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Trade Flows in Renewable Energy Industry in Malaysia: Evidence from a Gravity Model

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Abstract:
The main objectives of this paper are to investigate the interactions 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 econometric model shows evidence of a positive effect of environmental regulations that promote the use of renewable energy on the export performance and competitiveness of renewable energy manufacturing industries in Malaysia. The results indicate that Porter hypothesis is valid so that whenever the emission of CO2 in the destination country decreases 1% the trade flows of renewable energy increases by 34% in Malaysia.

Keywords: *Gravity model, Renewable energy, Trade flows, Solar PV industry, CO2emission.*

I. INTRODUCTION

The renewable energy industry remains one of the most vibrant, fast-changing, and transformative sectors of the global economy. Technology improvements, cost declines, and the catalytic influence of new financing structures, have turned the sector into a driver of economic growth. Global investment in renewable energy edged up 2% in 2017 to USD279.8 billion, taking cumulative investment since 2010 to USD2.2 trillion, and since 2004 to USD2.9 trillion [1]. These investments have benefitted from policies to promote the production and use of renewable energy that are implemented in an increasing number of countries around the world.

The interaction between trade flows and environmental regulations has become quite a topical issue. There is a growing global consensus that the world must deal with the threat of climate change in part through the deployment of clean energy technologies.

Over the period 2007-2016, total renewable energy capacity in the world doubled, while wind capacity quadrupled and solar PV capacity had an astonishing growth rate of more than 3000% [2].In total, modern renewables increased at more than twice the rate of the increase in global energy demand [3].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 [3].

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 [1].

In Malaysia the value traded of solar PV and wind industry 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 Fig.1.

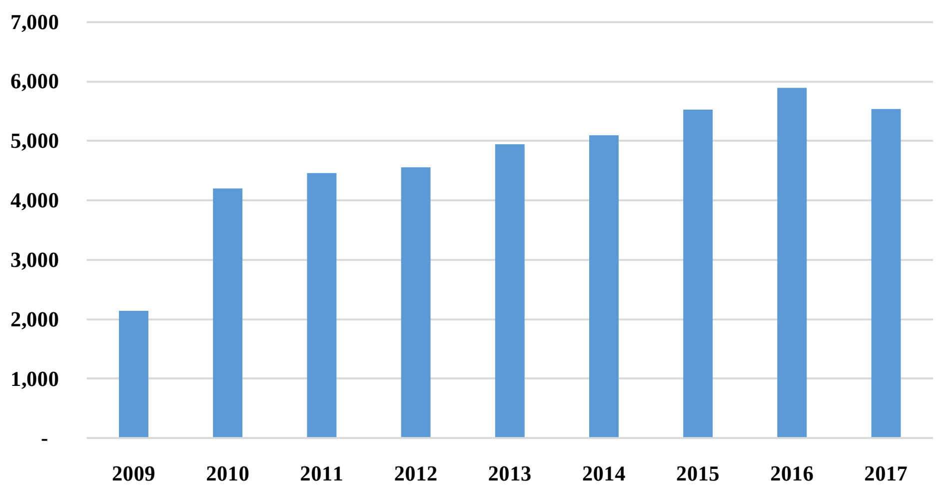

Fig.1 Trade value of renewable energy industry in Malaysia (in Millions US$)

The main two objectives of this paper is firstly, to investigate the interactions between trade flows and technological development with regard to environmental technologies, the motivation for that is the Porter hypothesis, the environmental regulations will positively affect innovation and comparative advantage on global market by using gravity model. Secondly, 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.

The Porter hypothesis, resulting from one if the various discussion on the relationship between trade flows and government policies. Using gravity model [4] analysed the determinants of transmission channels through which environmental technologies are exported to advanced and developing countries. 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 [5] also focus on the effect of environmental policy stringency - such as environmental protection expenditures or energy and environmental tax revenues - on the export of environmental goodsof 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.

November-December 2019
ISSN: 0193-4120 Page No. 3459 - 3470

A large body of literature had been trying to use a gravity model of international trade, [6] 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 [4], [6] and [7] 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 [8]establishes a statistical correlation between large domestic markets and large export shares, while [9]find that domestic renewable power generation of the exporting countries play a significant positive role in export performance.

II. EMPIRICAL MODEL AND DATA

The gravity model explains trade flows among countries by the market size, which is measured by GDP and the distance between countries [10]. Tinbergen used an analogy with 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 variableis 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 [7]. As suggested by [11] some studies [7] 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 Table A1). Following [7]; the International Centre for Trade and Sustainable Development (ICTSD) identified HS 6-digits product category codes according to the different renewable energy sectors [13,14]. Their product categorization is displayed in the Appendix Tables A1 and A2

The estimated model is:

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

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

November-December 2019
ISSN: 0193-4120 Page No. 3459 - 3470

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 [12].
- $(LANG_{o,d})$: 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.
- $(BOR_{o,d})$: 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

In this context Malaysia has already signed and implemented 7 bilateral FTAs withJapan,Pakistan,India, New Zealand,Chile,AustraliaandTurkey. While at the ASEAN level, Malaysia has 6 regional FTAs withASEAN Free Trade Agreement (AFTA),China,Korea,Japan,Australia,New ZealandandIndia.

III. Results and Discussion

The study estimates all the specification models using the Prais–Winsten panel-corrected standard error (PCSE) estimator. In this case, although feasible generalized least squares (FGLS) could be an alternative estimation procedure, but FGLS produces estimates which are conditional on the estimates of the disturbance covariance matrix and are conditional upon any autocorrelation parameters estimated [15]. 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 typically unacceptably optimistic (anticonservative) and the overconfidence in the standard errors makes this method unusable, unless T >N[16]. Moreover, the ordinary least squares (OLS) or Prais–Winsten estimates with PCSEs have coverage probabilities that are closer to nominal. That why, the baseline models in this study are estimated using the procedure of the PCSE.

Two models are displayed in table 1. The first is representing the original 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 extended gravity model, it is the main explanatory model since the objective of the study is to investigate the interaction between trade flows of renewable energy industries and environmental regulation represented by CO2 emission and the demand of renewable energy in destination countries. The results show thatthe bilateral trade agreements between Malaysia and destination countries (BFTA) is not significant in the second model as well. Whereas only three countries of the sample have a bilateral trade agreements with Malaysia and this could be not sufficient enough to get a significant effect. The results are in line with [6],[7] 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.

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 4.5

November-December 2019
ISSN: 0193-4120 Page No. 3459 - 3470

percent in trade flows of renewable energy industries in the second model. This drop partly reflects increased transportation cost of goods.

It is demonstrated that there are 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 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.

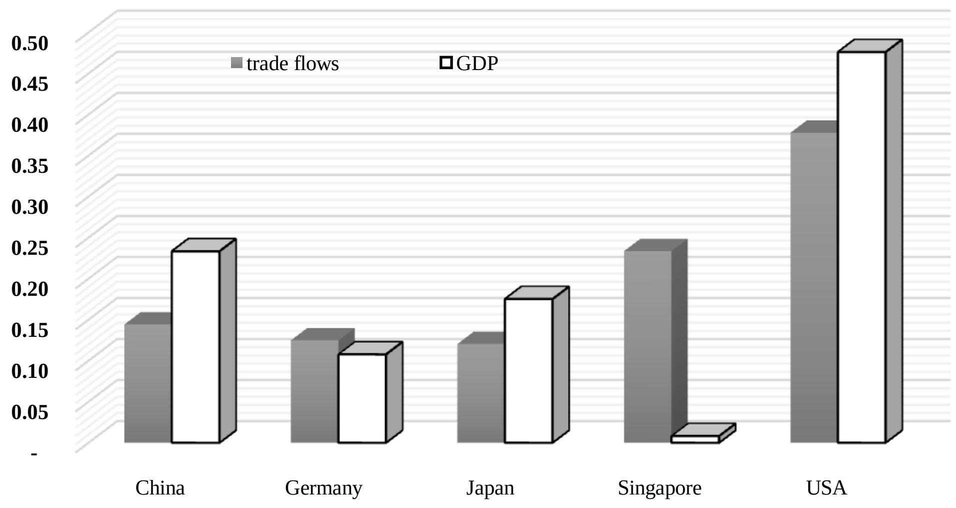

Fig. 2 the Top 5 countries with highest vaule traded with Malaysia and thier GDP

The variable of renewable energy demand in the destination countries $(REDEMAND_{d,t})$is statistically significant with the expected sign, it means that everything else hold constant, if a country increase the demand of renewable energy industries by 1 percent the trade flows of Malaysia will increase by 6.5 percent.

The elasticity of $(CO2_{d,t})$on trade flows has a negative and significant effect on trade flows. This negative sign of the CO2 emission variable is a good thing, it means that the destination country has a full awareness of environmental regulations, the results show that whenever the emission of CO2 in the destination country decreases by 1 percent the trade flows of renewable energy increases by 34 percent in Malaysia. The results are also consistent with Porter hypothesisand confirm those of previous econometric studies [4],[5],[6] and [7] on the positive effect of environmental regulation on the export of the renewable energy industry, and generalize to them to the context of a truly global

November-December 2019
ISSN: 0193-4120 Page No. 3459 - 3470

industry, where both industrialized countries and emerging countries compete for market shares.

TABLE 1. PCSE estimation results

	Original Gravity Model	**Extended Gravity Model**
$CONSTANT$	-43.59**	-37.736**
	(6.67)	(6.78)
$ln(GDP_{o,t})$	0.866**	0.877**
	(0.24)	(0.24)
$ln(GDP_{d,t})$	1.42**	1.298**
	(0.76)	(0.08)
$ln(REDEMAND_{d,t})$		0.065**
		(0.028)
$ln(DIST_{o,d})$	-0.197**	-0.459**
	(0.06)	(0.047)
$(LANG_{o,d})$	0.267**	0.270**
	(0.074)	(0.07)
$(BOR_{o,d})$	2.568**	2.658**
	(0.17)	(0.14)
$(ASEANFTA_{o,d})$	1.126**	1.474**
	(0.14)	(0.15)
$(BFTA_{o,d})$	-0.272	-0.338
	(0.26)	(0.19)
$ln(CO2_{d,t})$		-0.34**
		(0.053)
Number of obs.	169	169

November-December 2019
ISSN: 0193-4120 Page No. 3459 - 3470

Number of groups	19	19
R^2	0.69**	0.71**
Wald χ^2	51791.93**	37727.1**
Standard errors in parentheses. **p<0.05		

IV. Conclusion

The econometric model shows evidence of a positive effect of environmental regulations that promote the use of renewable energy on the export performance and competitiveness of renewable energy manufacturing industries in Malaysia. The main results indicate that Porter hypothesis is valid, as CO2 emission represents as proxy of environmental regulations, the results show that whenever the emission of CO2 in the destination country decreases 1% the trade flows of renewable energy increases by 34% in Malaysia.

TABLE 2. 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

November-December 2019
ISSN: 0193-4120 Page No. 3459 - 3470

	(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
	(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

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.Competitiveness based on a strong home market can best be maintained as the technology requires continuous innovations where intimate user-producer interaction is crucial [7].

However, the decreases of market prices of renewable energy technologies enhanced competition on the global market. For solar PV technologies, market price decreases have been much faster than anyone could have imagined, since the last ten years ago, they are projected to continue to decrease at a fast pace [17]. As economists predicted [18], 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 with more countries that demand more renewable energy industries.

APPENDIX

TABLE A1. 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

November-December 2019
ISSN: 0193-4120 Page No. 3459 - 3470

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)

TABLE A2. 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

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