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Building a low carbon China through Coasean bargaining

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ABSTRACT

This study explores how an institutional innovation in the 20th Century – Coasean bargaining - could contribute to build a low carbon China in the 21st Century. China has surpassed all nations and become the world's largest emitter of CO_2 since 2007. A time-series analysis has revealed that crude oil and coal consumption, inter alia, are the primary factors contributing to the variations in CO_2 emissions in China. To honour China's commitments in the Paris Agreement 2015, this paper, with reference to the empirical results, estimates the impacts on various sources of energy consumption before 2030. Developed upon the Coasean bargaining framework (1960), the cap-and-trade (CAT) markets have contributed to reduce the pollutants and greenhouse gas emissions in the US and EU. This paper will illustrate how the CAT market can be complementary to administrative measures for CO_2 reduction in China. It will also discuss the institutional settings and constraints of the 7 pilot CAT markets in China, and also the national one to be rolled out in 2017.

1. Introduction

Climate change has adversely affected China; resulting in severe air and water pollution, heat waves, more frequent cyclones, droughts and excessive rainfall in different parts of China (Xinhua News Agency, 2008). The situation is exacerbated by excessive fossil-fuel burning and cement production. As a result, since 2007 China has surpassed other nations, and become the largest carbon emission country in the world (index mundi, 2016a).

Collective international efforts such as the Kyoto Protocol 1997 and the Copenhagen Accord 2009 had been sought to tackle the challenges of climate change. Nevertheless, China had not taken part in these treaties. The Paris Agreement 2015 has resulted in the first global binding treaty under which virtually all nations[1] on the planet commit to keep the world's temperature from rising 2°C at most above the pre-industrial levels. These nations also agree to take actions to keep the temperature from rising 1.5°C at most above the pre-industrial levels (United Nations, 2015). China has committed to shoulder her responsibility under the Paris Agreement and has submitted its *Intended Nationally Determined Contributions* (INDC) in June 2016. The salient commitment is, by 2030, to reduce carbon intensity per GDP by 60–65% of 2005 levels. What does it mean in term of the formulation of action plans to reduce the sources of carbon emissions? This paper will investigate the key determinants of carbon emissions in China through a time-series regression analysis. The results will facilitate a better understanding of the challenges to be addressed in the coming years.

It is generally believed that the most effective ways to achieve the reduction targets are through administrative directives and measures. However, the experiences of using the cap-and-trade (CAT) market in the US Acid Rain Programme and the European emission trading scheme (EU ETS) have demonstrated that market-based solutions can also form an integral part to reduce carbon emissions. The institutional design of the CAT market is based on Nobel Laureate economist Ronald Coase's ideas on bargaining (Coase, 1960). With a Coasean bargaining platform put in place in China, some of the administrative directives could be replaced by market mechanisms. Price signals would be enabled such that high value-added products would be manufactured to supersede those low value-added and environmentally unfriendly ones. This process may rectify the problem of unsustainable urbanization and economic growth in the past decades. This study will discuss the institutional factors that facilitate or limit the development of a Coasean bargaining platform for the environmental market in China, which could play its part in making the country a low carbon one in the 21st Century.

This paper first discusses the adverse effects of climate change across different parts of in China, and performs a time series analysis of the key determinants of carbon emissions in China as a whole. Then, it illustrates the Coasean bargaining framework that underlies the establishment of CAT markets. It goes on to discuss the development and operation of the 7 pilot CAT markets in China from 2013 onwards. The final section concludes the major findings and discusses the institutional challenges to be overcome for the setup of a national CAT market

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[1] Although the US announced on Jun 1, 2017 that the country will cease to take part in the Paris Agreement, the earliest effective date of the withdrawal will be on Nov 4, 2020.

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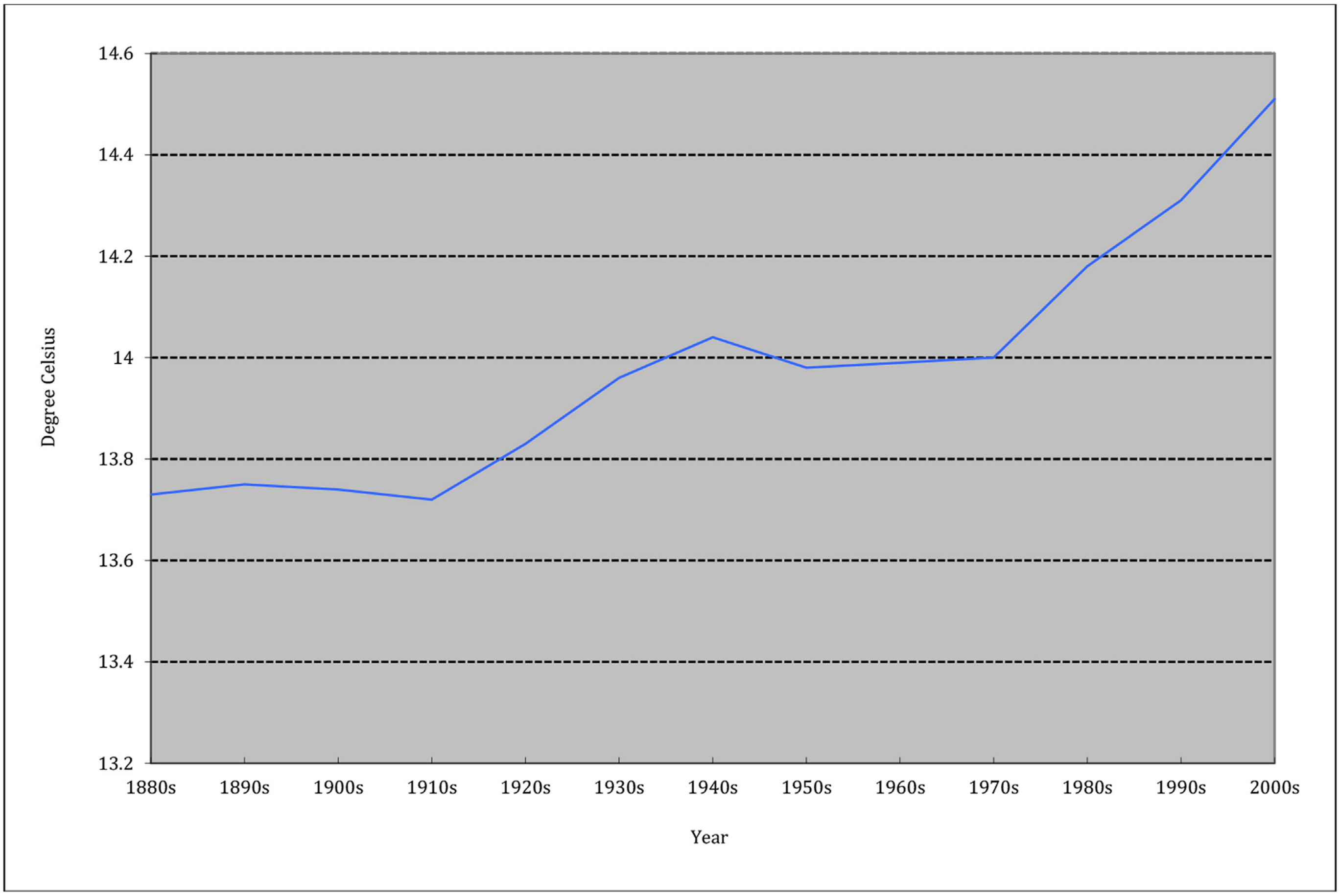

Fig. 1. Global temperatures (°C) from the 1880s through the 2000s. Source: Goddard Institute for Space Studies (2010).

in China.

2. Global warming and China

World meteorological observations reveal that the earth average temperature has been on the rise since the pre-industrialization era (see Fig. 1). Osborn (2016) claims that average global temperature from 2000 through 2009 was 0.61°C higher than those from 1951 through 1980. If this situation persists, global temperature is forecasted to rise by 2°C in the next century. With respect to temperature, the China situation has been quite similar to the world situation, with average temperature rising by nearly 1.1°C from 1908 through 2007. It is predicted that China will experience an average temperature rise of 3.5°C by the end of the year 2100 (Tracy, Trumbull, & Loh, 2006). Due to the country's huge territory and great geographical differences, the harmful impacts resulting from climate change are multiform for different parts of China, with hotter summers, excess rainfall, cyclones, thunderstorms, droughts in eastern coastal areas; snowstorms in central and southern China, dust storms in northern China (Xinhua News Agency, 2008). The China Meteorological Administration forecasted that tropical cyclones have become more devastating, due to sea surface temperature rise in coastal areas of Southeast China.

In eastern coastal areas of China, there will be increasing possibility of having droughts in the near future. According to the World Bank estimates, approximately 480 million people (40 percent of the total PRC population) are facing some sorts of water scarcity in China (New York Times, 2008). Advocated by the Intergovernmental Panel on Climate Change (IPCC, 2014), a general belief that human activities have contributed to climate change has been formed, although the idea is being challenged by the Nongovernmental International Panel on Climate Change (NIPCC, 2015). Regardless of their debates, China has to do something to deal with the worsening environment. The following section will present some startling facts about carbon emission in China since the 1960s.

3. Stylized facts about China's CO_2 emissions

China's carbon emissions increased from 780.7 Mt CO_2 in 1960 to 1.47 Gt CO_2 by 1980, and further expanded to 9 Gt CO_2 by 2011, the increases averaging at an annual rate of 4.9% over this period. Cumulative emissions amounted to 137 Gt CO_2 from 1960 through 2011 (index mundi, 2016a). Due to the huge amount of coal consumption together with cement production, China's carbon emissions escalated drastically during this period, making China the largest emitter in the world in 2006 (PBL Netherlands Environmental Assessment Agency, 2007). In 2012, they shockingly amounted to the emissions by the US and EU as a whole. Given the uninterrupted increase in carbon emissions, China realises it must take actions to reduce global CO_2 emissions by changing energy consumption patterns and modes of energy production.

Fig. 2 reveals that CO_2 emissions from all types of fuel consumption have been increasing throughout the past 52 years, with an exception of 1997 and 1998. In 2011, nearly 73.3% of carbon emissions came from solid fuel consumption (such as coal); 12.4% from liquid fuel consumption and 2.7% from gaseous fuel consumption and 11.6% from cement production. In 2011, China produced 3.5 billion tons of coal, composing almost 50% of the world's total. From 2010 through 2012, the volume of China's cement production was, shockingly, more than the US's total cement production for the 20th Century as a whole (Liu, 2015). The excessive use of coal, and cement production make China

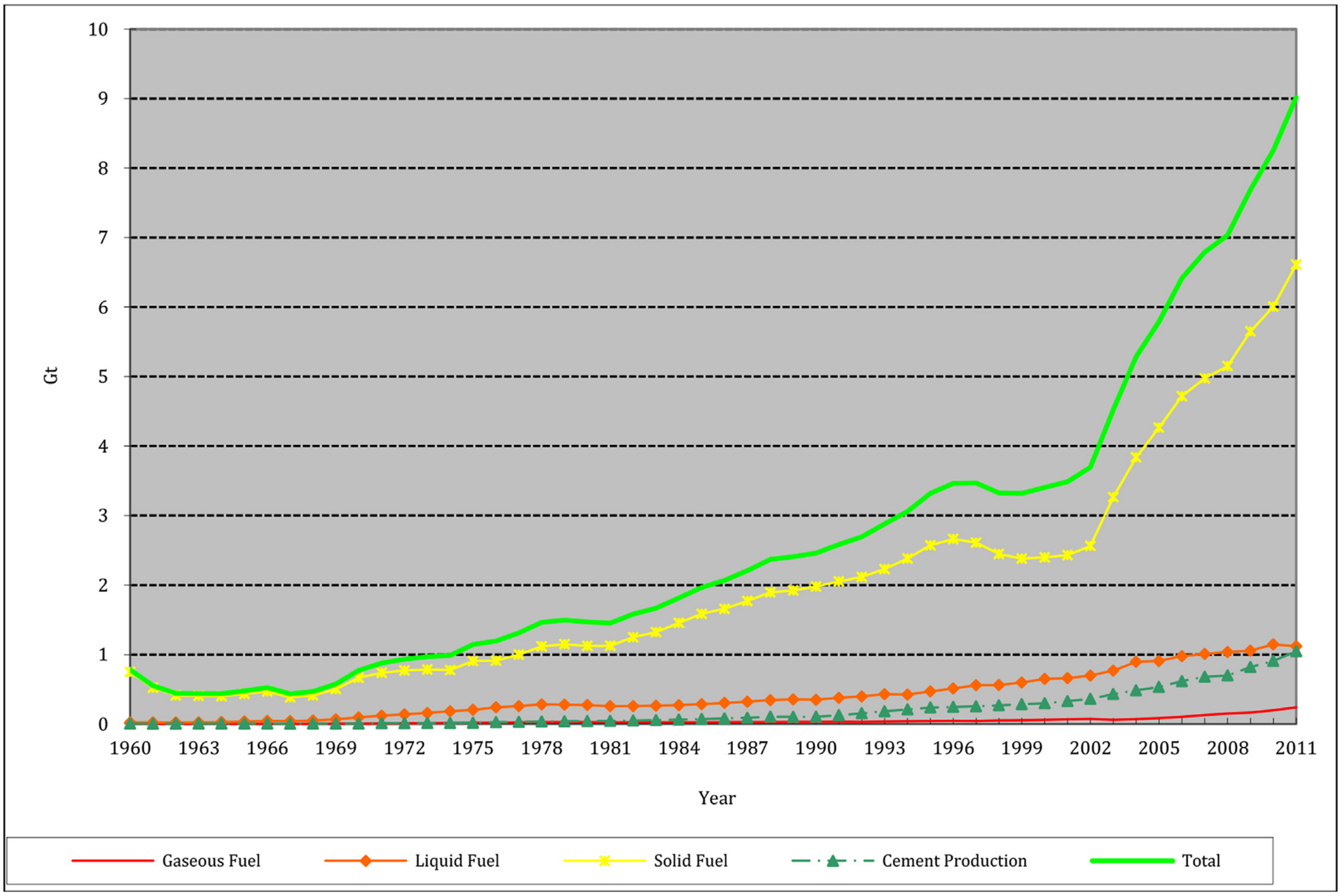

Fig. 2. China's CO_2 emissions by fuels (Gt) from 1960 through 2011. Source: index mundi (2016a).

become the most polluting nation in respect of carbon dioxide (see Fig. 3).

Since China is a country of huge territory, substantial geographical variations in carbon emissions is anticipated. Such differentials have been remarkable between the developed provinces and the underdeveloped provinces. Liu (2015) also reveals that 150 Chinese cities emitted 70% of China's carbon emissions, amounting to 6 Gt CO_2 in 2010. This emission level was even more than the total emissions in the US in the same year. There have been significant per-capita emission differentials among Chinese cities. In less developed cities, per-capita emissions are well below than those of modern cities, due to less urbanization there. As resource-based or manufacturing-based cities, such as Tangshan city, Suzhou city, Baotou city and Zibo City, per-capita carbon emissions consistently exceed 20 tons CO_2, which are well above that of a city average at a level of 7.5 tons CO_2 (Liu, 2015).

If we decompose the CO_2 emissions from total fuel combustion by industrial sectors in China, 32.96% come from the manufacturing and construction sectors, 51.94% from power generation, and 7.91% from the transportation sector, and 1.96% from other sectors in 2011. One distinguishing feature is that Chinese exports contribute to nearly one quarter of China's carbon emissions. Liu (2015) suggests that export-related emissions are eight times more than import-related emissions, resulting in unfavourable emissions trade balance.

As a rising power, China should certainly take its responsibility of reducing carbon emissions, for many reasons. First, it agreed to the Paris Climate Summit 2015, by joining together with other countries to reduce carbon emissions. Second, its carbon intensity ranked the highest in the world, with the exception of 1998–2002 (see Fig. 4). Third, climate change has also caused environmental problems in China, including poor air quality, more frequent cyclones and flooding. Fourth, China can also benefit from a reduction in carbon emissions, such as less drastic climate change, better air quality and new business opportunities (Bollen, Guay, Jamet, & Corfee-Morlot, 2009; Hallegatte & Corfee-Morlot, 2011; OECD, 2000).

4. How much CO_2 China needs to reduce?

Climate change causes environmental disaster to all nations of the world, requiring a global solution to solve it. In the Kyoto Protocol 1997, the European Community (EC) and 35 nations have reached an agreement to reduce greenhouse gas (GHG) emissions by 5% of the 1990 levels from 2008 through 2012. The target GHGs include, inter alias, CO_2 and nitrous oxide (N_2O). To comply with the agreement of the Copenhagen Accord 2009, 144 nations agreed to keep the temperature from rising 2°C at most by 2020. In 2009, the G8 countries (France, Germany, Italy, the UK, Japan, the US, Canada, and Russia) agreed to cut their greenhouse gas emissions by 80% by 2050 though they did not specify the baseline emissions level and year. Nevertheless, it was only until the Paris Agreement 2015 that China finally became a signatory of international treaties to combat with climate change.

In the Paris Climate Summit 2015, many countries compromised that they should try their best to achieve zero, or near-zero, carbon emissions by 2050 if they intend to reverse the trend of global warming. In this respect, 17 leading cities, including London, Sydney and Yokohama, have promised to switch to green energy generation and reduce energy consumption. The Paris Climate Agreement has resulted in the first binding treaty under which all nations will join to keep global temperature from rising 1.5°C-2°C at most from the pre-industrial levels.

China has become the world factory since the 21st century. China's

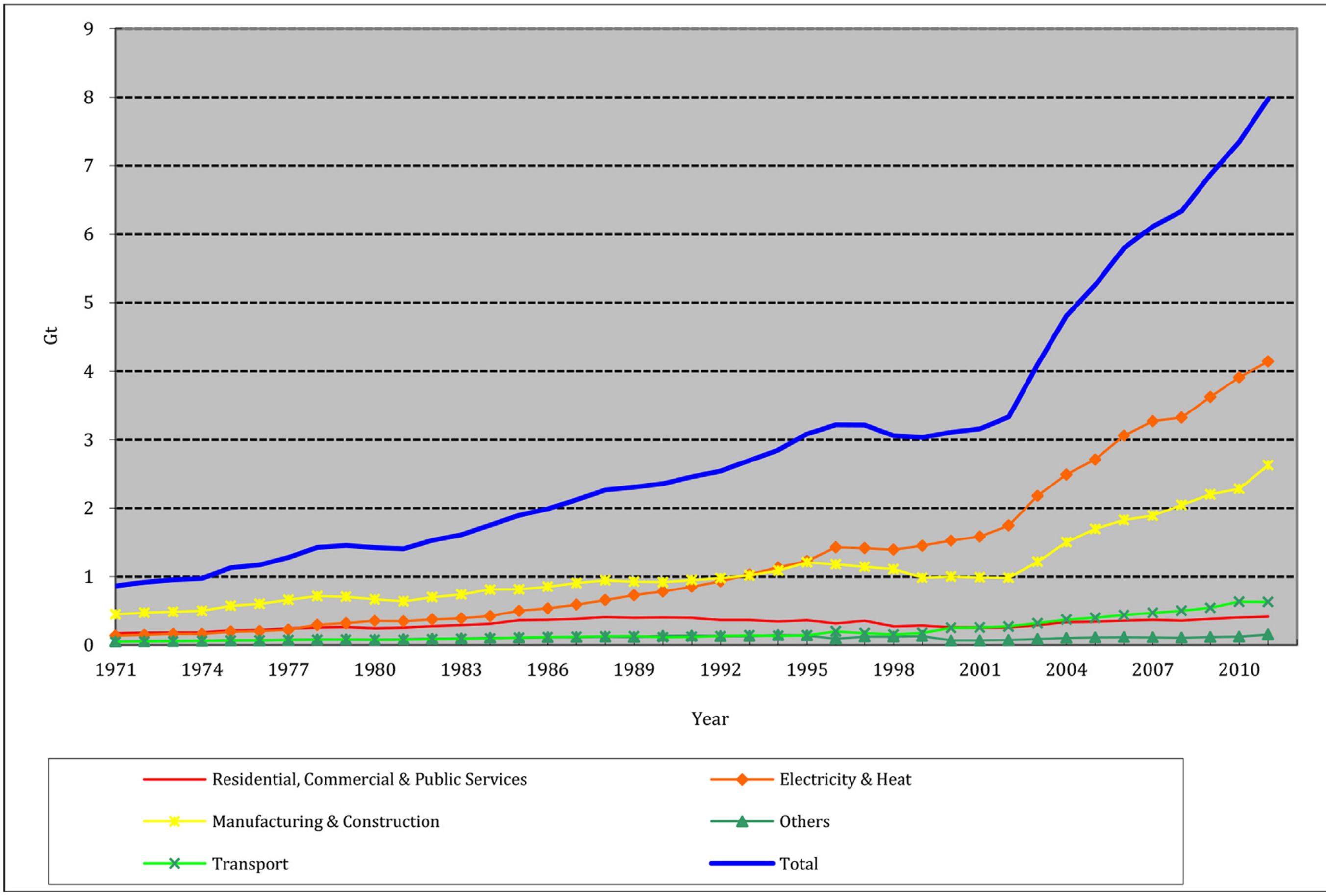

Fig. 3. Carbon emissions from total fuel combustion by sector (Gt) in China. Figures are compiled by the authors. Source: index mundi (2016a).

share of manufacturing output was about 6.9% of world total in 2000 while this figure has tripled to reach 22.4% in 2012 (Meckstroth, 2014). However, economic affluence is associated with severe air and water pollution, deforestation and many other environmental problems. Sandor, Kanakasabai, Marques, and Clark (2015) suggest that more than 0.4 million Chinese people die in early age because of respiratory illness, while yearly health care expenditure in respect of respiratory illness amounted to 3.87% of GDP. There are pressing needs to adopt mitigation policies to rectify the worsening situation (OECD, 2009). To honour the commitments to the Paris Agreement, China submitted an INDC in June 2016, which outlines the overarching mission to reduce carbon emission. To translate the mission into action plans, one should understand the key determinants of carbon emission in China first. A time-series analysis is thus called upon to reveal the past and current situations.

Using time-series regression techniques, Choy, Ho, and Mak (2013) found that a 1% increase of electricity consumption in Hong Kong would trigger a 1.17% increase of carbon emission in Hong Kong. Following their methodology, we have estimated a model of CO_2 emissions for China as a whole from 1987 through 2011. Specifically, the amount of CO_2 (kilotonnes) emitted is a function of coal consumption (measured in millions of short tons), crude oil consumption (in 1000 barrels), kerosene consumption (in 1000 barrels), distillate fuel oil (DFO) consumption (in 1000 barrels), LPG consumption(in 1000 barrels) and cement production (in 10,000 metric tons). Taking a double-log form of the estimated equation, this study utilizes a total of 25 yearly observations. Yearly data are obtained from the index mundi, a website that retrieves facts and statistics from multiple sources, and presents them in a systematic format.

Table 1 reveals that coal consumption and crude oil consumption are the primary determinants of the variations in CO_2 emissions in China. For the former, it suggests that a 1% decline in coal consumption causes CO_2 emissions to decline by 0.3% during the period between 1987 and 2011. For the latter, it suggests that a 1% decline in crude oil consumption causes CO_2 emissions to decline by 1.29% for the same period. The relatively small response coefficients for other input variables suggest that kerosene, distillate fuel oil and LPG consumption have a significant but modest (negative) impact on CO_2 emissions in China. This means that if consumption of these three fuels increased, CO_2 emissions would decline by a small margin. The variable CEMENT has been estimated to be highly significant, bearing a positive effect. If cement production were to be decreased by 1%, CO_2 emissions would decrease by 0.1% only. Furthermore, the amount of CO_2 emitted in time *t* also depends on the amount emitted in time *t-1*, as demonstrated by the estimate for *AR*(1).

A hypothetical case is presented here to illustrate how the empirical findings can be used to formulate action plans. Suppose China had signed the Kyoto Protocol that aimed to reduce the emissions by 5% of 1990 level from the 2011 level. This means that China must reduce roughly 74.08% of the emissions (6.7 Gt CO_2). That is to say, China must reduce crude oil consumption by 57.54%, all other things being constant. Alternatively, China could reduce their crude oil and coal consumption, and increase distillate fuel oil and LPG consumption, all other things being constant. Particularly, the Council for Sustainable Development (2011) assumes that a tree can absorb 23 kg of CO_2 throughout its life cycle. This means that a total of 290.51 billion trees would need to be planted in order to reach the target. Assuming each tree crown occupies 1 m^2 of footage, it would mean that one-quarter of the whole area of China, irrespective of cities, highways, hilly areas and deserts, etc., would have to find a way to plant trees, something which

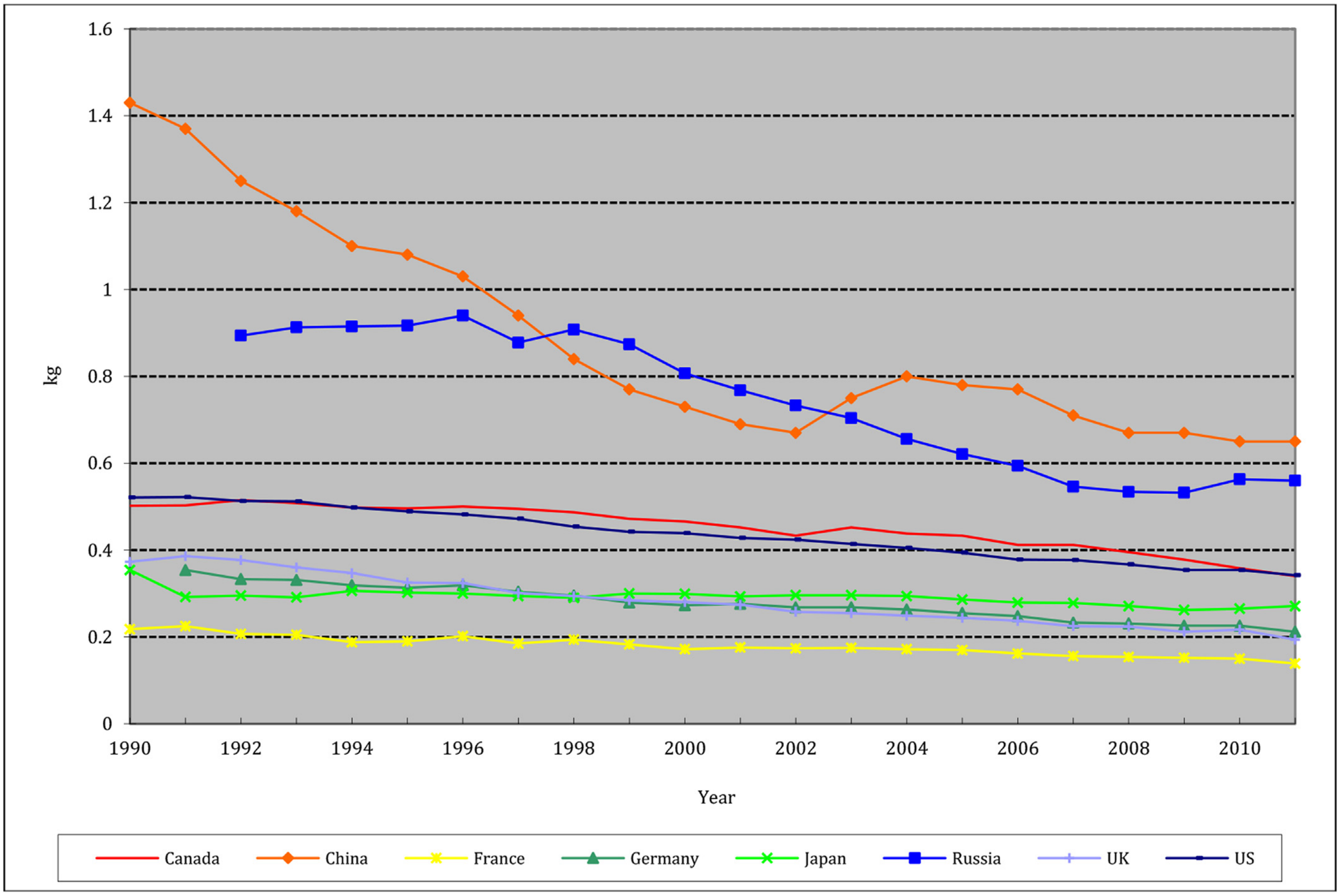

Fig. 4. Carbon intensity by country (CO_2 emissions kg per 2011 PPP $ of GDP) from 1990 through 2011. Source: index mundi (2016b).

Table 1
Estimated coefficients.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	−0.535380	1.014691	−0.527628	0.6050
ln(COAL)	0.296597	0.086596	3.425081	0.0035
ln(CO)	1.287463	0.264304	4.871138	0.0002
ln(KEROSENE)	−0.092894	0.014832	−6.263010	0.0000
ln(DFO)	−0.442843	0.091311	−4.849827	0.0002
ln(LPG)	−0.114736	0.041572	−2.759899	0.0139
ln(CEMENT)	0.095662	0.036681	2.607970	0.0190
AR(1)	−0.563897	0.219490	−2.569131	0.0206
R^2	0.997737	Akaike info criterion		−4.341093
Adjusted R^2	0.996746	Schwarz criterion		−3.948408
Log likelihood	60.09312	Hannan-Quinn criter.		−4.236914
F-statistic	1007.560	Durbin-Watson stat		2.298457
Prob(F-statistic)	0.000000			

Notes: The variable LPG and Cement are statistically significant at 5% confidence level while the rest of variables are statistically significant at 1% confidence level. AR(1) is statistically significant at 5% confidence level.

is technically impossible.

Further, it is far trickier to work out the actual impacts as a result of fulfilling China's INDC under the Paris Agreement. China has set its goal to reduce 60–65% of carbon intensity per GDP in 2030 from the 2005 level. That means CO_2 emissions must decrease to 0.89–1.02 kg per GDP (kg per 2005 US$ of GDP) by 2030. The Organization for Economic Co-operation and Development (OECD) forecasts that China's GDP in 2030 will reach USD26.3 trillion. It follows that the total carbon emissions in China could in fact increase by 37.3 Gt (c.f. 57 Gt if China had not signed the Paris Agreement) before 2030, as opposed to the general perception that it would decrease. In terms of annual growth, increases in CO_2 are assumed as 11% pa. While keeping a 7% pa. GDP growth by 2030 (OECD, 2008).

Irrespective of how one interprets the empirical results, China will need to try to reduce carbon emission intensity in order to achieve the goals stipulated in the INDC, while maintaining economic growth. Conventional wisdom assumes that the most effective ways to reduce carbon emission is through administrative directives and measures. This assumption is challenged by Coase's (1960) seminal paper on social cost, in that market-based solutions can also resolve problems of externalities. The following section will discuss the Coasean bargaining framework, and the institutional innovation arising from this framework to tackle climate change – using CAT.

5. Coasean bargaining framework and the CAT market

Neoclassical economics believes that externalities have originated from a market failure in which private costs are not equivalent to social costs, thus failing to produce an efficient outcome for the society as a whole. This school of thought urges the government to intervene in the matter, with a view to eliminating the effects of externalities. Particularly, Pigou (1920) recommends that governments penalize the polluter by imposing an amount of tax that is equivalent to the cost of harm to affected parties. By the same token, the government should subsidize an individual with an amount equivalent to the benefit that affected parties can obtain from his act.

However, this proposition does not go unchallenged. The justification of economic intervention established on welfare analysis was questioned by Rothbard (1956) which highlights when people participate in an exchange, their preferences can be revealed and involved parties would be better off when compared to not doing an exchange.

Since Pigou's solution involves imposing taxes and providing subsidies by the government, people's preferences are not revealed and the values of harm and benefit are only obtained through a rough guess.

Pigou's idea has been severely challenged by Coase (1960). Coase (1959, 1960) was the first one to propose the course of actions to eliminate the inefficiencies associated with externalities through bargaining among affected parties. A prerequisite of such a bargaining process is a clear delineation of property rights (Coase, 1959). In his seminal paper on social costs, Coase (1960) demonstrates that when transaction costs of bargaining, contracting, monitoring etc. are zero, mutual benefits could be obtained for the polluting parties to pay the polluted parties for the pollution if the latter possess the right of clean air. It is equally true in the opposite scenario, for the polluted parties to pay the polluting not to pollute if the latter possess the right of pollution. Although the second scenario sounds awkward at first glance, it underpins the wide acceptance of the Coase Theorem, which states that resources allocation will be optimal if transaction costs are zero or negligible, and private property rights are well defined, irrespective to whom the rights are assigned. In the absence of government interventions such as imposing the Piguovian tax etc., this market-based voluntary Coasean bargaining process can ensure efficiency. In a world of positive transaction costs, the main crux to the success of Coasean bargaining is to keep the transaction costs low.

In fact the second scenario also helps in explaining the mechanism of CAT. Regardless of a mandatory or voluntary scheme, a CAT market starts by capping the emission levels of the participating parties. The parties also agree to reduce the emission levels gradually, according to a pre-defined schedule. It is essentially a process of defining the property rights to the participants. High output participants who fall short of emission rights could buy the unspent quota from the low output participants. The Coasean bargaining process actually takes place in the CAT market, which endeavours to keep the transaction costs low by standardizing the contracts, providing an efficient trading system and lowering the dispute resolution costs etc. The whole mechanism is to ensure that the marginal emission quota will go to the highest value users. Prices of the quota are entirely market determined. When the market price of a commodity that produces pollutants or GHG during the manufacturing process goes up, the manufacturer will bid for the emission quota in the CAT market. Manufacturers of lower market value products might as well sell their quota to their higher value-added counterparts. As Coase explains the *Sturges v. Bridgman* judgement in the social cost (Coase, 1960) paper, the Coasean bargaining process would ensure the higher value user, either the doctor or the confectioner, to use the premises irrespective to whom the property right was assigned. The CAT market also facilitates efficient use of the emission quota, as it enables the consumption by the highest value users at the margin. A market-based solution, in this sense, is far more efficient than administrative solutions, such as taxation and subsidies etc. Theoretically speaking, the ones who value the environment more can outbid the manufacturers, to obtain the emission quota. This is in line with the second scenario in the Coase (1960) paper aforementioned.

Early implementation of CAT to reduce pollution includes the Acid Rain Program, which dealt with emissions of pollutants in the US. Innovative mitigation to reduce global pollution has been established on the internalization of externalities within the international context. The CAT markets have already operated in many countries and economic organizations to deal with GHG emissions, such as Canada (Alberta), Australia (New South Wales), EU, Japan (Tokyo), New Zealand, Norway, Switzerland, the United Kingdom and the USA. In addition, there are some other regional emission trading systems, such as the Western Climate Initiative (WCI), which covers some states and provinces in the USA, Canada and Mexico. Sandor et al. (2015) has outlined the generic operations of a CAT market.

According to Sandor et al. (2015), the Acid Rain Programme resulted in a 67% reduction of SO_2. It saved USD 170–430 billion and 20,000 to 50,000 lives in 2010. As the operation costs were minor, thus it brought about a net benefit of USD 167–427 billion. The EU ETS is also a successful story. Sandor et al. (2015) finds that EU27 countries managed to achieve an emission target cut of 17% while keeping a 4% of GDP growth. It far exceeded the 8% target set by the Kyoto Protocol.

The Coasean bargaining framework can also be adapted to encourage the use of renewable energy. Renewable energy certificates (RECs) are new products in the US, Europe and Australia which intend to boost the renewable energy market (solar, wind, water and alike) through the process of carbon offsets. Participants under the voluntary schemes commit to raise the proportion of renewable energy in their power consumption portfolios, and, by doing so, they could offset their carbon liabilities. Participants need not consume more renewable energy in reality, but could buy RECs from others who have produced renewable energy in surplus, or reduced carbon emissions more than their commitments. The market prices of RECs are entirely market driven. Higher prices of RECs in turn can boost the production of renewable energy and alleviate the pressure of getting government subsidies by the manufacturers.

6. Development of CAT markets in China

In the 11th Five-year Plan (2006–2010), the PRC government announced a series of policy initiatives to cut greenhouse gas emissions by reducing energy intensity by 20%, and increasing the use of renewable energy in the energy mix from 6% to 10% by 2020. In the 12th Five-year Plan (2011–2015), the PRC government announced its determination to establish the national CAT market by 2015, with targets of reducing energy intensity by 16% below the 2010 level, and by increasing forest area by 12.5 ha. As a pilot test, the National Development and Reform Commission would first initiate a carbon trade market in selected cities and provinces.

With respect to the Chinese context, CAT markets of crude oil and coal have the biggest potential to be set up. Based on our estimates, a reduction in their consumption can reduce CO_2 emissions significantly. Due to severe pollution and global warming, there is an urgent need for China to reduce its energy consumption, especially for crude oil and coal. Moreover, these two commodities have a long history of spot and future markets, specifying detailed information about quality, prices and date of delivery in the contracts.

From the very beginning, China has launched seven pilot CAT markets to test the water. The first pilot market operated in Shenzhen in June 2013. Surprisingly, Shenzhen is a part of Guangdong but the operation of its pilot market is via Guangdong ETS and the China Emissions Exchange. While Shenzhen does not impose absolute reductions on companies, the pilot market plans to reduce its carbon intensity by 32% of the 2010 level, over the period between 2015 and 2017. Furthermore, this pilot market restricts its absolute emissions growth to less than 10% on an annual basis, with 2013 being the baseline.

Outside of these pilot markets, Guangdong has started its trading in the China Emissions Exchange since December 2013. With a cap of total emission cap at 388 Mt, it is the largest emissions trading system (ETS) in China. One special feature of the Guangdong market is that it tests the water by requesting companies to acquire a certain portion of their permits via auctions. The sum of revenue which amounted to at least US $101 million each year, can finance the operation of the market (Song & Lei, 2014). Since 16 December 2013, ten contracts have been auctioned, with a transaction volume of 14.25 million Guangdong Emissions Allowances (GDEA), and revenue of 0.12 billion US dollars. For the first three and a half months of 2015, there was only one auction involving 422,461 Guangdong Emission Allowances (GDEA) at total consideration of US$2,386,905 being held. For the same period, 244,518 tons of GDEA were transacted in the aftermarket, involving US $718,883 (Partnership for Market Readiness, 2015, pp. 1–8).

The Beijing carbon trading market was launched since November 2013. It is the only pilot market which imposes yearly absolute emission reduction restrictions on the industrial and services sectors. The annual allowances to the companies under this scheme gradually reduce from 98% of their 2009–2012 averages in 2013 to 94% in 2015 (Song & Lei, 2014). For the first three and a half months of 2015, Beijing traded 966,627 tons, involving a total consideration of US$6.9 million (Partnership for Market Readiness, 2015, pp. 1–8). Notwithstanding power generating and heating plants are not required to join the ETS in the first place, Beijing completely banned coal consumption but use natural gas to generate electricity in early 2017.

In Tianjin, the carbon trading market has been launched since 26 December 2013. Although individual investors, such as financial institutions, are not covered in the ETS, they are permitted to trade in carbon trading market, resulting in wider price volatility. As at 15 April 2015, the market traded 1,089,620 tons, involving a total consideration of US$3.7 million. For the first three and a half months of 2015, the transaction volume was about 16,180 tons, involving revenue of US$65 thousand dollars. The average price was about US$4.02 per ton (Partnership for Market Readiness, 2015, pp. 1–8). Surprisingly, there were no over-the-counter transactions although they are permitted.

In Shanghai, the carbon trading market has been launched since November 2013. It is the only pilot market that requests airline companies to apply for emissions permits for their domestic commercial flights (Capacity Building for the Establishment of Emissions Trading Schemes in China, 2016). Shanghai's pilot market also periodically examines its participating members' energy saving efforts, granting extra carbon dioxide allowances to any companies with energy saving actions taken from 2006 through 2011. The average price was about US $4.85 per ton (Partnership for Market Readiness, 2015, pp. 1–8). One distinguished feature of the Shanghai market is that its allowances are transacted exclusively online.

When compared to the above five pilot markets, the Hubei and Chongqing pilot markets were launched later. Hubei commenced its carbon trading market since May 2015. Daily transactions amounted to 20,000 tons at prices ranging from US$3.57 to 4.29 per ton. Cumulated volume of transaction amounted to 1.92 Mt as at 15 April 2015, involving total revenue of US$7.6 million dollars. The Chongqing Carbon Market was launched since June 2014, however, its first transaction did not taken place until 17 March 2015. On that day, the total transaction volume amounted to 155,000 tons, of which 6.61% from Chongqing Emission Allowances Phase 1 (CQEA-1) at a total consideration of US $39,650, and 93.54% from CQEA-1 at a total consideration of US $717,686 (Partnership for Market Readiness, 2015, pp. 1–8).

Based on these experiences from the pilot markets, China has its goal to build a national carbon trading market finally in 2017, which is 2 years later than the original plan stated in the 12th Five-year Plan. However, the difficulty of integrating these seven pilot markets into a national one and developing a carbon trading market in each of the non-pilot regions is almost beyond comprehension. Due to great variations in political, cultural and economic conditions, each provincial or city market is unique so that the design of the market is so different. To make progress in establishing the market, the State Council Carbon Trading Regulatory Authority is responsible to set up the cap and allocation mechanism, to design the emissions measurement, to report, and to verify guidelines, etc (Partnership for Market Readiness, 2015, pp. 1–8). Furthermore, as China has a huge territory, there is a need to have provincial-level governmental departments to perform all carbon trading related activities within their jurisdictions, and to coordinate the activities among different provincial and the national markets.

7. Conclusions

Environmental disasters associated with climate change have become the most challenging problem for the globe in the new millennium (IPCC, 2014). Adger, Huq, Brown, Conway, and Hulme (2003) claim that the extent of impact on different countries is not the same, and some nations would be more adversely affected by global warming when compared to others. Nonetheless, it is of vital importance for all nations to jointly mitigate carbon emissions, adopt a more earth-friendly lifestyle and switch to renewable energy, in order to tackle global warming (Pizarro, 2009; de Oliveira, 2009).

The CAT market is considered as a promising way to reduce emissions. Its principle is established on Coasean bargaining (Coase, 1960) and a Theorem of Exchange. The beauty of the Coase Theorem (1960) lies in the confidence that the most efficient solution to overcome the problems of externalities is a bargaining process among relevant parties, when the transaction costs are zero or negligible. Without any supranational environmental protection authority, the Coasian bargaining approach is especially amazing for tackling international externalities (Bauler, 2015).

To reduce carbon emissions, since 2003 China has operated seven pilot CAT markets in Shenzhen, Guangdong, Beijing, Tianjin, Shanghai, Hubei and Chongqing. Based on these experiences from the pilot markets, China has its goal to build a national CAT market finally by 2017. Due to great variations in political, cultural and economic conditions, each provincial or city market is unique so that the design of the market is so different. Hence, the difficulty of integrating these seven pilot markets into a national one and developing a CAT market in each of the non-pilot regions are almost beyond comprehension.

As the largest CO_2 emitter in the world, China must shoulder its responsibility for reducing carbon emissions. Additionally, the situation is that global warming has also adverse impacts on different parts of China, such as droughts, more frequent cyclones and flooding. If China has the determination to achieve its targets in accord with the Kyoto Protocol 1997 by reducing the emission level by 5% of the 1990 level from the 2011 level, it must reduce roughly 74.08% of the emissions (6.7 Gt CO_2). That is to say, China must reduce its fuel consumption significantly to keep its promise. Without doubt, it would also be helpful to reduce CO_2 emissions if China could use more LPG and distillate fuel oil to generate power and heat. It is also desirable for China to consume more renewable energy, including as wind, solar and hydroelectric power.

Nevertheless, the development of CAT markets in China is not free of problems. With reference to experience from other countries, such as the Acid Rain Programme and EU ETS, the major problems that China may need to overcome include, i) allocation of quota at the outset, ii) oversupply of quota, iii) uncertainty of future quota, iv) conflicts with other programmes and administrative directives, and v) future status of the programme. Because of these reasons, the prices of carbon per ton fluctuated dramatically in both the Acid Rain Programme (USD 0 to 1200 per ton) and EU ETS (Euro 0 to 30 per ton). In the case of the EU ETS, about 98% of transactions were carried out in the option and future markets, and only 2% was in the spot market, indicating that the majority of trading was for hedging and speculative activities. Nevertheless, the noticeable thin spot market may indicate that the CAT markets have attracted massive attention outside of the manufacturing sector, which is helpful to the future development of the programmes. It also suggests that the development of the national CAT market in China should put more emphases on, inter alia, robust and credible legal, court and dispute resolution systems to cope with the potential challenges of the option and future markets.

This paper has attempted to explain and document how an institutional innovation in the 20th Century – Coasean bargaining - could contribute to build a low carbon China in the 21st Century. The full-blown operation of the national CAT market starting from 2017 in China will shed light on other potential markets in the Asian regions. Perhaps a continental or even global scale of Coasean bargaining platform will bring about more benefits to humankind and the environment, which, in turn, will require more institutional innovations and experiments in the years to come.

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