Estimating the Impact of COVID-19 on Emissions and Emission Allowance Prices Under EU ETS

BY KENNETH BRUNINX AND MARTEN OVAERE

Introduction

The COVID-19 pandemic has upended the world economy: factories are idle, planes are grounded, and people are locked in their homes. This decrease in economic activity has significantly decreased energy use and carbon emissions. Evaluating the effect of the first three weeks of lockdown in Europe, we estimate that carbon emissions under the European Union Emissions Trading Scheme (EU ETS) are around 38 MtCO2 lower per month than usual. Under a cap and trade system, this unanticipated negative demand shock would only decrease the price of emission allowances, but not how much is emitted in total under the fixed cap. Starting in 2023, however, a cancellation policy will be in effect, such that a fraction of surplus allowances in the EU ETS' market stability reserve (MSR) will be canceled (see Bruninx et al. (2020) and European Union (2018) for all details). Because the amount of cancellation is conditional on the surplus of allowances, the negative demand shock from COVID-19 might affect both the price of emission allowances and cumulative emissions. Using the long-term equilibrium model of Bruninx et al. (2019), we show across a range of negative demand shocks that the MSR and the cancellation mechanism do exactly what they are designed to do. A negative demand shock has very limited effect on emission allowances prices and is largely translated into lower cumulative carbon emissions.

In the remainder of this paper, we subsequently estimate the size of the negative demand shock in the EU ETS (Section 2) and its impact on emission allowance prices and cancellation volumes (Section 3). Last, we discuss the implications of this analysis and suggest some directions for further analysis.

Estimating the negative demand shock

The European Union Emissions Trading Scheme (EU ETS) limits emissions from the electric power sector, the energy-intensive industry and intra-European aviation. This cap-and-trade system covers around 45% of the EU's greenhouse gas emissions, equaling 1749 MtCO2 in 2018 (European Environmental Agency, 2020). To estimate the size of the negative emission allowance demand shock, we identify the change in monthly emissions from the three sectors covered by the EU ETS below.

First, we estimate the change of emissions from electricity generation, based on the methodology of Ovaere and Gillingham (2019). We run a regression analysis using more than five years of hourly electricity generation by technology from ENTSO-E (2020). Based on this analysis, we are able to identify the change in average, hourly output of carbon-emitting electricity generation technologies due to the COVID-19 pandemic.

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Note: Instead of asking for exact figures, these surveys ask for the direction of change compared to a normal production level. Possible answers are above normal/normal/below normal. The presented number is the difference between percentages of respondents giving favorable and unfavorable answers, while the "normal" answers are ignored.

		Gas	Lignite	Hard coal	Oil
Belgium	(MWh/h)	-770***	/	/	0
Czechia	(MWh/h)	-69***	38***	-581***	12***
France	(MWh/h)	-1114***	/	58	16
Germany	(MWh/h)	-2861***	-1873***	-2860***	-91***
Great Britain	(MWh/h)	-1037***	/	-1881***	0
Netherlands	(MWh/h)	-41	/	+568***	/
Portugal	(MWh/h)	-1	/	+85***	/
Spain	(MWh/h)	-3433***	317***	1449***	3
Total	(MWh/h)	-9427	-3152	-1519	-59
Carbon intensity	(tCO_2/MWh)	0.374	0.97	1.04	0.624
Change in carbon emissions	(tCO_2/h)	-3526	-3057	-1580	-37

Note: $p<0.05$ (*), $p<0.01$ (**), $p<0.001$ (***).

Table 1 Effect of COVID-19 lockdown in different countries on average, hourly output of carbon-emitting electricity generation technologies (MWh/h)

We add month fixed effects and non-linear time trends to control for regular patterns in generation output and for broader time trends impacting output by conventional generation technologies. We run a separate regression for every carbon-emitting generation technology (natural gas, lignite, hard coal and oil) and in each European country of our sample. In this analysis, we consider Belgium, Czechia, France, Germany, Great Britain, Netherlands, Portugal and Spain. Together they consist of 65% of EU ETS electricity generation.

We find that in our sample, gas generation decreases on average by 9427 MWh/h, lignite by 3152 MWh/h, hard coal by 1519 MWh/h and oil-fired generation by 59 MWh/h (Table 1). This is a decrease of respectively 22%, 19%, 13% and 7% compared to the 2019 average (ENTSO-E, 2020).

Combined with the assumed carbon intensity for gas, lignite, hard coal and oil listed in Table 1, carbon emissions from electricity generation are estimated to be 8200 tCO_2/h lower in our sample. Extrapolating these estimates and correcting for the scope of our sample (65%), every additional month of similar lockdown measures would decrease electricity-related carbon emissions by 9 $MtCO_2$.

Second, aviation has decreased by 90% (Statista, 2020), from a pre-COVID 2018 level of 67 $MtCO_2$ per year (European Environmental Agency, 2020). This leads to a decrease of around 5 $MtCO_2$ aviation-related EU ETS emission for every additional month of similar lockdown measures.

Last, data for idle industrial production is not yet available for March 2020, but we can make an educated guess of the impact by looking at the business tendency survey of European countries for March 2020 (OECD, 2020). For example, the March 2020 future production tendency of manufacturing firms in the Euro area dropped to -9.4, down from 4.7 in February 2020, meaning that in the span of one month, the share of optimistic manufacturers decreased with 14.1%.▯ This decrease is even more pronounced in countries like Italy (-23.9), Czechia (-20.6) or Germany (-18.2). Similarly, the confidence indicator dropped by 28.6 in China in February 2020. We assume that industrial production activity decreased by 50%, or 24 $MtCO_2$ per month from a pre-COVID 2018 level of 584 $MtCO_2$ per year (European Environmental Agency, 2020). Hence, in what follows, we use a negative demand shock of 40 $MtCO_2$ per month that the lockdown is extended in its current form.

The impact on cumulative emissions & emission allowance prices

We analyze the impact of this negative demand shock on the emission allowance price and allowed emissions under EU ETS, leveraging our stylized EU-ETS-MSR model (Bruninx et al., 2019). This model is based on the detailed long-term investment model of Bruninx et al. (2020) and assumes rational, price-taking and risk-neutral firms that optimize their abatement and banking actions over the complete EU ETS horizon. We study three demand shock scenarios, starting from an initial demand shock of 120 $MtCO_2$ (i.e., a three month lockdown) or 240 $MtCO_2$ (i.e., a six month lockdown) in 2020:

A V-shaped demand shock, in which carbon emissions return to a business-as-usual before the end of 2020. The total negative demand shock is, hence, 120 $MtCO_2$ or 240 $MtCO_2$.

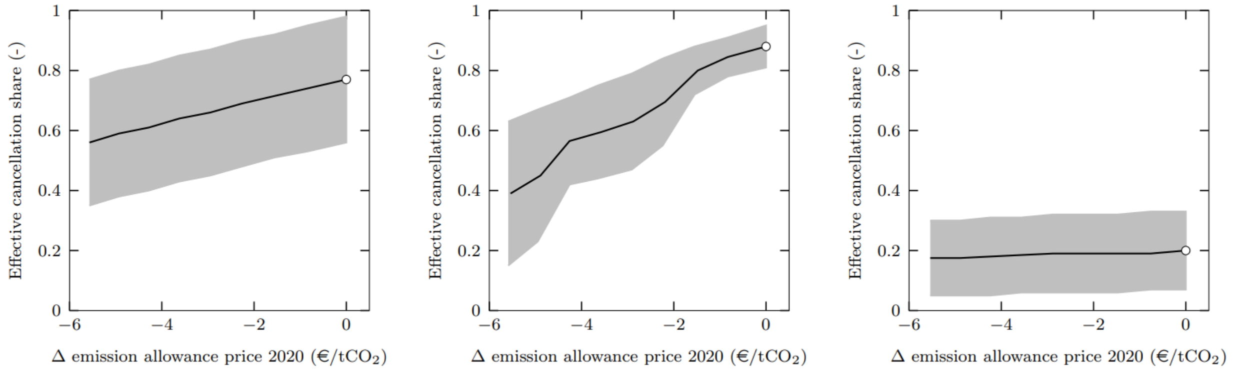
- A U-shaped demand shock, which gradually vanishes between 2020 and 2025. In these scenarios, we assume the demand shock linearly decreases from its initial value in 2020 to zero at the end of 2025. The total negative demand shock is, hence, 420 $MtCO_2$ or 840 $MtCO_2$.
- A persistent demand shock, in which 25% of the initial demand shock becomes permanent post2020. The total negative demand shock is, hence, 1470 $MtCO_2$ or 2940 $MtCO_2$.

In each scenario, the state of the EU ETS at the end of 2019 is fixed, based on the records of the surplus in the market, the holdings of the MSR and the emissions up to 2019 (European Commission, 2019). Verified emissions for 2019 are estimated to be 10% lower than emissions in 2018 (Sandbag, 2020).

Since the marginal abatement cost curve the EU ETS is fundamentally uncertain, we run each demand shock scenario with a linear, quadratic and cubic marginal abatement cost curve, following (Bruninx et al., 2019). Baseline emissions are set to 1900 $MTCO_2$, as in Perino and Willner (2017). The discount rate is set to 10% and inflation equals 2% per year. The slope of each abatement cost curve is calibrated to reproduce the average 2019 emission allowance prices (24.7 e/tCO_2, based on EEX (Last accessed: April 1, 2020)) without the negative demand shock. If this calibration yields marginal abatement costs at historical emission levels in 2018 below 0.1 e/tCO_2, this case is not retained in the results (Bruninx et al., 2019).

As a first result, we find in our model that the MSR and its cancellation mechanism are very effective at stabilizing the emission allowance price in response to negative demand shocks. The allowance price in 2020 decreases by less than 0.1e/tCO_2 and this result holds for different marginal abatement cost curves, magnitudes or shapes of the shock. As a second result, we find that the demand shocks differ in their effect on cumulative emissions. In general, short-lived V- and U-shaped shocks are translated largely into lower cumulative emissions, because the MSR absorbs and cancels the increased allowance surplus. On the other hand, persistent demand shocks decrease cumulative emissions much less, as a significant part of the demand shock occurs far away in the future, after the market stability reserve has stopped absorbing and cancelling emission allowances.

In reality, however, the price of EU emission allowances has dropped significantly, by around 6 e/tCO_2. Because this does not happen in our model with rational, price-taking, risk-neutral and perfectly optimizing firms, we adapt our model such that we do observe price shocks. We do this by assuming that firms temporarily change their discount rate by one to eight percentage points during the shock. A temporary change in discount rates makes banking of allowances during the shock less profitable, i.e., it is better to secure the required allowances for future emissions after the shock. This may reflect the situation that many utilities and companies face today: as their financial positions are stressed, they may liquidate assets – such as emission allowances procured to cover future emissions – to improve their cash position. Similarly, they won't have cash to spare to bank emission allowances for compliance with future emissions. Note that in the persistent demand shock



(a) V-shaped negative demand shock (b) U-shaped negative demand shock (c) Permanent negative demand shock

Figure 1 Summary of the results, separated according to the type of shock. The change in emission allowance price in 2020 is calculated by comparing the calculated emission allowance prices before and after the shock. The effectiveness of the negative demand shock is calculated as the change in allowed emissions over the simulated period (2019-2060) before and after the negative demand shock relative to the magnitude of the demand shock. An effectiveness of one means the cumulative emissions under the EU ETS decrease with an equal amount as the negative demand shock as a result of the market stability reserve's cancellation policy. The white-filled marker is obtained without a shock in the discount rate. The change in emission allowance price increases with the shock in the discount rate.

scenarios, these changes in discount rate are only enforced in 2020, whereas we assume the discount rate to evolve linearly to its original value in the U-shaped demand shock scenarios.

Figure 1 summarizes the impact of all three emission allowance scenarios on the emission allowance price (x-axis) and on the cumulative emissions cap (y-axis), represented by the effective cancellation share, which is the fraction of the demand shock that translates into lower emissions. The white-filled marker in Fig. 1 presents the average result without any change in discount rates, while the black line shows how the emission allowances price and the effective cancellation share on average drop when the future becomes less important (modeled by changing the discount rate). The gray area represents the uncertainty around this average, from the six modeled scenarios (two shocks magnitudes times three curvatures of the marginal abatement cost curve). This figure shows that the emission allowance price does not decrease because of the negative demand shock as such, but because of changes in market participants' importance of the future. Remarkably, we also find that the temporarily decreased emission allowance price leads to a lower effective cancellation share. This happens because emission abatement is temporarily less profitable, such that part of the negative demand shock is offset by lower abatement, before the surplus is absorbed and canceled by the market stability reserve.

Conclusion

The COVID-19 pandemic has brought the world's economy to a standstill. In this paper, we estimate the impact of this temporary downturn in economic activity on carbon emissions under the European Emission Trading system, its emission allowance prices and the effectiveness of its market stability reserve to absorb these demand shocks. First, we show that the current lockdown measures lead to emission reductions around 38 $MtCO_2$ per month: 9 $MtCO_2$ per month due to reduced electricity consumption, 5 $MtCO_2$ as the result of reduced intra-European air traffic and 24 $MtCO_2$ in avoided industrial emissions. Second, we illustrate that such negative demand shocks as such do not explain the observed drops in emission allowance prices, as the market stability reserve is able to absorb these demand shocks to a large extent. However, if temporary changes in companies' perception of the profitability of banking emission allowances lead to price decreases, a rebound effect may occur, leading to lower effectiveness values. Hence, if one reduces the impact of an event such as the COVID-19 pandemic to the emission allowance demand shock as such, one may overestimate the ability of the market stability reserve to absorb these shocks.

The presented analysis is, however, based on a stylized representation of the abatement options and costs under EU ETS. Exploring more detailed representations of these abatement options and costs, as in Bruninx et al. (2020), as well as the impact of an event like the COVID-19 pandemic on these abatement costs and options, e.g., through changes in fuel prices, may lead to additional insights. Further work may also focus on the exploration of the impact on emission allowance price paths beyond 2020 and price path recovery.

Acknowledgement K. Bruninx is a post-doctoral research fellow of the Research Foundation - Flanders (FWO) at the University of Leuven and EnergyVille. His work was funded under postdoctoral mandate no. 12J3320N, sponsored by FWO.

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