HIGH SCHOOL EDITION
Journal of Student Research
Volume 11 Issue 3 (2022)

A Study of the Endowment Effect in Phase II and III of the EU Emissions Trading System

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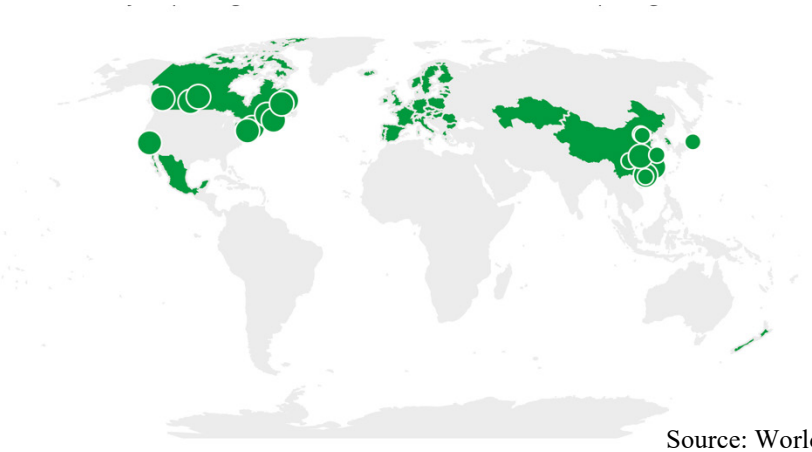
ABSTRACT

This paper investigates the endowment effect in the European Union Emissions Trading System (EU ETS) over Phase II and Phase III using complete transaction records from the market. The results show that for most companies in both Phase II and Phase III, their WTA (willingness to accept)/WTP (willingness to pay) ratio is less than or equal to 1, signifying that there is an insubstantial degree of the endowment effect in the EU ETS. This challenges the results of a pioneering study and brings into light the need for a more rigorous study to re-examine the endowment effect in the carbonmarket.

Introduction

The European Union Emissions Trading System

The increase in anthropogenic emissions of greenhouse gases (GHGs) has raised concern for climate change, which threatens global public health and brings unprecedented challenges for future generations. In response, country leaders have gathered at the United Nations climate summit to pledge emission reduction targets to limit global warming to 1.5C above preindustrial levels. Emissions trading is a market-based approach to regulate the industrial sector's GHG emissions and meet the nation's emission reduction target. Governments can issue annual permits to companies that desire to limit the amount of GHG they can emit. Those exceeding this cap must buy unused permits from less-polluting companies or face being taxed at a higher rate. The current major trading schemes include the European Union Emissions Trading System (EU ETS), the China Emission Trading Scheme, and the California Cap and Trade Program (Figure 1).



Source: World Bank

Figure 1. Map of regional, national, and subnational ETS initiatives. There are 30 ETS initiatives being implemented worldwide. The World Bank predicts that in 2021, these initiatives would cover 16.1% of global GHG emissions.

The EU ETS has operated since January 1, 2005, in all EU countries and Iceland, Lichtenstein, and Norway (The European Commission). It regulates emissions of roughly 12,000 installations in the power and manufacturing sector and airline industry. Companies receive a set amount of European Union emission unit allowances (EUA), each permitting one ton of CO2 emissions. At the end of the year, companies must surrender enough EUAs to cover its assigned cap or pay heavy fines as penalty. Installations that reduce emissions can hold the EUAs for future use or sell them to another installation in need. The cap is gradually reduced over time to meet the EU's goal of reaching carbon neutrality by 2050. The intent of the EU ETS is to achieve a cost-effective allocation of permits and incentivize companies to transition investing in low-carbon technologies.

The EU ETS operates in trading phases and is currently in its fourth phase (2021-2030) (The International Emissions Trading Association). The first phase (2005-2007) was the pilot phase. The lack of background information resulted in an overallocation of permits and sluggish trade. Huang et al. (2014) reported that 204 of the 666 firms did not participate at all. With this feedback, Phase II (2008-2012) introduced inter-phase banking of allowances, tighter allocation of EUAs, and harsher penalties for non-compliance to improve the fluidity of the market. Phase III (2013-2020) extended its compliance cycle and implemented an annual linear decrease of cap emissions of 1.73%. Auctioning, rather than free allocation, became the default method of obtaining permits (Carratù 2020). For example, companies were obligated to purchase at least 20% of EUAs in 2013, and 70% by 2020.

Implications of Behavioral Economics in the Emissions Trading System

Most of the previous research have evaluated the market efficiency based on the assumption that participating companies behave rationally (Kreutzer, 2006; Burtraw & McCormack, 2017). Behavioral Economics introduces the concept of cognitive biases: humans rely on heuristics, or shortcuts, to preserve cognitive energy and consequently deviate from the standard economic model (Shiloh et al., 2002; Montague, 2007). This suggests that people will make the most convenient choice and not necessarily the most optimal one (Mullainathan & Thaler, 2000). A heuristic suggested to be relevant to the carbon market is the endowment effect, which finds that individuals place a higher value on goods when they own it as opposed to when they do not (Kahneman, 2013).

Loss aversion is a plausible explanation for the paradox of the endowment effect. Buying moves one from a stance of not owning to owning a good (a gain), whereas selling moves one from a stance of owning to not owning the good (a loss) (Morwedge & Giblin, 2015). The endowment effect only holds under certain circumstances, such as when goods and money are not strictly comparable, and the goods are purchased for the purpose of personal use rather

than resale (Kahneman et al., 1990). In addition, the item bargained is not easily replaceable and is associated with self (like a reward for an outstanding performance) (Morewedge et al., 2009).

Of 76 endowment effect studies, the environmental field exhibits the highest level of the endowment effect (Tunçel & Hammit, 2014). Kahneman et al. 1990 predicted that the endowment effect would apply to transferable pollution permits. The EU ETS is bounded by conditions similar to what is described in the previous section. First, the EUAs are endowed to companies, creating a strong sense of ownership. They also serve concrete uses by authorizing the possessor to manufacture more products without being taxed at higher rates. The EUA supply is finite, therefore not easily replaceable, and its price is also ambiguous because it is determined by the market and fluctuates from day to day.

A few select studies provide evidence of the endowment effect. In the EU ETS, there are "short" Generation Companies (Gencos) whose initial allocation of EUAs wasn't adequate to cover their total emissions and "long" Generation Companies whose initial allocation of EUAs exceeds the amount necessary, creating surplus to be sold. It is expected that both parties should be active in the carbon market because if permits are not relocated, then short Gencos would have to control pollution at a higher cost and long Gencos would lose the opportunity to earn money. However, it was discovered that short Gencos were much more active, causing an imbalance to the supply and demand (Huang et al., 2014). When surveying 429 EU ETS participants, potential sellers stated that they only started to sell if there was an excess supply of 5,000 to 10,000 EUAs (Gronwald et al., 2015). Because the permit belongs to the seller and serves a practical function, sellers value it more and choose to reserve it for future use or price it at a high cost. On the other hand, there is no loss aversion for money given up in a purchase, which explains why buyers were more eager to seek a trade (Novemsky & Kahneman, 2005).

However, the few papers that have applied Behavioral Economics in their study of the emissions trading system remain inconclusive or insufficient. Several only mention the possibility of heuristics playing a role without empirical evidence (Kreutzer, 2006; Burtraw & McCormack, 2017). Song and Ahn (2019) ground their findings of the endowment effect and status quo bias, another heuristic, on survey-based experiments with hypothetical scenarios, which may fail to simulate a real market environment. Wang et al. (2020) pioneered the study of the endowment effect in Phase II (2008-2012) of the EU ETS by analyzing transaction data, concluding that for more than 80% of the analyzed Phase II transactions, there was an indication of the endowment effect. However, Wang et al.'s (2020) results are not updated with Phase III (2013-2020) data.

With major revisions made and more stringent supervision in Phase III, it is worthwhile to continue examining the extent of the endowment effect in the EU ETS. Accounting for this heuristic in a company's decision-making process offers a more holistic picture and can help address problems the carbon market is currently facing, like inactive trading.

The objective of this paper is to continue using insights from Behavioral Economics to develop a more comprehensive understanding of the EU ETS up to its most recent completed phase. This paper will use data analysis to assess the magnitude of the endowment effect in the EU carbon permit market and interact with the results of previous studies. The endowment effect predicts that companies will have a disparity between the maximum price they are willing to pay for the permits (WTP) and the minimum price they are willing to sell the permits at (WTA).

Data and Methodology

The European Union Transaction Log (EUTL) records the trading history of all accounts in the EU ETS and contains 361,432 Phase II transaction records and 389,900 Phase III transaction records. The records vary in transaction type: external (transfer between registries), internal (transfer between one registry), issuance (initial creation of a unit), among others. They also vary in unit type, among which EUA (the standard European Union allowance), CER (international credits from Clean Development Mechanism projects), ERA (international credits from Joint Implementation projects) are relevant to EU ETS. The raw data was cleaned using Python 3 to keep records that are external and involved a EUA, CER, or ERA unit. To limit the influence of other factors on companies' transaction decisions, the

study only focused on transactions from 2012 (Phase II) and 2013-2017 (Phase III), which were periods of price stability (Figure 2). Removing considerable fluctuations in the permit price eliminates external factors that influence the value of the WTP and WTA (i.e., buyers would be tempted to raise the asking price if they anticipate the market permit price to inflate soon).

Figure 2. The daily EU carbon permit price from 2005 to 2022. The carbon permit price has fluctuated between a lowest of 0.01 EUR and highest of 89.26 EUR. This study focuses on transaction data from periods of price stability in Phase II and Phase III.

The daily carbon price data is derived from the European Energy Exchange, which compiles the Emission Spot Primary Auction Reports from 2012 to 2021. Each file details the auction date and auction price in euro per tCO2 throughout the year. The transaction records were aligned with EEX's auction reports by date to assign each unique transaction with a price. In other words, the spot carbon price on the day of the transaction is assumed to be the seller's WTA and buyer's WTP. If a transaction occurred on a day without a daily carbon price, then it was eliminated.

The ideal companies to analyze were determined by how often they sold and bought permits. For both Phase II and Phase III, each companies' selling and buying frequency, and the ratio between these two values were calculated. A company whose ratio fell lower than 0.5 or reached higher than 1.5 was identified as a biased buyer or biased seller respectively and was eliminated. This is to ensure that the companies surveyed would not be a biased buyer or biased seller. When a company's position is neutral, its corresponding WTP and WTA can be appropriately compared with one another. This data cleaning process narrowed down the data size of 2,338 companies to 682 companies in Phase II (Figure 3). In Phase III, 8,748 companies were reduced to 2,090 companies (Figure 4). To test the hypothesis that experience weakens the endowment effect, these remaining companies were categorized into two groups for both phases: those whose total number of transactions fell under 30 and those whose transactions exceeded 30. Specifically, this tested whether the experience obtained from the period of one phase is enough to reduce the endowment effect. If so, it is expected that the endowment effect of companies whose transactions exceed 30 is less than the endowment effect of companies whose transactions are under 30.

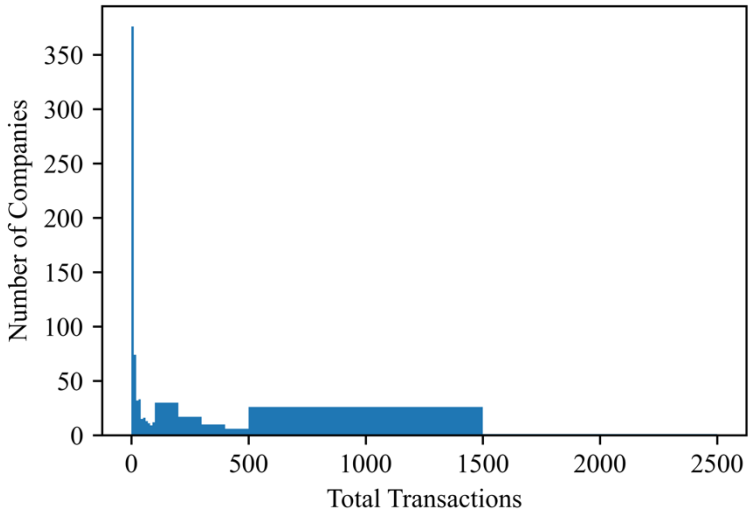


Figure 3. Distribution of total transaction number for 682 companies whose selling and buying frequency ratio is between 0.5 and 1.5 in Phase II. More than 75%, or 482 companies, conducted less than 30 transactions.

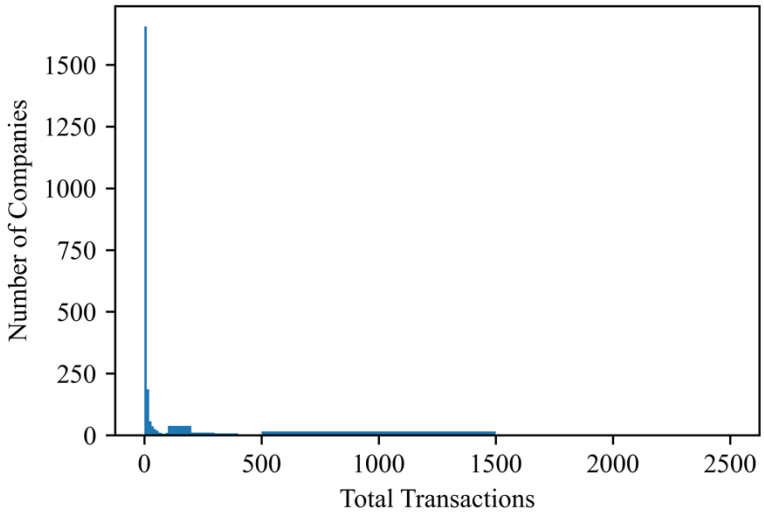


Figure 4. Distribution of total transaction number for 2,090 companies whose selling and buying frequency ratio is between 0.5 and 1.5 in Phase III. More than 90%, or 1901 companies, conducted less than 30 transactions.

For each of these companies, their transaction records were collected, including the date, their status as a buyer or seller, and the price settled on that trade. Like Wang et al. (2020), only alternating subsequent transactions (buying following a selling or selling following a buying) were taken into consideration. This would produce a direct comparison between the company's WTA and their successive WTP, or vice versa. If a company didn't have any alternating subsequent transactions, it was eliminated. This further reduced the data size to 98 companies with under 30 transactions and 161 with over 30 transactions in Phase II. In Phase III, data from 1337 companies with under 30 transactions and 184 companies with over 30 transactions were ultimately collected. In each buying-selling and selling-buying pair, the ratio between the selling price (WTA) and buying price (WTP) was found to measure the strength of the endowment effect, as used in several other studies (Song & Ahn, 2019; Horowitz & McConnell, 2002; Brown & Gregory, 1999). In the end, each company would have a set of WTA/WTP ratios.

The median of each company's WTA/WTP ratios was calculated and compared to the baseline of 1. Because the endowment effect claims WTA to be larger than WTP, the ratio should be larger than 1 for a company to have the endowment effect.

Results

Results of Phase II from this paper significantly differ from that of Wang et al (2020). Whereas Wang et al. finds that most companies tend to exhibit the endowment effect through their transactions, this paper finds the opposite. Most companies, regardless of their total number of transactions, paid the same or more for the EUA than the price they sold it at. Of the 98 companies with under 30 transactions, 28 companies (28.57%) had a median WTA/WTP ratio less than 1, 31 companies (31.63%) had a ratio of 1, and 39 companies (39.8%) had a ratio above 1 (Figure 5). The ratio ranges from 0.71 to 1.36, although most companies are clustered around 1 (Figure 6).

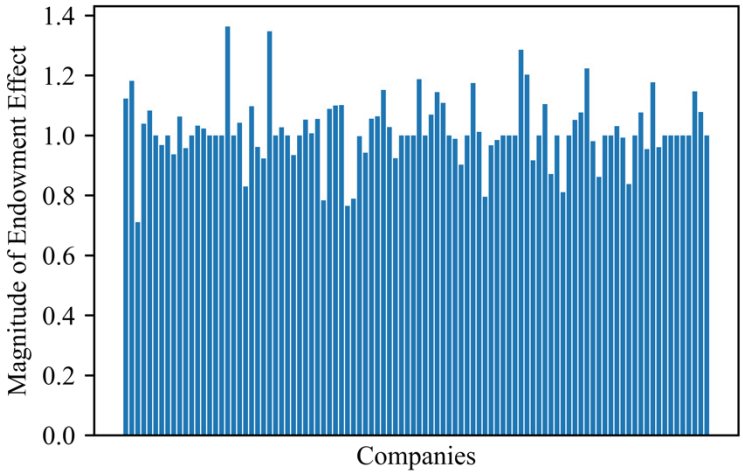


Figure 5. The magnitude of the endowment effect of 98 companies with under 30 transactions in Phase II. Roughly 40% of companies have a WTA/WTP ratio exceeding 1, and most of them have a ratio under 1.2, suggesting they experience a weak to moderate endowment effect.

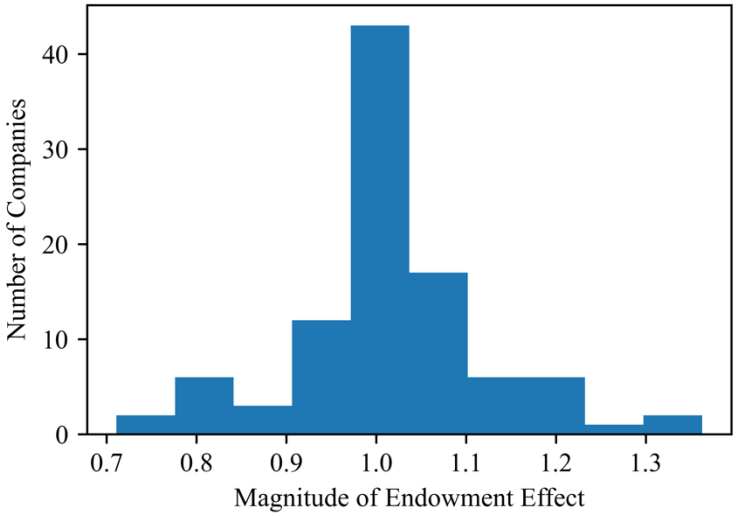


Figure 6. Distribution of the endowment effect of 98 companies under 30 transactions in Phase II. While there are outliers with a WTA/WTP ratio of lowest 0.71 and highest 1.36, the majority of companies have a ratio that falls between 0.9 and 1.1, with most at 1.

Of the 161 companies with over 30 transactions, 35 companies (21.74%,) had a ratio less than 1, 78 companies (48.45%) had a ratio of 1, and 48 companies (29.81%) had a ratio above 1 (Figure 7). There is a similar ratio range of 0.79 to 1.3, but it is even more apparent that the ratio 1 dominates, suggesting almost half of the studied companies bought and sold permits at the same price (Figure 8).

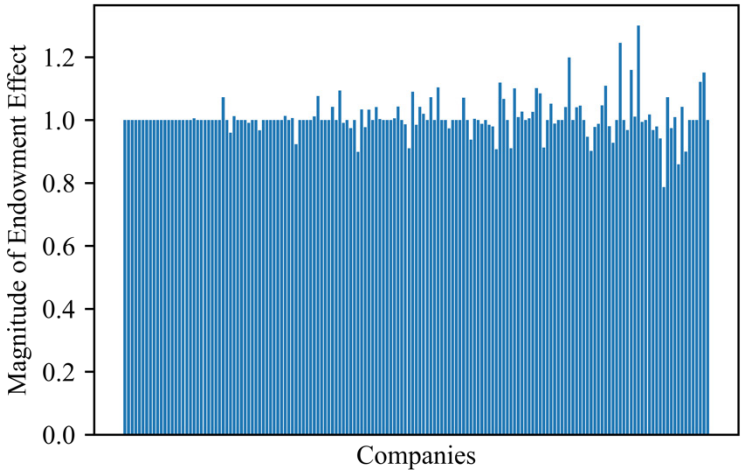


Figure 7. The magnitude of the endowment effect of 161 companies with over 30 transactions in Phase II. Roughly 30% of companies have a WTA/WTP ratio exceeding 1, and almost all of them have a ratio under 1.2, suggesting they experience a weak to moderate endowment effect.

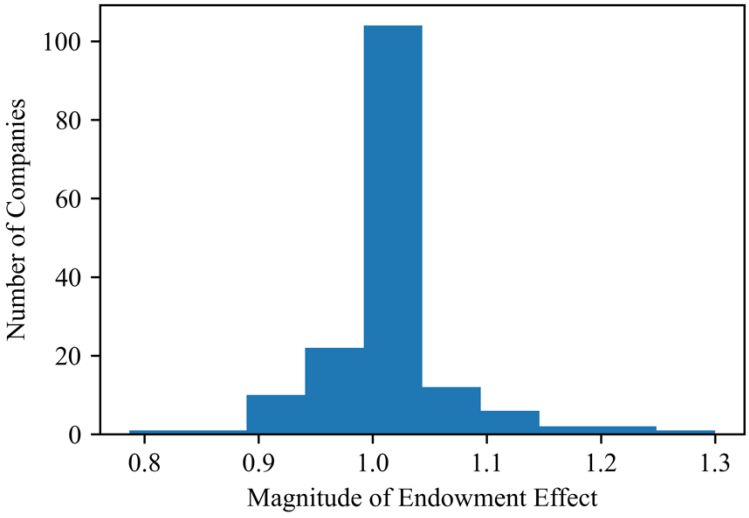


Figure 8. Distribution of the endowment effect of companies over 30 transactions in Phase II. While there are outliers with a WTA/WTP ratio of lowest 0.79 and highest 1.3, the majority of companies have a ratio that falls between 0.95 and 1.1, with most congregated at 1.

Phase III companies had an even weaker endowment effect. Of the 1337 companies with transactions under 30, 47.87% had a WTA/WTP ratio under 1, 18.85% had a ratio of 1, and 33.28% had a ratio above 1 (Figure 9). The ratio is between 0.3 and 3 (Figure 10).

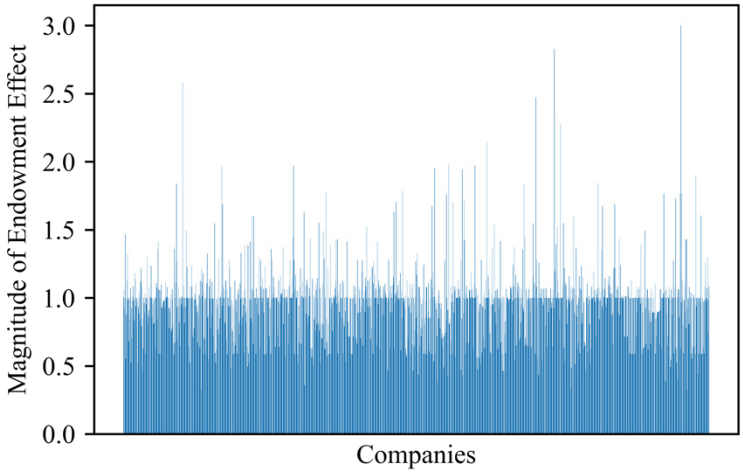


Figure 9. The magnitude of the endowment effect of 1337 companies with under 30 transactions in Phase III. A little more than 30% of companies have a WTA/WTP ratio exceeding 1, and compared to Phase II, the ratio can be much larger.

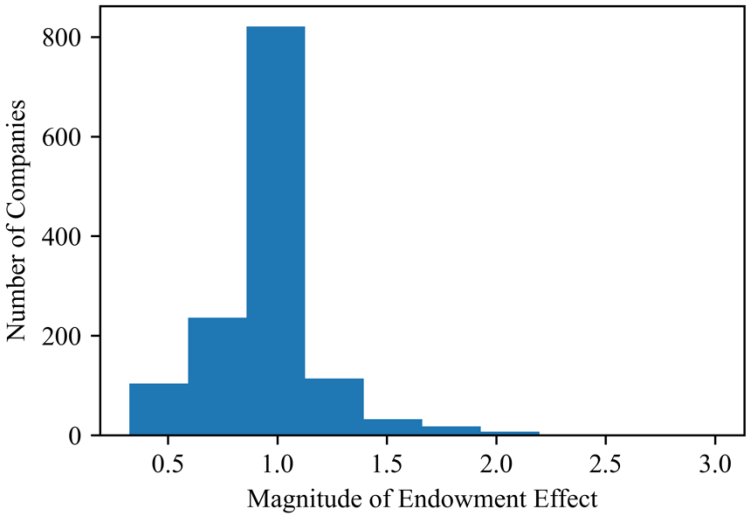


Figure 10. Distribution of the endowment effect of companies under 30 transactions in Phase III. While there are outliers with a WTA/WTP ratio of lowest 0.3 and highest 3, the majority of companies have a ratio that falls between 0.5 and 1.5, a wider range than that of Phase II, but with most still at 1.

Of the 184 companies with transactions over 30, 48.37% had ratios smaller than 1, 20.65% equal to 1, and 30.98% had ratios above 1 (Figure 11). The ratio ranges from 0.52 to 1.86, closing the gap between the lower and upper bounds (Figure 12). Compared to Phase II, the magnitude of the endowment effect in Phase III has an overall wider range and more companies congregate at a ratio under 1.

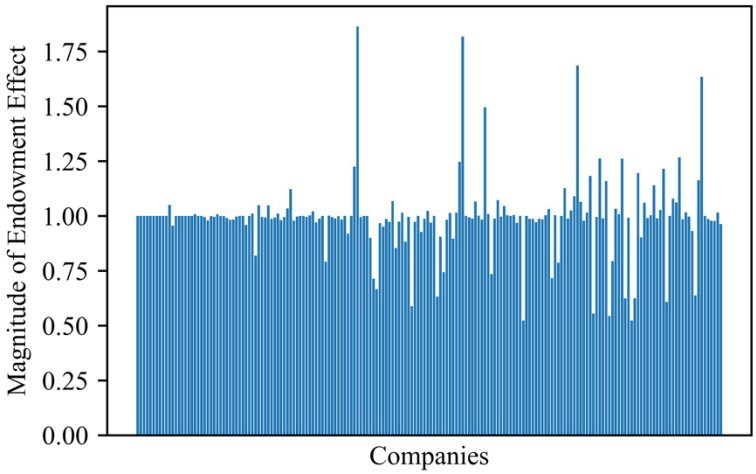


Figure 11. The magnitude of the endowment effect of 184 companies with over 30 transactions in Phase III. Around 30% of companies have a WTA/WTP ratio exceeding 1.

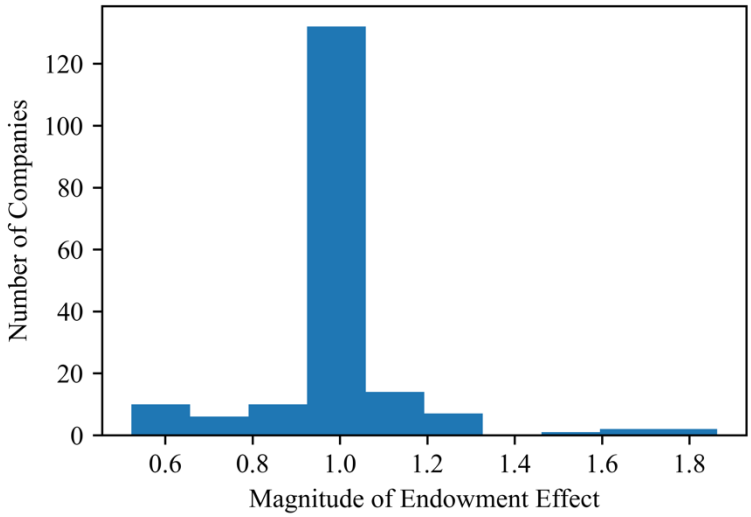


Figure 12. Distribution of the endowment effect of companies over 30 transactions in Phase III. While there are outliers with a WTA/WTP ratio of lowest 0.52 and highest 1.86, the overwhelming majority have a ratio at 1.

Discussion

Because transactions must happen at the acceptance of both the buyers and sellers, a reasonable price helps develop a smoother and more robust market. Costly EUAs put the buyers at a disadvantage and jeopardizes these corporations' production efficiency. Consequently, they may impose heavier costs on their products, ultimately hurting the consumers. On the other hand, sellers influenced by the endowment effect may lose potential buyers and the EUAs they hold become unprofitable. Therefore, it is important that the EU Commission adopts policies that are in accordance with their targets and mitigate the endowment effect.

Results from this paper show there is no dominant impact of the endowment effect in the carbon permit market because the trend is that the WTP is equal to or higher than the WTA for most companies, regardless of the number of transactions they conducted. The disparity between these results and Wang et al.'s (2020) results stems

from the different approach in filtering the data. While Wang et al. analyzed 65,077 transactions in Phase II, this study analyzed 12,667 transactions and 28,374 transactions in Phase II and Phase III respectively. Stricter parameters were established by only selecting transactions from companies whose selling frequency was proportional to their buying frequency. On the other hand, Wang et al. accepted any transaction as long as it was an alternating subsequent transaction (buying following a selling or selling following a buying). This suggests they studied a different set of subjects, encompassing companies with varying trading experiences and with an imbalance of buying and selling records.

Several implications are also put forth to explain why the endowment effect is not present.

Studies have shown that market experience weakens the endowment effect (Engelmann & Hollard, 2010; Tong et al., 2016). Frequent trading trains agents to view selling commodities as a monetary gain rather than a loss of ownership. Expert traders are generally identified as those who have constantly traded for a span of several years (Engelmann & Hollard, 2010). Because data from this paper comes from 2012 to 2017, at least seven years after the EU ETS was initiated, many companies may have gained experience and learned to behave rationally. The experience acquired from a few additional transactions, however, does not matter, because the absence of the endowment effect was slightly more recurring in companies under 30 transactions for Phase II and at a consistent rate for Phase III. Companies with under 30 transactions likely do not have an urgency to sell nor buy permits because they already more or less meet the compliance requirements. The weak demand causes them to value the permits less than companies over 30 transactions, who are more desperate, thus resulting in a higher percentage of them to have no endowment effect.

When looking at individual companies, the outliers of Phase III display a stronger endowment effect than those of Phase II, even though Phase III occurs at a later stage. For example, the maximum magnitude of the endowment effect is 1.86 for a company over 30 transactions in Phase III compared to 1.3 for a company over 30 transactions in Phase II. This can be due to the larger sample size in Phase III, with a total of 259 companies in Phase II compared to 1521 companies in Phase III, which inevitably increases the number of outliers. Another cause can be the tighter allocation of permits in Phase III, which makes EUAs limited and thus more valuable to the seller. However, this is only the case for a few companies and does not speak for the bigger picture.

It should also be noted that the EU ETS has compliance pressure, which was not a factor in Kahneman et al's (1990) experiments. Entities must pay an additional EUR 100/tCO2 for each ton of CO2 not covered by an EUA. Consequently, they may raise their WTP to satisfy the seller and facilitate trade because punishment is much more costly. Calabuig et al. (2016) found that the endowment effect disappeared with punishment (Kolnhofer-Derecskei, 2017). In addition, Carmon and Ariely (2000) reasoned that buyers and sellers differ in how they assess the value of an item, contributing to the discrepancy between WTP and WTA. If buyers acknowledge the benefits of the good and sellers acknowledge the alternative uses of money they gain, the endowment effect is reduced. This may be the mindset of the ETS companies because the consequence of noncompliance forces them to see the benefits of meeting requirements.

Conclusion

Emissions trading is a common government regulatory program to curb greenhouse gas emissions and promote green industrial development. Because it establishes a market that involves economic decision-making, Behavioral Economics is applicable. However, current research heavily focuses on the financial market, leaving a knowledge gap in the cap-and-trade system that can hinder progress. This paper conducts empirical research and analysis to test the endowment effect in the EU ETS.

Using data from the European Union Transaction Log, this paper observes the transaction records of 682 companies and 2090 companies in Phase II and Phase III respectively. Because the WTA/WTP ratio of most companies is smaller than or equal to one, this paper argues that the endowment effect is not prevalent in the second and third phases of the EU ETS. This implies that the market design severely weakens the endowment effect. However, this research contains shortcomings that future work should strive to overcome.

First, this study assumes that the daily corresponding closing price is the trading price between two parties. This can only be a rough estimate, especially because on some days, even the daily permit price fluctuates (Figure 13). In addition, not every day's auction price is available, making it impossible to determine the WTA and WTP on those days. This instantaneously reduces the number of transactions that can be studied.

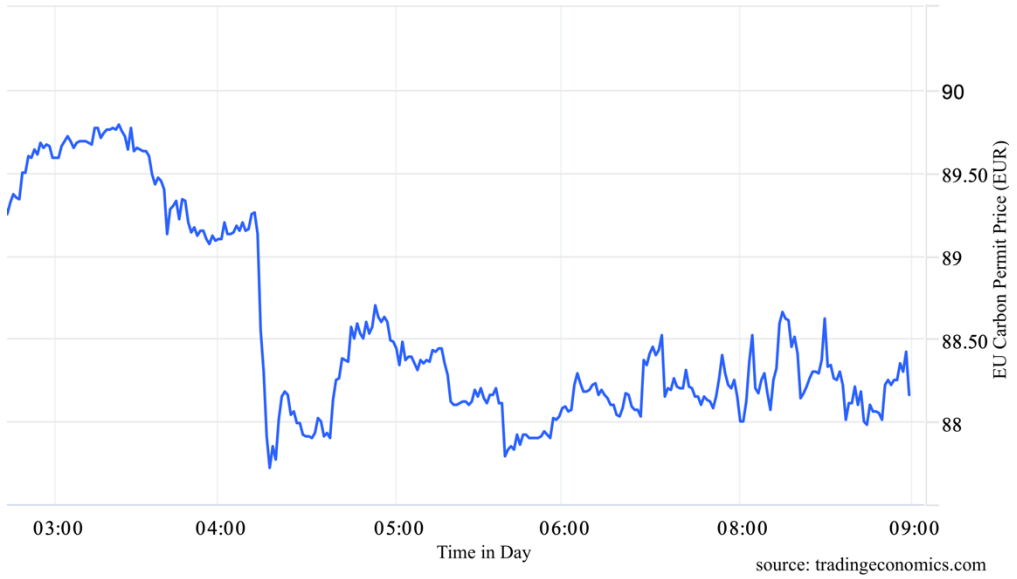


Figure 13. The carbon permit price every minute in one day. The carbon permit price fluctuated between 89.77 EUR to 87.71 EUR in one day, a 2.06 EUR difference.

Moving forward, the European Union Transaction Log should be more transparent with the data by publishing each transaction's trading price. This would lead to more comprehensive studies that can quantify the endowment effect. Robust findings can not only inform the EU Commission of the soundness of their policies and enhance the EU ETS, but also guide other governments in refining their own cap-and-trade initiative.

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