Can Clean Technology Exports Affect CO2 Emissions for Partners? Evidence from China.

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Shaker Saber Adly
Associate Professor, Economics and Foreign Trade Department, Helwan University, Cairo, Egypt
mail: saberadly@commerce.helwan.edu.eg

Abstract
This paper uses a panel vector error correction model (panel VECM) to examine the impact of Chinese exports of clean technology intensive goods on carbon dioxide (CO_2) emissions in China's partners between 2001 and 2013. The results suggest that Chinese exports of clean technology intensive goods play a crucial role in reducing CO_2 emissions in the short run but not in the long term. Finally, Carbon dioxide emissions CO_2 considered an item of demand factors which affect the production of clean technology intensive goods in the long run only. JEL: $F_{18} – O_3$

Keywords: Clean technology; CO_2 emissions; Panel VECM

Definition of Clean Technology

Researchers have not agreed on a single and specific definition for the term "technology" which could be due to the various aspects through which the term is analyzed. For example, there are both a management and an economic aspect for the concept of technology. From the perspective of management, technology was defined as the practical arts, skills, knowledge and procedures for manufacturing and using useful things [1]. Also pointed out that technology is the application of science through relevant relationships [2]. From the economic perspective, production technology is defined as a description of the relationship between inputs (factors of production) and outputs (goods and services) [3]. The latter definition is in agreement with what most researchers reached, like [4], who said that technology is the method by which inputs from resources are turned into products. The previous examples of definitions of technology indicate that technical relationships between inputs and outputs are the only focus. And, Environmental impacts resulting from technology are ignored, whether they are positive or negative. Clean technology (clean tech) or Green Technology can be defined as follows: It is a phenomenon that comprises the production of versatile goods, services and processes with an added value, with an environmental purpose or benefit [5]. Installation of all or some production components adopted for limiting pollution or eliminating it. This technology is characterized by being clean throughout all production stages from beginning to end. In clean technology, devices and production supplies are compatible with environmental requirements [6]. It is viewed as a wide concept that comprises the integration of technology to limit pollution and waste, in addition to efficiency of energy consumption and natural resources. This applies to all stages of production, waste disposal, reusing products and providing complementary services. It also includes both materials used in production as well as management practices [7]. It is these processes and clear standards that are necessary for participating with and exchanging digital information. It must be noted that the process of technological exchange must be characterized by reliability, a low degree of error and is more accurate than human transactions [8]. In general, the terms "Clean-Up Technology" and "Clean Technology" can be differentiated. The first term indicates limiting environmental damage through updating certain measures for limiting pollution, modifying them or adding to them, in terms of End-of-Pipe technology. Therefore, technology did not take environmental considerations into account from the beginning. The second term deals with avoiding environmental damage from beginning to end and reaching the required outputs [9]. Through the above, we can clarify that clean technology is the process of adapting production technology from the beginning to achieve environmental goals. In addition, it seeks to limit environmental pollutants like carbon dioxide (CO_2) emissions, as well as contributing to managing some environmental issues, like global warming. In real world, there is a wide gap between idealistic and realistic solutions for the application of clean technology in production and giving up polluting technology. Firms prefer using polluting technology in production because they deal with environmental issues as if they were static. They ignore all negative impacts resulting from environmental quality deterioration in general. This problem is intensified with the low investment in research and development (R&D) as one of the essential requirements of applying clean technology in production [10].

Investment in Clean Technology

The investment in clean technology shows growth in varying rates during the period 2004-2015. Table 1 shows low investment in clean technology (CTI) in comparison to Gross

Domestic Product (GDP), which did not exceed 0.4% at that period. However, the average of growth rate in these investments was 16%, which exceeds the growth rate of GDP of the world (5% during that period). It is also noteworthy that investment in clean technology is an economic variable that pro-cyclical with GDP.

Source

- World Bank (2015), World Development Indicators Database.
- MacDonald Jennifer (2016), Bloomberg New Energy Finance.

In addition to, the flow of clean technology investment in a given country is affected by three basic elements [12] as follows:

- The geographic nature of the host country, especially when it comes to the field of renewable energy technology;
- Relevant rules, procedures and regulations.

The stage in the Product Life Cycle of the goods where clean technology shall be applied.

Generally, investment in clean technology faces a number of barriers that hinder it from expansion and spreads in the world. The most important barriers are as follows [13]:

- Infrastructure barriers, due to the limited and poor projects under construction, insufficient awareness of investors and organizational and institutional restrictions.
- Barriers related to the fields of clean technology, such as the high level of risk in the fields of clean technology in comparison to the expected returns and the lack of a clear pricing and subsidizing policy in comparison to traditional types of energy.
- Financing barriers. The most important financial barriers are insufficient environmental bonds markets and securitization of debts as well as various insurance issues.

Incentives for Expansion in Applying Clean Technology

Expansion in using clean technology is classified as a list of public or social goods. This results in the emergence of a number of positive externalities, such as a number of benefits resulting from limiting negative effects of environmental pollution and the most important of which is climate change. Generally, the phenomenon of clean technology is subject to what is known as failure of the market system, which requires creating political, economic and governmental policies to correct the market failure, while taking the following factors into consideration [14]. The designed policies must be as direct as possible; the designed governmental policies must be technologically neutral. This means that governmental purposes and tools must be directed at promoting clean technology, not governmental intervention to provide clean technology to the market, in order to reduce the impact of crowding out effect. Policies of promoting clean technology must come in a comprehensive governmental strategy to face the issues of environmental pollution and climate change. Taking the effectively of the price factor and pricing policies of energy into consideration, as one of the essential tools in promoting clean technology. When the technology used in the beginning of the project is advanced and complex, this has an inverse effect on the process of transformation to clean technology, due to the high cost of technological transformation. Generally, some the most important incentives (the role of the government) necessary for promoting the application of clean technology are as follows [15- 17].

Traditional Incentives

Progressive tax of pollution, which is linked the amount of pollution generated by each firm. Also, financial and knowledge incentives and applied governmental researches must be provided for institutions that turn to use clean technology. These subsidies must be guaranteed to be sustained.

Agreements: The government and business sector must conclude agreements in every country. Through these agreements, firms must pledge to participate in reducing environmental burdens in the country, within a specific time framework, which is subject to evaluation and monitoring continuously.

Direct Governmental Incentives: Direct promotion of buying clean technology by firms, such as the Renewable Portfolio Standards, which includes motivating firms to use renewable energy.

Indirect Governmental Incentives: Indirectly promoting buying clean technology by firms, such as the Cap & Trade Program, which includes linking profit incentives to the reduction of levels of pollution.

Demand Incentives: Through governments encouraging consumers to fulfill their needs of renewable energy.

Trade patterns in clean technology intensive goods

Goods produced through intensity of clean technology are considered environmental goods. Thus, environmental goods include a number of various goods and categories. For example, the OECD divides environmental goods into about 164 customs codes. The APEC divides environmental goods into 109 customs codes. Generally, clean technology intensive goods received the attention of the OECD classification. Therefore, the definition of clean technology intensive goods is “a group of industrial and consumption goods, which are not only manufactured for an environmental purpose, but also for production and final processing purposes. They are characterized by positive environmental features, in comparison to their alternatives" [18]. Based on Zugraw, 2015, the list of goods produced by clean technology intensive goods is 86 customs code, as shown in the Appendix. Examples of these goods are photosensitive semiconductor devices. It also includes Appliances for pipes, boiler shells, tanks, vats or the like (excluding pressure-reducing valves, etc. Table 2 shows the evolution of global exports of both clean technology intensive goods (CTEX) and the total of goods (TEX) from 2001-2015. It is shown that the exports of clean technology intensive goods do not exceed 2%-3% out of the total exports in goods. This reflects the weak global orientation toward the adoption of clean technology as a global issue. It is noteworthy that the degree of stability is higher in case of exports of clean technology intensive goods in comparison to exports of total goods. Regarding the yearly growth rate (2001 – 2015), it is about 13% of clean technology intensive goods in comparison to 12% of total goods exports.

Table 3 shows the top 10 exporters of clean technology intensive goods in the world for 2015. China is the first exporter with 19.4% of world exports of technology intensive goods (CTEX). It is followed by the USA and Germany, and each of them has 12.5% and 11.2%, respectively. It is noteworthy that the ten countries altogether have 70% of world exports of technology intensive goods (CTEX). As for the relative importance of CTEX out of TEX, it is between 3%-5%. This indicates the weak orientation of these countries toward the application of clean technology ideally, through extending this technological pattern. Regarding the top 10 importers of clean technology intensive goods (CTIM) in the world for 2015, it is noteworthy that there are no essential differences except in the order of the same list of largest exporters except Canada coming instead of Italy. Thus, Table 4 shows the United States being at the top of the list, with 13%, followed by China with 9% out of world imports of clean technology intensive goods. It is noteworthy that the list of ten countries together has 52% of total world imports of clean technology intensive goods. As for the relative importance of clean technology intensive goods out of the total goods imports, it ranges between 2% and 4%. This confirms the weak orientation of these countries toward ideally using clean technology through the expansion of this technological pattern.

Trade in clean technology intensive goods in China

As we mentioned in both Tables 3 and 4, China is a major player in clean technology intensive goods from both export and import perspectives. Thus, Table 5 shows the evolution of exports of clean technology intensive goods in China 2001- 2015. In year 2001, China has only 4% of world exports of technology intensive goods (CTEX). It is grown annually and reached to 14% in year 2015. This indicates the strong awareness of China toward the application of clean technology as a new trade pattern. Also, Table 6 shows the structure of exports (in terms of top 10 products) of clean technology intensive goods for China in 2015. For example, product with custom code 854140 resembles 24% of total exports of clean technology intensive goods. In general, top 10 products of clean technology resemble 72% of total exports of clean technology intensive goods. But now we will analyze the tariffs barriers in the importing markets towards Chinese exports of clean technology intensive goods. Table 7 shows that for both of top 10 imported countries and top 10 exported products of Chinese clean technology intensive goods. We note that product with custom code 850131(DC motors of an output > 37, 5 W but <= 750 W and DC generators of an output <= 750 W) is the highest restricted product in the top 10 products with average custom tariffs 4.25%. On the other hand, product with custom code 854140 (Photosensitive semiconductor devices, incl. photovoltaic cells whether or not assembled in ...) is the only product in the top 10 products with free trade case. So this may be implies to a negative relationship between custom tariffs and market access for Chinese exports in case of clean technology intensive goods. In addition to, Table 8 represents the major foreign suppliers of Chinese imports (in terms of top 10 partners) of clean technology intensive goods for 2015. For example, Japan resembles 22% of total Chinese imports of clean technology intensive goods. In general, top 10 suppliers of clean technology resemble 72% of total imports of clean technology intensive goods.

Data, Methodology and Estimation

To test the relationship between Chinese exports of clean technology intensive goods (CTEX) and CO_2 emissions in to 10 partners we propose to use co-integration techniques and causality tests using panel data over the period of 2001 to 2013. Our estimation approach checks the stationarity of all variables using panel unit root tests. Next, panel co-integration approach is implemented to test whether the CTEX is co-integrated with CO_2, i.e., if there is a non-spurious long-term relationship between the two series. Finally, we run the vector error correction model. Co_2 emissions have been attained from world development indicators data base (World Bank). And Chinese exports of clean technology intensive goods have been attained from International Trade Center, Calculations Based on UN COMTRADE Statistics [19].

Table 1: *Evolution of Investment in Clean Technology (CTI) and GDP from 2004-2015. Value in billions of US$.*

Year	CTI	change %*	GDP	change %*
2004	62	-	43512	-
2005	88	42	47104	8
2006	128	45	51034	8
2007	175	37	57531	13
2008	206	18	63071	10
2009	207	0.5	59776	(5)

2010	274	32	65588	10
2011	318	16	72660	11
2012	297	(7)	74155	2
2013	272	(8)	76237	3
2014	316	16	77845	2
2015	329	4	73507	(6)
	Average %*	16	Average %*	5

Our econometric estimation depends on the following steps

Panel unit root test: Panel unit root test is the first step in our estimation to test the staionarity of our variables. Table 9 summarizes the unit root test in both of level and first difference without both of trend and intercept. The results show that both of variable CTEX and variable CO_2 have unit root test at level because the probability value greater than 5%. And, have not unit root test at the first difference, because the probability value lowers than 5%. This means, our variables are non-stationary at level and stationary or integrated at the same order which is the first difference.

Johansen -Fisher panel co-integration test: Because step one satisfied, we can test if there is any long run relationship between CTEX and Co_2 through Johansen Fisher panel co-integration test. Table 10 indicates that we cannot accept the null hypothesis of none co-integration between CTEX and CO_2 because P-value is lower than 5%. Thus, there is at most one co-integration between CTEX and CO_2 because P-value is higher than 5%.

Vector Error Correction Model one (VECM)1: Because step two satisfied, we can test if there is any long run causality between CTEX and Co_2 through panel VECM test. Our estimated equation is the following: Table 11

$D(CO_2) = C(1)*(CO_2(-1) - 0.000465314803198*CTEX(-1) - 18862.1319447) + C(2)*D(CO_2(-1)) + C(3)*D(CO_2(-2)) + C(4)*D(CTEX(-1)) + C(5)*D(CTEX(-2)) + C(6).$

Now we will test if there is a short run causality running from Chinese exports of clean technologies (C(4) D(CTEX(-1)) + C(5)*D(CTEX(-2))) to Carbon dioxide emissions CO_2 ($D(CO_2)$). Based on Wald test our null hypothesis is (C(4)D(CTEX(-1)) = C(5)*D(CTEX(-2)) = zero, But the alternative hypothesis is (C(4)D(CTEX(-1)) = C(5)*D(CTEX(-2)) ≠ zero. Table 12 indicates that because the p-value of Chi-square is lower than 5% we cannot accept the null hypothesis. In other words, there is effective short run causality running from Chinese exports of clean technologies to Carbon dioxide emissions CO_2 ($D(CO_2)$).

4. Vector Error Correction Model Two (VECM) 2:

In vector error correction model one we test the causality between Chinese exports of clean
Technology intensive goods CTEX as independent variable. And, the Carbon dioxide emissions CO_2 as a dependent variable. But in vector error correction model two we test the causality between the Carbon dioxide emissions CO_2 as independent variable. And, Chinese exports of clean technology intensive goods CTEX as a dependent variable. We can test if there is any long run causality between CTEX and Co_2 through panel VECM test. Our estimated equation is the following:

C (4) D (CTEX (-1)) + C (5)*D (CTEX (-2)))

$D(CTEX) = C(1)*(CTEX(-1) - 2149.08271374*CO_2(-1) + 40536281.7065) + C(2)*D(CTEX(-1)) + C(3)*D(CTEX(-2)) + C(4)*D(CO_2(-1)) + C(5)*D(CO_2(-2))+ C(6)$

Also, Table 13 indicates that because the error correction term C (1) is negative in coefficient and significant (p-value lower than 5%), so there is an effective long run causality running from Carbon dioxide emissions $C(4)*D(CO_2(-1)) + C(5)*D(CO_2(-2))$ to Chinese exports of clean technologies D(CTEX). Now we will test if there is a short run causality running from Carbon dioxide emissions $C(4)*D(CO_2(-1)) + C(5)*D(CO_2(-2))$ to Chinese exports of clean technologies D (CTEX). Based on Wald test our null hypothesis is $C(4)*D(CO_2(-1)) = C(5)*D(CO_2(-2))$ = zero, But the alternative hypothesis is $C(4)*D(CO_2(-1))=C(5)*D(CO_2(-2)) \neq$ zero. Table 14 indicates that because the p-value of Chi-square is greater than 5% we cannot reject the null hypothesis. In other words, there is not short run causality running from Carbon dioxide emissions $C(4)*D(CO_2(-1)) + C(5)*D(CO_2(-2))$ to Chinese exports of clean technologies D (CTEX).

Table 2: *Opportunities and points of vigilance.*

Year	CTEX	TEX	CTEX / TEX %*
2001	154309098	6114485767	3
2002	157753866	6403653403	2
2003	180714412	7463423856	2
2004	220016585	9087575488	2
2005	247916036	10342324066	2
2006	295596713	11952137642	2
2007	367495563	13774387292	3
2008	443089811	15973576744	3
2009	375316908	12313949381	3

2010	453994498	15063695476	3
2011	514103849	18077986104	3
2012	500439895	18364576876	3
2013	507814447	18864055146	3
2014	524654950	18866319713	3
2015	485063193	16346668440	3

Table 3: *Evolution of exports of clean technology intensive goods and total goods exports 2001-2015. Value in thousands of US $.*

	CTEX	TEX	CTEX / TEX %*
China	94243996	2281855922	4
United States of America	60703127	1503870438	4
Germany	54599762	1331193671	4
Japan	26876042	624873508	4
Italy	24474183	458751239	5
United Kingdom	16614799	465921609	4
Korea, Republic of	16611496	526900733	3
France	15809374	573055549	3
Mexico	14450281	380749925	4
Hong Kong, China	13727022	510532990	3
Total top 10	338110082	8657705584	4
Total top 10 / The world %*	70	53	

Table 4: *Evolution of imports of clean technology intensive goods and total goods imports 2001-2015. Value in thousands of US $.*

Country	CTIM	TIM	CTEX / TEX %*
United States of America	73916476	2306822161	3
China	45738561	1681670816	3
Germany	30152350	1056340529	3
Japan	17964292	625568421	3
United Kingdom	17452724	629228889	3
Mexico	17337832	395232221	4
Canada	16248794	419151924	4
France	14884715	651495605	2
Korea, Republic of	14159976	436547721	3
Hong Kong, China	14047313	559283822	3
Total top 10	261903033	8761342109	3
Total top 10 / The world %*	53	53	

Table 5: *Evolution of exports of clean technology intensive goods in China and the world 2001-2015. Value in thousands of US $.*

Year	China	World	China / World %*
2001	266098209	6114485767	4
2002	325595970	6403653403	5
2003	438227767	7463423856	6
2004	593325581	9087575488	7
2005	761953410	10342324066	7
2006	968935601	11952137642	8
2007	1220059668	13774387292	9
2008	1430693100	15973576744	9
2009	1201646800	12313949381	10
2010	1577763800	15063695476	10
2011	1898388400	18077986104	11
2012	2048782200	18364576876	11
2013	2209007280	18864055146	12
2014	2342343011	18866319713	12
2015	2281855922	16346668440	14

Table 6: *Top 10 exported products of clean technology intensive goods in China 2015. Value in thousands of US $.*

Custom code (H.S)	Product label	value
854140	Photosensitive semiconductor devices, incl. photovoltaic cells whether or not assembled in ...	22831268
850440	Static converters	17808018
848180	Appliances for pipes, boiler shells, tanks, vats or the like (excluding pressure-reducing valves, ...	10056454
850300	Parts suitable for use solely or principally with electric motors and generators, electric ...	3987130
848190	Parts of valves and similar articles for pipes, boiler shells, tanks, vats or the like, n.e.s.	3487191
850131	DC motors of an output > 37.5 W but <= 750 W and DC generators of an output <= 750 W	2150215
900190	Lenses, prisms, mirrors and other optical elements, of any material, unmounted (excluding such ...	2131091
841370	Centrifugal pumps, power-driven (excluding those of subheading 8413.11 and 8413.19, fuel, lubricating ...	2098272
850490	Parts of electrical transformers and inductors, n.e.s.	2050188
850431	Transformers having a power handling capacity <= 1 kVA (excluding liquid dielectric transformers)	1584955
	Total top 10 products*	68184782

Table 7: *Top 10 exported products of clean technology intensive goods in China 2015 with tariffs levels in to partners. Value in percentage %.*

Custom code (H.S)	SA	Hong Kong, china	Japan	Korea, Republic of	India	Germany	Singapore	Thailand	Vietnam	UK	average *
854140	0	0	0	0	0	0	0	0	0	0	0
850440	.44	0	0	.75	.33	1.74	0	6.67	0	.74	.07
848180	.65	0	0	4	.2	2.2	0	0	0	.2	.93
850300	.06	0	0	.65	6	2.7	0	0	0	.7	.11
848190	.75	0	0	.4	6	2.2	0	0	0	.2	.06
850131	3	0	0	8	.5	2.52	0	10	9	.52	.25
900190	0	0	0	8	9.5	2.2	0	0	0	2.2	2.19
841370	0	0	0	.1	.5	1.02	0	0.3	4	.02	.09
850490	.55	0	0	4	.5	1.36	0	0	0	.36	.48
850431	.73	0	0	.08	8	2.47	0	10	7.86	.47	.96
Average*	.62	0	0	.3	.75	1.84	0	2.7	2.09	.84	

Table 8: *Top 10 suppliers of Chinese imports of clean technology intensive goods in 2015.*

Market	Value	% Share of top 10
Japan	7248796	22
Taipei, Chinese	6254871	19
Germany	5272088	16
United States of America	4953481	15
Korea, Republic of	4324863	13

Malaysia	1193646	4
Italy	1057599	3
United Kingdom	907909	3
Market	Value	% Share of top 10
France	867133	3
Singapore	828983	3
	Total top 10 markets*	32909369

Table 9: *Panel unit root test outputs.*

Variable	Test in	Method	Statistic	Probability
CTEX	Level	Levin, Lin & Chu t*	6.54597	1
		ADF - Fisher Chi-square	2.67898	1
		PP - Fisher Chi-square	4.58959	0.99
	1st difference	Levin, Lin & Chu t*	-6.21183	0
		ADF - Fisher Chi-square	62.7682	0
		PP - Fisher Chi-square	55.0142	0
CO_2	Level	Levin, Lin & Chu t*	1.19	0.883
		ADF - Fisher Chi-square	16.8299	0.664
		PP - Fisher Chi-square	14.2187	0.8192
	1st difference	Levin, Lin & Chu t*	-7.8837	0
		ADF - Fisher Chi-square	97.1802	0
		PP - Fisher Chi-square	115.602	0

Table 10: *Johansen Fisher panel co-integration test outputs.*

Hypothesis	Fisher Stat.* (from trace test)	Probability	Fisher Stat.* (from max-eigen test)	Probability
None	72.13	0	71.45	0
At most 1	20.74	0.4123	20.74	0.4123

Table 11: *Test long run causality from CTEX to CO_2.*

Coefficient	Std. Error	t-Statistic	Prob.
C (1)	-0.00216	0.005175	0.000

Table 12: *Test short run causality from CTEX to CO_2.*

Test Statistic	Value	df	Probability
Chi-square	8.069001	2	0.0177

Table 13: *Test long run causality from CO_2 to CTEX.*

	Coefficient	Std. Error	t-Statistic	Prob.
C (1)	-0.12346	0.033908	3.64089	0.0004

Table14: *Test short run causality from CO_2 to CTEX.*

Test Statistic	Value	df	Probability
Chi-square	4.945668	2	0.0843

Conclusion

Our paper had an objective to answer the following main question, "Can Chinese exports in case of clean technology intensive goods reduce the emissions of Carbon dioxide emissions CO_2 for partners?", the results indicate that, in short run, increasing the Chinese exports of clean technology intensive goods has significant effect in reducing the emissions of Carbon dioxide emissions CO_2 for partners. But, in long run increasing the Chinese exports of clean technology intensive goods has insignificant effect in reducing the emissions of Carbon dioxide emissions CO_2 for partners. This means that China can play a vital role in the environment challenges especially in the short run. Another result related to the incentives to produce clean technology intensive goods. Carbon dioxide emissions CO_2 considered an item of demand factors which affect in the production of clean technology intensive goods in the long run only. These results have vital implications for policy maker in both of china and its main trade partners. Specifically, to reduce pollution in trading partners of china in short run, it is necessary to continue increasing the imports from Chine's clean technology intensive goods. For example, the governments of Chines trade partner's should formulate and implement free trade policy to eliminate Carbon dioxide emissions CO_2. Furthermore, it would also be important to design tax policies that encourage investments in clean technologies industries.

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