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On Carbon Tariffs and Price Distortions

A study of the EU's CBAM and imports from China

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Abstract

Consumption-based emissions have increased rapidly during the last few decades and measures to battle climate change have included numerous initiatives to reduce greenhouse gas emissions. The European Union is currently in the process of implementing its new Carbon Border Adjustment Mechanism, to level the playing field between domestic producers and importers by setting the same requirements concerning carbon emissions. This mechanism is supposed to minimise carbon leakage by applying carbon tariffs to EU actors importing goods from countries outside the EU.

This paper investigates how carbon tariffs affect global trade flows by analysing the possible effect on the EU's imports from China in the production sectors covered by the proposed first phase of CBAM. The theoretical framework is loosely based on the Gravity Model of trade theory. Price sensitivity and embodied emissions are estimated to study the effect of the carbon tariff in a regression model, with the results suggesting a significant decline in demand for Chinese imports.

Keywords: CBAM, Carbon Border Adjustment Mechanism, Carbon Tariff, Price Sensitivity, Carbon Trading Market

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List of Abbreviations

CBAM	Carbon Border Adjustment Mechanism
CHRTD	Chatham House Resource Trade Database
EC	European Commission
EEA	European Economic Area
EFTA	European Free Trade Association
ETS	Emissions Trading System
EU	European Union
EUA	European Union Allowance
EU-27	The 27 member countries of the European Union
GDP	Gross Domestic Product
GHG	Greenhouse Gas
IEA	International Energy Agency

1. Introduction

The Economist (2021a) states that "China is the world's biggest polluter", mainly because of fast industrialisation and economic growth. Several studies have analysed the fact that global consumption-based emissions have increased rapidly during the last few decades and concluded that the main driving force is increased trade with China after the country's entry into the World Trade Organisation (WTO) in 2001 (Weber et al., 2008; Yunfeng and Laike, 2010; Vennemo et al., 2008). Weaker environmental institutions in China have entailed lower production costs, and made Chinese firms more competitive, particularly in carbon-intensive industries (Andersson, 2017).

The European Union's Green Deal is an attempt to tackle climate change and was proposed by the European Commission (EC) in December 2019, adopting a set of proposals to make the union's policies fit for reducing greenhouse gas (GHG) emissions. The objective is at least a 55% reduction by 2030 (compared to 1990 levels), and achieving net zero emissions by 2050 (EC, 2019). In 2005, The European Union implemented the first international emissions trading system in the world, the EU ETS, to reduce GHG emissions. The ETS works as a cap-and-trade program, where a cap is set on the allowed amount of emissions in the region (EC, n.d.). The EU is now in the process of implementing a Carbon Border Adjustment Mechanism (CBAM) with the main purpose of preventing carbon leakage, phasing out the system of free emission rights previously included in the ETS, as well as encouraging partner countries to increase further measures on carbon pricing. The CBAM will function as a carbon tariff placed on the EU importer, resulting in increased costs for importing carbon-intensive goods. The first phase is proposed to include imports of iron and steel, fertilisers, aluminium, cement and electricity generation. (EC, 2021).

In 2020, 8% of China's exports went to EU member countries, valued at approximately 12.6 billion USD (Chatham House, 2021). The hypothesis of the study is that CBAM will presumably change the trade flows to the EU, and this paper aims to research how specifically China's exports and competitiveness with EU producers will be affected by the CBAM. This is accomplished by loosely applying theory from the Gravity Model in trade theory, and calculating the price elasticity of tariff-affected goods, as well as embodied carbon emissions in the production process to apply a carbon tariff on the product prices. Additionally, the study touches on the subject of whether the CBAM can incentivise other countries outside the EU to engage in equivalent carbon-trading market initiatives.

Results indicate that import costs will increase significantly with the implementation of the CBAM certificates. The sector most affected by this is surprisingly not the most carbon-intensive one, fertilisers, but instead aluminium, which however represents the largest import weight of the three sectors analysed: aluminium, fertilisers and cement. The imposed carbon tariff will decrease import demand and likely relocate trade to within the EU where the costs for carbon emissions are applied to the producer. This should spark an incentive for global producers to develop more sustainable production industries, as the EU importers will favour carbon-efficient producers due to lower import costs.

The remainder of the study is structured as follows: the next section (2) details the functionality of CBAM as well as China's newly implemented carbon trading market. Section 3 describes the methodology and data used for the study. Section 4 presents the results attained from the data, followed by a discussion of the results and potential implications in section 5.

2. Carbon Trading Markets

2.1 Carbon Border Adjustment Mechanism

CBAM is focused on the imports of carbon-intensive products, to prevent the EU's efforts to reduce GHG emissions from being countered by the import of products manufactured in countries outside the EU. It also aims to create a level playing field between producers in the EU (who pay tax on emissions through the ETS) with producers outside the EU who do not have to bear the extra cost (The Economist, 2021b). The purpose of the pricing is that it should be high enough to encourage green investments and more environmentally friendly production.

The functionality of CBAM is rather simple. In the proposal, the European Commission states that EU importers will be required to purchase carbon certificates corresponding to the carbon price as if the goods would have been produced in the EU or any country covered under the EU ETS. However, if a non-EU producer can show through an independent verification process that the carbon used in production has already been paid for domestically, the certificate cost is fully removed from the EU importer's bill. In hope of providing businesses and other countries with legal certainty and stability, the EC states that "the Carbon Border Adjustment Mechanism will be phased in gradually and will initially apply only to a selected number of goods at high risk of carbon leakage: iron and steel, cement, fertilisers, aluminium and electricity generation." The phasing-in of CBAM is proposed as the start of a reporting system from 2023 regarding the products stated above, in hopes of stimulating a smooth roll-out and easing dialogue with third countries. A later phase includes the importers starting to pay a financial adjustment in 2026 and phasing out the free allowances previously allowed in the EU ETS. (EC, 2021)

In the proposal of CBAM, the price of emissions certificates will be based on the weekly average auction price of EU ETS allowances, in euros per metric tonne of carbon dioxide emitted. CBAM is designed to secure the avoidance of carbon leakage as well as ensure equal treatment of locally made products and imports from countries outside the EU, by guaranteeing that importers and domestic producers pay the same carbon price. (EC, 2021).

The CBAM proposal has met a lot of criticism. The EC claims the mechanism to be compatible with WTO regulations and fair by requiring the same standards from importers as domestic producers. However, countries outside the region have expressed their concerns. The Australian Prime Minister has called carbon tariffs "trade protectionism by any other name", and Russia declared that the CBAM could violate trade rules. (Blekinsop, 2021)

Exporting companies in countries with already established forms of an ETS may adjust smoothly to the CBAM, but in others, exporters would be required to supply extensive information on their emissions during production. Furthermore, since the mechanism only covers certain products, the exporting manufacturers could be incentivised to switch products to possible substitutes not subject to charges. In some cases, the production of other components may be greener, and in others, they would simply not be subject to the additional costs and global emissions would not fall. (Blekinsop, 2021)

2.2 China's ETS

On February 1, 2021, China's carbon trading market came into effect, immediately becoming the largest carbon market in the world (by volume), covering over 4 gigatonnes of carbon-dioxide emissions (IEA, 2021). This is part of the Chinese strategy aiming to reduce GHG emissions by 60% by 2030 and attain net zero emissions by 2060. However, unlike the EU ETS, the program does not include a total emissions cap. Instead, it rates polluters after benchmarks of size, carbon intensity and fuel type. Expectations on the trading market were that it could cover more than 70% of the domestic carbon-emitting industries, although the first phase only touches roughly 2 000 power generators, with the generator sector as a whole covering approximately 30% of China's emissions. Furthermore, polluters that exceed their emissions cap need only pay for 20% of the overextended emissions, and the maximum value of any fines is set at 30,000 yuan, corresponding to just over $4,600. (The Economist, 2021a). Currently, metals are not included in the trading system, but this may change in later stages of implementation. However, the production costs for aluminium, iron and steel will increase as a result of the rising prices of fossil fuels for production, as determined by the framework of the Chinese ETS. Accelerated climate action may bring substantial benefits for China in promoting its emerging position as a leader in global clean energy technology. (IEA, 2021)

3. Methodology

3.1 The Gravity model

The theoretical basis for this study has its foundation in the Gravity Model, which is based on Newton's Law of Gravity, although in the way that countries trade in proportion to their respective market size and proximity (Yotov et al., 2016). The economic control variables in this study differ somewhat from the variables proposed in the model, as proximity need not be the physical distance between the countries, but could apply to trade facilitation as the inclusion in the WTO.

The gravity model is typically used as an ex-post model, analysing the effects of an already enforced trade policy. Therefore, this study will use the theory as an underlying assumption that when trade costs increase due to imposed barriers, in this case the CBAM tariff, trade volume should decrease. Intuitively, the size of trade between countries is not just determined by the trade costs between them, but also by the costs of trading with other countries, including itself. This suggests that the trade costs for intraregional trade within the EU should also be considered when determining the effects of the EU's trade with China. If the trade costs for intraregional trade within the EU are lower than when trading with China after the implementation of CBAM, EU importers will likely relocate the trade towards countries within the EU.

The gravity model assumes that the relationship between trade variables is not linear, and to estimate the coefficients in linear regression, the use of a logarithmic regression model is commonly used.

3.2 Price elasticity of demand

To determine how the implementation of the CBAM will affect Chinese exports to the EU the elasticities of demand on the commodity prices are calculated. The elasticity determines the shift in demand due to a change in the price of a good or service. CBAM can be considered as a tax on the imports of goods from the affected sectors, applied to the importing party if not supplied by the exporter, consequently increasing the importing price of said goods. High elasticity for a good means that a percentage increase in the price would result in a percentage decrease in demand larger than the initial price increase, and reversely for low elasticity.

The price elasticity of demand is calculated as

$$e_{(p)} = \frac{dQ/Q}{dP/P} \tag{1}$$

where the percentage change in demand (Q) is divided by the percentage change in the price (P) to determine the price sensitivity and the subsequent effects of a price change on the demanded quantity of the good. This is typically done by using a log-log model regression analysis, taking the natural logarithm of both sides in the function as shown below.

$$ln\, y = \beta_1 lnx_1 + \beta_2 lnx_2 + ... + \beta_n lnx_n + \varepsilon \tag{2}$$

Using a log-log model is of added use as the model is assumed to be non-linear, whereas the log transformation generates the required linearity for an OLS regression.

For this study, there is a unit increase with the implementation of CBAM, as the prices will increase by a nominal amount, and not a percentage change. Therefore, the semi-elasticity is calculated using a semilogarithmic model, representing the percentage change in demand by a unit shift in the average price per tonne (USD/1000 kg). This is calculated by logging the dependent variable (Trade volume in tonnes) and the control variables, but not the price variable. This will therefore be presented as

$$ln(Trade) = \beta_1 Average\, price + \beta_2 lnx_2 + ... + \beta_n lnx_n + \varepsilon \tag{3}$$

3.3 Data

The dataset for the study is a panel data set, collected from the Chatham House Resource Trade Database (CHRTD), including the 27 EU member countries. Further, the EEA/EFTA countries are also covered under the EU ETS and will be included in the CBAM. Lichtenstein was removed from the study due to a lack of data, together with Switzerland which has its own ETS that is seemingly not covered by the CBAM. The study thereby includes 30 countries in the sample, including China.

Table 1. Countries included in the study

Austria	France	Malta
Belgium	Germany	Netherlands
Bulgaria	Greece	Norway
China	Hungary	Poland
Croatia	Iceland	Portugal
Cyprus	Ireland	Romania
Czech Republic	Italy	Slovakia
Denmark	Latvia	Slovenia
Estonia	Lithuania	Spain
Finland	Luxembourg	Sweden

To most effectively analyse the effects of CBAM on future trade, the dataset covers trade values from Chinese exports to European importers from 2016 to 2020, as these are the most recent trade statistics available. The study focuses on direct trade, as including a third country in the trade process would mean more extensive institutional variations that could cause discrepancies in the data.

Electricity generation as a category was excluded from the study, as Chinese energy exports in 2020 were solely distributed to countries outside the EU, with more than half of it going to Hong Kong, followed by Macao, Mongolia, Vietnam and other countries in the area (Harvard University, 2022). Furthermore, the production of iron and steel was also excluded due to a lack of comparable data on carbon emissions in production, without which it is not possible to analyse the effects of a carbon tariff such as CBAM. The data is thereby divided into the following three categories: aluminium, cement and fertilisers. CHRTD provides the imported weights of the resources as well as values. The resource groups of cement and aluminium are provided in the data set with embodied carbon-dioxide emissions, whereas those for fertilisers are calculated manually (see more in section 3.3.2).

3.3.1 Carbon price per tonne CO_2

As it is proposed that the price of CBAM certificates will be based on the weekly average price of emissions allowances (EUA), this study is based on the assumption that the CBAM certificates will correspond to the average price of EUA. The price of carbon permits under the EU ETS has been fluctuating around approximately 80 euros per tonne during 2022 (Statista,

2022) and this is therefore the assumed value of the CBAM certificates required for the imported goods covered by the mechanism. Assuming parity between the dollar and euro as they have lately fluctuated around that level in the current economic climate, this carbon price is simply transformed into USD carrying the same value as before. All of the results will thereby be presented in USD.

3.3.2 Calculating emissions for fertiliser production

As the dataset from CHRTD does not include embodied carbon emissions for fertiliser production, they are estimated manually. With the help of previous research that has already estimated these industry emissions in China, the embodied emissions are calculated in the export weights of the resource.

Synthetic nitrogen (N) is used extensively in conventional fertilisers and has played a pivotal role in enhancing food production. China is the largest producer and consumer of N fertiliser, and in a study conducted by Zhang et al. (2013), the carbon footprint of China's N fertiliser production is estimated. They find that for every tonne of N fertiliser manufactured, 13.5 tonnes of CO_2-equivalent is emitted, which is substantially higher than the equivalent of 9.7 in European manufacturing of N fertiliser. China produced 54 million tonnes of fertiliser in 2020, nitrogenous fertiliser being the most dominant one (Statista, 2021). Therefore, the study continues under the assumption that the average emissions of Chinese fertiliser production correspond to 13.5 tonnes of CO_2 per manufactured tonne.

3.3.3 Control variables

So as not to include variations that are not explicitly affected by the price change, additional variables are added to control for variations in demand not correlated to price shifts. As proposed in the Gravity Model (explained in 3.1), the economic size of the exporter and importer tends to affect bilateral trade as large economies tend to trade more. The economic size of the trading partners is included in the analysis in the form of Gross Domestic Product (GDP). Additionally, the exchange rate between the exporting and importing country is added, as this intuitively would affect the bilateral trade. If the Export/Import exchange rate increases, for example, the importer currency depreciates against the exporter currency making it more costly for the importer to trade. This would result in decreased trade, establishing the assumption that the exchange rate should have a negative relationship with the dependent variable. Finally, the alternative price for importing from within the EU should affect the demanded trade volume from China, since the importer would most likely choose the cheaper price, all else equal. If the EU price is cheaper than the Chinese price, the demanded trade volume from Chinese exports would presumably decrease. Hence, a dummy for the price ratio is included in the regression, valued at 0 if the European price is more expensive than the Chinese and 1 otherwise.

$$ln(Trade) = \beta_1 Price + \beta_2 ln(EXCH) + \beta_3 ln(GDP_{exp}) + \beta_4 ln(GDP_{imp}) + \beta_5 d_{price} \quad (4)$$

The European price is not simply added as a variable since changes in the Chinese price and the European price could be closely correlated. For example, average prices may increase due to worldwide inflation or production shortages. This would cause measurement errors in the estimated coefficients. Focusing only on the cut-off price, showing if the European is higher than the Chinese, we should be able to see an effect on demand in Chinese exports when the prices increase (a description of the variables and data sources is provided in Appendix A.).

4. Results

4.1 Price Sensitivity

The results by regression with random effects, suggested by the Hausman test, and robust standard errors show estimates statistically significant on a 0.1% level in the average price and GDP of the importing country. The estimates for the rest vary, with generally more statistically significant estimates on the regression coefficients for aluminium. This could perhaps be explained by there being more observations for that resource group in the dataset. To achieve fully representative estimates in determining such large-scale trade as is viewed in this study, many more variables would have to be considered. Statistical insignificance most likely indicates that not enough data has been collected. However, the important variables needed for estimating the carbon price effect are significant.

Table 2. Semi-elasticity of price for the affected goods in Chinese exports
The effect of a one-unit increase in price on the percentage change in demand

	(1)	(2)	(3)
Ln(Weight, tonne)	Aluminium	Cement	Fertilisers
Average price (USD/tonne)	-0.000812***	-0.000357***	-0.0000433***
	(-3.48)	(-3.31)	(-10.23)
Ln(Exchange rate)	-0.0118	0.00516	-0.583*
	(-0.16)	(0.01)	(-2.44)
Ln(GDP exporter)	1.341***	-0.889	-0.725
	(3.74)	(-0.37)	(-0.70)
Ln(GDP importer)	0.961***	1.401***	1.038***
	(9.47)	(3.64)	(3.57)
Price dummy EU/CHN	-0.00558	-1.669*	-1.065*
	(0.01)	(2.28)	(2.42)
_cons	-23.99***	0.286	3.946
	(-4.78)	(0.01)	(0.23)
N	140	93	137

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

As the semi-elasticity of the average price has been calculated, this can be interpreted as the percentage decrease in trade weight caused by a 1 USD price increase. For example, a price increase of aluminium by 1 USD should decrease the demanded volume by 0.0812%. Intuitively, the price dummy is negatively correlated with the imported trade volume. By using the Halvorsen & Palmquist (1980) correction for interpreting dummy variables in a semilogarithmic equation, the dummy unit-effect is calculated as

$$100 \cdot (e^{\beta} - 1) \tag{5}$$

if the dummy switches from 0 to 1, where β is the coefficient of the dummy variable. The dummy thereby causes a decrease in Chinese imports if the Chinese price becomes more expensive than the EU price.

4.2 Carbon emissions in production

After estimating the coefficients in a regression analysis, average emissions per tonne manufactured product are calculated and presented in Table 3. The emissions for fertiliser production were manually calculated by the average of 13.5 tonnes emitted CO_2 per manufactured product, thereby lacking variation in the emissions data. Surprisingly the emissions from cement production also lack variation, which can be explained by these having possibly been calculated on an average by the Chatham House in the same manner as was done manually for this study, and was not registered by each trade.

Table 3. China's average emissions (tn) per tn manufactured product in 2020
As emissions for Fertiliser production are manually calculated by an average, these lack variation.

Product sector	Obs	Mean	Std. Dev.	Min	Max
Aluminium	28	5.407	.845	2.736	6.011
Cement	17	.84	0	.84	.84
Fertiliser	28	13.5	0	13.5	13.5

The aluminium sector is shown to have an average carbon footprint of 5.407 tonnes of CO_2 emitted per tonne of manufactured product. Fertiliser production is the most carbon-intensive sector with a CO_2 equivalent of 13.5 tonnes, while cement is surprisingly low-intensive compared to the others, emitting 0.84 tonnes of CO_2 for every tonne manufactured product.

4.3 CBAM-induced price shifts

The price shift caused by the added cost for CBAM certificates is as previously mentioned proposed to correspond to the EU ETS certificate prices. With the assumption that a 1-tonne CO_2 emission certificate costs 80 euros, this means that the average price per tonne of imported aluminium from China would increase by approximately 432.56 euros, resulting in a price increase of almost 17% from the initial price shown in Table 4.

Table 4. Mean Chinese export prices per tonne, 2020

Product	Obs	Mean	Std.Dev.	Min	Max
Aluminium	28	2578.38	628.861	962.157	3571.122
Cement	17	1056.958	1899.568	227.716	7500
Fertiliser	28	870.676	1271.03	118.499	6772.059

From the results in Table 2, we can calculate the suggested demand decrease of Chinese imports caused by the price increase, shown in Table 5. Aluminium and cement are not affected in the dummy variable, as the EU price remains more costly than the Chinese for aluminium and reversely for cement.

Fertiliser production has been shown to be heavily carbon-intensive compared to the other product sectors, and this causes the average price to increase initially by 124% and decrease Chinese imports by almost 12,730 tonnes. As fertiliser prices surge due to the high carbon footprint of production the average Chinese price becomes more expensive than within the EU (1,950 and 1,100 USD, respectively). Hence, the dummy variable value changes from 0 to 1. This implies an added decrease in trade from the dummy variable by 65.53 tonnes. The import weight from 2020 used to calculate the percentage change in demand is shown in Appendix B.

Table 5. CBAM-induced changes in price and demand

Product	Price change (USD)	Demand change (tonnes)	Price change %	Demand change %
Aluminium	+ 432.6	- 184,731.2	+ 16.8	- 35.1
Cement	+ 67.2	- 559.2	+ 6.4	- 2.4
Fertiliser	+ 1080	- 12,795.1	+ 124	- 4.7

5. Discussion

The changes in price and demanded quantity presented in Table 5 show that the largest decrease in weight imports would not be caused by the largest increase in price, which is interesting. This suggests that the aluminium sector is more price sensitive than the fertiliser sector, which affects the total imports from China significantly as most imports from the studied product sectors come from aluminium. Cement production is surprisingly carbon-efficient and was barely affected by the carbon tariff price. Furthermore, the Chinese cement prices in 2020 were higher than the EU prices, suggesting that the cement imports from China could be either very specific goods that can only be imported from there, or that the produced volume within the EU does not cover the demanded quantity, thereby importing the rest from China. This implies that the cement industry will probably not be affected by the carbon tariff, as the price already is more costly than in the EU.

The rising costs for aluminium and fertiliser imports applied to the EU importers will likely cause them to shift trading partners to within the EU, given the opportunity. Because of the already implemented carbon certificate costs for EU producers in the EU ETS, the importers will not have to add the certificate costs of CBAM, making it cheaper to import certain products (fertilisers) from within the EU than from China. This should spark an incentive for Chinese producers to make their products less carbon-intensive, in order to maintain their export position. The Chinese ETS is seemingly a step in that direction, and if subsequent phases include further sectors, China could very well maintain or even increase its stance as the EU's largest trading partner.

Further studies on this subject could include the possibilities of importers switching to substitute products, not covered by the carbon tariff, as well as include further production sectors that could be covered in subsequent phases of the carbon trading market. The Chinese iron and steel industry did not supply any data on embodied emissions during production, but as this is the largest export sector for China to the EU, this will likely be heavily affected. The CBAM is not implemented yet, and we haven't seen the actual effects of it in practice, but this study does imply that the mechanism will change the scenery of global trade, and possibly incentivise other countries to decrease their carbon emissions in production. If not, the EU's trade, as well as global trade due to the region being the world's largest trading bloc, will likely develop to be more protectionistic. Another interesting analysis would be to investigate the effects on exports from more environmentally friendly production sectors in the EU, for example, the Green Steel Industry in Sweden. As carbon emissions are included as a cost, countries with advanced manufacturing facilities in "green production" will likely produce the future's most desirable products on the market.

Appendix

Appendix A. Variable description and data source

Variable	Data source
Trade Weight (in 1000kg)	Chatham House Resource Trade https://resourcetrade.earth/
Trade Value (in 1000USD)	Chatham House Resource Trade https://resourcetrade.earth/
Embodied CO_2 emissions (in 1000kg)	Chatham House Resource Trade https://resourcetrade.earth/
GDP (in million USD)	OECD https://data.oecd.org/gdp/gross-domestic-product-gdp.htm
Exchange rate (measured /USD) manually converted to Exporter/Importer currency rate	OECD https://data.oecd.org/conversion/exchange-rates.htm

Appendix B. EU imports from China, 2020

Product	Import Weight	Import Value
Aluminium	526 000 tonnes	1 200 million USD
Cement	23 300 tonnes	7.6 million USD
Fertilisers	272 000 tonnes	85 million USD

References

Andersson, F. N.G., (2017) International trade and carbon emissions: The role of Chinese institutional and policy reforms. *Journal of Environmental Management,* vol. 2018, no. 205, pp. 29-39

Chatham House (2021), *Resource Trade Earth Database*. Available at: https://resourcetrade.earth/

European Commission. (n.d.). *EU Emissions Trading System (EU ETS)*. Available at: https://ec.europa.eu/clima/eu-action/eu-emissions-trading-system-eu-ets_en#about-the-eu-ets [Accessed September 18, 2022]

European Commission. (2019). *What is the European Green Deal?* Available at: https://ec.europa.eu/commission/presscorner/detail/en/fs_19_6714 [Accessed October 3, 2022]

European Commission. (2021). *Carbon Border Adjustment Mechanism: Questions and Answers*. Available at: https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_3661 [Accessed September 18, 2022].

Halvorsen, R. & Palmquist, R. (1980). The interpretation of dummy variables in semilogarithmic equations, *American Economic Review*, vol. 70, no. 3, pp. 474.

International Energy Agency, IEA. (2021). *World Energy Outlook*, IEA. Available at: https://iea.blob.core.windows.net/assets/4ed140c1-c3f3-4fd9-acae-789a4e14a23c/WorldEnergyOutlook2021.pdf [Accessed September 20, 2022]

Blenkinsop, P. (2021). *Analysis: Europe faces sceptical globe with carbon border levy*. Reuters. Available at: https://www.reuters.com/business/sustainable-business/europe-faces-sceptical-globe-with-carbon-border-levy-2021-07-05/ [Accessed October 3, 2022]

Statista. (2021). *Production of nitrogen fertilizer in China from 1990 to 2019*. Available at: https://www.statista.com/statistics/275858/nitrogen-fertilizer-production-for-chinas-agriculture/ [Accessed October 9, 2022]

Statista. (2022). *European Union Emission Trading System (EU-ETS) carbon pricing in 2022*. Available at: https://www.statista.com/statistics/1322214/carbon-prices-european-union-emission-trading-scheme/#:~:text=EU%2DETS%20futures%20pricing%20in%20the%20European%20Union%202022&text=The%20price%20of%20emissions%20allowances,dioxide%20on%20July%2022%2C%202022. [Accessed October 3, 2022]

The Economist. (2021a). *Can China's new carbon market take off?* Available at: https://www.economist.com/finance-and-economics/2021/02/27/can-chinas-new-carbon-market-take-off [Accessed September 20, 2022]

The Economist. (2021b). *The EU's proposed carbon tariff gets a mixed reaction from industry.* Available at: https://www.economist.com/business/2021/08/07/the-eus-proposed-carbon-tariff-gets-a-mixed-reaction-from-industry [Accessed September 25, 2022]

The Growth Lab at Harvard University. The Atlas of Economic Complexity. [Data set]. Available at: http://www.atlas.cid.harvard.edu

Vennemo, H., Aunan, K., He, J., Hu, T., Li, S., Rypdal, K. (2008). Environmental impacts of China's WTO-accession. *Ecological Economics,* vol. 64, no. 4, pp. 893-911.

Weber, C.L., Peters, G., Guan, D., Hubacek, K. (2008). The contribution of Chinese exports to climate change. *Energy Policy,* vol. 36, no. 9, pp. 3572-2577.

Yotov, Y.V., Piermartini, R., Monteiro, J.-A., & Larch, M. (2016). An Advanced Guide to Trade Policy Analysis: The Structural Gravity Model. *World Trade Organization*.

Yunfeng, Y., Laike, Y. (2008). China's foreign trade and climate change: A case study of CO2 emissions. *Energy Policy,* vol. 38, no. 1, pp. 350-356.

Zhang, W., Dou, Z., He, P., Ju, X., Powlson, D., Chadwick, D., Norse, D., Lu, Y., Wu, L., Chen, X., Cassman, K., & Zhang, F. (2013). New technologies reduce greenhouse gas emissions from nitrogenous fertilizer in China, *Proceedings of the National Academy of Sciences of the United States of America,* vol. 110, no. 21, pp. 8375-8380.