Middle-East Journal of Scientific Research 25 (9): 1853-1860, 2017
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2017.1853.1860

The Trade Implication of a Chinese ETS

Xianming Meng and Mahinda Siriwardana

UNE Business School, UNE, Armidale, Australia

Abstract: This paper uses the recent GTAPE database and a CGE modelling framework to simulate the effect of a national ETS of US$7 per tonne on global trade. The simulation results show that the ETS causes substantial trade creation and trade diversion. Chinese exports and import decrease substantially while the trade between most other countries increases to various degrees. The study concludes that, due to trade linkage, a global action is needed to reduce emission effectively.

Key words: Emission trading scheme · CGE modelling · International trade · Energy and resources · Chinese economy

INTRODUCTION

Climate change has become a great concern for mankind. In 1992, the United Nations Framework Convention on Climate Change was negotiated at the Earth Summit. In 1997, the Kyoto Protocol established legally binding targets of reduction of greenhouse gas emission. In the 2010 Cancun agreements, all parties agree to commit to a maximum temperature rise of 2 degree Celsius above pre-industrial level and to establish a Green Climate Fund. The 2014 Climate summit in New York generated unprecedented worldwide marches, calling for actions on climate change.

China as the world largest developing country and the world No.1 carbon dioxide emitter has been facing the hard choice between economic growth and emission reduction. The escalating environmental problems from carbon emissions have finally prompted the Chinese government to tackle the carbon emission issue. In October 2011, the National Development and Reform Commission (NDRC) initiated seven pilot ETS programs in four municipalities (Beijing, Tianjin, Shanghai and Chongqing), two provinces (Hubei and Guangdong) and one local-level city Shenzhen (located in Guangdong province). All seven pilot regions have launched their pilot ETS programs. According to the NDRC, the pilot ETS programs will last till 2015. After 2015, a nationwide ETS is expected to be established and implemented during the Thirteenth Five-Year Plan period (2016-2020).

Since China is the largest carbon emitter as well as the largest trading nation in the world. China's actions on climate change will not only affect its economy and environment, but also its international trade significantly. Moreover, the significant trade linkage between China and the rest of the world may also affect the economy of other countries as well as the effectiveness of China's ETS. To gauge these effects, this paper employs the most recent GTAPE database and the GTAPE model to simulate the impact of a national ETS in China.

The remainder of the paper is organised as follows. Section 2 reviews the previous studies on carbon pricing with an emphasis on international trade and on China. Section 3 describes the database used for modelling, the model structure and simulation design. Based on the modelling results, section 4 analyses the impact of a Chinese national ETS on China, global bilateral trade and the international trade in energy and natural resources. The last section summarizes the paper.

Literature Review: There are many studies on carbon pricing in China, including [1-12]. Due to space limitation, only some representative studies are reviewed here. As early as the late 1990s, [6] used a time recursive dynamic CGE model to analyse the macroeconomic and sectoral effects of carbon taxes designed to cut China's carbon emissions in 2010 by 20 per cent and 30 per cent respectively. The 1991 Chinese I-O table was aggregated into 10 sectors, which included 4 energy sectors – coal, oil, natural gas and electricity. The simulation results suggest that, under the two basic scenarios (the emission cut by 20 per cent and 30 per cent in 2010, with carbon tax revenue retained by the government), China's GNP drops

Corresponding Author: Xianming Meng, UNE Business School, UNE, Armidale, Australia.

by 1.5 per cent and by 2.8 per cent and its welfare reduces by 1.1 per cent and by 1.8 per cent. If the carbon tax revenues were used to offset reductions in indirect taxes, the negative effects of carbon taxes on both GNP and welfare would be reduced. At the sectoral level, the changes in gross output vary significantly with the coal sector being affected most severely.

Based on the CGE model by [13], [14] developed a dynamic energy-environment-economy CGE model to examine the impacts of carbon tax on China. The simulation results showed that a carbon tax of 30, 60 and 90 RMB per tonne starting from 2013 would result in a reduction of carbon emissions by 4.52%, 8.59% and 12.26%, a decrease in GDP by 0.11%, 0.25% and 0.39% and a decline in emission intensity per unit of GDP by 34.79%, 37.49% and 39.92% in 2020, respectively. The study also found that if the carbon tax revenue is returned to households and industries, the negative impact on the economy will be alleviated.

[15] developed a CGE model to study how the emission reduction burden and associated cost would be distributed across regions in China. They compared the effect of the disaggregated provincial targets with the single national target and found that a single national target results in 25% lower welfare loss relative to the provincial-targets approach. Using an endogenous subsidy for households and/or for industrial electricity users, they also simulated the effect of the fixed end-use electricity prices policy in China and claimed that the fixed electricity price will magnify the national welfare losses.

To study the impact of border tax adjustments (BTAs) imposed by the USA and the EU on China's international trade, [16] developed a CGE model with four regions (USA, EU, Japan and the rest of world) as China's trading partners. The simulation results suggested that the BTAs will lead to large losses in Chinese imports and exports. Moreover, these trade losses will induce an economic contraction in China, indicated by a significant decrease in GDP and decreases in income for enterprises, households and the government. As a response to BTAs, the paper suggested a policy to enhance China's power in world price and to improve energy technology efficiency.

[17] used a dynamic CGE model to study the energy consumption and carbon emission in China. The simulation results showed that with a carbon tax, the Chinese economy would slow down relative to the benchmark scenario and the carbon emission intensity per unit of GDP would decrease continuously. The paper also found that the carbon tax is very important for emission reduction and for the optimization of energy consumption. If the carbon tax is accompanied by a company income tax reduction, it is claimed that the GDP growth rate would increase while energy consumption and carbon emissions would reduce.

From different perspectives, these studies on carbon pricing in China provide useful information on the linkage between carbon pricing and international trade and on the possible impact of a Chinese carbon emission reduction policy. However, these studies have a major limitation; namely, they did not provide detailed information about the impact of carbon pricing on global bilateral trade and on international trade in energy and resource commodities, which plays a key role in the wake of a carbon price. This study tries to bridge this existing research gap.

Data, Model and Simulation Design: Since China is the largest carbon emitter as well as the largest trading nation in the world. China's actions on climate change will not only affect its economy and environment, but also its international trade significantly. Moreover, the significant trade linkage between China and the rest of the world may also affect the economy of other countries as well as the effectiveness of China's ETS. To gauge these effects, this paper employs the most recent GTAPE database and the GTAPE model to simulate the impact of a national ETS in China.

The data used in this paper is from GTAPE Database 8.1 with a base year of 2007, which is the latest available global emissions and input-output database. There are 57 industries and 134 regions in this database. For the purposes of this study, this database is aggregated into 35 regions and 32 sectors. The aggregation retains great detail of the industrial structure of both China and its major trading partners.

GTAPE database 8.1 includes input-output data, carbon emissions data and behaviour parameters for countries/regions in the world. Since the carbon emissions are the key data for this study, it is worthwhile to describe them, with the emphasis being on China. The database gives detailed emissions from the domestically produced or imported fuels and related products (i.e. coal, oil, gas and oil products) used by the government, the household and each industry. For example, the emissions of all Chinese industries from using domestic coal, oil, gas and oil products are 3801.64 Mt, 24.31 Mt, 62.12 Mt and 829.18 Mt, respectively. For imported fuels, the emissions are 76.46 Mt, 12.50 Mt, 4.22 Mt and 75.49 Mt, respectively. It is apparent that, domestically produced coal and oil products are the major contributors to industrial emissions. For households, the emissions from oil are negligible because of the very little household consumption of oil. The emissions of Chinese households from using domestic coal, gas (gas service in the database) and oil-products are 145.80 Mt, 29.61 Mt and 154.57 Mt, respectively. For imported fuels, they are 2.7 Mt, 1.42, Mt and 12.72 Mt. Once again, the data indicate that the domestic coal and oil products are the major contributors of carbon emission for Chinese households. The amount of emissions by the Chinese government is negligible. In comparing the emissions by industry, household and the government of China, it is clear that industry plays a major role. By adding up the emissions by industries and households, the total emissions by China mount to 5268.66 Mt. A caveat about the emission data is needed. Since the database includes only emissions from burning fuels (i.e. stationary emission) and thus neglects activity emissions (e.g. fugitive emissions and emissions from bush fires), the actual emission amounts should be significantly higher.

The model used in this study is GTAPE. To facilitate the understanding of the modelling results, the authors provide a brief description of the model structure here. Each region in the model includes a government, a representative household and a number of industries. The consumption behaviours of governments and households are described by a constant distance of substitution function. The industries are assumed to minimise costs in a competitive environment and thus, with the exception of the margin sectors, they are making zero economic profit (i.e. making an average return in the economy). While ordinary intermediate inputs are combined with value-added through a Leontief (fixed proportion) function, energy inputs (coal, oil, gas, oil products and electricity) are combined through a constant elasticity of substitution (CES) function to form a energy bundle, which in turn combined through CES functions with capital and land and further with labour to form the value-added. This structure allows for the substitution among energy inputs and substitution between the energy bundle and the primary factors. The cost of emissions is calculated at the point of production or consumption. The emission prices are determined by market through the constraint of the emission quota.

As an Annex 2 country China has not set an emission reduction target as do annex-1 countries. Instead China has only set a target related to emission reduction: reducing the emission intensity by 17% by 2020. Without an emission reduction target, it is impossible to simulate the carbon price of an ETS. In this study, the authors use the likely carbon price suggested by the China carbon policy survey by [18]. According to this survey, the average carbon price expected by experts in China is 41RMB /tonne in 2016 and 53 RMB/tonne in 2018. Because the value in GTAPE database is denominated in US dollars, we converted this average carbon price to about US$ 7 per tonne.

Results Analysis: The changes of bilateral trade for selected regions are shown in Table 1. Although the changes are measured in million US$, the numbers in Table 1 show the changes in real values (the changes of trade volume) which exclude the trade value changes due to price changes.

As China is the source of the change in this study, we start with the results on bilateral trade between China and other countries. The second row indicates remarkable decreases in exports from China to all selected countries, notably, a decrease of US$ 434.87 million exports to EU, US$ 376.05 million to the Middle East, US$ 346.52 million to the US and US$ 234.13 million to Korea. Total Chinese exports decrease by US$ 3068.67 million. These large decreases in Chinese exports are expected. The carbon price leads to a high energy cost and thus causes cost-push inflation across the Chinese economy. The increased price of Chinese produce disadvantages the Chinese exports greatly. As a result, Chinese exports lose competitiveness and lead to a reduced market share.

The results on Chinese imports are mixed. As the second column shows, Chinese imports from Australia, Japan and Korea increase while imports from other countries decrease. The demand for imports may be affected by many factors. First, the substitution effect plays a significant role. The change of relative prices between imports and domestically-produced goods directly affects consumers' choice between imports and local produce. In the wake of the Chinese carbon price, Chinese goods become more expensive and imported goods become relatively cheaper, so imports demand will increase. Second, the income effect influences the aggregate imports demand. As shown in Figure 3, the carbon pricing will reduce Chinese GDP and household income. This will lead to a decrease in consumption and investment by Chinese government and household. As a result, the import demand decreases. Last, the import-export linkage may also play a significant role. There is a sizeable intra-industry trade in electronics and electrical goods, i.e. Chinese import components, assemble them in

Table 1: Changes in bilateral trade at the wake of US$7 ETS in China (US$ million)

Importer / Exporter	Australia	China	Japan	Korea	US	EU_25	Russia	Middle east	Africa	Rest of world	Total
Australia	0.00	329.14	-232.63	20.35	3.27	3.25	1.55	5.06	2.30	65.65	197.96
China	-65.32	0.00	-108.33	-234.13	-346.52	-434.87	-74.29	-376.05	-198.33	-1230.83	-3068.67
Japan	20.91	92.45	0.00	154.95	70.67	51.03	11.06	26.36	12.02	302.67	742.13
Korea	6.54	150.98	44.47	0.00	12.17	15.92	8.34	18.37	13.04	105.37	375.21
US	45.05	-81.09	145.11	59.27	0.00	400.95	13.70	61.07	36.04	864.36	1544.46
EU_25	88.23	-303.77	139.82	69.83	528.97	3521.27	162.27	224.72	185.99	814.27	5431.61
Russia	3.28	-225.46	25.99	16.59	46.49	179.27	0.00	46.99	4.58	158.13	255.85
Middle east	11.28	-1258.77	306.46	136.31	225.88	365.10	19.82	173.61	62.32	450.21	492.21
Africa	6.46	-694.76	67.86	29.43	264.23	296.04	3.35	67.31	119.16	182.07	341.15
Rest of world	82.34	-169.78	300.32	83.10	681.97	887.43	100.66	195.66	86.87	-1248.53	1000.03
Total	198.76	-2161.04	689.07	335.70	1487.14	5285.40	246.46	443.10	323.99	2745.09	9593.67

China and export them overseas. This intra-industry trade necessitates significant import-export linkage. As the Chinese exports decrease in the face of an ETS, there will be a head-on effect on imports. The numbers in the second column tend to indicate that the income effect and the import-export linkage play a dominant role for imports from most countries while the substitution effect plays a major role for imports from Australia, Japan and Korea. Since the total increase in imports from these three countries is much less than the decrease in imports from other countries, total Chinese imports decrease by US$ 2161.04 million.

Turning our intention away from China, we find that most bilateral trade between other countries shows positive changes. This is an apparent indication of trade diversion: as the volume of Chinese exports decreases, the trade volume for other countries increases. This trade diversion is achieved automatically through price mechanism: the decrease in Chinese exports will lead to an increase in world prices of the types of goods exported from China and thus stimulate other countries' supply of these tradeables. As a result, Chinese exports will be replaced, partially or in full, by exports from other countries. The modelling results show that a large part of trade is diverted to USA, EU, Middle East, Japan and Korea. This result is of no surprise given that they are China's top trading partners.

However, some countries experience decreases in bilateral trade, for example, the trade from Australia to Japan and the trade among countries in the 'rest of world' group. The decrease in Australian exports to Japan can be easily explained by the price effect. As China and Japan are the top importers for Australia, a substantial increase in Chinese importation of Australian goods will bid up the price of Australian exports. Under this circumstance, Japan would respond by importing less. The decrease in trade in the 'rest of world' group may be the results of trade linkage. Chinese exports may be used as components to produce exports in other countries, or Chinese exports may be re-exported by other countries to a third country in the 'rest of world' group. In this case, a decrease in Chinese exports can lead to decreases in both exports and imports of the 'rest of world' group.

In noting that a Chinese ETS causes trade diversions from China to other countries, an interesting question arises: can it lead to trade creation? A clear sign of trade creation is the increase in Chinese imports from Australia, Japan and Korea. The substitution effect results in households' switching their expenditure from domestic goods to imports. As a result, the high cost domestic produce due to the carbon price is partly replaced by the low cost imports. Trade creation may also happen in other countries. As total Chinese imports demand decreases considerably, the prices of these goods decrease. The lowered prices encourage more efficient and/or low cost produce and drive the high cost produce out of markets, so the low cost imports may replace high cost domestic produce in other countries. The overall effect of trade diversion and trade creation is indicated by the change in total world trade – an increase of US$ 9593.67 million. This means that, not only the decreases in Chinese exports and imports are diverted to other countries, but also a remarkable amount of trade is generated between other countries.

Last, it is of interest to consider the impact of the Chinese ETS on the balance of trade for each country. The last column shows the total exports from each country while the last row shows the total import into each country. The total exports minus the corresponding total imports give the trade balance of the country. The trade balance of China will worsen by US$ 907.62 million because China's exports decline much more than its imports. This is not surprising given the fact Chinese imports are affected by a number of offsetting factors, for

Table 2: The impact of a Chinese ETS on exportation of energy and resources

Country	Coal	Oil	Gas	Minerals	Oil products	Electricity
China	0.005	4.551	78.965	0.284	-1.04	-28.483
Hong Kong	9.296	-7.31	5.829	-1.192	-0.71	7.247
Japan	1.487	-0.2	0.978	-0.348	-0.126	3.549
Korea	0.641	-2.215	-2.467	-0.616	-0.074	4.158
Taiwan	1.847	-0.358	-1.588	-0.361	0.064	1.026
Other East Asia	18.859	-0.39	-2.243	-1.133	0.323	1.136
Cambodia	0.057	-1.131	0.707	0.142	-0.082	1.597
Indonesia	1.449	-0.743	0.187	-0.235	-0.079	1.107
Laos	1.596	-0.711	1.713	-0.696	-0.28	0.483
Malaysia	10.079	-0.209	0.536	-0.217	-0.103	0.93
Philippines	16.553	-0.857	0.676	-0.557	0.092	1.4
Singapore	0.822	0.016	0.798	0.079	0.117	2.791
Thailand	1.168	-1.627	-26.672	-0.362	0.017	1.313
Viet Nam	12.166	-0.378	1.5	-0.809	-0.55	0.324
Other Southeast Asia	0.642	-0.209	0.34	-0.872	-0.114	1.891
Bangladesh	0.19	-0.367	1.595	0.03	0.215	0.971
India	0.192	-0.388	-0.081	-0.868	0.131	0.797
Pakistan	0.175	-0.276	0.566	-0.83	0.171	1.212
Sri Lanka	0.058	-0.307	0.73	0.01	0.068	1.504
Other South Asia	0.421	-0.123	3.749	0.055	-0.027	0.412
Canada	0.414	-0.211	0.047	-0.135	0.014	0.333
US	0.19	-0.162	0.39	-0.076	0.049	0.682
Mexico	0.276	-0.142	0.529	-0.135	0.006	0.599
Other North America	1.122	-0.166	1.864	0.18	0.067	1.509
Chile	0.112	-0.108	3.316	-0.157	0.027	1.034
Peru	0.096	-1.191	0.247	-0.256	0.079	1.245
Other South America	0.137	-0.181	0.228	-0.373	0.031	0.53
Australia	0.52	-0.566	2.351	-0.548	-0.288	3.64
New Zealand	1.005	-0.018	2.772	-0.625	0.094	1.339
Other Oceania	0.458	-0.053	1.258	0.018	-0.053	1.214
EU_25	0.142	-0.179	0.08	-0.009	0.068	0.268
Russia	0.252	-0.239	0.45	-0.181	0.017	0.37
Middle East	0.579	-0.141	0.984	-0.134	0.104	0.847
Africa	0.235	-0.164	0.316	-0.121	0.112	0.595
Rest of world	0.149	-0.15	0.168	-0.119	0.031	0.4
Total world exports	0.972	-0.167	0.377	-0.253	0.008	-0.193
Total world supply	-4.895	-0.14	-0.035	-0.263	-0.155	-0.669
Total usage by China	-14.676	-2.226	-6.278	-2.215	-2.098	-5.397

Note: Results are shown as percentage changes

example, a decline in Chinese income will depress imports while an increase in prices of Chinese produce has a positive effect on imports. For the majority of other countries, the trade balance improves. Notably, the EU improves its balance of trade by US$146.20 million, the US by US$57.32 million, Japan by US$53.06 million, the Middle East by US$49.11million. The improvement in balance of trade for most countries is easy to comprehend in the light of the trade diversion. Because Chinese exports decrease more than its imports, the exports of the other countries must, by and large, increase more than their imports, so their trade balance should improve. However, Australia and the 'rest of world' are experiencing a deterioration of trade balance: US$0.80 million decrease for Australia and US$1745.06 million decrease for the 'rest of world'. As both total exports and total imports increase for each country except China, the deterioration of trade balance for Australia and the 'rest of world' must result from smaller increases in exports than in imports. Again, this may be explained by trade linkage: Australian and the countries in the 'rest of world' group may export substantially to China and/or import from China to make its exports, so the substantial decline in Chinese exports and imports has a negative impact on these countries' exports.

Table 2 displays the percentage change in exports induced by the ETS. Generally speaking, the exports demand is determined by the prices of exports and the income of households in foreign countries. In terms of China, since the change in foreign income due to the Chinese ETS is of secondary effect and thus fairly small, the exports demand is mainly determined by the exports prices of listed commodities. The prices of commodities are affected by a number of factors. On one hand, the cost of carbon pricing will increase the prices of emission-intensive goods. Similarly, the high energy cost due to carbon pricing will increase the prices of energy intensive goods. These factors tend o push up the prices of exports. On the other hand, the economic contraction in the face of the ETS will reduce the income for Chinese households. This will lead to reduced domestic demand and have a downward pressure on commodities. The dual effect of an economic contraction is the reduced demand for primary factors (labour, capital and land) and thus reduced factor prices. This will reduce the production cost and will also have a downward pressure on commodities. The changes in Chinese export prices depend on what factor is dominant. The emission cost is the dominant factor for electricity and oil products, so the prices of these goods will go up and the exports of these goods decrease. The large decrease in electricity exports (-28.483%) is consistent with a large increase in electricity prices. For other listed commodities, the decrease in demand plays an important role. This leads to lower prices and increased exports of these commodities. The tremendous increase (78.965%) in the exportation of Chinese gas is also related to two other factors. One is the substitution effect: the Chinese will export much of its gas of higher emission intensity but use more imported gas which has much lower emission intensity. This reasoning is consistent with the large increase in importation of gas discussed previously. The other is that the Chinese exportation of gas is fairly small – only US$ 1.23 million in base year. So the high percentage change only means about US$0.97 million in the volume of gas exports.

For most countries, the exports of electricity, oil and minerals change in the opposite direction to China while the exports of coal and gas tend to increase as Chinese exports increase. These trends are similar to that of changes in imports. As discussed earlier, these trends indicate that the price effect dominates in the international trade of oil, minerals and electricity while the import-export linkages affect the international trade of coal and gas more significantly. In terms of geographic region, most countries in Asia and Oceania will be affected significantly while other parts of the world, with the exception of Chile and Peru, will be impacted only very mildly. The large decrease in Thailand' exports of gas (-26.672%) is largely due to its extremely small base of exports – only US$0.025 million in the base year. Similarly, the considerable increase in exports of coal for Malaysia and Philippines is also due to its small export base (around US$ 1 million). The greater than 10% increase in exports of coal for 'Other East Asia' and Viet Nam is more related to those countries' trade linkage with China. The total exports of coal from the 'Other East Asia' countries are about US$312.55 million in the base year, of which US$ 271.18 million is exported to China. The export of coal from Viet Nam to China is about US$ 941.80 million, which is the bulk of its total exports of coal US$ 1428.25 million.

The overall effect of the Chinese ETS on the world exports market is shown in the last three rows in Table 3. The change in total world exports is quite similar to the change in total world imports in Table 2 as total imports must equal total world exports. The slight differences in numbers are due to the different values used for trade volumes calculation, i.e., the transportation cost and insurance fee are not included in the f.o.b price, which is used for exports, but are included in the t.i.f. price used for imports. For coal and oil, the total world exports increase as Chinese exports increase. In the case of oil, minerals and oil products, the price effect dominates so the changes in exports from China will have negative effects on exports from other countries. The price effect also dominates the exportation of electricity but the total world exports follow the same trend as China. This is because the large decrease in exports of Chinese electricity outweighs the increases in electricity exports in other countries. The row of total world supply shows the overall effect of the ETS on the supply and the consumption of energy and resources globally. While the global trade in some energy and resource goods increases, the world supply and consumption of all listed commodities decreases. The substantial decrease in world coal usage is expected given its high emission intensity. The significant decrease in electricity supply also correlates with the high emission cost of electricity generation. However, it is somewhat unexpected that the supply of minerals decreases more than other energy goods such as oil, gas and oil products. This may be due to the high energy cost of minerals production. The Chinese usage of all energy and resources decreases and the degree of decrease is much bigger than that of the total world supply. This is reasonable because the ETS is implemented in China and China has a much smaller energy and resource base than that of world supply. A larger impact on a smaller base will result in asignificantly higher percentage change.

CONCLUSIONS

The environmental and macroeconomic results show that the ETS is very effective in environmental protection but will have a mildly negative impact on the Chinese economy. The ETS will reduce China's carbon emission by 14.511% or 764.5 Mt, but the real GDP will also reduce by 0.142%. The electricity price will increase by 7.624%, but the CPI and GDP price indexes will increase only slightly. The bilateral trade results show that Chinese exports from all other countries will decrease substantially while Chinese imports also decrease with the exception of imports from Australia, Japan and Korea. The bilateral trade between most other countries increases but the trade volume decreases between Australia and Japan and among countries in the 'rest of world' group. The trade balance will improve for most countries except China, Australia and the 'rest of the world' group.

The impact of the ETS on international trade in energy and natural resources is significant. The changes in Chinese exports are considerable. For electricity, Chinese exports decrease by 28.483% while the imports decrease by 15.698%. This is apparently due to the substitution effect resulting from the hike on electricity price when the ETS is in place. Chinese exportation of oil products decrease thanks to their considerable and similar emission intensity for oil products produced in China and elsewhere. On the other hand, the exportation of both coal and gas increase in the face of the ETS. This is explained by the very high emission intensity of Chinese coal and gas and comparatively much lower emission intensity of coal and gas imported to China, i.e. the ETS will induce Chinese' firms to import less emission intensive coal and gas and, in the mean time, to export more emission intensive coal and gas produced in China. The exportation of both oil and minerals increases while their importation decreases. This is explained by the decreased Chinese domestic demand as the results of the economic contraction induced by the ETS. The impacts on other countries are mixed. For electricity, minerals, oil and oil products, most countries experience opposite movements as Chinese imports and exports change. For coal and gas, the changes of exports and imports for most countries follow the Chinese trend. Countries in Asia and China's major partners in energy resources trade, like Australia and Chile, will experience significant changes in international trade.

In considering the global effect, an ETS in China will increase the Chinese use of imported energy resources which have low emission intensity but, in the meantime, it will prompt China to export its highly emission-intensive energy resource. This will cause an increase in carbon emissions in other countries. This international trade effect means an ETS in one country or in a few countries is less effective because emissions can be exported to countries that do not have a carbon pricing policy. Thus, a global approach to reducing emissions is necessary.

REFERENCES

1. Wang, K., C. Wang and J. Chen, 2009. Analysis of the Economic Impact of Different Chinese Climate Policy Options Based on a CGE Model Incorporating Endogenous Technological Change, Energy Policy, 8: 2930-2940.
2. Wei, C., J. Ni and L. Du, 2011. Regional Allocation of Carbon Dioxide Abatement in China, China Economic Review.
3. Fan, Y., Q. Liang, Y. Wei and N. Okada, 2007. A Model for China's Energy Requirements and CO2 Emissions Analysis, Environmental Modeling and Software, 22: 378-393.
4. He, Y., S. Zhang, L. Yang, Y. Wang and J. Wang, 2010, Economic Analysis of Coal Price - Electricity Price Adjustment in China Based on the CGE Model, Energy Policy, 38: 6629-6637.
5. Liang, Q., Y. Fan and Y. Wei, 2007. Carbon Taxation Policy in China: How to Protect Energy- and Trade-Intensive sectors, Journal of Policy Modelling, 29: 311-333.
6. Zhang, Z., 1998a. Macro-Economic and Sectoral Effects of Carbon Taxes: A General Equilibrium Analysis for China, Economic Systems Research, 10(2): 135-159.
7. Zhang, Z., 1998b. Macroeconomic Effects of CO2 Emission Limits: A Computable General Equilibrium Analysis for China, Journal of Policy modeling, 20(2): 213-250.
8. Zhang, Z., 2000. Can China Afford to Commit Itself an Emissions Cap? An Economic and Political Analysis, Energy Economics, 22: 587-614.
9. Zhang, Z., 2010. The US Proposed Carbon Tariffs and China's Responses, Energy Policy, 38(5): 2168-2170.
10. Zhang, Z., 2011. Energy and Environmental Policy in China: Towards a Low Carbon Economy, Edward Elgar, Cheltenham, UK and Northampton, USA.
11. Cao, J., M. Ho and D. Jorgenson, 2009. The Local and Global Benefit of Green Tax Policies in China, Review of Environmental Economic and Policy, 3(2): 189-208.

12. Garbaccio, R., M. Ho and D. Jorgenson, 1999. Controlling Carbon Emissions in China, Environment and Development Economics, 4: 495-518.
13. Lofgren, H., R. Harris and S. Robinson, 2002. A Standard Computable General Equilibrium (CGE) Model in GAMS, International Food Policy Research Institute.
14. Zhou, S., M. Shi, N. Li and Y. Yuan, 2011. Impacts of Carbon tax Policy on CO2 Mitigation and economic growth in China, Advances in Climate Change Research, 2(3): 124-133.
15. Zhang, D., S. Rausch, V. Karplus and X. Zhang, 2012, Quantifying Regional Economic Impacts of CO2 Intensity Targets in China Report 230, MIT Joint Program on the Science and Policy of Global Change, http://hdl.handle.net/1721.1/73005.
16. ang, L., Q. Bao, Z. Zhang and S. Wang, 2013. Carbon-Based Border Tax Adjustments and China's International Trade: Analysis Based on a Dynamic Computable General Equilibrium Model. Crawford School Research Paper No. 1301. Available at SSRN: http://ssrn.com/abstract=2213057 or http://dx.doi.org/10.2139/ssrn.2213057.
17. Chi Y., Z. Guo, Y. Zheng and X. Zhang 2014. Scenarios Analysis of the Energies' Consumption and Carbon Emissions in China Based on a Dynamic CGE Model, Sustainability, 6(2): 487-512.
18. Jotzo, F., D. De Boer and H. Kater, 2013, China Carbon Pricing Survey 2013, http://ccep.anu.edu.au/data/2013/pdf/wpaper/CCEP 1305.pdf.