in 2015, the government subsidy accounts for 7% of the annual turnover. Therefore, these two values, 15% (export tax rebates) and 7% (government subsidy), were used as the baseline in the simulation through the CGE model. Thereafter, cases at three different export tax rebate ratios, 0%, 20%, and 30%, and three R&D subsidy ratios, 0%, 10%, and 15%, were simulated to study the effect of export tax rebates and R&D subsidy on export of these two industrial exports to different countries.

The effects of the varying export tax rebates and R&D subsidy on export are summarized in Tables V and VI. It can be concluded as follows:

Export tax rebates had a greater influence on the PV industry than HEMI, while the financial subsidy policy had a similar influence on these two industries. As seen in Tables V and VI, for the high risk region, when the export tax rebates were decreased by 7%, the export of PV industrial products was decreased by 15%, while that of the HEMI was decreased by only 4%. For partnership countries, when the export tax rebate was increased by 13%, the export of the PV industry was increased by 9% and that of HEMI was increased by only 1%.

The change in export rebate led to different export variations for countries in different regions. The increase in export rebate had a greater influence on high risk and partnership regions. With the increase in export rebate, the increase in export was slowed down. As seen in Table VII, when the export tax rebate was increased by 5% or 15%, the export in the high risk and partnership region was increased obviously, while the export in the low risk and normal relation region was increased slowly. However, when the export rebate was decreased, the decrease of export in the low risk and normal relation was significant. When the export rebate was increased from 15% to 20%, the export to high risk regions was increased by 10%. With the continuous increase in export tax rebate, the increase in export was slowed down, suggesting that the marginal utility of export rebate was weakened. The change of R&D subsidy led

TABLE VI. HEMI export to different countries with the variation of financial subsidy.

	Political and economic risks			Relation with China		
	High risk	Medium risk	Low risk	Partnership	Normal	Poor
Export tax rebates 0%	96%	94%	87%	95%	86%	99%
Export tax rebates 20%	106%	102%	101%	101%	101%	103%
Export tax rebates 30%	115%	103%	103%	107%	103%	105%
R&D subsidy 0%	99%	94%	97%	99%	100%	99%
R&D subsidy 10%	101%	103%	104%	102%	101%	106%
R&D subsidy 15%	102%	105%	110%	105%	101%	112%

TABLE VII. Export of these two industries to different countries with the variation of financial subsidy.

	Political and economic risks			Relation with China		
	High risk	Medium risk	Low risk	Partnership	Normal	Poor
Export tax rebates 0%	91%	90%	83%	89%	83%	93%
Export tax rebates 20%	110%	106%	104%	105%	104%	106%
Export tax rebates 30%	114%	108%	106%	111%	106%	108%
R&D subsidy 0%	99%	94%	96%	99%	100%	98%
R&D subsidy 10%	101%	103%	103%	102%	101%	105%
R&D subsidy 15%	102%	105%	109%	105%	101%	111%

to different variations of export to different countries. The increase in R&D subsidy had the greatest influence on the low risk and poor relation region. With the increase in export tax rebate, the export volume was decreased.

As seen in Table VII, different from the variation of export caused by the export rebate, when the R&D subsidy was increased by 3% and 8%, the export in low risk and poor relation regions increased rapidly, the export in the high risk region increased slightly, and the export in the normal relation region had no significant variation, suggesting little influence. When the R&D subsidy was increased by 3% and 8%, the export to poor relation region increased by 5% and 11%, respectively. This indicates that the R&D subsidy was an effective subsidy for countries in poor relation regions.

IV. CONCLUSIONS

Investigations on the influence of government FTS policy on export to different countries were carried out and comprehensively analyzed in this study. It was found that for the PV industry and HEMI, the suitable subsidy types were different for different countries. Therefore, the subsidy policy should be enacted based on the target country of export. On the other hand, suitable subsidy should be adopted for different industries. For the PV industry, export rebate should be mainly adopted to avoid the trade dispute. The conclusions are summarized as follows:

- (1) Export rebate was the main subsidy for Central Asian and Southeast Asian countries. Besides, the rebate rate should be increased. The countries in these regions have high risk but a partnership relation with China. In these regions, the variation of export tax rebate affected export obviously. When the export tax rebate was increased from 15% to 20%, the export was increased rapidly. Furthermore, due to the good relation of countries in this region with China, the financial subsidy would not cause trade conflicts. Therefore, the export tax rebate can be increased in these two regions.
- (2) For the Northeast Asia region, the export rebate should be used with the R&D subsidy together. The Northeast Asian countries had higher political and economic risks and had a poor relation with China. When the export tax rebate was increased from 15% to 20%, the export had little variation. However, when the export rebate was decreased, the export was decreased significantly. When the R&D subsidy was increased from 7% to 10%, the export was increased by 3%. With the continuous increase of R&D subsidy, the increase in export was slowed down and the marginal effect was weakened. Therefore, for Northeast countries, an integration of export rebate at 15% and R&D subsidy at 10% was considered to maximize the marginal effect.
- (3) For European and American regions, the R&D subsidy should be the main critical type. The European and American countries had low risk but a poor relation with China. With the increase in export tax rebate, the export to these countries had a certain amount of increase. However, the CGE model did not consider the anti-dumping policy. Therefore, for the export

to these countries, a much higher export rebate may cause anti-dumping and then reduce the export. For example, in 2012, the government subsidy of China to the PV industry caused the anti-dumping and anti-bribery by USA to China and then resulted in a decrease of 79% in export.⁵¹ Different from the government subsidy, R&D subsidy is the one that would not cause trade conflicts. The WTO states that the R&D subsidy is not unfair competition.⁵² Moreover, when the R&D subsidy was increased by 3%, the export to the countries in this region was increased by 5%; when the R&D subsidy was increased by 8%, the export to these countries was increased by 11%. Therefore, it is better for Chinese government to use R&D subsidy to companies exporting products to European and American countries.

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