HEDGING CARBON RISK USING EUROPEAN CARBON ALLOWANCE

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Abstract

Climate change and associated carbon regulation create downward risk for investors. We propose a simple method to hedge carbon risk using European Carbon Allowances. We replicate an index using composite stock and a carbon hedge. We obtain minimal tracking error compared to the benchmark, while eliminating carbon emissions exposure. Our hedging method can be use instead or in conjunction with decarbonized index. The hedged index allows investors to obtain the same results as the benchmark and profits from policies restricting carbon emissions.

Keywords: Carbon futures, CO2 emissions allowances, Carbon Risk, Hedge Portfolio

Le changement climatique et la réglementation associée en matière de carbone créent un risque vers le bas pour les investisseurs. Nous proposons une méthode simple pour couvrir le risque carbone en utilisant les quotas européens de carbone. Nous répliquons un indice en utilisant des actions composites et une couverture du risque carbone. Nous obtenons un écart de suivi minimal par rapport à l'indice de référence, tout en éliminant l'exposition aux émissions de carbone. Notre méthode de couverture du risk carbone peut être utilisée à la place ou en conjonction avec un indice décarbonisé. L'indice avec couverture carbone permet aux investisseurs d'obtenir les mêmes résultats que l'indice de référence et de bénéficier des politiques de restriction des émissions de carbone.

Mots clés : Contrats à terme sur le carbone, quotas d'émission de CO2, risque carbone, couverture de portefeuille

Table of Contents

Table of figure

1 Introduction

While the existence of Climate change is scarcely debated, its impact is still uncertain in term of timing and intensity. There may even be short term gain to climate change for some countries. However, the long term costs, even in the best case scenario, will be substantial [1] [2] [3]. The measures required to limit Climate change have and will have important costs. Those costs have impeded political actions. Promising more taxes and regulations today for benefits in the distant future is not the most compelling message, even if inaction results in catastrophic consequence. That is more so when public perception is that Climate change is not a settled issue.

Though one thing can be sure, carbon risk is important and growing. For our purpose, we will define carbon risk as such: “Uncertainty about policies aimed to limit carbon emissions”. Currently this uncertainty is material both in term of scope and timing. Policy decisions can be from governments, regulators, or other such institutions. Hence, uncertainty about measures to limit Climate change and when those measures will be implemented have created a risk for investors, especially long-term ones. One possibility is that no significant effort is taken at scale. The probability of such is remote but possible. Nonetheless, numerous countries have committed themselves to act against carbon emissions [4]. Pressure to act will also increase as consequences of Climate change become clearer. Investors can thus expect more actions by governments.

Regardless of their own belief on Climate change, investors are trying to protect their investment from carbon emissions risk. Many take into consideration ESG (Environmental, Social and Governance) in their investment strategy. ESG investing is a large and growing share of the overall market, which may account for a third of assets under management by 2025 [5].

However, ESG investing might not address carbon risks, depending on the methodology used to create such score. The risk of regulation and taxation of carbon emissions is concentrated mainly on high emissions emitters on an absolute level not relative to peers. ESG score/rating that classify based on relative strength is thus not appropriate.

ESG scores that focus on risk exposure to ESG factors, both systematic and company specific, are more adapted to hedging carbon risks. Nonetheless, they can lead to sectors underweighting.

Using those ratings, decarbonized index can be constructed by underweighting or removing the highest carbon emitting companies and replicating a standard benchmark index, such as S&P500 [6]. According to Andersson, Bolton and Samara (2016) "*An investor holding such a decarbonized index is hedged against the timing risk of climate mitigation policies because the decarbonized indexes are structured to maintain a low tracking error with respect to the benchmark indexes."* [6]

We propose another additional method to hedge carbon risk and significantly reduce one's portfolio carbon emissions: European carbon allowance (EUA). This method does not preclude other strategies, requires minimal monitoring and can easily be implemented in existing portfolio. Carbon emissions of a portfolio become entirely negated by a small amount of EUA, while maintaining low tracking error.

The introduction of European Carbon Allowance (EUA) in a portfolio allows to fully benefits from any increase in regulation or taxation of carbon emissions. If such events do not materialize, then the returns correspond to the index. In essence, the portfolio has a "free option on carbon risks".

2 Literature review

2.1 Literature on ESG score/rating

There is no consensus on whether there exists excess profit by investing in high ESG scoring ("green premium") or by investing in low ESG scoring ("brown premium"), or even if ESG score have any impact on the risk-return of companies.

Pollard et al. (2018) find that ESG score provides excess return and should thus added as a risk premium comparable to Fama and French value, market, size, profitability, and investment premia factors [7]. Pedersen, Fitzgibbons and Pomorski (2020) propose a model where ESG score provides information about firm fundamentals and affect investors preferences. They find that their proxy for E (Environmental)s is a weak predictor for future returns and that investors demand appears strong for it, which may explain low returns. [8]

Albuquerque et al. (2019) propose corporate social responsibility (CSR) as an investment to increase product differentiation for consumers and thus the ability for firms to extract higher profit margin [9]. While CSR and ESG are not entirely equivalent, product differentiation could be a factor in explaining some ESG excess returns. Similarly, ESG rating can also differentiate firms for debt financing (Jang et al.2020) [10]. El Ghoul et al. (2011), Chava (2014), El Ghoul et al. (2018) all give further evidence of reduced cost of capital for high ESG or CSR scoring firms [11] [12] [13].

Chava et al. (2021) find "*that firms with high ES ratings have statistically significantly lower downside risk, whereas such firms do not differ from the others based on standard, unconditional market risk or average returns*." But they suggest that lower downside risk cannot be sole rational of ES investing [14]. Some (e.g. Hong and Kacperczyk, 2009) argue that low ESG scoring firms, similarly to "sin stock", should have higher returns, given that institutional investors shun them and thus create arbitrage opportunities [15].

Bolton and Kacperczyk (2020) argue that "*stocks of firms with higher total carbon dioxide emissions (and changes in emissions) earn higher returns, controlling for size, book-to-market, and other return predictors*". This carbon premium is not explained "*through differences in unexpected profitability or other known risk factors.*" [16]

The mixed results might be explained by the fact that ESG score and total carbon emissions are not synonymous, even when only the Environmental dimension is considered. ESG ratings/scores have a fundamental problem: For what purpose are they provided?

Is it a tool to compare two peers or near-peers and rate their relative strength? MSCI ESG ratings and Refinitiv ESG score rates companies by sector. This method incentivizes each firm to compete for the top spot, driving innovation. Investors do not underweight sectors with high carbon exposure and thus take full advantage of diversification benefits [17] [18]. On the other hand, trying to hedge absolute carbon risks with those scores is not possible. For example, Bayer AG and Holcim AG have the same 2018 MSCI “BBB” rating despite Holcim producing 46 time more direct CO2 emissions than Bayer. [19]

Is ESG score the exposure to systematic and company specific ESG risks? And how is that risk managed? This is the method that Sustainalytics use. Here, the comparison between peer is limited to how well they limit risks or hedge their exposure to risks.

The lack of consistent methodology and purpose of ESG score smay explain the unclear profitability of ESG investing in the literature. According to D. Avramov et al. (2022) “[…] *ESG uncertainty could affect investors’ demand, the risk-return trade-off, and reduce economic welfare for ESG-sensitive agents.*”[20].

2.2 Literature on European carbon allowance

Literature on European Carbon Allowance (EUA) can be classified in a few broad categories: EUA effect on macroeconomic output (carbon emissions, investment, innovation), financial property of EUA or market efficiency of the carbon market and arbitrage opportunities.

According to Abrell et al. (2011) EUAs have a positive impact on reducing carbon emissions during the first phase [21]. Martin et al. (2012) review finds that the EU ETS (European Emission Trading System) impact on abatement, innovation, technological adoption and competitiveness has been marginal [22]. Laing et al. (2013) concur with the assessment that investment and innovation have only been weakly influenced by EUAs, however the low carbon price during phase I and phase II (2005-2012) may be the smain culprits for such low impact. In addition, windfall profits from free allocation were limited in time. [23]

More relevant for our current use of EUAs are their financial properties. Afonin et al. (2017) examine the portfolio diversification benefits of EUAs and find it only for short sales during Phase I. They conclude that their results show *“the maturing nature of the carbon market in Europe and establishment of an asset class driven by fundamentals”* [24] On the contrary, Zhang et al.(2017), *who focus on the “time-varying relationships between the EU-ETS carbon market and other financial markets“,* remark that the correlation between returns rates is weakening over time. Hence the relative independence of EUA can be used to harness diversification benefits [25]. Chevallier (2009) study the links between macroeconomic risk factors and carbon futures and defends that carbon allowances are very distinct from other energy commodities. Thus reinforcing the idea that EUAs may be used for portfolio diversification [26].

Furthermore, Pardo (2021) shows that EUAs can be used as a hedge against unexpected inflation in some countries [27]. While inflation was not much of a concern during the last decade, recent high levels of inflation in the Euro zone elevate the relevance of this property.

Market inefficiencies in the carbon market have been found by multiple sources. Narayan and Sharma, (2015) create a forward return-based predictive regression model which generates more profits than a constant returns model. Carbon spot returns can be predicted using this model [28]. Palao et Pardo, (2021) explore the negative convenience yields in the carbon market and the drivers behind them. While some carbon trading variables can explain this situation, their findings *“support the idea that portfolio managers and passive investing, carried out by Exchange Trade Funds, may be responsible for the long positions taken in EUA carbon futures.”* This pressure on EUA futures demand by actors seeking to hedge or diversify their investment can better explain the contango situation [29]. Milunovich and Joyeux (2010) investigate market efficiency in EUA futures market and find arbitrage opportunities. [30]. Because their study only covers Phase I, it is difficult to generalize those findings to the other phases.

Frino et al., (2010) highlight a significant increase in liquidity and subsequent reduction in transaction costs over time. They find that December futures concentrate most of this liquidity, given regulatory auditing requirement. They also report *“detrimental effects of information asymmetry on price volatility and bid–ask spreads”* [31].

The European Emission Trading System (EU ETS) has changed quite significantly since its inception. Some of the policies prescriptions advocated in the literature have been put in place, such as full auctioning and limiting carbon leakage by introducing carbon tariffs (Carbon Border Adjustment Mechanism). Other improvements such as the Market Stability Reserve aim to improve market liquidity and limit price shock.

3 European Carbon Allowance (EUA)

3.1 Overview

Introduced in 2005, the European Union Effort Sharing Regulation provides the framework for the collective greenhouse gas emissions reduction in the EU. Intended as one of the mechanisms to drive innovation and achieve carbon neutrality by 2050, the European Union Emissions Trading System (EU ETS) operates on the “cap and trade” principle. [32] [33] [34]

A greenhouse gas emissions cap is decided by European institutions. The cap is reduced every year in order to meet the climate goal of the EU. Every company in the system must surrender the required amount of allowance to cover their emissions at the end of the year. Should a company fail to do so, a fine is imposed. A market allows for the emissions to be traded between participants. The allowances are introduced in the market either through auction or given for free [32]. Since the 2^{nd} Phase, the EUAs can be banked for use in later years. The EU ETS covers gas emissions that can be measured, reported and verified with a high level of accuracy. [35]

Table 3.1

<table>
<tr><th>Gas emissions covered</th><th colspan="3">Sectors</th></tr>
<tr><td rowspan="5">Carbon dioxide CO2</td><td colspan="3">Electricity and heat generation</td></tr>
<tr><td colspan="3">Electricity-intensive industry</td></tr>
<tr><td>Oil refineries</td><td>Steel works</td><td>Production of iron</td></tr>
<tr><td>Aluminum production</td><td>Metalwork</td><td>Cement production</td></tr>
<tr><td colspan="3">Commercial aviation within the European Economic Area (EEA)</td></tr>
<tr><td>Nitrous oxide N2O</td><td colspan="3">nitric, adipic, glyoxylic acids and glyoxal</td></tr>
<tr><td>perfluorocarbons PFCs</td><td colspan="3">Aluminum production</td></tr>
</table>

As of January 1st, 2021, those are the sectors and gasses are covered by the EU ETS [36].

While participation is mandatory in those sectors, there are multiple exceptions. In some sectors only large installations are included. "*States may exclude from the EU ETS installations that have reported to the competent authority of the Member State concerned emissions of less than 2'500 tonnes of carbon dioxide equivalent,*". [36, p. 21] The flights outside the European Economic Area are exempt until the 31st of December 2023. [35]

3.2 History

Following the 1997 Kyoto protocol, which sets emissions reduction goals for 37 countries, the European Commission presented a White paper in 2000 as a basis for the development of the EU ETS. [37] The EU ETS Directive was adopted in 2003 and Phase 1 began on January 1st 2005 [32] [34] [35].

3.2.1 Phase 1 (2005 - 2007)

This phase served as a pilot for the system. Only CO2 emissions from power generators and energy intensive industries (iron, steel oil refining and cement, etc.) were covered. Almost all allowances were given for free and the penalty for non-compliance was €40 per tonne.

Phase 1 created a price for carbon, free trade of EUAs across the EU and the infrastructure needed to monitor, report and verify actual emissions. However, the total amount of allowances exceeded the emissions as the caps were set based on estimates. Furthermore, Phase 1 allowances could not be banked for Phase 2. This led to the price for allowances falling to 0. [35]

3.2.2 Phase 2 (2008 - 2012)

Coinciding with the first commitment period of the Kyoto protocol, Phase 2 cap on allowances was reduced according to the actual verified emissions from the previous phase (6.5% reduction compared to 2005). International credits from the Kyoto Protocol's Clean Development Mechanism (CDM) and Joint Implementation (JM) were allowed, which totaled to around 1.4 billion tonne of CO2-equivalent. [6, p. 5] This change and the 2008 economic crisis, which led to emissions reductions greater than expected, had a downward impact on carbon price during Phase 2. [35]

Three additional countries joined the system: Iceland, Lichtenstein and Norway. The flights within the EU ETS were added. [38] Nitrous oxide emissions from the production of nitric acid were included by several countries. With some countries holding auctions, the proportion of free allocation decreased to roughly 90%. The penalty for non-compliance was increased to €100 per tonne. [35]

3.2.3 Phase 3 (2013 - 2020)

The previous system of national caps on emissions was replaced by a single EU-wide cap. Auctioning became the default method of allocation and rules concerning the free allocation were harmonized. [5, p. 3] More gasses and sectors were included. The New Entrants Reserve (NER) program, with 300 million allowances, was created to fund the development of innovative, renewable energy technologies and carbon capture and storage. [35]

In 2018, the Market Stability Reserve (MSR) was established to improve the market resilience to major shocks and address the structural imbalance between supply and demand. Governed by predefined rules, the MSR functions by adjusting the annual auction volume. [36, p. 6]

3.2.4 Phase 4 (2021 - 2030)

Multiple propositions concerning the EU ETS are currently in consultation or are waiting on ratification by European institutions. One of the main propositions is adjusting the number of allowances issued (target cuts of -62% by 2030, compared to 2005). [39]

Given this, changes to the Market Stability Reserve were also proposed to minimize the price impact and ensure price stability. The minimum amount of allowance placed in the reserve (the percentage from the total number of allowances in circulation) and intake rate (percentage of annual auctioned allowance assigned to the reserve) is to be adjusted accordingly. [39] [40]

The different levels of carbon emissions regulation across the world create the risk of carbon leakage. Carbon leakage is a phenomenon created by high carbon emitting industries relocating their activities to or importing from countries where the carbon emissions costs are lower. That behavior would increase the total carbon emissions if left unaddressed. For this reason and given the declared ambition of the EU toward zero emissions by 2050, a Carbon Border Adjustment mechanism (CBAM) was proposed to price the carbon content of imported goods. That tariff barrier is intended to conform to the World trade organization (WTO). [39] [41]

4 Method

4.1 EUAs as Hedge against Carbon risk

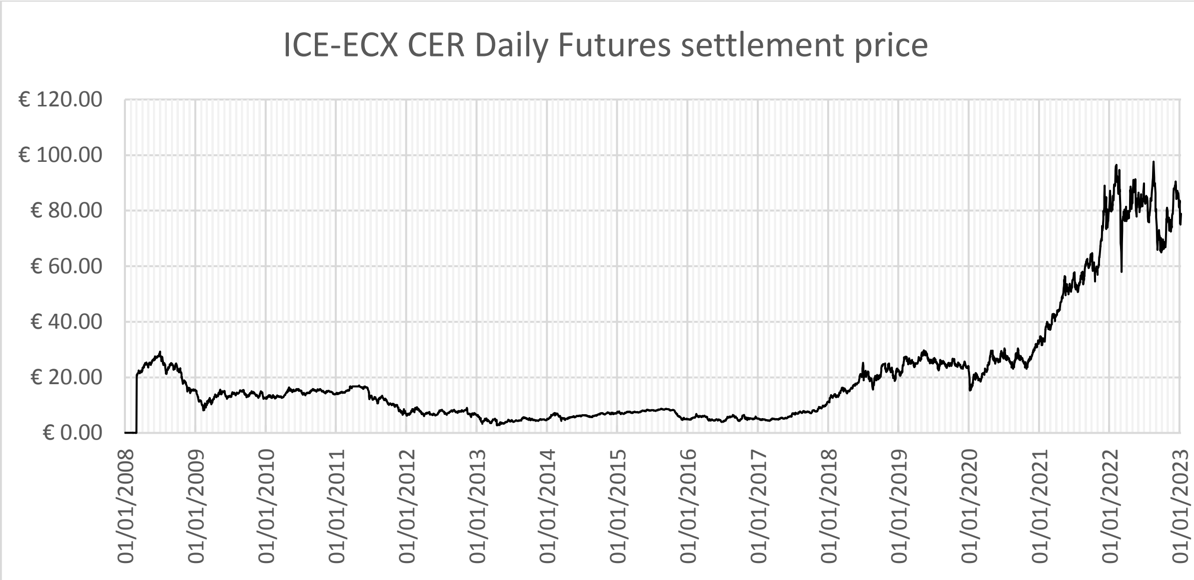

Figure 4.1

ICE ECX daily futures settlement price between 01.01.2008 and 01.01.2023 from Refinitiv eikon, accessed 10.01.23

As we seek to hedge uncertainty about policies aimed to limit carbon emissions, European Carbon Allowance (EUA) are a perfect tool. The EU has anchored its fight against Climate change chiefly on the emission trading system. Thus, increased regulation will mainly increase the coverage of the EUA or reduce the emissions cap. More participants mean a more liquid market with lower transaction costs and cap reduction means a upward pressure on price.

EUAs are designed to have a perfect negative correlation to CO2 emissions. Every EUA held by an investor reduces the total emission by 1 tonne of CO2. This relation holds true under most circumstances. One possible break-down may be for example if the carbon price is higher than the penalty for non-compliance. Another may be if carbon emission allowance supply is superior to EUA demand, as appends during the 2008 financial crisis and again in 2012 with the European debt crisis. The former can only last while the penalty fine is not adjusted, and the Market Stability Reserve alleviate the risk of the later.

EUAs cover mostly direct emissions (scope 1) and emissions from electricity usage (scope 2). An explanation of that limited coverage is that underlying CO2 emissions of EUA must be accurately measured and are regulated by European authorities, with heavy fines in case of non-compliance. Indirect emissions (scope 3) measurement is far less reliable as it involves the whole production chain. This limitation results in most firms covered to be electricity producer or large energy consumer (e.g. oil producer, steel producer, aluminum production, etc.). Ideally scope 3 emissions should be included to protect against carbon risk. The cost of components with high carbon footprint will increase if/when taxes or regulation are imposed on them.

One large caveat is that accurate carbon emissions measurement for portfolio is difficult. Ideally, added carbon emissions of each company should be used, similarly to value added approach to GDP. The widely used scope 1, 2 and 3 are suited for comparing two peers but risk double counting carbon emissions when used in determining portfolio carbon emissions. As an illustration of this problem, one can imagine the following scenario: An investor owns an oil pumpjack and an oil powerplant. The pump is powered by the powerplant. The total carbon emissions are those of the powerplant. However, the portfolio carbon footprint is the carbon emission of the powerplant (scope 1), and the carbon emissions of the energy consumed by the pumpjack (scope 2). In this case the carbon emission of the portfolio is superior to the total carbon emissions, which is a contradiction. Unfortunately, no data exists about the added carbon emissions and as such scope 1 and 2 are used as proxy.

As mentioned before, carbon leakage is a challenge for the full coverage of the EU ETS. Some companies can easily relocate their production outside the carbon market and thus avoid carbon cost. There exist only two realistic solutions to this problem: either cap and trade system are implemented and linked together around the globe or tariff are put in place to price in carbon costs. The second option has been selected by the EU because the international community lacks interest for the first [41].

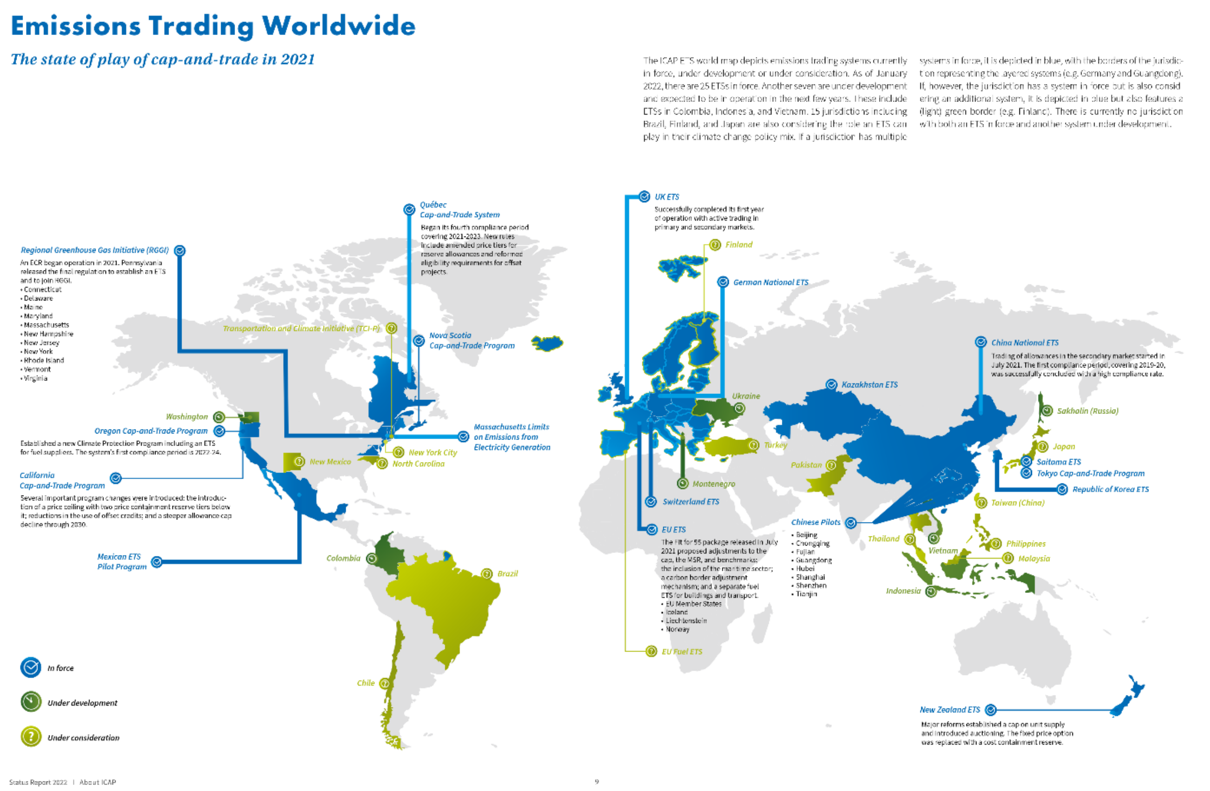

Figure 4.2

Emissions Trading Worldwide: 2022 ICAP Status Report [42]

Using EUAs impose a geographical limit on our portfolio hedge design as they are linked only with European carbon risk (e.g. Chinese carbon regulation has no direct impact on EUAs). The scope could be increased by using other carbon emissions trading systems.

A major risk one might assume when hedging with EUA, is that European regulators abandon or scale back the carbon emissions trading system. This possibility is currently remote but on the long term this might change. Direct carbon taxation, while unpopular today[43], may be pursed in the future. In this case, EU ETS might be abolished and EUAs value would then be all but worthless.

4.2 Designing an index which hedge carbon risk

Our goal is to replicate a benchmark index using fewer composite stocks than the benchmark. The main difference between the two indices should hopefully only be exposure to carbon risk. So long as carbon risk is not fully incorporated, the two indices will have similar returns. In this case tracking error will be minimal. When carbon risk is correctly priced or further unexpected carbon regulation are enacted, the hedged portfolio should outperform the benchmark.

Obtaining a portfolio replicating an index that is hedged against carbon risk can be done in a few different ways. One consideration is whether to first screen high carbon emitting companies. Doing so inevitably constrain the optimization problem. It has the benefit of sending a clear signal to excluded companies.

Inclusion in an index is desirable for firms. Inclusion in a decarbonized index should be doubly so if interest in carbon risk mitigation increases. As the index composition would be periodically changed, competition about carbon emissions reduction will result from this design choice. Filtering can be done sector-wise to avoid sectors mismatch compared to the benchmark. Else the filtering would likely exclude most energy, mining and material sectors. This type of filtering sector-by-sector reinforces competition between firms for the inclusion in the decarbonized index.

Filtering based on absolute carbon emissions runs the risk of excluding larger firms. Normalizing carbon emissions can reduce that bias. Normalization of carbon emissions should consider the input/output of each sectors. For example, service industry could be normalized according to the number of employees or the sales, electricity producer according to the GWh (gigawatt-hour) produced, steel producer or aluminum producer according to electricity consumption.

Once companies have been selected, the replication problem can be formulated as minimizing the tracking error under a carbon reduction constraint or alternatively as minimizing carbon emissions under a tracking error constraint.

We minimize the tracking error without any carbon reduction constraint but with a minimum EUA requirement constraint. Optimizing and then hedging the portfolio may lead to high tracking error. While minimum EUA requirement allows to benefit from carbon hedge carbon reduction and still maintain similar ex ante tracking error.

The optimization problem can be described as such:

$$min\, TE = \; std(R * w \; - \; B)$$

$$Q > q * w$$

where

std = the standard deviation

w = a vector of portfolio weight

R = a matrix of stock total return index

B = the benchmark total return index

q = matrix of carbon intensity

Q = vector of carbon emissions limit

This formulation minimizes ex ante tracking error. Positive tracking error ex post are expected if the decarbonized index outperforms the benchmark

Our optimization using EUA can even eliminate the carbon emissions constraint, as even a small minimum allocation of EUAs will be enough to eliminate the portfolio carbon emissions.

Then the constraint becomes:

$$w_i > t$$

where

w_i = weight of EUAs

t = minimum EUA requirement

Our Data come from Refinitiv eikon, accessed on the 10.01.2023. We have a sample of 368 companies with relevant information about their scope 1 emissions, scope 2 emissions, market capitalization and total return index for the period between 2012-01-01 and 2020-12-31.

We normalize carbon emissions using the market cap of each firm. Sales could also have been used to normalize carbon emissions, or others as mentioned previously.

$$m_i = \frac{Market\ cap\ _i}{\sum_i^N Market\ cap\ _i}$$

$$carbon\ emissions\ per\ million\ invested = \frac{1'000'000}{m_i *\ CO_2\ emissions_i}$$

We use the period between 2012-01-01 and 2016-12-31 as a training period. The period between 2017-01-01 and 2020-12-31 is use of out-of-sample testing. Ideally, the carbon hedge index should be rebalanced periodically, if data availability permits. The index only has long position without leverage.

One can create carbon neutral replication by first minimizing tracking error and then adding the required EUA to cover the portfolio carbon emissions. However, this may significantly increase the ex ante tracking error.

We test six scenarios: one base case with no minimum EUA constraint, 1% minimum EUA, 5% minimum EUA, 10% minimum EUA, 20% minimum EUA, 30% minimum EUA.

5 Results

In most scenario, we obtain low ex ante tracking error thanks to our method of minimizing ex ante tracking error under a EUA minimum requirement constraint.

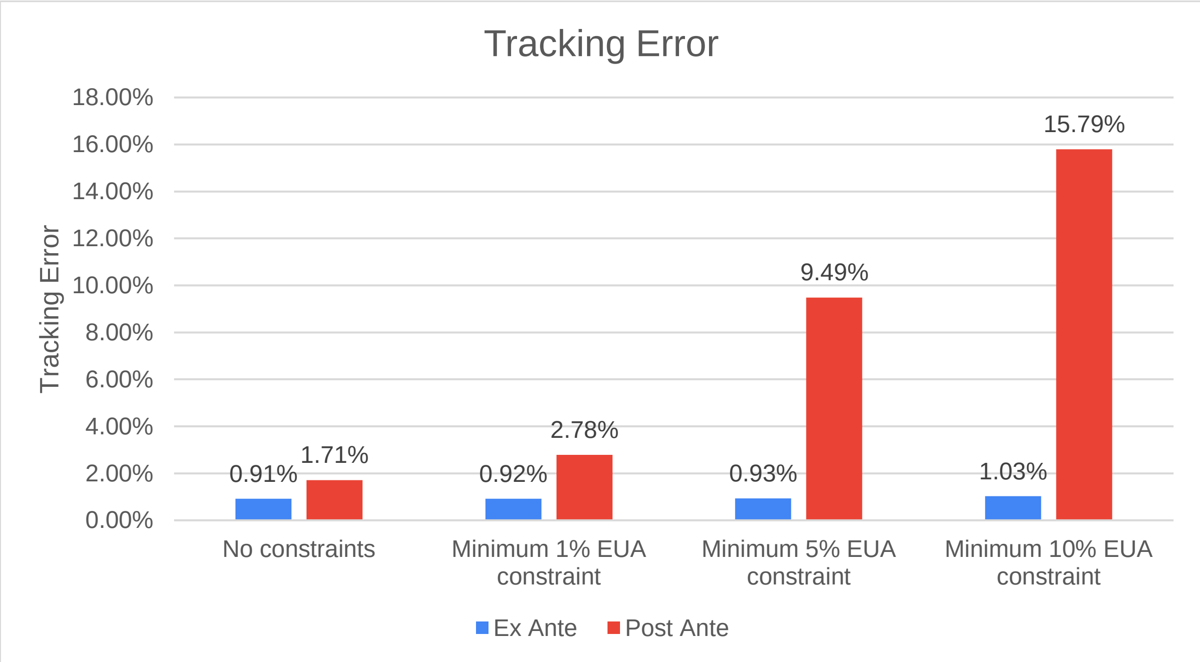

Figure 5.1

The ex post tracking error is important, even for the minimum 1% EUA constraint. The difference is mainly attributable to the large price increase of EUA futures over the 2018-2022 period. That increase may be the results of better pricing of carbon risk. In march 2018, an European directive amending the EU ETS was accepted [36], thus improving the perspective of the EU commitment and intention over carbon trading policy. An alternative explanation may be the entry of more investors in the market for diversification or hedging purpose.

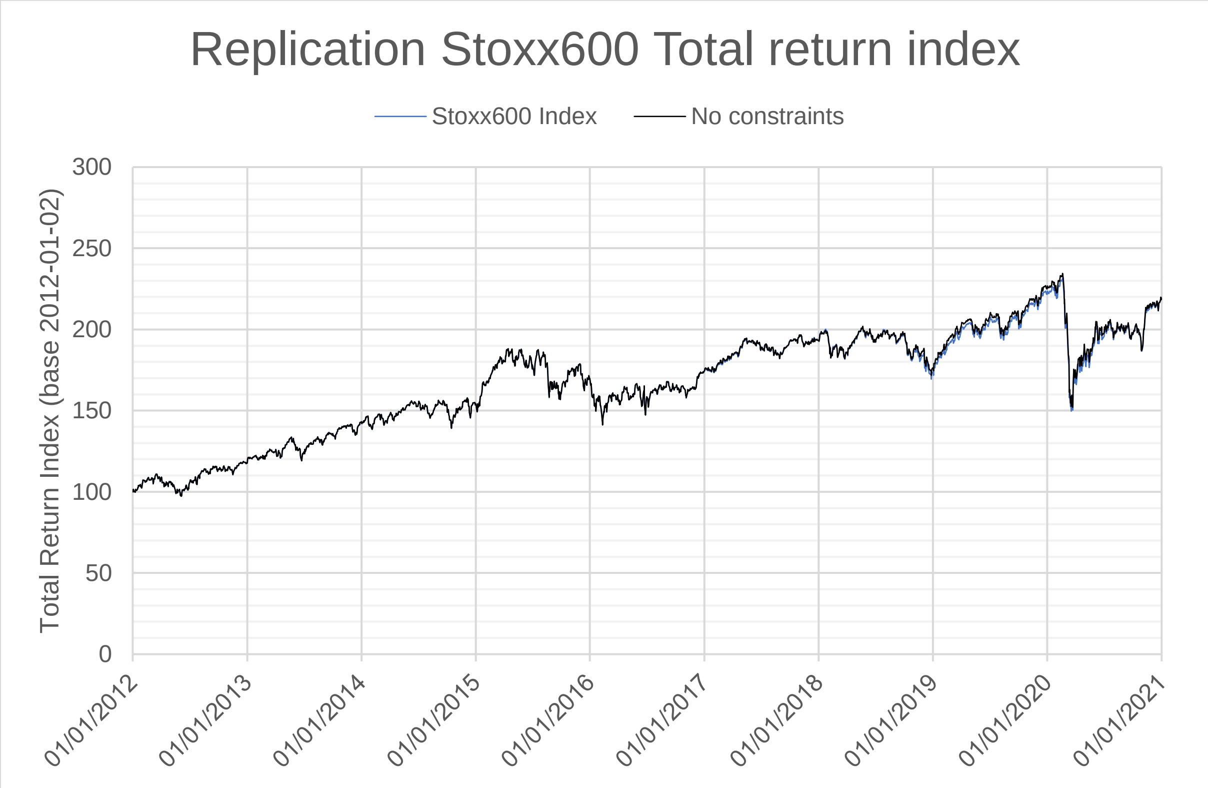

Figure 5.2

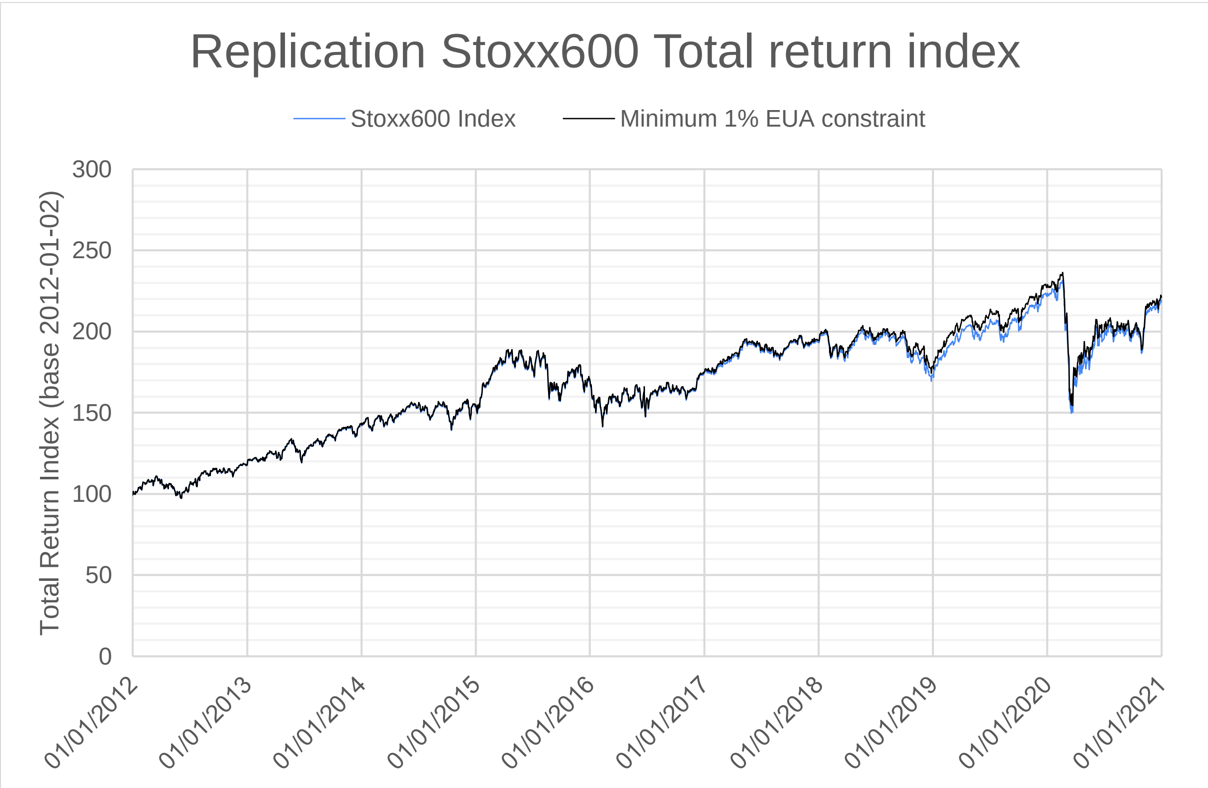

Figure 5.3

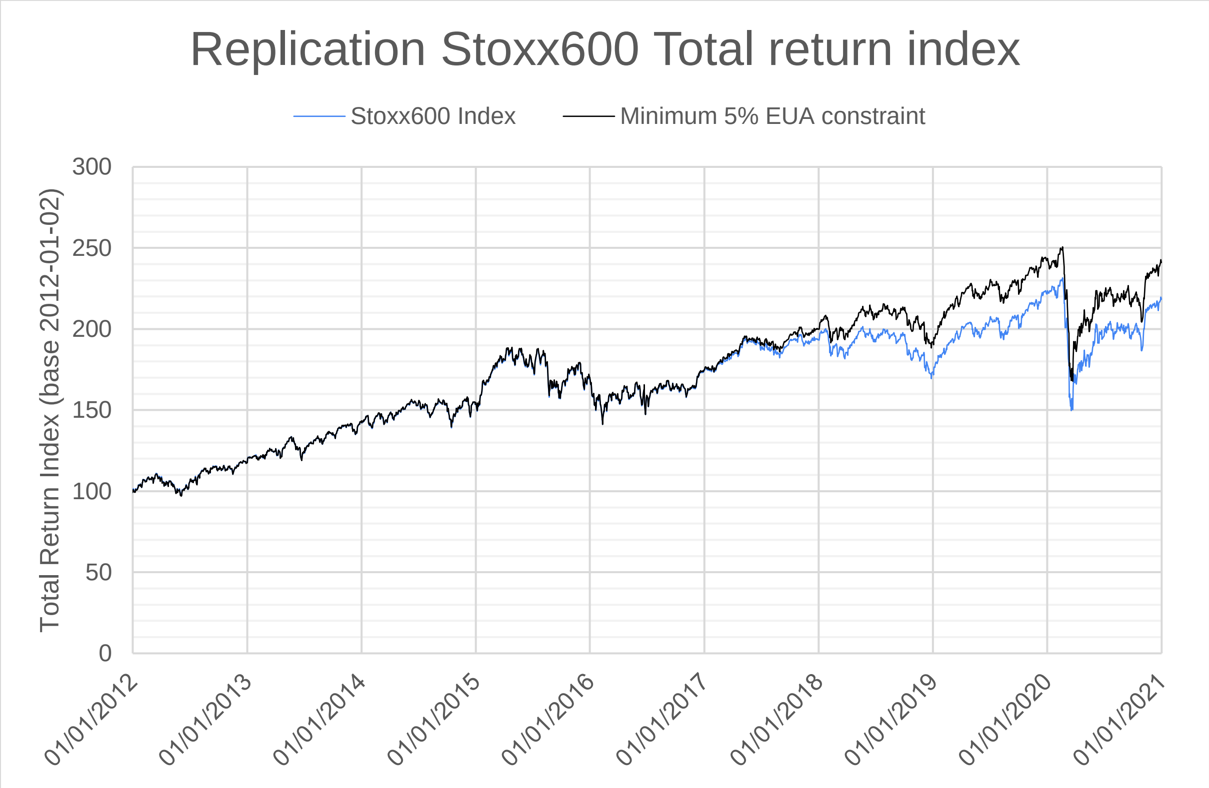

Figure 5.4

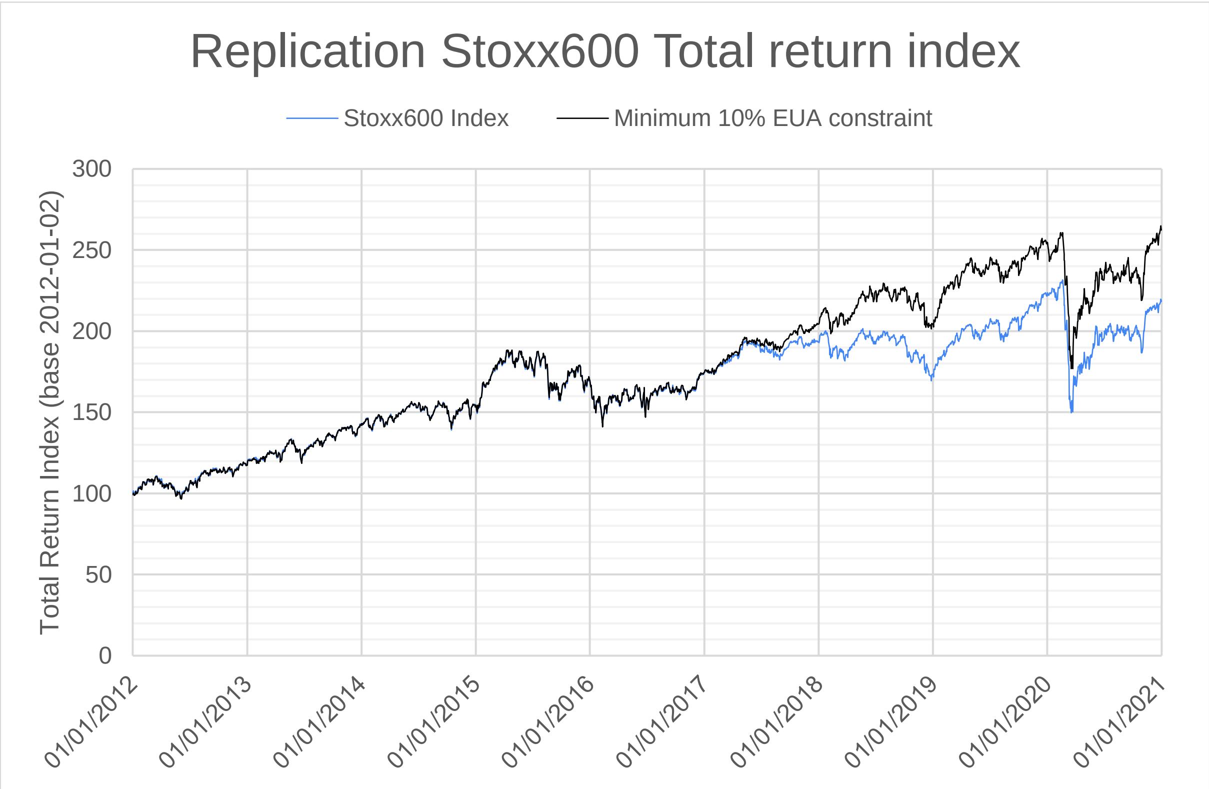

Figure 5.5

The portfolios produced with EUA constraint all have negative carbon emissions per million invested. The low price of carbon emissions futures during the period may be an explanation of such surprising results. In 2020, the average price was 25.18 €, compared to the average price in 2022 of 80.93 €. For example, the 1% EUA constraint (10’000 € per million invested), can offset 397 tonne of CO2 emissions per million invested with the average 2020, but only 123 tonne with the 2022 average price. The replicated portfolio has an average of 374 tonne of CO2 emissions per million invested during the 2012-2020 period. Thus, as carbon price increases, the cost to hedge the portfolio increases, even if the replicated portfolio carbon footprint decreases.

A possibility could be to use decarbonized portfolio to reduce the cost of the carbon hedging. But as mentioned before, they present other trade-off for investors, such as underweighting some sectors or increasing tracking error.

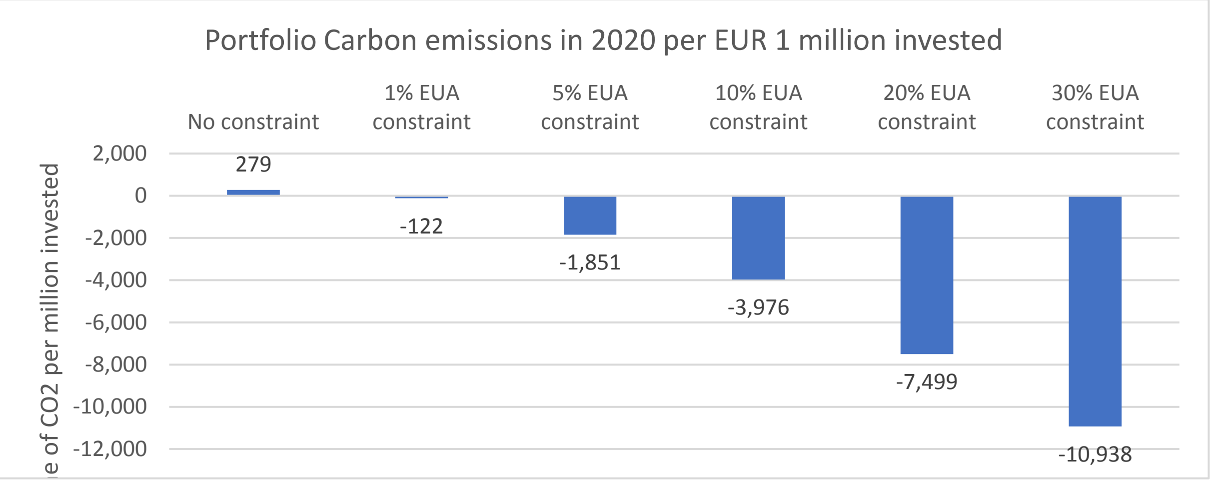

Figure 5.6

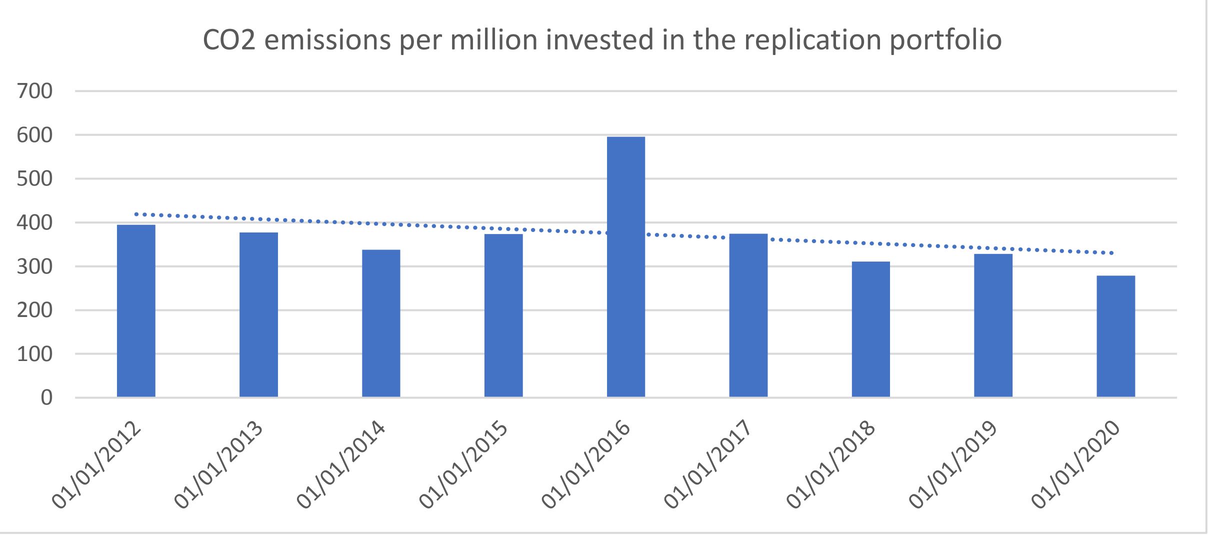

Figure 5.7

Multiple improvements could be made over this carbon risk hedging strategy. The scope could be extended to cover more recent development for carbon market. Including other carbon trading market into the analysis could change the dynamic of the carbon hedge. While they are not as developed as the EU ETS, they had the benefits of hindsight. As such, other countries have distinctly different carbon trading systems.

Finding the optimal mix of strategies between decarbonization and carbon risk hedging could also be an important improvement. Highlighting the trade-off between decarbonization and carbon risk hedging would improve investors understanding.

Other general improvement over the accounting of carbon emissions would also improve all portfolio with a carbon emissions reduction goal. Carbon added valuation of firm (analogue to value added approach to GDP), perhaps by proxying the electricity production/consumption, could really help in assigning precisely carbon contribution.

6 Conclusion

With strong indication that more carbon taxation and regulation will be enacted in the medium to long term, we showed a simple method to hedge against carbon risk. European carbon allowances futures were selected for their attractive properties, mainly their direct correlation with European regulation and their perfect negative correlation with CO2 emissions. Filtering by ESG score, as a method to reduce carbon risk exposure, was rejected because of the methodology used to produce the scoring, namely peer comparison. Decarbonization of an index is also a viable tool to limit carbon exposure and can be used beside hedging the risk.

Next, we construct an index, where European carbon allowances futures are used to eliminate the carbon exposure, while minimizing the tracking error compared to a benchmark. This method can be used as a supplement to other method to decarbonize index or standalone to protect against carbon risk. While carbon costs are not priced entirely the expected profits match the benchmark index, but excess profits can be expected if carbon risk materialize or are anticipated by markets.

Further improvement can be made by identifying the optimal mix between carbon risk exposure, carbon risk reduction and carbon risk hedging. In addition, applying the model to other geographic area with carbon trading market could improve the comprehension of carbon hedging in general.

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