

# Carbon Prices and the Skill Premium

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The views expressed here are those of the authors, and not necessarily those of the Norges Bank.

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We study how **higher EU ETS carbon price** affects **workers**

- Consequences for employees are important for the welfare and firm performance
- Being a market-based policy, ETS allows firms to use different margins of adjustment
- Ex ante, the effect is not obvious!

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→ Two channels interact with each other
4. No effects on hiring/separation



- **Climate policies:**

EU ETS & Firm behavior: Decline in emissions without a worsening in performance (Martin et al. 2014, Calel&Dechezlepretre 2016, Marin et al. 2018, Bolton et al. 2023, Dechezlepretre et al. 2023, Colmer et al. 2024)

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- Determinants of wage differences among workers and firms (Acemoglu 1998, Autor et al. 2003, Acemoglu et al. 2012)

→ Carbon prices may influence these differences due to skills and policy design

→ Importance of the design of the carbon market

The EU ETS is a cap-and-trade program

- The EU sets an annual emission amount and issues allowances accordingly
  - 40% of emissions in the EU
  - Phase 1 (2005-2007), Phase 2 (2008-2012), Phase 3 (2013-2020), Phase 4 (2021-2030)
- Phase 3: Single, EU-wide cap on emissions in place of the previous system of national caps
- Main participation criteria: Installation's thermal input capacity of more than 20 MW
- Firms submit their allowances by April 30 for the previous year
  - Participants can keep or sell their unused permits
  - Not submitting leads to a fine of 100 euros per tonne + allowance

# European Union Emissions Trading System

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Permits are distributed freely or via an auction

- In Phase 3, 43% of allowances are allocated for free. The rest is auctioned.
- Free allocation = Historical activity  $\times$  Benchmark  $\times$  Carbon leakage  $\times$  Linear reduction

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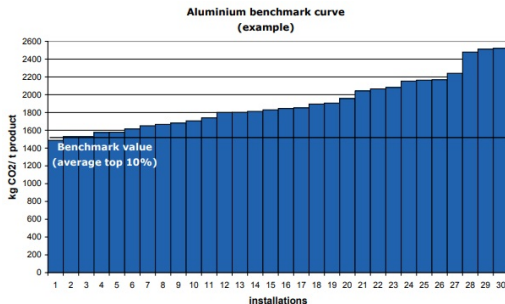
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- Benchmark: Average emission of the best 10 percent installations in that product.
- Carbon leakage: Sectors exposed to carbon leakage receive higher free allowances.

| Share of free allocation calculated based on benchmarks per sector | 2013 | 2014  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020 |
|--|------|-------|-------|-------|-------|-------|-------|------|
| Electricity production   | 0%   | 0%    | 0%    | 0%    | 0%    | 0%    | 0%    | 0%   |
| Industry sectors   | 80%  | 72.9% | 65.7% | 58.6% | 51.4% | 44.2% | 37.1% | 30%  |
| Industry sectors deemed exposed to carbon leakage                  | 100% | 100%  | 100%  | 100%  | 100%  | 100%  | 100%  | 100% |

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- Carbon leakage: Sectors exposed to carbon leakage receive higher free allowances.
- Linear reduction reduces total allowances every year

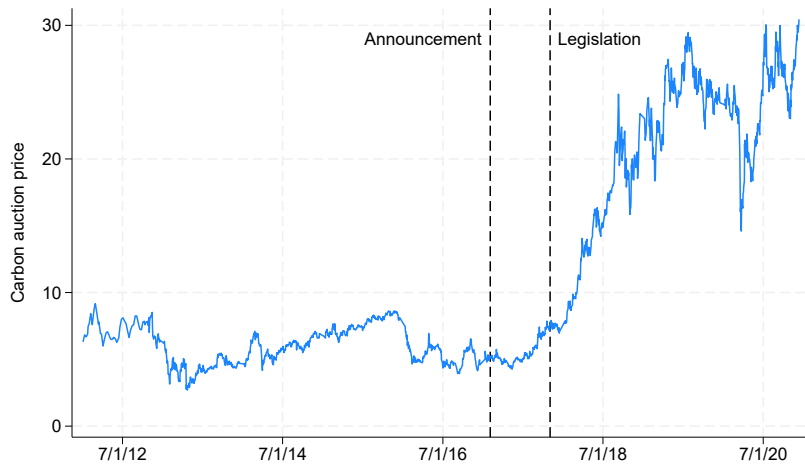
| Year   | 2013   | 2014   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   |
|--|--------|--------|--------|--------|--------|--------|--------|--------|
| Linear reduction factor<br>(electricity generators)              | 1      | 0.9826 | 0.9652 | 0.9478 | 0.9304 | 0.9130 | 0.8956 | 0.8782 |
| Cross sectoral correction factor<br>(non-electricity generators) | 0.9427 | 0.9263 | 0.9098 | 0.8930 | 0.8761 | 0.8590 | 0.8417 | 0.8244 |



- ETS, labor market, firm characteristics, individual characteristics
  1. ETS transactions log: Carbon emissions, free allowances (EUTL)
  2. Labor market: Wage components, hours obtained from employee-employer matched data (CBS)
  3. Firm characteristics: Balance sheet, income statement, sector (CBS)
  4. Individual characteristics: Education, age (CBS)
  5. We manually match EUTL variables with CBS variables
- 2014-2020 (Phase 3), annual

- The carbon price until 2017 was deemed to be too low to incentivize the firms (€5)
  - Low economic activity & structural oversupply
- In 2015, the Market Stability Reserve (MSR) is announced to start operations in 2019
  - MSR's main purpose is to absorb the oversupply of allowances
- In Feb 2017, the EU increases the MSR's absorption capacity significantly
  - Absorption of 24% of unused allowances instead of 12% if unused is above a threshold
  - Permanent cancellation of allowances
  - Legally introduced in Nov 2017
- These changes have increased the carbon prices in ETS substantially!

# Carbon Prices



- Firm's profit

$$p \times f(A_f, L_{ft}, K_{ft}) - w_{ift} L_{ft} - p_c \times (C_{ft}(A_f) - F_s)$$

# Conceptual Framework

- Firm's profit

$$p \times f(A_f, L_{ft}, K_{ft}) - w_{ift} L_{ft} - p_c \times (C_{ft}(A_f) - F_s)$$

- Nash bargaining determines the wages, yielding:

$$\max_{w_i} (w_i - \omega_i)^\beta (V_j(p_c) + V_i(p_c) - w_i)^{(1-\beta)}$$

where  $w_i$ : salary;  $\omega_i$ : outside option;  $V_j$ : Firm-level surplus;  $V_i$ : Worker-level surplus

- Straightforward to show that

$$\frac{\partial w_i}{\partial V_j} > 0; \quad \frac{\partial w_i}{\partial V_i} > 0; \quad \frac{\partial w_i}{\partial V_i} \Rightarrow \omega_i \uparrow$$

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- $p_c$  can increase OR decrease firm surplus, hence wages
- Workers related to carbon efficiency can have higher wages  
→ Especially workers with better outside options

Exploit the increase in carbon prices in a matched difference-in-differences setting:

$$y_{it} = \beta ETS_i \times Post_t + \gamma_i + \delta_t + \epsilon_{it}$$

Event-study version:

$$y_{it} = \sum_{\tau=-3}^3 \beta_{\tau} ETS_i \times \mathbb{1}(t = t^* + \tau) + \gamma_i + \delta_t + \epsilon_{it}$$

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Matching is done at two levels:

- Worker level: matching on two lags of log(wage), age, part-time, tenure, and gender dummies
- Firm level: matching on industry, log(# employees), and profits per worker

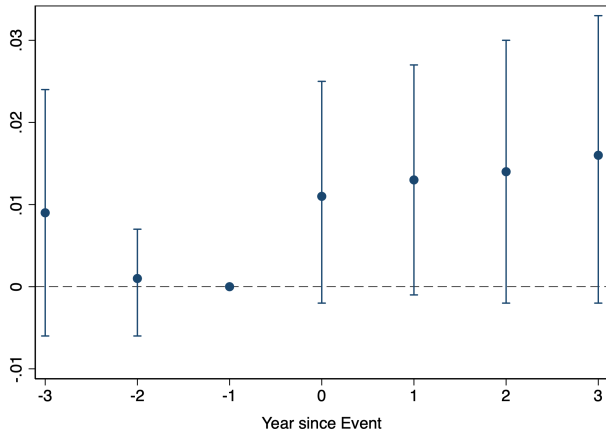
## Balance Test

- ETS firms are larger and more profitable, workers are older and earn more
- Differences insignificant after matching

| <i>Sample:</i><br>Variable | Full Sample       |                    |                    | Matched Sample     |                    |                     |
|----------------------------|-------------------|--------------------|--------------------|--------------------|--------------------|---------------------|
|                            | Control           | Treated            | Difference         | Control            | Treated            | Difference          |
| Age <sub>t-1</sub>         | 42.82<br>(0.125)  | 44.395<br>(0.408)  | 1.575<br>(0.426)   | 45.166<br>(0.218)  | 45.173<br>(0.272)  | 0.007<br>(0.348)    |
| log(Wage <sub>t-1</sub> )  | 10.302<br>(0.020) | 10.796<br>(0.040)  | 0.494<br>(0.045)   | 10.84<br>(0.035)   | 10.876<br>(0.026)  | 0.036<br>(0.044)    |
| log(Wage <sub>t-2</sub> )  | 10.257<br>(0.020) | 10.756<br>(0.037)  | 0.498<br>(0.042)   | 10.804<br>(0.032)  | 10.833<br>(0.025)  | 0.029<br>(0.040)    |
| log(Size)                  | 5.461<br>(0.133)  | 8.382<br>(0.330)   | 2.921<br>(0.355)   | 6.286<br>(0.152)   | 6.248<br>(0.127)   | -0.038<br>(0.198)   |
| Profits/Employment         | 20.33<br>(1.255)  | 48.759<br>(13.779) | 28.429<br>(13.798) | 79.800<br>(12.304) | 68.625<br>(11.806) | -11.175<br>(17.028) |
| N                          | 2,868,897         | 162,543            | 3,031,440          | 23,001             | 23,001             | 46,002              |

## Baseline Effect

- Virtually no effect on wages
- Coefficients small in magnitude and insignificant



## Carbon Price Shock, Cash Flows, and Wages

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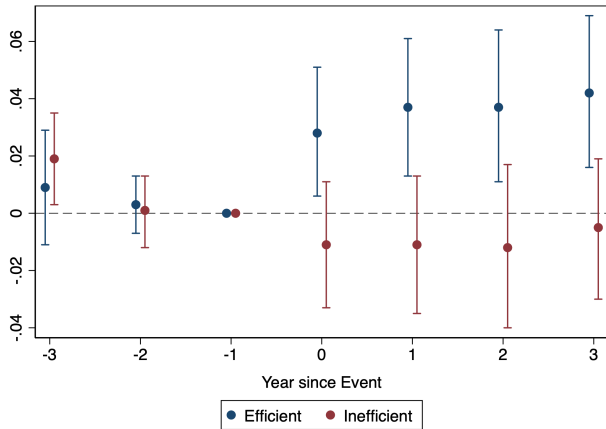
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- We sort firms in quartiles, going from the firms with highest surplus (efficient) to the firms with the highest deficit (inefficient)

## Sorting by Efficiency – Event-Study Results

- Fairly large, positive effect on wages for efficient firms
- Conversely, inefficient firms experience negative effects (albeit insignificant)





## Sorting by Efficiency – Results

- Significant effects on wages and hourly wages; marginally significant for earnings, but only for efficient firms

| Sample:        | All                                      |                     |                   |                  | Efficient                                |                     |                    |                  | Inefficient                              |                     |                    |                   |
|----------------|--|---------------------|-------------------|------------------|--|---------------------|--------------------|------------------|--|---------------------|--------------------|-------------------|
|                | (1)                                      | (2)                 | (3)               | (4)              | (5)                                      | (6)                 | (7)                | (8)              | (9)                                      | (10)                | (11)               | (12)              |
| ETS×Post       | 0.009<br>(0.006)                         | 0.009<br>(0.008)    | 928.0*<br>(525.3) | 0.006<br>(0.004) | 0.029***<br>(0.010)                      | 0.025**<br>(0.010)  | 1145.0*<br>(623.7) | 0.001<br>(0.007) | -0.012<br>(0.010)                        | -0.024<br>(0.017)   | -436.9<br>(1246.1) | -0.001<br>(0.007) |
| Observations   | 313,316                                  | 313,316             | 322,014           | 322,014          | 82,366                                   | 82,366              | 84,350             | 84,350           | 75,607                                   | 75,607              | 77,812             | 77,812            |
| R <sup>2</sup> | 0.932                                    | 0.846               | 0.844             | 0.399            | 0.935                                    | 0.863               | 0.865              | 0.400            | 0.933                                    | 0.840               | 0.845              | 0.390             |
| Dep. Var.      | $\log(\frac{\text{Wage}}{\text{Hours}})$ | $\log(\text{Wage})$ | Earnings          | Employed         | $\log(\frac{\text{Wage}}{\text{Hours}})$ | $\log(\text{Wage})$ | Earnings           | Employed         | $\log(\frac{\text{Wage}}{\text{Hours}})$ | $\log(\text{Wage})$ | Earnings           | Employed          |

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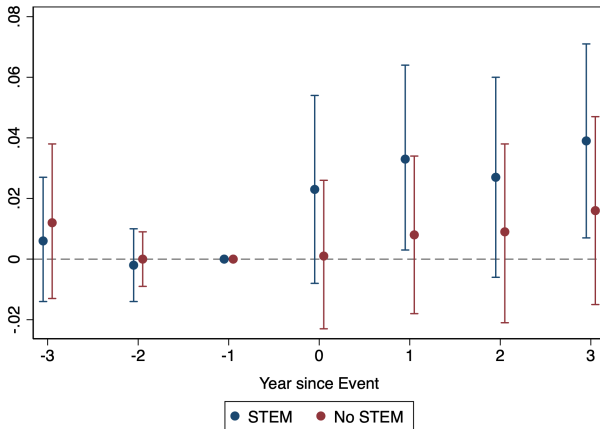
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- We hypothesize that STEM (engineering, math/physics, and computer science majors) are the most valuable to cut emissions (Vona et al. 2018, Saussay et al. 2023)
- The increase in their “market value” is likely to be reflected in higher wages



## Education – Event-Study Results

- Positive effect of shock on wages only for STEM workers
- Small and insignificant for all the others





## Education vs Firm Efficiency

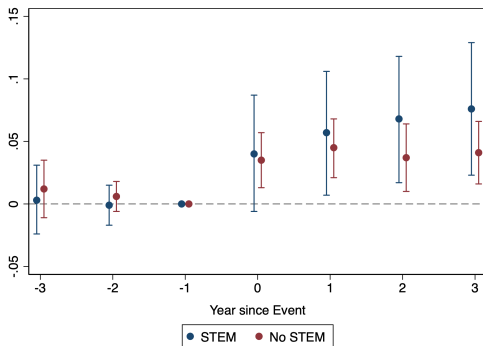
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- Are results driven by STEM workers being concentrated in efficient firms?

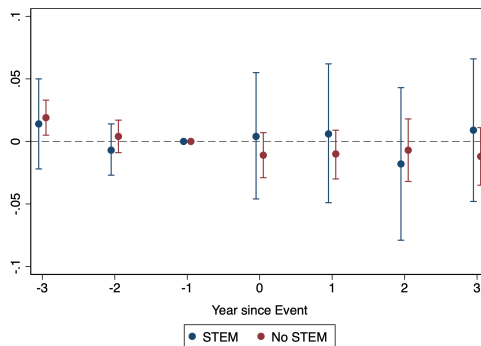
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- No: Effects are distinct

A. Efficient Firms



B. Inefficient Firms



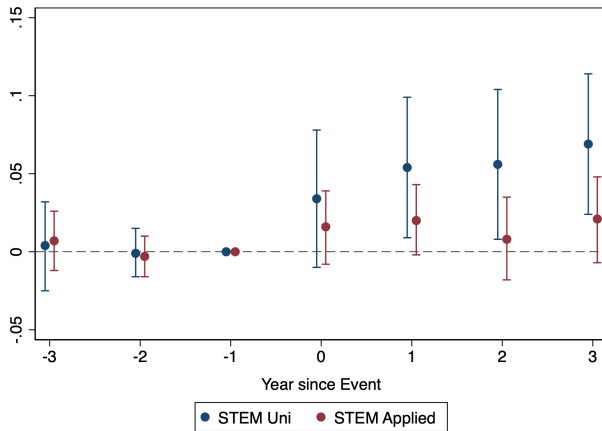
## Education – Zooming in on STEM Workers

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- Results larger for the former



- Null effects for Non-STEM graduates, similar to workers with no degrees at all
- Only STEM workers benefit from increase in carbon price

|                   | (1)              | (2)              | (3)              | (4)              | (5)              | (6)                | (7)                | (8)              |
|-------------------|------------------|------------------|------------------|------------------|------------------|--------------------|--------------------|------------------|
| ETS $\times$ Post | 0.010<br>(0.006) | 0.014<br>(0.011) | 0.028<br>(0.015) | 0.006<br>(0.010) | 0.008<br>(0.011) | 0.026**<br>(0.012) | 0.050**<br>(0.018) | 0.012<br>(0.010) |
| Observations      | 98,779           | 80,167           | 32,435           | 47,732           | 49,332           | 30,835             | 12,261             | 18,574           |
| R <sup>2</sup>    | 0.905            | 0.912            | 0.907            | 0.906            | 0.911            | 0.916              | 0.912              | 0.908            |
| Sample            | No<br>Degrees    | Some Uni         | Uni              | Appl. Sc.        | No STEM          | STEM               | STEM<br>Uni        | STEM<br>Appl.    |

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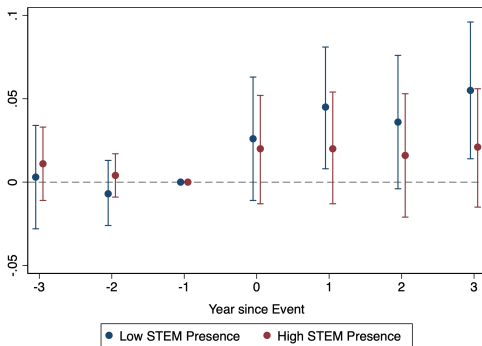
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  2. A dummy equal to one if the worker is a “switcher,” i.e., has previously changed job

- The wage of a high-skill worker can also depend on their outside options ( $\omega_i$ )
- We use two proxies
  1. The fraction of STEM workers in the province
    - Intuition: A STEM worker should be in high demand if they leave the firm
  2. A dummy equal to one if the worker is a “switcher,” i.e., has previously changed job
    - Intuition: Threat of quitting more credible

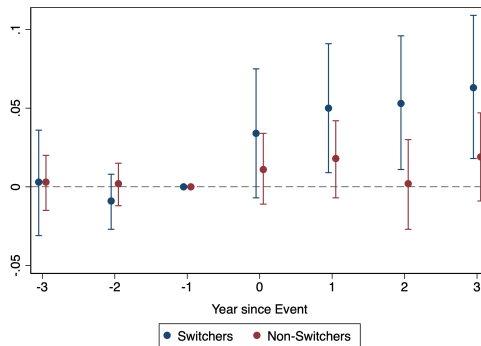
# Outside Options – Results

- Distinguish workers between:
  - A. High vs low density of STEM graduates
  - B. Switchers vs non-switchers

A. Sorting by Density of STEM Graduates



B. Job Switchers vs Non-Switchers



## Extensive Margin Results

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## Extensive Margin Results

- Two approaches to test whether increase in carbon price leads to changes in the extensive margin:
  1. Look at changes in the fraction of STEM workers (columns 1 and 2)
  2. Look at likelihood that a hired/separated worker is STEM (columns 3 and 4)
- No significant effects
- Suggests that, in the short run, labor supply is quite inelastic → large wage effects

|                | (1)                                | (2)  | (3)              | (4)              |
|----------------|------------------------------------|--|------------------|------------------|
| ETS × Post     | 0.002<br>(0.004)                   | 0.001<br>(0.004)                           | 0.008<br>(0.006) | 0.010<br>(0.008) |
| Observations   | 1,926                              | 1,926                                      | 294,174          | 278,496          |
| R <sup>2</sup> | 0.944                              | 0.952                                      | 0.101            | 0.144            |
| Dep. Var.      | $\frac{\text{STEM}}{\text{Total}}$ | $\frac{\text{STEM Hr.}}{\text{Total Hr.}}$ | STEM Hire        | STEM Sep.        |



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- Workers in efficient firms experience wage gains
- Strong evidence of increased demand for high-skill workers
- However, with limited supply of STEM workers in the short run, little room for additional hiring
- As a result, high-skill workers reap all the benefits → increase in the skill premium