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Including Aviation in the European Union Emissions Trading Scheme: Impacts on Industries, Macro-economy and Emissions in China

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Abstract

In October 2008, European Union (EU) announced that it would include the international aviation in the European emission trading system (EU ETS). This paper builds a static computable general equilibrium (CGE) model based on the 2007 input-output table, and estimates the impacts from this policy on China's macro-economic, residents' welfare, aviation industry, and carbon dioxide (CO2) emissions. Our results indicate that the implication of this policy has negative effects on China's economy and residents' welfare; nevertheless, it also reduces the outputs of industries especially that in aviation industry.

Keywords: CGE, EU ETS, aviation industry

1. Introducation

1.1 Background

In recent years, the aviation industry keeps growing fast with the average annual growth rate of 5% and stimulates the economic growth. However, the international aviation is also responsible for about 2%-3% of anthropogenic greenhouse gas emissions (Wang, 2010). With the increasing of the air transportation's greenhouse gas emission, its accumulated contribution to climate change becomes larger over time. In order to cap CO2 emissions of the aviation sectors, the European Commission, the European Parliament and the European Council decided to include international aviation in the existing European Union's CO2 Emissions Trading Scheme (EU ETS) in December 2008. According to this policy, more than 2000 airlines whose flights will land at or depart from any airport in the EU should be included in the EU ETS since 2012, including Air China, China Eastern, China Southern and other 33 airline carriers from Mainland China.

This policy causes controversies globally. Different interest groups exhibite different attitudes over it (Guo, 2010). The first group, including Thai and Korean airline carriers, welcomes the policy, and is ready to join the EU ETS. The second group is somehow supportive, including Brazil and Middle Eastern airline carriers, believing they would benefit from the EU ETS in the long term because of their advantages in developing new bio-fuel. However, the third group, including airline carriers from China, United States, and many other countries, protests that the policy is not fair and has potential negative impacts on their aviation industries (Malina *et al*, 2012). It is widely believed by those in the third group that European Union (EU) charges for "carbon fee" unilaterally are a violation of the "Chicago Convention" and the "Kyoto Protocol". Some even declair that such a policy will not only violate other countries' airspace sovereignty thereby against international law, but also increase the cost of the international aviation unnecessarily.

China Air Transport Association (CATA) has insisted its attitude of opposition since EU announced the implementation of this policy. The CATA united more than 20 foreign airline carriers to co-publish the "Beijing Joint Statement". In this statement, the CATA officially expressed its strong opposition to the policy, and called upon other countries to oppose the policy. This statement also manifests that the policy forces the developing and developed countries bear the same responsibility for emissions reductions, which violate the the prevailing principle of "common but differentiated responsibility".

1.2 Literature Review

This controversy also draws many attentions from Economics and policy research communities. Qin and Chen

(2011) roughly describe the operational mechanism of EU ETS and the policy that including the aviation industry into the EU ETS in details. Guo (2010) briefly introduces the existing controversy, and qualitatively discusses the potential impacts after the implementation of this policy. Until now, the existing literatures largely focus on introducing the policy and related controversies, and their endeavors to provide some policy suggestions on dealing with the climate change, energy consumption, emissions reduction, or better policy design of a "fair" emissions trading scheme (Gao, 2007; Gong, 2010; Li, 2010; Zheng & Song, 2010; Li, 2010).

However, there are many other studies, which try to quantify the policy's impacts on macroeconomic and industries. Vespermann and Wald (2010) employ a simulation model to quantify both economical and ecological impacts from the inclusion of aviation industry to the EU ETS system, and find that the ecologic effect is based on the design of the system and the emission reduction is comparably low. Anger (2010) applies a dynamic model called Energy–Environment–Economy Model, and find that adding air transport to the EU ETS has no impact on economic growth in the EU, but by contrast can decrease the CO2 emissions by 7.4%. Andrew and Zhang (2011) investigate the effects of unilateral measures, such as the EU-ETS system, on airline competition and global emissions with a cost-benefit method, and conclude that the unilateral regulation will actually increase the amount of global greenhouse gas emissions in the long term. Taking the Lufthansa and Continental Airlines as examples, Scheelhaase *et al*. (2010) indicate the effects on competition between European and non-European aircraft operators, and believe that the policy is good for the non-EU airlines in terms of the competitiveness. Albers *et al.* (2009) analyze the impact of the policy on the cost of different routes and people's needs, and then give the result that the policy will cause a small increase in the cost, but it is not enough to affect the structure of the aviation industry. Using a tourism arrivals model, Pentelow and Scott (2011) examine the implications of the proposed climate policies for the world's most tourism dependent region—the Caribbean, and find that there will be no meaningful impact on arrival numbers to the Caribbean under the current policy, but will have a great decrease if the policy become more stringent.

In summary, few existing qualitative studies can quantify the impacts of this policy to China, although some try to quantify the influences of the policy on European countries rather than China. In fact, the quantification of the impacts is crucially important for understanding China's further policy-making. Therefore, we aim to investigate the impacts of the policy on China's macro economy, the aviation industry (and of course other industries), and the CO2 emissions reduction.

2. Method

In a Computable General Equilibrium (CGE) model, sets of equations are used to describe supply, demand and market relations in an economy under a series of constraints. The CGE model, originating from Walrasian general equilibrium theory, is commonly used nowadays. To assess the impacts of the policy including China's aviation industry into the EU ETS system, we employ a simple static multi-region CGE model, including producers, consumers, government and abroad sectors.

2.1 Production and Trade Module

The model assumes that there are only two production factors: labor and capital. The factors can mobile within each region; product and factor markets are full competition structures so that their returns to scale are constant. The Leontief input-output matrix is applied to describe intermediate demands; the Cobb-Douglas (CD) function is used to define the production.

$$X_i = A_i L_i^{al_i} K_i^{1-al_i} \tag{1}$$

$$INT_{ij} = a_{ij} X_j \tag{2}$$

where X_i denotes the output in sector i; A_i stands for efficiency parameters; al_i represents the elasticity of substitution between the labor and the capital in sector i; INT_{ij} means the intermediate input of commodity j in sector i; a_{ij} indicates input-output coefficient; X_j means the output in sector j.

As for the import, the Armington assumption is adopted in the paper, i.e., we assume that there exists imperfect substitutability between imports and domestic products sold domestically, and that consumers choose commodities between domestic and foreign products in order to maximize their utility. As for export, this model uses a constant elasticity transformation (CET) function to allocate total domestic products between exports and domestic sales to maximize the producers' interests.

2.2 Price Module

We define the international market prices of the imported and the exported goods as exogenous variables in the CGE model. The price functions are as follows:

$$PM_i = \overline{PWM_i} \times (1 + tm_i) \times ER \tag{3}$$

$$PE_i = \frac{\overline{PWE_i} \times (1 + te_i) \times ER}{tar + 1} \tag{4}$$

Eq.(3) indicates that the price of imported goods, where PM_i is determined by the international price of imported goods $\overline{PWM_i}$, market rate of exchange ER and import tariff rates tmi. Eq.(4) indicates that the price of exported goods PE_i is determined by the international price of the exported goods $\overline{PWE_i}$, market rate of exchange *ER*, export rebate rate te_i and ad valorem rate for carbon *tar*.

2.3 Income Module

$$YG = \sum YTM_i + \sum YTX_i + YTD + YTH + \overline{FTR} \tag{5}$$

$$YH = YHL + asch \times YK + EHT + GHT + \overline{NFN} \tag{6}$$

where *YG* represents government revenue; YTM_i denotes the import tariff revenue; YTX_i is the indirect tax revenue; *YTD* means the corporate income tax; *YTH* stands for personal income tax; $\overline{FTR}$ is transfer payment from the foreign to our government; *YH* means households income; *YHL* represents households income from labor; *asch* stands for ratio of the capital returns for residents to the total capital returns; *YK* respresents total capital gains); *EHT* denotes transfer payment from enterprises to residents; *GHT* means transfer payment from government to residents; $\overline{NFN}$ stands for foreign transfer payment to residents.

2.4 Demand Module

Resident consumption is described by the Extended Linear Expenditure System (ELES) function, which derives from the Stone-Geary utility function based on the maximization of consumer utility.

$$PQ_i \cdot CH_i = PQ_i \cdot bn_i + mch_i \left(YH - \sum_j^n PQ_j \cdot bn_j \right) \tag{7}$$

where CH_i denotes household demand for commodity *i*; *YH* stands for households income; bn_j means the family's basic demand for commodity *i*; mch_i is the family's marginal consumption of commodity *i*.

2.5 Macro Closure Module

According to Yan and Fan (2009), the Keynesian economic theory can explain and best fit the reality of China's current macroeconomy with excess labor supply. Therefore, this model chooses the Keynesian closure rule, and assumes that there exists unemployment, and that the labor demands for the various sectors are endogenous.

$$\sum_i K_i = \overline{TK} \tag{8}$$

$$\overline{TI} = SH + SE + SG + \overline{NSAV} \tag{9}$$

$$Q_i = INT_i + CH_i + \overline{CG_i} + II_i + ST_i \tag{10}$$

Eq.(8) shows the clearing of capital market, where K_i stands for capital requirements of sector *i*, *TK* for the total supply of capital, which is set exogenously. Eq.(9) shows the invest-saving balance, where $\overline{TI}$ stands for the total investment, *SH* for household savings, *SE* for corporate savings, *SG* for government savings, $\overline{NSAV}$ for foreign savings, which is exogenous. Eq.(10) shows the clearing of products market, where INT_i stands for the intermediate input of sector *i*; $\overline{CG_i}$ for government consumption; II_i for investment demand; ST_i for inventory needs of sector *i*.

3. Scenarios

According to the policy, all CO2 emissions from flights departing from or flying into any EU airport have to be offset; thereby emissions from aviation activities are limited. For the first trading period in 2012, the quantity of allowances to be allocated among airlines will be equivalent to 97% of the mean average of the historic annual emissions from air transportation in the years 2004–2006. 85% percent of these allowances are granted for free, the remaining 15% of allowances are to be auctioned. From 2013 on, the total quantity of allowances will be reduced to 95% of historic aviation emissions and the free quota be reduced to 82%. And by 2020, the all

allowances will be auctioned. An airline carrier could sell its surplus carbon allowances if its emissions are below the free quota, and has to buy appropriate amount to offset some of the excess emissions if its emissions are higher than the free quota but less than the total quota. If one's emissions exceed the total quota, the airline carrier is required to purchase the excess from carbon market before 30 April of next year; otherwise, it will be imposed a fine of 100 Euros per ton for CO2 emissions, and offsets the excess by the following year's quota.

In this paper, we assume that all of China's international flights are limited in carbon emission in accordance with the rules of EU ETS, and that the allocation of the allowances is based on the data in 2007. Considering the policy in EU and its trends, we set up three purchasing ratios, that is, 15%, 50%, and 100%, as three scenarios.

According to Zhu and Wang (2010), the purchase proportion of the quota to the ad valorem tax rate is defined

$$tar = \frac{\tau \times EC}{X} \times tar_c \tag{11}$$

where *tar* stands for the ad valorem tax rate; τ for the purchase proportion of the quota; *EC* for the CO2 emissions from the International routes of aviation; *X* for the total production value of International routes of the aviation industry; tar_c for the price per tons of the carbon dioxide emissions. By Eq.(11), we can get that *tar* are 0.1664%, 0.5547%, and 1.1094%, respectively, corresponding to the three scenarios that τ=15%, 50%, and 100%, respectively.

4. Data Sources

The Social Accounting Matrix (SAM) provides a detailed description of the economy in a region in a given period and a consistent source of data for the model. Based on the input-output table in 2007 and data from the China Financial Yearbook 2008, China Tax Yearbook 2008, China Statistical Yearbook 2008, the China SAM2007 is obtained. The SAM is balanced by means of the RAS method. We split with the 142 departments in the 2007 input-output table and categorize them into 13 sectors. We suppose that a department produces only one product, and the prices of products are 1 in the base period. Then we calculate the China micro-SAM2007 and balance the micro-SAM2007 using the RAS method. The data involved in the aviation sector are taken partly from the Civil Aviation Statistics 2008, partly from the macro SAM table. The values of exogenous parameters including miscellaneous substitute elasticities and carbon emission factors are from the related literatures (Wang et al., 2010; Zhao & Wang, 2008; Liu & Fu, 2011). The values of endogenous parameters are estimated with the method of calibration in GEMPACK based on the equations and the data in the SAM.

5. Results

5.1 Macroeconomic Impacts

We select the nominal gross domestic product (nominal GDP), real gross domestic product (real GDP), government revenue and household income as representative indicators of China's macro-economic.

As one might see in Table 1, the policy has negative impact on China's nominal GDP: when the ratio is 15%, the nominal GDP will decrease 840 million RMB; when the ratio increase to 50% or 100%, the nominal GDP will decrease 2790 or 5530 million RMB. The real GDP, on the contrary, increases slightly, simply because the increase of production in aviation industry (5% per year) is greater than the loss this policy induces.

Table 1. Changes in GDP under different purchasing ratio

Change	The ratio of the CO2 that need to buy		
(million RMB)	15%	50%	100%
Nominal GDP	-840.5	-2786.5	-5530.2
Real GDP	341.8	1133.7	2250.3

The household income and government revenue decrease under all three scenarios (see Table 2): at the purchasing ratio 15%, government revenue and household income decrease by 130 million RMB and 210 million RMB; at 100%, the losses of government revenue and household income are 880 and 1400 million RMB respectively. Therefore, the implementation of this policy has negative impact on Chinese residents' welfare.

Table 2. Changes in income under different purchasing ratios

Change (million RMB)	The ratio of the CO2 that need to buy		
	15%	50%	100%
Government Revenue	-130	-440	-880
Household Income	-210	-700	-1400

5.2 Impact on Foreign Trade

The results also show that the purchasing of carbon allowances for the international airline increase the operating costs and diminish the profits of the aviation industry.

Table 3. Changes in export price under different purchasing ratios

Change (%)	The ratio of the CO2 that need to buy		
	15%	50%	100%
Agriculture	-0.0043	-0.0142	-0.0282
Coal Mining and Washing	-0.0043	-0.0142	-0.0282
Oil and Gas Exploration	-0.0043	-0.0142	-0.0282
Other Extractive	-0.0043	-0.0142	-0.0282
CGPP	-0.0043	-0.0142	-0.0282
MTE	-0.0043	-0.0142	-0.0282
Other Manufacture	-0.0043	-0.0142	-0.0282
PSEHT	-0.0043	-0.0142	-0.0282
Construction	-0.0043	-0.0142	-0.0282
International airline	-0.1704	-0.5658	-1.1251
Domestic Airline	-0.0043	-0.0142	-0.0282
Other Transport and Storage	-0.0043	-0.0142	-0.0282
Other Services	-0.0043	-0.0142	-0.0282

The decline in profits is also reflected in export prices (see Table 3), that is, the greater reduction in export prices indicates the greater loss in the industry. The international airline industry suffers a great decline in its export price, which decreases by 1.13% at the purchasing ratio 100%. The declines in the export prices decrease the export profits; then decreased profits reduce quantity of exports. The combination of decline in price and decrease in quantity reduce the value of exports. From the results, on can estimate that the value of exports decrease by 1220 million RMB at the purchasing ratio 100%.

5.3 Impact on Industries

One can find that the implementation of policy will incur the reduction of sectoral outputs in all the thirteen sectors. The sectoral output loss of International Airline, Domestic Airline and Manufacture of Transportation Equipment are 0.156%, 0.0793%, and 0.0232% respectively (see Figure 1).

Table 4. Changes in output under different purchasing ratios

Changes（million RMB）	The ratio of the CO2 that need to buy		
	15%	50%	100%
Agriculture	-92.9	-312.9	-616.1
Coal Mining and Washing	-9.6	-31.8	-62.7
Oil and Gas Exploration	-14.3	-47.7	-94.4
Other Extractive	-13.0	-45.0	-89.0
CGPP	-21.1	-71.7	-141.2
MTE	-115.4	-385.8	-765.1
Other Manufacture	-1352.7	-4495.7	-8872.1
PSEHT	-23.6	-84.4	-165.5
Construction	-207.0	-677.4	-1348.5
International airline	-30.5	-100.8	-199.8
Domestic Airline	-36.0	-119.1	-236.2
Other Transport and Storage	-60.4	-200.3	-397.9
Other Services	-401.7	-1317.6	-2603.1

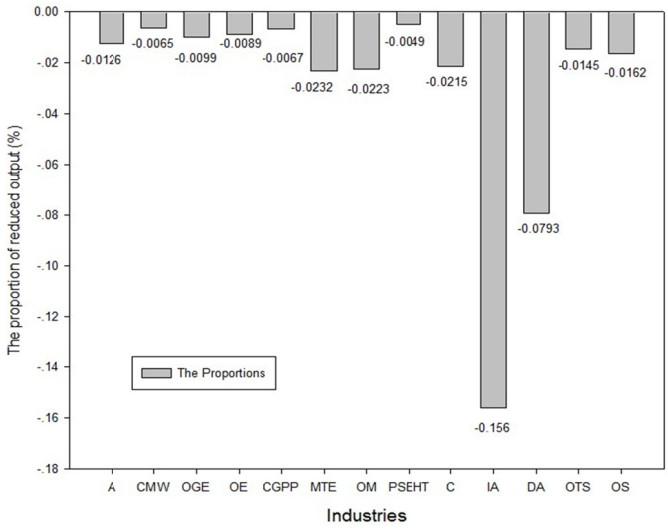

Figure 1. Proportions of reduction in output at the purchasing ratio 100%

The changes in absolute terms of all the 13 sectors are shown in Table 4 and Figure 1. The increasing of the operating costs in aviation sector under the policy results in a huge reduction in the output. The output of aviation industry will decrease by 436.0 million RMB at the purchasing ratio 100%. Meanwhile, Manufacture of Transportation Equipment is closely associated with aviation industry, thereby greatly influenced by the reduction in aviation sector, and suffers a significant reduction in output. The output of Manufacture of Transportation Equipment industry decreases by 765.1 million RMB. For other 12 sectors, they are also subject to certain negative impact on the output. In summary, the total loss of the output for all the industries at the purchasing ratio 100% reaches 15591.6 million RMB.

5.4 Impact on Emissions

As mentioned above, the policy reduces the output of aviation industry, and thereby CO2 emissions from this industry. According to our results, CO2 emissions will decrease slightly by 0.0021 percent, 0.00071 percent and 0.014 percent at the purchasing ratios of 15%, 50% and 100%. It is obvious that the policy has only negligiable impacts on CO2 emissions since the reductions are dispointingedly unsignificant.

6. Conclusions

This paper aimed at quantifying the impacts on China from the inclusion of the aviation industry into the EU ETS system using a simple CGE model. The results indicate that the implementation of this policy will have

significant negative impacts on China's aviation industry, reduce China's nominal GDP and the residents' welfare, influence China's total exports and the export price, and definitely hold back the growth of China's economic production. Interestingly, although the original purpose of this unilateral and coercive policy is to reduce aviation's CO2 emissions, the results show that the emission reduction is dispointedly trivial.

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