CSCanada
International Business and Management
Vol. 11, No. 1, 2015, pp. 32-40
DOI:10.3968/7287

ISSN 1923-841X [Print]
ISSN 1923-8428 [Online]
www.cscanada.net
www.cscanada.org

Comparison Between Subsidy Policies on Photovoltaic Industry of China and the U.S.: Based on Three-Stage Sequential Game Models

HUANG Shi[a],*

[a]Business School, China University of Political Science and Law, Beijing, China.
*Corresponding author.

Supported by National Social Science Foundation of China (12BJL060); Humanities and Social Science Foundation of Ministry of Education of China (11YJA790043).

Received 30 June 2015; accepted 25 July 2015
Published online 31 August 2015

Abstract

This paper firstly analyzes the effects of China's and the U.S. subsidy policies through comparing the developing strategies, specific subsidies and industrial conditions. Then by establishing two three-stage sequential game models, the inherent defects of China's subsidy are studied. Finally the advantages of the U.S. industrial and trade policy portfolio are analyzed to give policy enlightenment. The result shows: China's export oriented production subsidies could not maximize social welfare in the short term. It was not conductive to the development of core industrial competitiveness because of the extrusion effect of R&D. What's more, it tended to provoke quick and excess production capacity which led to a large number of low-priced exports, causing trade conflicts and loss of oversea markets. While the U.S. combined regulatory compliant subsidy and trade remedy. Market subsidy increased the demand and helped industry to expand production scale and lower the cost. R&D subsidy encouraged R&D investment and improved industrial competitiveness. Trade remedy was used to prevent foreign low-priced import shocks and guarantee the effectiveness of the two subsidies. To sum up, China shall change the export-oriented development strategy, develop core competitiveness on technology, eliminate unreasonable subsidies, make good use of market subsidy, R&D subsidy and trade remedy measures.

Key words: Industrial policy; Subsidy; Trade remedy; Photovoltaic

Huang, S. (2015). Comparison Between Subsidy Policies on Photovoltaic Industry of China and the U.S.: Based on Three-Stage Sequential Game Models. *International Business and Management, 11*(1), 32-40. Available from: http://www.cscanada.net/index.php/ibm/article/view/7287
DOI: http://dx.doi.org/10.3968/7287

INTRODUCTION

The U.S. trade investigations targeted at developing countries are gradually shifting from traditional industries to strategic emerging industries. With China's industrial upgrading process, the trade between U.S. and China is transforming from complementarity to competitive. Thus, the U.S.-China trade conflict is more than an international trade problem, but having influencing on international industry competition and policy formulation. In these circumstances, the traditional subsidy policies, which used to expand exports and prompt industrial development, fail to follow the new situations of international trade and industrial competition.

The U.S. and China have made plans and policies to promote their photovoltaic industries, in order to lead the renewable energy industries and occupy the economic commanding heights in post-petroleum era. China's State Council's Decision on Speeding up the Cultivating and Developing *Strategic Emerging Industry and People's Republic of China's Twelfth Five Year Plan for National Economic and Social Development Program*, promulgated in 2010 and 2011 respectively, included photovoltaic industry as China's one of strategic emerging industries. In 2012, President Barack Obama promulgated U.S. Blueprint for Manufacturing Revitalization, also called photovoltaic industry as its one of key supported industries to back industry upgrading and energy security. However, the U.S. had clear developing ideas, which referred to a combination of industrial subsidy and trade remedy measures. While China conducted export-oriented policies involving mainly production subsidy, which gave rise to excess production. Therefore, the detailed comparison and analysis will offer reference to the Chinese government to make proper subsidy policies for the strategic emerging industries in the future.

1. LITERATURE REVIEW

Currently, there are three general directions in the research of government subsidy. First, the research on the subsidy instruments, especially fiscal appropriation, finance discount and tax returns. For example, Capron and Van Pottelsberghe investigated on the relationship of government's R&D appropriation subsidy and companies' R&D investment (Capron & Van, 1997). Mohnen investigated on the effects of tax returns (Mohnen, 1997) and Joost Heijis investigated on the effects of Spain government's loan to the corporations' R&D with discounted interest (Joost, 2005). The second kind is the research on subsidy periods, especially the comparison of prior subsidy and post one. According to Huang, Xie and Chen, Xie's investigation, post subsidy' welfare effect is superior for it can suppress rent-seeking and resource conservation (Huang & Xie, 2007; Chen & Xie, 2009). The third kind is on the objects of subsidy. Kesavayuth and Vasileios compared the welfare effects of the duopolistic R&D subsidy and the production subsidy and concluded that technology spillovers level has great influence on the strengths and weaknesses of these two subsidies (Kesavayuth & Vasileios, 2012). Based on Hetelling model, Xiao and Wang conducted dynamic game analysis on the R&D subsidy and the production subsidy, respectively (Xiao & Wang, 2013). Zhou, Sheng and Chen applied empirical analysis to prove that the subsidies of R&D and production process have incentive function on export and potential mismatch effects on resources (Zhou, Sheng & Chen, 2014).

In a word, previous research on governments' subsidy was usually target at a particular aspect of subsidy based on theoretical or empirical analysis, but rarely specifically modeled a practical case to make comprehensive judgment. In this paper, specific models are set according to U.S.-China's trade conflicts on photovoltaic industry and their trade policies, showing the disadvantage of China's production subsidy and how to combine proper industry subsidy with trade remedy measures to develop strategic industry.

2. COMPARISON BETWEEN THE U.S.'S AND CHINA'S INDUSTRIAL DEVELOPMENT STRATEGIES

2.1 The Industrial Development Strategies and Subsidy Policies

China and the U.S. shared the same strategic objective to boost their individual photovoltaic industry competitiveness in the international market. But the specific strategies were quite different.

The U.S. was cradleland of photovoltaic technology. On one hand, it put emphasis on technical innovation to increase electricity generation efficiency for cost reduction and lead technological development direction in industry. On the other hand, domestic market cultivation was adopted to form scale effects for the manufacturers to reduce cost and be competitive worldwide. As for China, photovoltaic industry was treated as an export-oriented industry, meeting strong market demand of Europe, the U.S. and Japan from 2001 on. Accordingly, lower value-added and technology demanding part of industry chain, namely photovoltaic battery manufacturing, obtained intensive capital investment to enhance scale effects, reduce cost and expand competitiveness. While domestic market cultivation and technological innovations were paid little attention.

With different development strategies, China and the U.S. promulgated totally different industrial subsidy policies. The U.S. had supportive policies in R&D, production investment and market consuming, among which the subsidies on R&D are of the largest amount. In 2012, 8 billion dollars among the financial budget were used in renewable energy R&D. The market consuming subsidies were at the second place, including consuming tax deduction, initial-installation subsidy, online electricity price and renewable energy quota system. At last, the government offered some production subsidies to qualified corporations as the auxiliary subsidies, like tax deduction, loan guarantee and cash subsidies. In contrast, China lacked support for R&D, on one hand; on the other, China had conducted market application subsidies on a few particular demonstration-scale projects, ignoring market subsidies covering civil and commercial photovoltaic product consuming. China's financial subsidies were mainly focusd on the corporation investment and exportation. In addition, the central government failed to carry out clear unified subsidy plans and the local governments' subsidy policies were twisted and chaotic, including offering cheap land and electricity supply, low-interest loan and income tax allowance, export tax rebate, which are actionable or even prohibited subsidies in WTO provisions[1].

The Table 1 was the main relevant subsidies of China raised against by U.S. countervailing measures. From the table, the Chinese governments' subsidies included a large amount of actionable or even prohibited subsidies aiming to promote production and export, such as preferential loan, provision of goods and services for LTAR, preferential tax provision, specified government grants and export incentives.

[1] WTO Agreement of Subsidy and Anti-subsidy (SCM) divides the subsidies into three categories: prohibited subsidies, actionable subsidies and non-actionable subsidies, and gives the specific definitions and scales of them.

Table 1
Main Related Subsidies in the U.S. Countervailing Investigation Towards China's Photovoltaic Product

Categories	Items
Prohibitive subsidy	(1) Export Tax Refund for Exporting FIEs
	(2) Grants for Export, such as research fund for export products, overseas-developing industry funds
	(3) Export Credit Subsidy Programs: Export Buyer's Credits
Actionable subsidy	(1) Golden Sun Demonstration Program, involved firms get grants
	(2) Preferential Policy Lending
	(3) Provision of Polysilicon, Land and Electricity for LTAR (Less Adequate Remuneration) Programs
	(4) Preferential Tax Program for High or New Technology Enterprises (HNTEs)
	(5) "Two Free, Three Half" Program for Foreign Invested Enterprises (FIEs)
	(6) Import Tariff and Value Added Tax (VAT) Exemptions for Use of Imported Equipment
	(7) VAT Rebates on FIE Purchases of Chinese-made Equipment
	(8) Policy-based Low Interest Loan
Non-actionable subsidy	(1) Enterprise Income Tax Law, Research and Development Program

Note. Adapted from Untied States Department of Commerce, International Trade Administration Memorandum, C-570-980 Investigation 1/1/10-12/31/10.

2.2 Effects of Subsidy on Photovoltaic Industries in China and the U.S.

The two countries' disparate policies led to industrial dilemma in China and trade conflicts between U.S.-China. In China, a large amount of production and export-related subsidies had taken effects in promoting industry competitiveness by purely expanding scale effects to increase rapidly the production output and export. As Figure 1 shows, started from 2004, the total exports and the U.S. market share of Chinese production grow rapidly. However, export and production oriented subsidies had significant defects. First, the excessive horizontal expansion at processing part of industry chain of production scale and industrial homogeneity in many regions nationwide led to a huge overcapacity and the low-price competition in the market. Second, low investment in R&D caused lacked of core technology so that equipment and key materials depended importing from abroad. Third, domestic market failed to be cultivated and more than 90% of the products were exported. As a result, exportation surged, low-price competition and non-rational governmental subsidy, multiplied the risk of being imposed on trade remedy measures by trade partners. Figure 1 also shows the expansion of photovoltaic cell production, insufficient domestic demand and excess production capability in China.

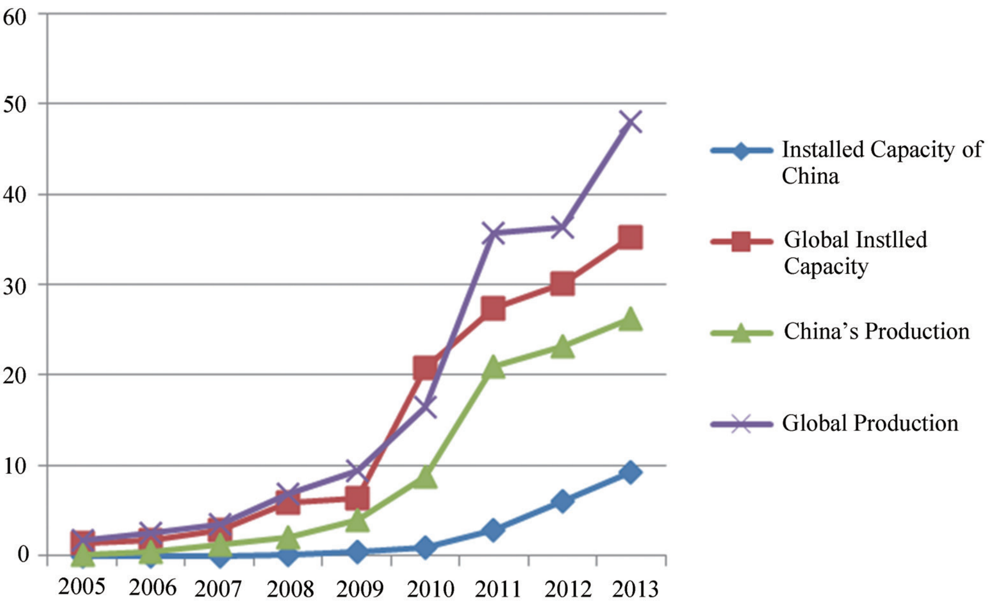

Figure 1
Market Demands and Supplies of Photovoltaic Batteries in China and in the world (Unit: GW)
Note. Adapted from Chinese Photovoltaic Industry Research Report for 2012, Chinese Solar Cell Industry Analyst Report for 2010 by The National Development and Reform Commission, P.R.C, North Star Energy Website.

U.S. government's R&D subsidies and market subsidies had greatly facilitated the domestic photovoltaic industry. Benefited from R&D subsidy policies, the U.S. invented the revolutionary "thin film" photovoltaic cells technology and kept the record of photo-electro transition rate (the crucial index) of photovoltaic batteries, which indicated the leading role of the photovoltaic technology worldwide. On the aspect of market application, U.S. consuming subsidy lowered the comparatively high generating cost of photovoltaic and expanded domestic market demands, which laid the domestic market foundation for its photovoltaic industry. But as shown in Table 2, from 2004, China's exporters rapidly occupied the international market with low cost and price. U.S. R&D subsidy could not help its corporation to obtain advantage over China's cheap product through new technology and enough quality gap (as shown in Table 3, photovoltaic products in U.S. market imported from China obtained higher and higher comparative advantage). Obviously, the producer surplus and market benefits cultivated by consuming subsidy had also been grasped by China's enterprises.

Table 2
Export of Photovoltaic Batteries for China and the U.S.

Year	Export sales for U.S. (U.S. Dollar)	Export sales for China (U.S. Dollar)	Export sales ratio (U.S./ China %)	Market share of Chinese photovoltaic products in the U.S. (%)
2004	1,393,875,246	644,213,418	2.164	10.8
2005	1,626,971,179	1,257,539,068	1.294	12.3
2006	1,624,482,628	2,459,654,426	0.660	14.5
2007	1,913,977,039	5,252,290,979	0.364	18.4
2008	2,364,209,170	11,745,396,579	0.201	17.2
2009	2,417,122,647	10,721,202,006	0.225	25.0
2010	3,250,274,739	25,178,622,946	0.129	36.1
2011	2,961,786,505	27,946,187,160	0.106	47.5
2012	2,380,096,767	17,483,232,531	0.136	31.8

Note. Adapted from UN Comtrade (the world's trade database, http://comtrade.un.org/), (HS coding: 854140, photovoltaic and semiconductor equipment).

The U.S. distinguished the photovoltaic industry as one of the strategic industries to raise national competitiveness and maintain sustainable development. Thus, when its domestic products were threatened by the export-oriented Chinese products, the U.S. adopted the trade remedy measures to eliminate the international shock of the products and to coordinate the subsidy policies.

Table 3
The Index Value of the Revealed Comparative Advantage for Chinese Photovoltaic Batteries in U.S. Market[2]

Year	RCA	CR
2004	0.78	
2005	0.82	1.05
2006	0.92	1.11
2007	1.09	1.19
2008	1.04	0.96
2009	1.30	1.24
2010	1.85	1.43
2011	2.57	1.39
2012	1.67	0.65

Note. Adapted from UN Comtrade (the world's trade database, http://comtrade.un.org/).

[2] The revealed comparative advantage index was introduced by Bella, Lhasa, an American economist in 1965, which is the measurement index of the market competitive capability of one's export products and is formulated by $RCA = (X_i/X_t)/(W_i/W_t)$, where X_i is the export volume of one's specific industry, X_t is one's total export volume, W_i is the export volume of the specific industry in the world, W_t is the total export volume in the world. The larger RCA value is, the better its market competitive capability is. The dynamic comparative advantage index is $CR = RCA_t/RCA_{t-1}$, which represents the variation of the comparative advantage: if $CR>1$, the comparative advantage increases; if $CR<1$ the comparative advantage decreases.

3. DEFECTS OF CHINA'S EXPORT-ORIENTED PRODUCTION SUBSIDIES

China's strategy is to simply expand production capacity and earn profits by exporting. Without a rational plan, Chinese photovoltaic industry obtained competitiveness and occupied international markets in short terms by great quantity of investment and production subsidies to expand scale and lower marginal cost. However, this development strategy had turned out to have defects. First, Chinese photovoltaic industry was large but not strong in the case of excess production and lack of core technology; second, the huge amount of subsidy failed to benefit domestic customers, to boost the industrial development to be free of government support which caused the fact that the tremendous continuous subsidy would spend large financial resources but failed to improve the social welfare; third, great export expansion benefited from actionable and prohibited subsidy in SCM in short terms was easy to cause trade conflicts, and exporters would lost the whole export market due to high tariff once were imposed on trade remedy measures. In the following part, perfect information three-stage game models will be established to analyze this phenomenon.

First, we establish the Cournot competition game model on the two domestic companies to explain why export-oriented production subsidy caused industry large but not strong, lack of core technologies, import-dependence of core production facility and raw material and export-dependence of sales market. Assumed with complete information, the two companies produce same-quality products and their output is q_i and q_j, respectively, with the same price $p = a - q_i - q_j$. One of the companies is engaged in R&D in order to reduce cost. The Return to Scale (RS) of the R&D investment x_j remains the same and there is R&D spillovers effect with coefficient $\theta(0\leq\theta\leq1)$ to the other company. The government only offers the fixed rate subsidy $Su(0\leq Su\leq1)$ to the production process. The initial cost for unit product is α, but the marginal cost decreases because of government subsidy and enterprise R&D investment. The enterprise interest function is the difference of the producer's profit and R&D cost; the government target function, namely the total social benefit, equals the consumer's surplus plus producer's profit and then minus subsidy. In the first stage, the government determines the optimum subsidy rate by maximizing the total social welfare. In the second stage, the company which intends to do the R&D makes its optimum R&D investment policy in order to maximize its interest. In the third stage, the two companies determine their optimum production outputs in order to maximize their own interest. For the dynamic game theory model with complete information, we apply the backward induction to achieve the subgame Nash equilibrium. The detailed process is as following:

In the third stage, when the two companies determine their optimal production output, we take the derivatives of their interest functions with respect to q_i and q_j.

The company i does not conduct R&D so its interest function is:

$$\pi_i = \{a - q_i - q_j - [\alpha(1 - Su) - \theta xj]\}q_i \qquad (1)$$

The company j conducts R&D so its interest function is:

$$\pi_j = \{a - qi - qj - [\alpha(1 - Su) - xj]\}qj - \eta jxj \qquad (2)$$

Solving $\partial\pi_i/q_i$=0 (3) $\partial\pi_j/q_j$=0(4) we get:

$$q_i = 1/3[a + (2\theta - 1)x_j - (1 - Su)\text{a}] \qquad (5)$$

$$q_j = 1/3[a + (2 - \theta)x_j - (1 - Su)\alpha] \qquad (6)$$

By substituting (5) and (6) into (1) and (2) to eliminate q_i and q_j, we get their interest functionπ_{1i} and π_{1j} with their own optimal production output. Back to the second stage, by taking π_{1i}'s derivative with respect to x_j and setting the derivative result to be 0, we get x_j, which is the optimal R&D investment of the company engaged in R&D.

Solving $\partial\pi_{1j}/\partial\pi_j$=0 (7) we get:

$$x_j = \frac{-4a + 4\alpha - 4Su\alpha + 9\eta_j + 2a\theta - 2\alpha\theta + 2Su\alpha\theta}{2(-2+\theta)^2} \qquad (8)$$

By substituting it to the equations π_{1i} and π_{1j}, respectively, to eliminate x_j, we get the two interest functions π_{1i} and π_{1j} of the two companies which have taken the optimal output policies.

Back to the first stage, the government determines the production subsidy in order to maximize its target function output. A benevolent government pursues the maximum social total welfare. Its target function is:

$$W(Su) = CS + \pi - SU \qquad (9)$$

where the consumers' welfare refers to:

$$CS = (qi + qj)^2/2 \qquad (10)$$

the companies' total interest is:

$$\pi = \pi_{2i} + \pi_{2j} \qquad (11)$$

And the subsidy function is:

$$SU = Su\cdot\alpha\cdot(qi + qj) \qquad (12)$$

By substituting (10), (11) and (12) to the equation (9), we get the government's target function with respect to the subsidy rate Su.

By solving $\partial W/\partial Su = 0$ (13) we get:

$$Su = \frac{(-1+2\theta)[\eta_j - 2\alpha(-2+\theta)(-1+\theta) + 2\alpha(-2+\theta)(-1+\theta) - 5\eta_j\theta]}{2\alpha(-2+\theta)(-1+\theta^2)} \qquad (14)$$

By substituting the balanced subsidy rate Su into the enterprise interest functions, the enterprise R&D investment, the enterprise production output and the government target function, it's able to get the key variables' balanced values in the case of the optimal subsidy policy. In this paper, the influence of the subsidy to the enterprise R&D investment and the market structure are primarily investigated. First, we set rational assumption of the parameter values, namely the market demand, cost and the enterprise R&D efficiency: $a = 30$ $a = 10$ $\eta_i = 30$. Substituted them into (14), we get:

$$Su = \frac{(50 - 40(-2+\theta)(-1+\theta) - 250\theta)(-1+2\theta)}{2\alpha(-2+\theta)(-1+\theta^2)} \qquad (15)$$

If $0\leq Su\leq1$, then $0\leq\theta\leq0.5$. So Assume the government is able to properly adjust the technology spillover by measures like intellectual property right regulations and market supervision, then government can rationally adjust technology spillover rate and subsidy rate to maximize the total social welfare.

If $\theta = 0.3$, so that the government is able to obtain the optimal economic state by adjusting the industrial technology spillover to an appropriate state and applying the optimal subsidy rate. Therefore, the relationship between the optimal subsidy rate and the enterprise R&D investment is as follow:

$$x_j = 0.173(382\text{-}34Su) \qquad (16)$$

So when the government is conducting the balanced production subsidy, we can make conclusions accordingly. First, from Eq. (16), the enterprise R&D investment is influenced by the crowing-out effect of the production subsidy. That is to say, the larger the subsidy rate, the less the motivation of the enterprise R&D investment. Second, from Eq. (5) and (6), the optimal production output of company taking R&D measures is proportional to its R&D investment, while that of the company which doesn't take R&D has the inverse ratio relationship with the R&D investment (notice that $0\leq\theta\leq0.5$). Third, the higher the production subsidy rate, the lower the optimal production output that the company taking R&D will get, while the higher the optimal production output that the company don't taking R&D will get. Therefore, though the government's production subsidy does good to both two companies by covering part of their marginal production cost, pure production subsidy suppresses the development of company engaged in R&D. Because on the one hand, it will restrain company's R&D investment and lower its optimal output; on the other, it will increase the optimal output of company not engaged in R&D. So, pure production subsidy tends to encourage companies to put investment on expanding production capacity instead of R&D.

Furthermore, we establish a Cournot competition game model based on two countries' competitive industries in order to explain that the export-oriented production subsidy for the Chinese government fails to streamline total social welfare, but cause wasting of financial resources.

Assume the information is complete, the two countries' industries produce same-quality products and their outputs are q_i and q_j, respectively, with the same price $p = a - q_i - q_j$. The American industry takes cost-reducing R&D and the returns to scale (RS) of the R&D investment is constant. On the contrary, the Chinese industry doesn't take R&D. China has no chance to get the benefits of the technology spillover effect since the American industry is equipped with the strict regulation to protect their intellectual property rights, and it don't make foreign direct investment to China. All the Chinese products is targeted to exported to the American market, in competition with the American products. Chinese government offers fixed rate production subsidy $Su_i 0 \le Su \le 1$ while the American government offers fixed rate subsidy Su_j to the R&D activities. The initial cost for unit product is α, but the real cost becomes less because of government subsidy and enterprise R&D investment. The enterprise interest function is the difference of the producer's profit (sales income minus sales cost) and R&D cost. The government target function, namely the total social welfare, equals the consumer's surplus plus producer's profit minus subsidy. In the first stage, the two governments determine the optimal production subsidy rate and R&D subsidy rate to maximize their own total social benefits, respectively; in the second stage, the American industry makes its optimal R&D investment policy in order to maximize its interest. In the third stage, the two countries' industries determine their optimal production outputs in order to maximize their own interest. For the dynamic game theory model with complete information, we apply the backward induction to achieve the subgame Nash equilibrium. The detailed process is as following.

The interest functions of the two countries' industries:

$$\pi_i = \{a - q_i - q_j - \alpha(1 - Su)\}q_j \tag{17}$$

$$\pi_j = [a - qi - qj - (\alpha - x_j)]qj - \eta_j x_j(1 - Su) \tag{18}$$

In the third stage, when the two countries' industries determine their optimal production output, we take the derivatives of their interest functions with respect to q_i and q_j, respectively.

$$\partial\pi_i / q_i = 0 \tag{19}$$

$$\partial\pi_j / q_j = 0 \tag{20}$$

Then we get:

$$q_i = 1/3(a - \alpha - x_j + 2Su_i\alpha) \tag{21}$$

$$q_j = 1/3(a - \alpha + 2x_j - Su_i\alpha) \tag{22}$$

By substituting (21) and (22) into (17) and (18) to eliminate q_i and q_j, we get their interest function π_i and π_j with their own optimal production output. Back to the second stage, by taking π_i 's derivative with respect to x_j and setting the derivative result to be 0, we get x_j, which is the optimal R&D investment of American industry in order to maximize its interest.

By solving $\frac{\partial \pi_{1j}}{\partial x_j} = 0$ (23) we get:

$$x_j = \frac{1}{8}[-4a + 4\alpha + 9\eta_j + (4\alpha - 9\eta_j)Su_j] \tag{24}$$

By substituting it to the equations π_{1i} and π_{1j}, respectively, to eliminate x_j, we get the two interest functions π_{2i} and π_{2j} of the two countries' industries which have taken the optimal output policies.

Back to the first stage, the two governments game to maximize their own government target function, namely their own social total welfare:

$$W_i(Su_i, Su_j) = \pi_{2i} - Su_i \cdot \alpha \cdot q_i \tag{25}$$

$$W_j(Su_i, Su_j) = (q_i + q_j)^2/2 + \pi_{2i} - Su_i \cdot \eta \cdot x_j \tag{26}$$

The two governments determine their own optimal subsidy rate, respectively. By solving $\frac{\partial W_i}{\partial Su_i} = 0$ (27) and $\frac{\partial W_j}{\partial Su_j} = 0$(28), we get the two balanced subsidy rates:

$$Su_i = 0 \tag{29}$$

$$Su_j = \frac{1}{9} + \frac{4}{27}(a - \alpha) \tag{30}$$

From the modelling results, for China, its optimal subsidy rate is 0 in order to maximize its social total welfare if only the export-led production subsidy is offered. In other words, China should not supply the production subsidy. Otherwise, the production subsidy from Chinese government will benefit the American customers through the cheap products. Because the production subsidy has led to output expansion, the increase of the industrial revenue is unable to cover the subsidy cost. Thus, although Chinese government's production subsidy policy has expanded the industry and export scale, China is unable to achieve the maximum social welfare in the short-term game equilibrium. Meanwhile, the expansion of industrial scale has failed to strengthen the competitiveness of photovoltaic industry. Therefore, the production subsidy policy is doomed to fail for the Chinese government in the long terms and will waste financial resources continuously.

Finally, the Chinese government's export-oriented production subsidy resulted in the quick expansion and lower prices of the Chinese photovoltaic products exported to American market. Susumu, Hajime and Kala established the import surge model and conducted a quantitative test. The results showed that the well-organized industry could effectively appeal to the government for the trade restriction measures towards the countries having export surge (Hajime & Kala, 2006). The U.S. government was supporting the domestic new energy industry, thus it was very likely to conduct trade restriction measures in the background of widening trade deficit. Currently, the trade remedies, such as anti-dumping, anti-subsidy policies had become the most severe trade restrictions that China suffered from the developed countries. The prerequisites of the "double-anti" policies were the essential damage of the U.S. industry, and the amount and the market share of import product surge in a short investigation period was the main judging criteria. Once China was imposed on high tariff because of antidumping and countervailing measures, exporters would suffer from severe trade restriction effect and lost the American market. Moreover, the "double-anti" policies will generate obvious demonstration effect, which will draw other markets' attention.

4. THE U.S.'S INDUSTRY AND TRADE POLICY COMBINATION

With the expansion of Chinese photovoltaic products in American market, the American industry and political circles have claimed to take antidumping and countervailing measures since 2010. They blamed the competition of the Chinese industry for American declining photovoltaic industry and claimed that the preferential policies that the Chinese government offered to its photovoltaic industry, including low-interest loan, low-price land, tax exemption and export credit, had helped the Chinese enterprise earn 28% extra price competitiveness. They believed that extra price competitiveness of the Chinese enterprises had made the quick expansion of Chinese photovoltaic products in American market, and China's exporters had grasped the benefit of U.S. government's great quantity of consuming subsidy[3]. So the U.S has taken trade remedies twice against China. In Nov. 2011, the U.S. conducted the first anti-dumping and countervailing investigation against the Chinese crystalline silicon photovoltaic batteries and the components. The case got its final affirmative determination in Dec. 2012. After that, the increase rate of Chinese photovoltaic cells exported to the U.S. declined sharply and even became negative. In June 2013, the export amount was less than 50% of that in the June 2012. Since July 2013, the Chinese enterprise started to set up factories in Taiwan and packed the cells from mainland to export to the U.S., which increased the Chinese export again. Therefore, in Jan. 2014, the U.S. government launched the second trade remedy investigation against the Chinese photovoltaic products, which include Taiwan in the investigation scale. The case got its final affirmative determination in Jan. 2015. According to the tariff theory, the tariff increase will lead the market distortion and may cause welfare loss. Some researchers have applied the mathematical models and quantitative methods to conclude that the U.S. trade remedies measures protected the domestic photovoltaic industry in a certain extent at the sacrifice of huge consumers' interest and the social total welfare (Hong & Huang, 2014; Zhan & Xiang, 2014). So, the antidumping and countervailing measures reflected the U.S. government's strategies about its industrial development. See Figure 2.

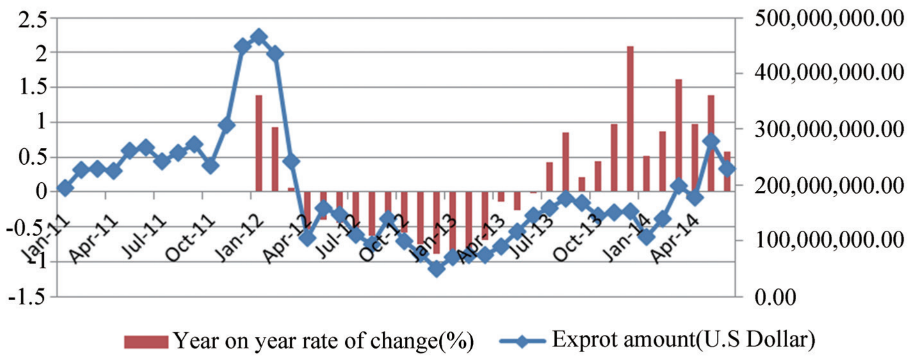

Figure 2
The Monthly Variation of Chinese Photovoltaic Export to the U.S.
Note. Adapted from UN Comtrade (the world's trade database, http://comtrade.un.org/)

From above analysis, the U.S. government' subsidies for its photovoltaic industry and the trade remedy measures against China were combined to promote and protect the industry strategically. Rational subsidies were central measures, on one hand, the consuming subsidy was taken to enlarge the domestic market scale, which would stimulate the domestic manufacturers to expand

[3] Congressional files from 59 congressmen to president Obama on November 2 2011.

their production scale and reduce the cost; on the other hand, helping the strategic industry enterprises to solve the problem that R&D investment is capital demanding, highly risky, of positive external effects through technology spillovers, the R&D subsidy encouraged the manufacturers to strengthen their technological innovation and core competitiveness. According to WTO *Agreement on Subsidies and Countervailing Measures* (SCM Agreement), the consuming subsidy that were non-specific and the R&D subsidy within a reasonable range belonged to the non-actionable subsidies, they would not damage the domestic exporters' international markets by being imposed on countervailing measures. As for trade measures, when the domestic industry was strongly shocked by the foreign corresponding industries, trade remedies were executed to protect the domestic industry. This was because, on one hand, the market subsidy is non-specific (which is different from buy-national policy) so that the foreign manufacturers were likely to occupy the domestic market and become the final beneficiaries. On the other hand, the R&D subsidy was unable to solve the problem of long pay off cycle so that the low-price foreign products probably occupied the domestic market quickly. The Table 4 reaches the strengths and weaknesses of the export-oriented production subsidy of Chinese government and the policies combination of U.S. government.

Table 4
The Comparison of the Promotion Policies of Photovoltaic Industries in China and the U.S.

	Policies	Strengths	Weaknesses
China: Export-oriented production subsidy	Production subsidy and export subsidy	(1) The effect of industrial promotion is direct and fast.	(1) Actionable and prohibited subsidies is easy to cause trade conflicts; (2) Cause market distortion, low efficiency of utilizing resources and excess production capacity; (3) Cause the crowding-out effects against R&D enterprises and provoke the short-termism that industry expand production at low value-added industrial chain; (4) Export surge raise the risk of trade conflicts.
The U.S.: The combination of the industrial subsidies and trade policies	R&D subsidy	(1) Belongs to non-actionable subsidies in reasonable range: reducing the R&D cost for enterprise; (2) Promoting the enterprise technological innovation and industrial competitiveness	(1) Unable to solve the problem of long pay off term and high risk for hi-tech R&D, so is hard to compete with low cost products in short terms.
	Market subsidy	(1) Belongs to non-actionable subsidies; (2) Cultivate immature industry by increase market demands	(1) Free-riders' behaviors of the foreign exporters
	The trade remedies: antidumping and countervailing measures	(1) The effects of R&D subsidy and market subsidy are protected by the trade restriction measures, which benefits the industry.	(1) Consumers' welfare loss; (2) Trade warfare if inappropriately used; cannot promote industry competitiveness in long terms

5. CONCLUSION AND SUGGESTIONS

The export-oriented production subsidy can expand the industry scale, lower marginal cost and improve export in short terms. However, it has many defects. Firstly, encouraging the expansion of the production scale at low value-added industry chain but restricting the R&D investment, which go against the promotion of the core competitiveness and cause excess production capacity and low-price competition. Secondly, the soaring export is likely to stimulate the trade partners to take trade remedy measures. Thirdly, continuous financial subsidy cannot improve the overall social welfare and waste financial resources, for sake that in short run the consumers of import country will finally benefit from those production subsidy and in long run industry still lack competitiveness. On the contrary, the policy combination follows clear strategy. Consuming subsidy helps domestic industry to expand scale and lower cost, R&D subsidy provokes R&D investment to obtain competitiveness in long run, both the two subsidies are non-actionable according to WTO SCM Agreement. Moreover, antidumping and countervailing measures are taken to eliminate sudden shock from trade partners' exports and guarantee the effectiveness of subsidies. Here we can get some useful policy suggestions for China to promote strategic emerging industries.

(1) China should change its industrial developing strategy. Clear and long-term goal shall be established to avoid the short-termism. Technology ability and core competitiveness of the strategic emerging industries should be emphasized instead of just earning profits by exporting to particular oversea markets.

(2) China should exclude the prohibited subsides and enhance the application of the non-actionable subsides, especially the R&D subsidy and consuming subsidy. The latter one, which is non-actionable, increases the consumers' interest and minimizes the market distortion.

The former one enhances the industrial technology and core competitiveness, but the targeted links and subsidy rate should be rationally determined according to the practical situations of the industry and market.

(3) Trade remedy measures like countervailing and antidumping have been the mainstream of trade conflicts, and are tended to be exploited as ways to protect strategic emerging industries worldwide. China shall pay attention to countervailing and antidumping measures. On the one hand, take measures like diversifying export markets, cultivating domestic market, improving technology and eliminating pure low price competition to lower the chance being imposed on such measures; on the other, respond to investigations actively if is imposed. More importantly, China shall learn to utilize countervailing and antidumping measures to protect domestic industries from being shocked by soaring imports, then combined with R&D subsidy and consuming subsidy to promote the development of strategic emerging industries in the long run.

REFERENCES

Chen, G., & Xie, F. (2009). The design and application of direct government subsidy for innovation. *Science and Technology Management Research*, (5), 6-7.

Chen, L. Q., & Tu, X. Q. (2013). A Study on U.S. bipartite system of countervailing strategy against China in new energy industry. *Journal of International Trade*, (5), 67-77.

Clark D. P. (2013). Shedding light on the recent us-china solar dispute. *Global Economy Journal*, *13*(2), 251-259.

Guellec, D., De, L., & Potterie, B. P. (1997). Does government support stimulate private R&D? *Economic Studies*, *29*(2).

Guo, X. D., He, W. T., & Xiao, X. Z. (2011). Government subsidies, extra behaviors and R&D behaviors of strategic emerging industry. *Microeconomics*, (11), 63-70.

Heijs, J. (2005). Identification of firms supported by technology policies: The case of spanish low interest credits. *Science and Public Policy*, *32*(3), 219-230.

Hong, J., & Huang, S. (2014). An analysis on the economic effects of the AD and CVD duties simultaneously imposed on China's solar energy industry by America. *Jingji Jingwei & Economic Survey*, (4), 49-55.

Huang, X. H., & Xie, L. (2007). A study on the implementing strategy of R&D subsidy in strategic trade industries: A comparison between beforehand subsidy and afterward subsidy. *Journal of International Trade*, (11), 9-13.

Kesavayutha, D., & Vasileios, Z. (2013). R&D versus output subsidies in mixed markets. *Economics Letters*, *118*(2), 293-296.

Shen, D. Y., & Liu, J. (2008). International economic analysis of non-actionable subsidies. *World Economy Study*, (3), 56-64.

Susumu, I., Hajime, K., & Kala, K. (2006). Protection for sale or surge protection? (NBER Working Paper No. 12258). *National Bureau of Economic Research*, *5*, 2-42.

Xiao, X. Z., & Wang, Y. P. (2013). R&D versus output subsidies in the competition of strategic and emerging industries. *Review of Industrial Economics*, *12*(4), 1-15.

Zhou, S. M., Sheng, Y., & Chen, Y. B. (2014). Production subsidy, export provoking and resources mismatch: From microeconomic evidence. *Journal of World Economy*, (11), 47-66.