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AUGMENTED GRAVITY MODEL OF THE COMPETITIVENESS OF RENEWABLE ENERGY EXPORTS IN MALAYSIA

Mohamed Khudari (a)*
*Corresponding author

(a) College of Graduate Studies, Universiti Tenaga Nasional, 43000 Kajang, Selangor, Malaysia, khudari@uniten.edu.my

Abstract

The main objectives of this paper are to investigate the relationship between trade flows and technological development with regard to environmental technologies, and estimate empirically the effect of renewable energy demand on the competitiveness of domestic manufacturing firms in Malaysia. By using a gravity model of international trade with a balanced dataset of 19 countries that have trade flows of renewable energy industries from Malaysia covering the period 2009-2017. The augmented gravity model shows that there is a positive evidence for the impact of environmental regulations on both the export of renewable energy industries and their competitiveness in Malaysia. Moreover, the results indicate that Porter hypothesis is valid, in this sense, CO2 emissions used as a proxy of environmental regulations, the results show that whenever the emission of CO2 in the destination countries decreases 1% the trade flows of renewable energy increases by 23.8% in Malaysia. The results indicate that if the competitive advantage increased in the destination country by 1 percent the trade flows of Malaysia will increase by 29.9 percent. The simulation model refers that the bilateral trade agreements between Malaysia and destination country could improve the trade flow by 32.2 percent. The policy recommends to expand the bilateral trade agreements with more countries (Brazil, Germany, and Mexico) that demand more renewable energy industries.

Keywords: Competitive advantage, gravity model, renewable energy, solar PV industry, CO2 emission, trade flows.

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Corresponding Author: Mohamed Khudari
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1. Introduction

Many economists would express their attitudes toward international trade in an even more positive manner. The evidence that international trade confers overall benefits on economies is very strong. By providing a bigger market, international trade allows producers to produce more cheaply, as producing a larger quantity usually lowers the costs. This aspect is important for all economies, particularly small economies, as they will have to produce everything expensively, if they cannot trade and have a bigger market. By increasing competition, international trade can force producers to become more efficient, insofar as they are not developing country firms that would get wiped out by vastly superior foreign firms.

As the scarcity of traditional energy sources and global warming are increasing the increased use of renewable energy has become an effective target for sustainable development. Many countries around the world have prioritized the development of renewable energy technologies with a range of policies and incentives. The manufacturing of these technologies has grown rapidly in recent years. The emergence of several rapidly industrializing economies in these industries has led to an increasingly globalized supply chain, and consequently an increase in the international trade of renewable energy technologies.

Modern renewables increased at more than twice the rate of the increase in global energy demand (REN21, 2017). During that time, the unit costs of renewable energy also declined, to the extent that solar PV and onshore wind power are now competitive with new fossil fuel generation in an increasing number of locations in the world (REN21, 2017).

The Export markets with the strongest potential, in the top level of the rankings, tended to have substantial opportunities across multiple subsectors (e.g., Canada, India, Mexico, Brazil, China, Chile, and Turkey). However, a few markets had overwhelmingly strong prospects in particular subsectors, due to unique driving factors such as the popularity of solar in Japan and France, solar PV in Malaysia, and abundance of wind farm projects in Uruguay (United Nations Environment Programme, 2018).

The value traded of solar PV and wind industry in Malaysia had increased during the period (2009-2017) around 8% and it formed 2.47% of total goods and services exports in 2017, while it was formed only 1.16% of total exports in 2009 as shown in Figure 01.

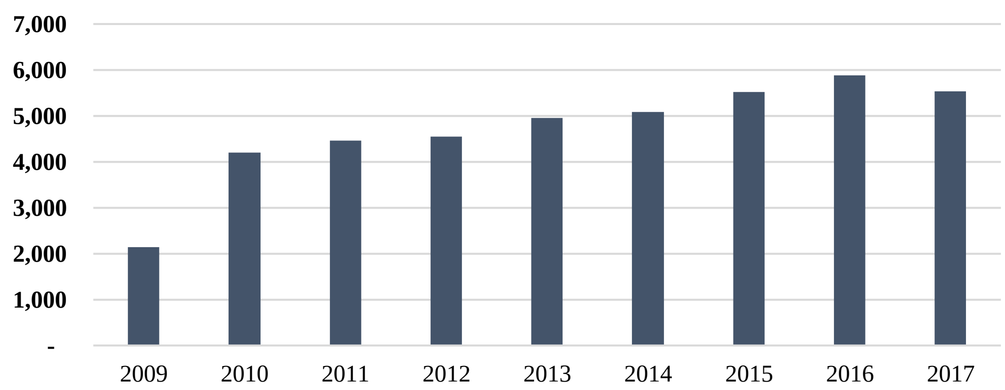

Figure 01. Trade value of renewable energy industry in Malaysia (in Millions US$)

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Corresponding Author: Mohamed Khudari
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2. Literature Review

A large body of literature had been trying to use a gravity model of international trade. Researchers using gravity model and analysed the determinants of transmission channels through which environmental technologies are exported to advanced and developing countries (Costantini & Crespi, 2008). Their results were consistent with Porter hypothesis: stricter environmental regulation, supplemented by strong national innovation system, were the crucial driver of export performance in the field of energy technologies. Another study also focusses on the effect of environmental policy stringency - such as environmental protection expenditures or energy and environmental tax revenues - on the export of environmental goods of a set of European countries. They found some evidence of competitive advantage in the new eco-industries markets and the related export opportunities for pioneering countries (Costantini & Mazzanti, 2012).

Groba (2014) focused on the effect of a regulatory framework supporting renewable energy, on the export success of solar PV from OECD countries. They find evidence for a positive effect and the Porter hypothesis was valid with early adopter of renewable energy policies gaining a comparative advantage. The results of this study are in line with the findings of (Costantini & Crespi, 2008; Groba, 2014; Kuik et al., 2019) in that the study also find some evidence of a positive effect of domestic environmental policy in importing countries on the competitive advantage of the renewable energy equipment manufacturing industry. In the wind industry (Lund, 2009) establishes a statistical correlation between large domestic markets and large export shares, while (Sawhney & Kahn 2012) find that domestic renewable power generation of the exporting countries play a significant positive role in export performance.

3. Research Questions

Based on the augmented gravity model this study raises the flowing questions:

1. What is the effect of increasing the free trade agreement for Malaysian trade flow of renewable energy?
2. What is the impact of degree of competitiveness of destination countries on Malaysian trade flow of renewable energy?

4. Purpose of the Study

The main purpose of this study are:

1. To estimate the effect of free trade agreement on the trade flow of renewable energy.
2. To estimate empirically the effect of renewable energy demand on the competitiveness of domestic manufacturing firms in Malaysia that produce renewable energy technologies. In this sense trade flows of renewable energy industries is representing one of the consequences of competitiveness in the industry.

5. Research Methods

The gravity model explains trade flows among countries by the market size, which is measured by GDP and the distance between countries (Tinbergen, 1962). Tinbergen (1962) used an analogy with

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Newton's universal law of gravitation to describe the patterns of bilateral aggregate trade flows from the origin country (o) to the destination country (d) as proportional to the gross national products (M_o and M_d) of those countries and inversely proportional to the distance between them($D_{o,d}$):

$$T_{o,d} = G \times \frac{M_o^{\alpha} \times M_d^{\beta}}{D_{o,d}^{\gamma}}$$

Whereas G is a gravitational constant measured by the inverse of the value of world production. The general notation by Tinbergen returns to the Newton's Law if $\alpha = \beta = 1$ and $\gamma = 2$.

The dependent variable is the bilateral export flows for wind and solar PV goods, from Malaysia (the origin country o) to the destination country d at time *t*. As many studies included time *t* to use panel data instead of cross-sectional data to estimate a gravity model. The advantages of using panel data could include the efficiency of estimation of time-invariant bilateral trade (Kuik et al., 2019). Some studies (Kuik et al., 2019) separated wind and solar PV industries in the regression in order to reduce aggregation biases, while this study didn't do the separate since it is studying the bilateral trade of one country (Malaysia) with 19 countries. It used a balanced dataset of 19 countries for wind and solar PV (as seen in Table 2). The study uses the 6-digit Harmonized System (HS) classification that is a commonly used and globally harmonized classification system to distinguish between goods that are internationally traded for the time period of 2009-2017. Data are extracted from the UNCTAD COMTRADE database. (As seen in Appendix A & B). Following (Kuik et al., 2019); the International Centre for Trade and Sustainable Development (ICTSD) identified HS 6-digits product category codes according to the different renewable energy sectors (Jha, 2009; Vossenaar & Jha, 2010).

The estimated model is:

$$\begin{aligned} ln(T_{o,d,t}) = {} & \beta_0 + \beta_1 ln(GDP_{o,t}) + \beta_2 ln(GDP_{d,t}) + \beta_3 ln(REDEMAND_{d,t}) + \beta_4 ln(DIST_{o,d}) \\ & + \beta_5(LANG_{o,d}) + \beta_6(BOR_{o,d}) + \beta_7(ASEANFTA_{o,d}) + \beta_8(BFTA_{o,d}) + \beta_9 ln(CO_{2\,d,t}) \\ & + \beta_{10}(NAC_{o,d,t}) + \varepsilon_{o,d,t} \end{aligned}$$

The variables are:

- ($T_{o,d,t}$): The bilateral export flow of wind or solar PV goods in millions of US dollars.
- ($GDP_{o,t}$): The gross domestic product in Malaysia in millions of US dollars are used to proxy economic sizes. It is taken from the World Development Indicator database of the World Bank.
- ($GDP_{d,t}$): The gross domestic product in the destination countries in millions of US dollars are used to proxy economic sizes. It is taken from the World Development Indicator database of the World Bank.
- ($REDEMAND_{d,t}$): The demand in the destination country. It is expected that an increase in demand in the destination country will lead to more exports to that country.
- ($DIST_{o,d}$): The natural logarithm of geographical distance weighted by population between two countries as computed by CEPII (Mayer & Zignago, 2011).
- ($LANG_{o,d}$): A dummy variable of a common language between countries; it is given the value 1 when both countries have a common language, and otherwise it is given value 0.

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Corresponding Author: Mohamed Khudari
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- $(BOR_{o,d})$: A dummy variable of a share border between Malaysia and destination countries; it is given the value 1 when both countries have a share border, and otherwise it is given value 0.
- $(ASEANFTA_{o,d})$: A dummy variable represents the ASEAN regional trade agreements, it is given the value 1 for the country has a free trade agreement with ASEAN, and otherwise it is given value 0.
- $(BFTA_{o,d})$: A dummy variable represents bilateral trade agreements between Malaysia and destination country, it is given the value 1 for the country has a free trade agreement with Malaysia, and otherwise it is given value 0.
- $(CO_{2\ d,t})$: The emission of carbon dioxide in the destination country is used as proxy of environmental regulations.
- $(NCA_{o,d,t})$: The nature of competitiveness advantage in Malaysia and destination countries, its value from 1 to 7 (best). This indicator is taken from the Global Competitiveness Index report.

In this context, Malaysia has already signed and implemented 7 bilateral FTAs with Japan, Pakistan, India, New Zealand, Chile, Australia and Turkey. While at the ASEAN level, Malaysia has 6 regional FTAs with ASEAN Free Trade Agreement (AFTA), China, Korea, Japan, Australia, New Zealand and India. Therefore, this research concerns on the impact of increasing the bilateral FTAs with more countries on the trade flows of renewable energy.

6. Findings

Many studies refer that the ordinary least squares (OLS) or Prais–Winsten estimates with panel-corrected standard error (PCSE) have coverage probabilities that are closer to nominal when the panels are between 10-20 with 10–40 periods per panel, therefore, the required models in this study are estimated using the procedure of the PCSE. Although feasible generalized least squares (FGLS) could be an alternative estimation procedure, but FGLS are conditional on the estimates of the disturbance covariance matrix and are conditional on any autocorrelation parameters that are estimated (Greene, 2003). In this study, since the time points are less than cross-section units; whereas $T = 8 < N = 19$ so using FGLS variance–covariance estimates are normally unacceptably optimistic (anticonservative) and the overconfidence in the standard errors makes this method unusable, unless $T > N$ (Beck & Katz,1995).

Three models are displayed in table 1. The first is representing the standard gravity model and shows that the interaction between trade flows of renewable energy and gravity variables is significant except with the bilateral trade agreements between Malaysia and destination countries (BFTA). The second model is representing the simulation of standard gravity model if Malaysia signed and implemented three more bilateral free trade agreements with the destination countries such as (Brazil, Germany, and Mexico). The third model is representing the augmented gravity model, it is the main explanatory model since the objective of the study is to investigate, on the one hand, the relationship between trade flows of renewable energy industries and environmental regulation represented by CO2 emission and the demand of renewable energy in the destination countries, and on the other hand, to estimate the relationship between trade flows of renewable energy and the natural of competitive advantage in the destination countries.

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Table 01. PCSE estimation results

	Standard Gravity Model	**Simulation Gravity Model**	**Augmented Gravity Model**
$CONSTANT$	-43.59**	-39.987**	-39.856**
	(6.67)	(6.43)	(6.78)
$ln(GDP_{o,t})$	0.866**	0.831**	0.975**
	(0.24)	(0.28)	(0.26)
$ln(GDP_{d,t})$	1.42**	1.254**	1.137**
	(0.76)	(0.06)	(0.06)
$ln(REDEMAND_{d,t})$			0.065**
			(0.028)
$ln(DIST_{o,d})$	-0.197**	-0.106**	-0.459**
	(0.06)	(0.038)	(0.047)
$(LANG_{o,d})$	0.267**	1.077**	0.347**
	(0.074)	(0.083)	(0.85)
$(BOR_{o,d})$	2.568**	3.120**	2.568**
	(0.17)	(0.077)	(0.14)
$(ASEANFTA_{o,d})$	1.126**	1.184**	1.326**
	(0.14)	(0.07)	(0.15)
$(BFTA_{o,d})$	-0.272		-0.238
	(0.26)		(0.182)
$(BFTAs_{o,d})$		0.322**	
		(0.14)	
$ln(CO2_{d,t})$			-0.238**
			(0.053)
$(NCA_{o,d})$			0.299**
			(0.050)
Number of obs.	169	169	169
Number of groups	19	19	19
R^2	0.69**	0.67**	0.72**
Wald χ^2	51791.93**	8840.1**	8179.4**

Standard errors in parentheses. **p<0.05

The results show that the bilateral trade agreements between Malaysia and destination countries (BFTA) is not significant in the first and third model. While in the second model the new BFTAs becomes significant. This indicates that if Malaysia signed more bilateral trade agreement the trade flows of renewable energy will increase by 32.2 percent.

All estimated gravity models show a strong positive effect of GDP and negative effect of distance on international trade; typical estimates shows that the 1 percent increase in the distance between Malaysia and destination country is associated with a fall of 45.9 percent in trade flows of renewable energy industries in the third model. This drop partly reflects increased transportation cost of goods.

It is demonstrated that there is a strong empirical relationship between the size of a country's economy and the volume of trade. Table 2 shows the mean of trade value imported of renewable energy industries from Malaysia, and the top 5 countries, namely; China, Germany, Japan, Singapore and USA, that have the highest value traded. Figure 2 summarizes the relationship between the trade flows and the

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size of economy, it is noticed that all the 5 countries are large economy except Singapore, however the trade flows between Malaysia and Singapore is quit high that could be related to other gravity variables such as the close distance and the share border between the two countries.

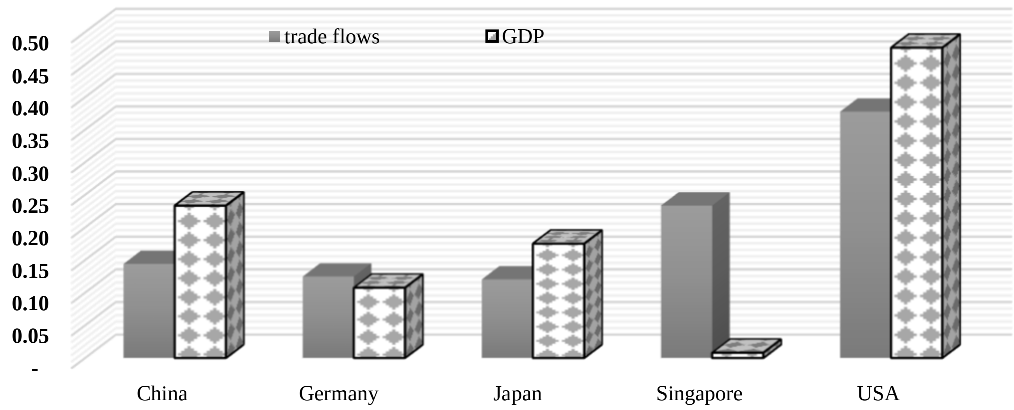

Figure 02. The Top 5 countries with highest vaule traded with Malaysia and thier GDP

The demand of renewable energy in the destination countries $(REDEMAND_{d,t})$ is statistically significant with the expected sign, that meaning, if a destination country increase the demand of renewable energy by 1 percent the trade flows of renewable energy industries of Malaysia will increase by 6.5 percent, when everything else hold constant. The results are in line with (Groba, 2014), (Kuik et al., 2019) it means that there is a significant evidence that the renewable energy demand has an effect on the competitiveness of domestic manufacturing firms in Malaysia that produce renewable energy technologies. Furthermore, the variable of nature of the competitive advantage in the destination countries $(NCA_{o,d,t})$ is supporting the main objective of this research, so the results show that it is statistically significant with the expected sign. It means that if the destination country increases the competitive advantage by 1 percent the trade flows of Malaysia will increase by 29.9 percent.

The elasticity of $(CO2_{d,t})$ on trade flows has a negative and significant effect on trade flows. This negative sign of the CO_2 emission variable is not worry about it; this means that the destination country has a full awareness of environmental regulations; the results show that a decrease by 1 percent in the emission of CO_2 in the destination countries will increase the trade flows of renewable energy by 23.8 percent in Malaysia. The results are also consistent with Porter hypothesis and in line with the previous studies (Costantini & Crespi, 2008; Costantini & Mazzanti, 2012; Groba, 2014; Kuik et al., 2019) that supported the positive impact of environmental regulation on export of renewable energy industries. In this context, the results could be generalized to other global industries, where both developed countries and emerging countries compete for market shares.

7. Conclusion

The augmented gravity model shows that there is a positive evidence for the impact of environmental regulations on both the export of renewable energy industries and their competitiveness in Malaysia. Moreover, the results indicate that Porter hypothesis is valid, in this sense, CO_2 emissions used as a proxy

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Corresponding Author: Mohamed Khudari
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of environmental regulations, the results show that whenever the emission of CO_2 in the destination countries decreases 1% the trade flows of renewable energy increase by 23.8% in Malaysia.

The results also suggest that, everything else hold constant, the increase of demand of renewable energy in the destination countries will increase the trade flow of renewable energy industries in Malaysia by 6.5%. This mean that the competitiveness of Malaysia renewable energy industry will be better whenever the destination country had increased their demand of renewable energy technologies. In this context, the competitiveness based on technology can be enhanced when strong local market is existence, whereas the continuous innovations and user-producer interaction play a crucial role (Kuik et al., 2019).

However, the decreases of market prices of renewable energy technologies enhanced competition on the global market. In regarding solar PV technologies, market price facing a rapid decline that is beyond imagination, so since the past ten years, they were expected that price would continue declining at a fast pace (IRENA, 2017). As economists predicted (Hirth, 2013), the economic value of solar PV would drop by whopping 50% when it became just 15% of electricity and that the value of wind would decline 40% once it rose to 30% of electricity. This will undoubtedly contribute to easing the transition to a low carbon economy that is high on political agendas since the successful conclusion of the Paris Agreement on climate change in December 2015.

This study recommends to the Malaysian policy maker to expand the ASEAN regional trade agreement and bilateral free trade agreements with more countries such as (Brazil, Germany, and Mexico) that demand more renewable energy industries.

Table 02. The panel data descriptive of Malaysian partners countries during the period (2009-2017)

Partner	Trade flows ($T_{o,d,t}$)	Renewable energy demand	DIST	GDP
Australia	73.509	8.634	3699.912	1247234.66
	(52.599)	(0.749)	(15.417)	(90359.43)
Brazil	13.709	44.379	115645.930	2290077.77
	(9.133)	(2.377)	(2623.271)	(112523.3)
Brunei	7.433	0.015	19.356	13757.333
	(2.874)	(0.001)	(0.171)	(372.976)
Canada	25.319	22.204	15202.900	1729997.88
	(20.144)	(0.284)	(267.284)	(104840.4)
China	461.733	12.402	161659.161	7797646.00
	(163.32)	(0.667)	(5407.390)	(1569595.)
France	98.188	12.618	23189.458	2725823.44
	(125.57)	(1.056)	(800.161)	(81048.13)
Germany	399.351	12.311	26802.465	3598010.77
	(315.11)	(1.659)	(1194.166)	(179268.3)
India	150.536	37.846	132914.493	2033062.11
	(84.748)	(1.678)	(1831.002)	(379290.2)
Indonesia	93.327	37.757	11374.514	897061.222
	(18.884)	(0.688)	(153.446)	(129274.8)
Japan	385.379	5.197	22120.637	5850999.88
	(137.63)	(0.817)	(1124.165)	(211705.7)
Korea	123.266	2.052	7498.050	1196364.11

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Corresponding Author: Mohamed Khudari
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	(77.710)	(0.707)	(242.193)	(103042.6)
Mexico	106.120	9.289	65794.261	1155641.77
	(131.33)	(0.236)	(590.939)	(92548.89)
Russia	29.303	3.410	30924.055	1627418.11
	(23.894)	(0.161)	(1322.172)	(83473.17)
Saudi Arabia	14.589	0.006	6504.296	617696.667
	(7.780)	(0.000)	(172.762)	(68338.36)
Singapore	474.813	0.573	68.244	268543.444
	(126.57)	(0.099)	(0.509)	(33434.52)
Thailand	260.245	23.101	2989.203	372948.778
	(45.523)	(0.470)	(107.959)	(33909.35)
Turkey	36.857	13.058	19731.894	961844.556
	(67.097)	(0.788)	(97.598)	(165454.0)
United Kingdom	42.283	6.081	22914.805	2589949.77
	(39.262)	(2.112)	(623.445)	(145208.2)
USA	1209.292	8.350	160858.993	15912790.6
	(670.542)	(0.556)	(4311.371)	(929161.94)

All values are the mean value during the period of (2009-2017). Standard errors in parentheses

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Appendix A: HS 2007 codes used for the wind industry

HS Code	Product
730820	Towers and lattice masts, of Iron or Steel
841290	Parts of Other Engines and Motors
848210	Ball Bearings
848220	Tapered Roller Bearings, Including Cone and Tapered Roller Assemblies
848230	Spherical Roller Bearings
848240	Needle Roller Bearings
848250	Other Cylindrical Roller Bearings
848280	Other Bearings, Including Combined Ball or Roller Bearings
848340	Gears and Gearing; Ball Screws; Gear Boxes and Other Speed Changers
850161	Ac Generators of an Output Not Exceeding 75kva
850162	Ac Generators of an Output Exceeding 75kva But Not Exceeding 375kva
850163	Ac Generators of an Output Exceeding 375kva But Not Exceeding 750kva
850164	Ac Generators of an Output Exceeding 750kva
850230	Other Generating Sets
850300	Parts, of Motors, of Generators, of Generating Sets, of Rotary Converters
850421	Liquid Dielectric Transformers, Not Exceeding 650kva
850422	Liquid Dielectric Transformers, Power Handling Capacity 650-10,000kva
850423	Liquid Dielectric Transformers, Exceeding 10, 000kva
850431	Other Transformers, Power Handling Capacity Not Exceeding 1kva
850432	Other Transformers, Exceeding 1kva But Not Exceeding 16kva
850433	Other Transformers, Exceeding 16kva But Not Exceeding 500kva
850434	Other Transformers, Power Handling Capacity Exceeding 500kva
854459	Other Electric Conductors, Exceeding 80v But Not Exceeding 1, 000v
854460	Other Electric Conductors, for a Voltage Exceeding 1, 000v
890790	Other floating structures
902830	Electricity meters
903020	Cathode-ray oscilloscopes and cathode-ray oscillographs
903031	Multimeters
903081	With a recording device(Volt Meters, Am Meters, Circuit Testers)

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Appendix B: HS 2007 codes used for the solar industry

Code	Product
700991	Unframed Glass mirrors
700992	Framed Glass mirrors
711590	Other articles of precious metal or of metal clad with precious metal
732290	Solar Collector, Air Heater, Hot Air Distributor, and Parts Thereof
830630	Photograph, picture or similar frames; mirrors; and parts thereof, of Base Metal
841280	Other Engines and Motors
841919	Other Instantaneous or Storage Water Heaters, Non-electric
841950	Heat Exchange Units
841989	Other Apparatus for Treatment of Materials By Temperature
841990	Parts of Apparatus for Treatment of Materials By Temperature
850230	Other Generating Sets
850440*	Static converters
854140*	Photosensitive Semiconductor Devices; Light Emitting Diodes
900190	Other: prisms, mirrors and other optical elements, of any material, unmounted, other than such elements of glass not optically worked
900290	Other Optical Elements, of Any Material, Mounted
900580	Other instruments: Monoculars, Other Optical Telescopes; Other Astronomical Instruments