Zurich University
of Applied Sciences

School of
Management and Law

Taxes versus Targets: An Empirical Analysis of two Policy Instruments on Greenhouse Gas Mitigation in the Industry and Service Sector

Building Competence. Crossing Borders.

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thomas.leu@zhaw.ch, 28 September 2022, Presentation at the Energy Evaluation Europe Conference

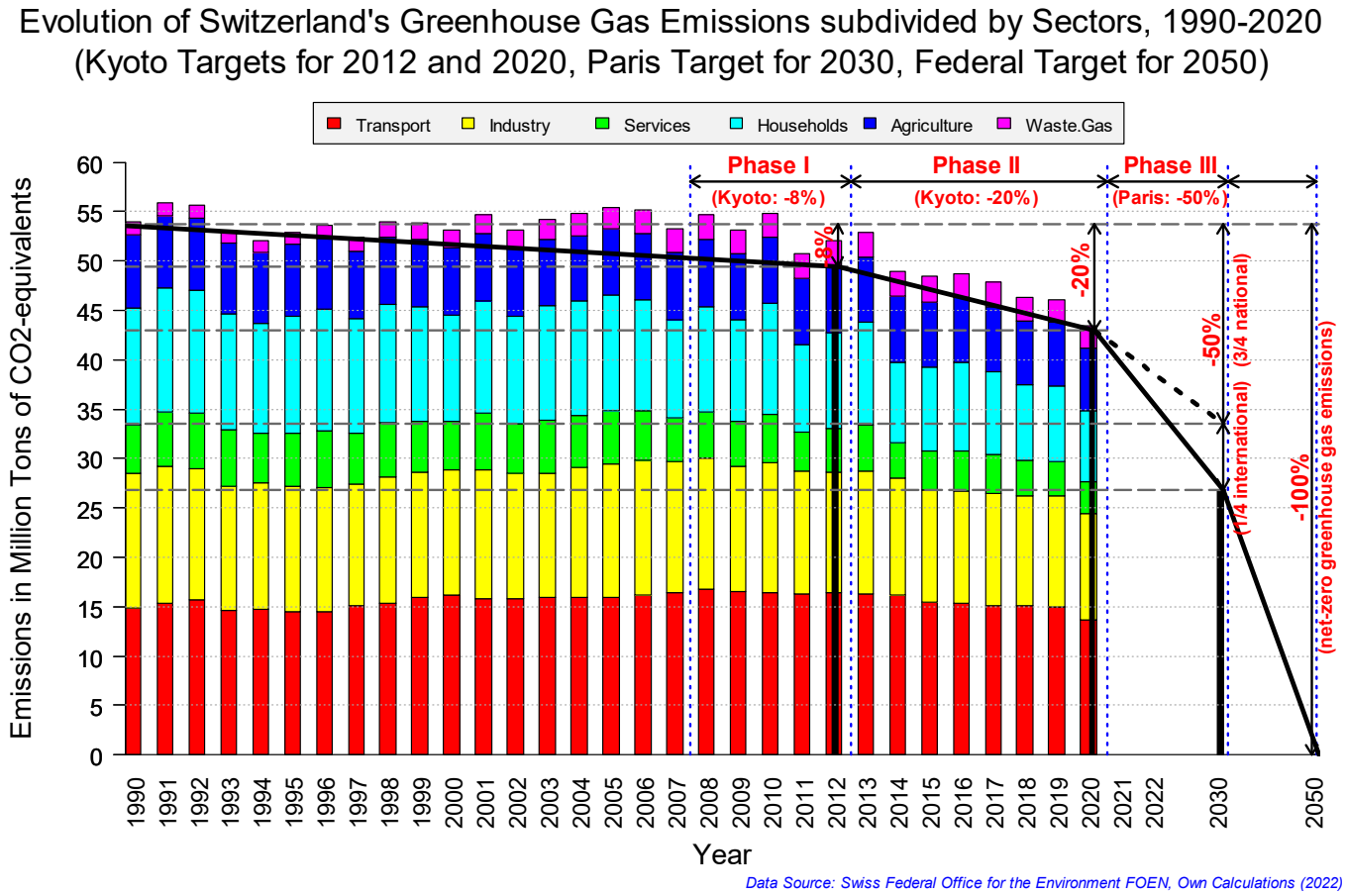
Motivation

- What is the effect of the Swiss climate policy mix on firms' energy consumption and CO_2 emissions in the industry and service sector?
- Is it possible to quantify a difference in the mitigation effect between a mandatory CO_2 levy and binding reduction target agreement.
- What are the challenges when facing such a research question?

Outline of the Presentation

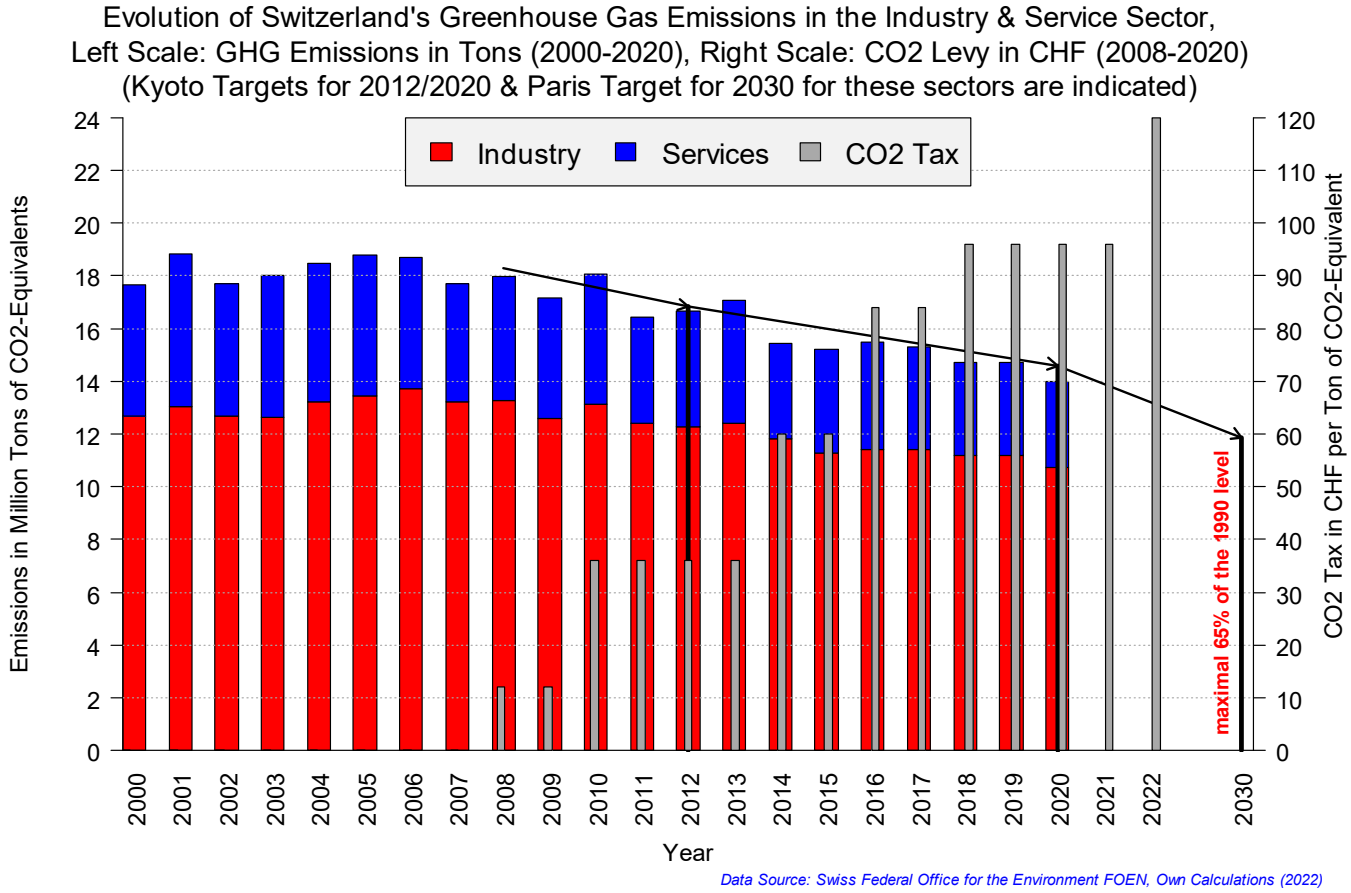
- Introduction to the topic
- Descriptive overview of the energy consumption and GHG emissions in the industry and the service sector
- Switzerland's energy and climate policy instruments for the industry and the service sector
- The CO_2 levy and economic incentives
- Project and research question
- Description of the underlying two different databases
- Strategy for linking these two datasets
- Empirical strategy and descriptive overview
- Results from a previous study taking into account only the CO_2 tax
- Conclusion and outlook

Evolution of Switzerland's Greenhouse Gas Emissions by Sector, Aggregate Data 1990 – 2020



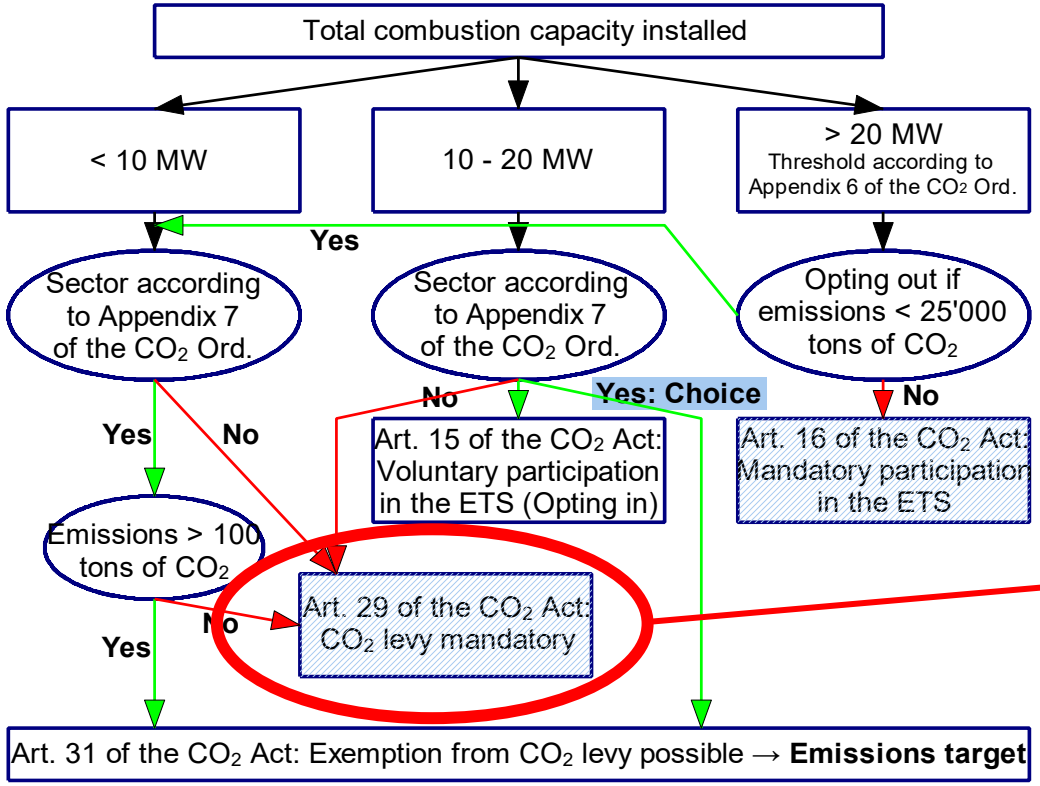
- In 2020, the industry and service sector account for 32.3% (**yellow** and **green** bars) of the total greenhouse gas emissions of 43.4 million tons of CO_2eq.

Evolution of Switzerland's Greenhouse Gas Emissions in the Industry & Service Sector, Aggregate Data 2000 – 2020



- The sectoral interim target path towards a maximum of 65% of the 1990 level in 2030 is indicated.
- The sectoral target of the CO_2 Ordinance is likely to be achieved.

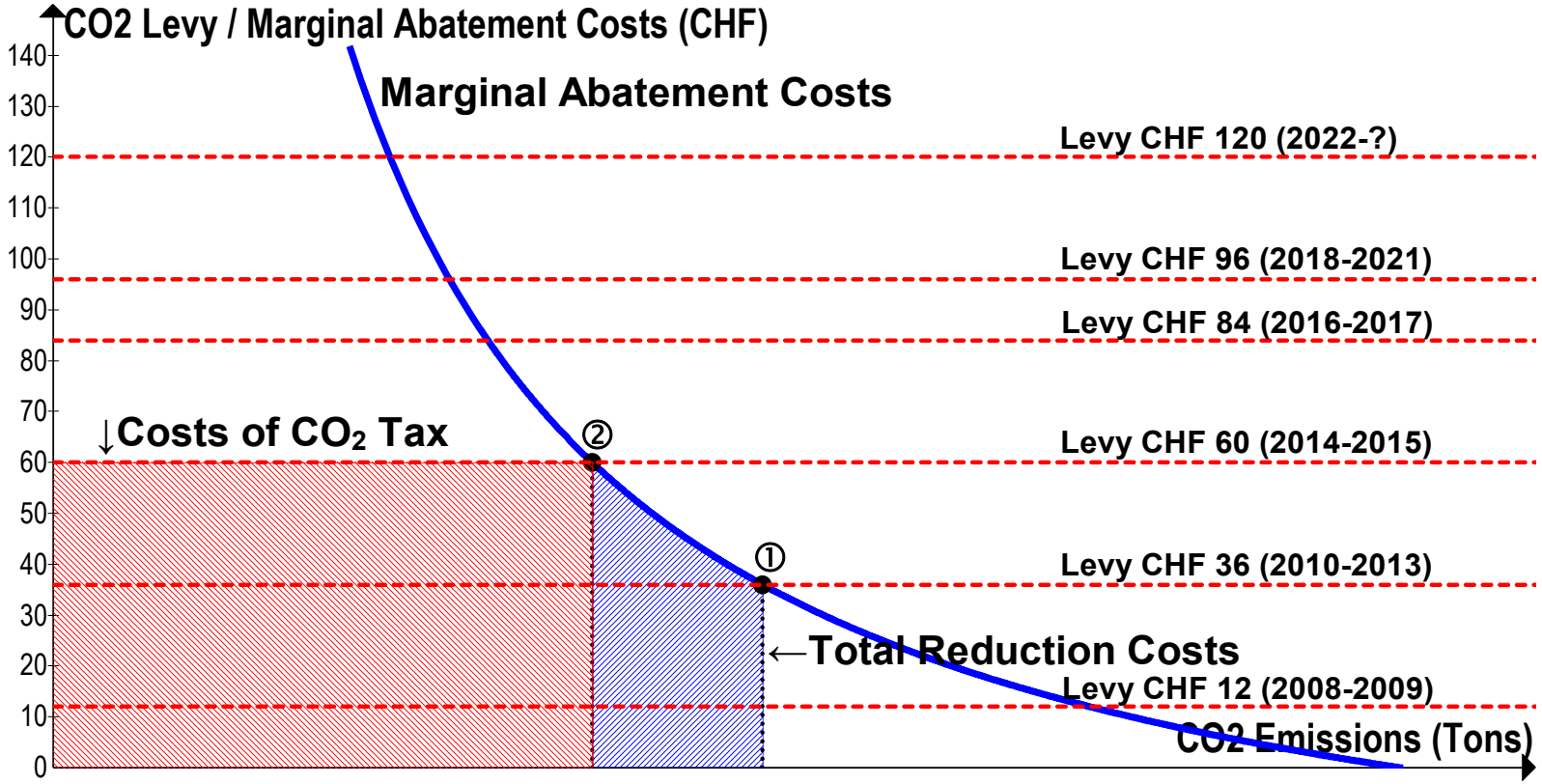
The three main Climate Policy Instruments available in the Swiss Industry & Service Sector



The CO_2 levy is the instrument for the majority of the installations.

- **CO_2 levy on fossil heating and process fuels:**
  Carbon tax imposed on fossil heating fuels (Default for the majority of the installations).
- **Emissions trading scheme (ETS):**
  Mandatory for 56 CO_2-intensive companies («cap-and-trade»-principle, linked to EU ETS).
- **Exemption from the CO_2 levy** possible for CO_2-intensive companies under certain conditions. In return, companies have to commit to an **emissions target.**

Economic Incentives for applying for an Exemption from the CO_2 Levy



- The CO_2 Levy was increased 5 times after its introduction in 2008; last time in 2022.
- **Starting position:** CO_2 tax increases from CHF 36 to CHF 60 per ton of CO_2eq.
- A rational firm moves along the marginal abatement cost function from point ① to point ②.
- Total reduction costs: **blue area.** Tax costs: **red area.**
- The **tax costs** can be saved by committing to a target agreement.

Research Questions and Research Project

Research Questions

- What is the impact of the CO_2 tax versus the target agreements on greenhouse gas emissions mitigations in the industrial and services sector?
- Can the null-hypothesis, which states that the impact on greenhouse gas emissions mitigations does not differ between the two groups, econometrically be rejected, by applying microdata of firm behavior.

Challenges

- Two different datasets from two sources (Federal Office of Energy & Energy Agency of the Swiss Private Sector) must be linked.
- Finding an adequate econometric strategy to avoid self selection bias issues as well as the lack of a control group.

The Process of Data Collection

	A	B	C	D	E	F	G	H
1	year	ID_AST	GROUP	AVOLLZ	ATEILZ	ABGF	BVM1	CVM1
2	1999	1	13	6	0	400	0.2736	0.42982952
3	2000	1	13	5	0	NA	0.2721312	0.35835935
4	2001	1	13	6	1	NA	0.2592	0.39438018
5	2002	1	13	3	0	NA	0.2574	0.32282597
6	2003	1	13	5	1	NA	0.2664	0.32297725
7	2007	1	13	4	1	300	0.2232	0.28762922
8	2008	1	13	2	2	300	0.2124	0.2517926
9	2009	1	13	1	1	120	0.1062	0.21592337
10	2005	2	9	9	0	1160	0.112716	0.25143985
11	2006	2	9	10	1	1160	0.1116	0.21562072
12	2007	2	9	10	1	1100	0.155765	0.23830067
13	2008	2	9	10	1	1100	0.128664	0.17992377
14	2009	2	9	12	1	1100	0.107438	0.28728601
15	1999	3	18	8	7	600	0.13572	0
16	2000	3	18	15	0	650	0.126	0
17	2002	3	18	11	9	650	0.1198872	0
18	2003	3	18	10	11	650	0.1461276	0
19	2006	3	18	14	7	650	0.1389672	0
20	2007	3	18	14	9	650	0.137743	0
21	2004	4	13	28	6	8937	2.0664576	1.14911685
22	2005	4	13	27	9	8937	1.838448	0
23	2006	4	13	32	0	7880	1.7243064	0.6180768
24	2007	4	13	20	17	7880	2.641327	0
25	2009	4	13	17	15	7880	2.041344	1.26811732
26	2011	4	13	32	0	8635	2.2096224	1.25955354

ID Zielverei nbarun	Art der ZV	ID Erfassungs einheit	Noga-Code	Jahr	Energieträger	Verbrauch [MWh/a]
cec1f7fb-c	Freiwillig (ohne zukünftigen Bescheinigungsanspr	cb89fe6c-7	107100	2019	Elektrizität (Bezug)	1'097
cec1f7fb-c	Freiwillig (ohne zukünftigen Bescheinigungsanspr	cb89fe6c-7	107100	2019	Erdgas (Brennstoff)	343
cec1f7fb-c	Freiwillig (ohne zukünftigen Bescheinigungsanspr	cb89fe6c-7	107100	2020	Elektrizität (Bezug)	1'080
cec1f7fb-c	Freiwillig (ohne zukünftigen Bescheinigungsanspr	cb89fe6c-7	107100	2020	Erdgas (Brennstoff)	407
cec1f7fb-c	Freiwillig (ohne zukünftigen Bescheinigungsanspr	cb89fe6c-7	107100	2021	Elektrizität (Bezug)	1'117
cec1f7fb-c	Freiwillig (ohne zukünftigen Bescheinigungsanspr	cb89fe6c-7	107100	2021	Erdgas (Brennstoff)	405
61b0bfac-(	Reduktionspfad (individuell)	ea105669-9	139600	2013	Elektrizität (Bezug)	3'968
61b0bfac-(	Reduktionspfad (individuell)	ea105669-9	139600	2013	Erdgas (Brennstoff)	11'419
61b0bfac-(	Reduktionspfad (individuell)	ea105669-9	139600	2014	Elektrizität (Bezug)	3'765
61b0bfac-(	Reduktionspfad (individuell)	ea105669-9	139600	2014	Erdgas (Brennstoff)	10'298
61b0bfac-(	Reduktionspfad (individuell)	ea105669-9	139600	2015	Elektrizität (Bezug)	3'126
61b0bfac-(	Reduktionspfad (individuell)	ea105669-9	139600	2015	Erdgas (Brennstoff)	8'383
61b0bfac-(	Reduktionspfad (individuell)	ea105669-9	139600	2016	Elektrizität (Bezug)	2'797
61b0bfac-(	Reduktionspfad (individuell)	ea105669-9	139600	2016	Erdgas (Brennstoff)	7'704
61b0bfac-(	Reduktionspfad (individuell)	ea105669-9	139600	2017	Elektrizität (Bezug)	2'651
61b0bfac-(	Reduktionspfad (individuell)	ea105669-9	139600	2017	Erdgas (Brennstoff)	7'700
61b0bfac-(	Reduktionspfad (individuell)	ea105669-9	139600	2018	Elektrizität (Bezug)	2'608
61b0bfac-(	Reduktionspfad (individuell)	ea105669-9	139600	2018	Erdgas (Brennstoff)	7'332
61b0bfac-(	Reduktionspfad (individuell)	ea105669-9	139600	2019	Elektrizität (Bezug)	2'572
61b0bfac-(	Reduktionspfad (individuell)	ea105669-9	139600	2019	Erdgas (Brennstoff)	6'584
61b0bfac-(	Reduktionspfad (individuell)	ea105669-9	139600	2020	Elektrizität (Bezug)	2'438
61b0bfac-(	Reduktionspfad (individuell)	ea105669-9	139600	2020	Erdgas (Brennstoff)	6'439
61b0bfac-(	Reduktionspfad (individuell)	ea105669-9	139600	2021	Elektrizität (Bezug)	2'374
61b0bfac-(	Reduktionspfad (individuell)	ea105669-9	139600	2021	Erdgas (Brennstoff)	6'509

Actual Position

Goal

Step 1:
Data origin & linking key

Step 2:
Linking at the Federal Statistical Office

Step 3:
Preparation of a common data set

Data from the Energy Agency (private):
Key: UID-no. (Company level)
Data includes the choosen policy (CO_2 levy, target agreement, mandatory emissions trading)

Data from the Federal Office of Energy:
Key: BUR-no. (Plant level)
Each BUR-no. is assigned to an UID-no.
Data includes controls (area, employees, etc.)

Linking data through common key identifier (UID-no.)
Assignment of the corresponding policy

Anonymized research data set

Empirical Strategy I

<u>Step I:</u> (Data from the representative survey conducted by the Swiss Federal Office of Energy; plants exempted by the CO2 levy are identified and eliminated from the dataset):

- The causal effect of the different levels of the CO_2 tax, paid by those plants not being exempted from the tax, is empirically analyzed.
- Standard firm fixed effects regression models which control for unobserved heterogeneity of time-invariant plant-specific characteristics, such as the management's attitude toward environmental aspects, are applied.
- Regressions of the form are estimated:

$$y_{it} = D_k\tau + x'_{it}\eta + A'_t\gamma + \theta_i + \lambda t + \varepsilon_{it}$$

  - y_{it}: dependent variable for the GGE of plant i in period t
  - D_k: policy vector indicating the different tax level periods
  - x_{it}: vector of time-variant firm specific factors (firm size, number of employees, etc.)
  - A_t: Vector of economy wide indicators (heating degree-days, oil price, economy-wide activity etc.)
  - λ: Time Trend to capture technological progress.

Empirical Strategy II

<u>Step II</u>: (Data from the representative survey conducted by Swiss Federal Office of Energy are linked with the data originating from the Energy Agency of the Swiss Private Sector):

- Plants of companies which committed themselves to a binding target agreement are identified by linking the SFOE sample with data from the Energy Agency.
- As firms self-select themselves into target agreement programs, differences-in-differences estimators or other quasi experimental methods are applied to best avoid self-selection issues.
- The null-hypothesis, which states that the impact on greenhouse gas emissions mitigations does not differ between the two groups, is being tested.
- The resulting empirical evidence might provide findings that allow to distinguish the impact of the CO_2 tax opposed to that of the target agreements.

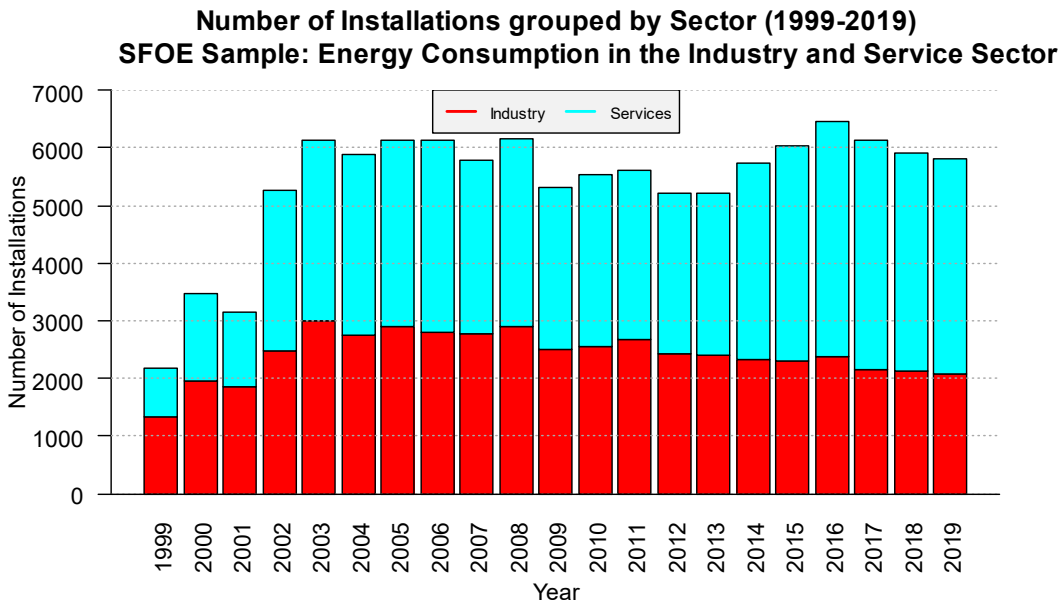
Description of the two Datasets I: Number of Installations / Firms

SFOE: Representative sample of installations:

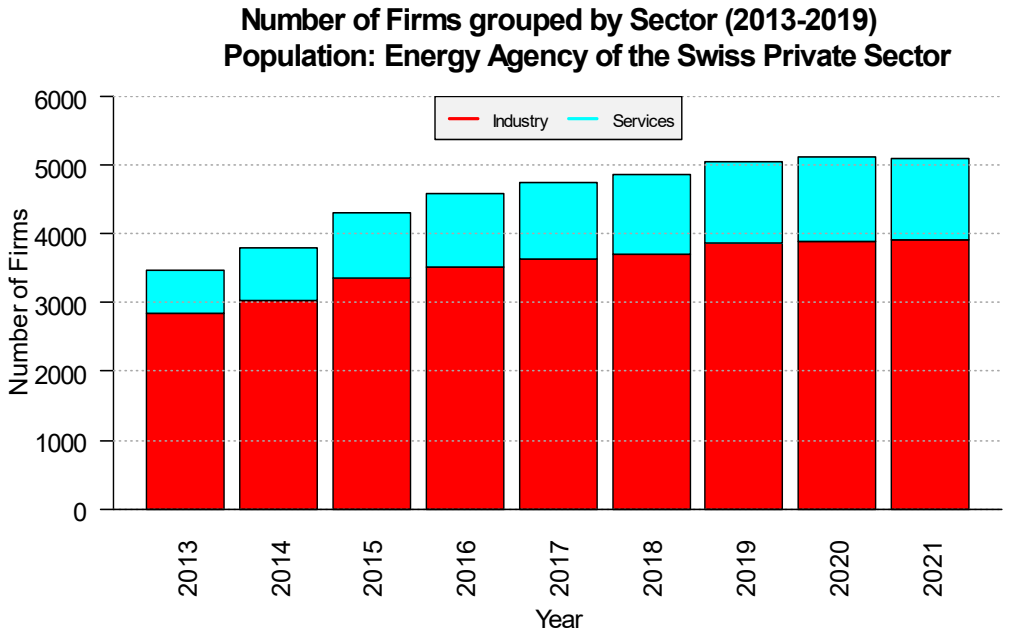
- Due to its representativeness, the SFOE sample more adequately represents the evolution of the economic sectors.

EnAW: Firms exempted from the CO_2 tax → target agreement:

- Self selection and the entry restriction led to an over-representation of the industry sector.



Data Source: Swiss Federal Office of Energy SFOE (N = 113'271)



Data Source: Energy Agency of the Swiss Private Sector EnAW (N = 41'079)

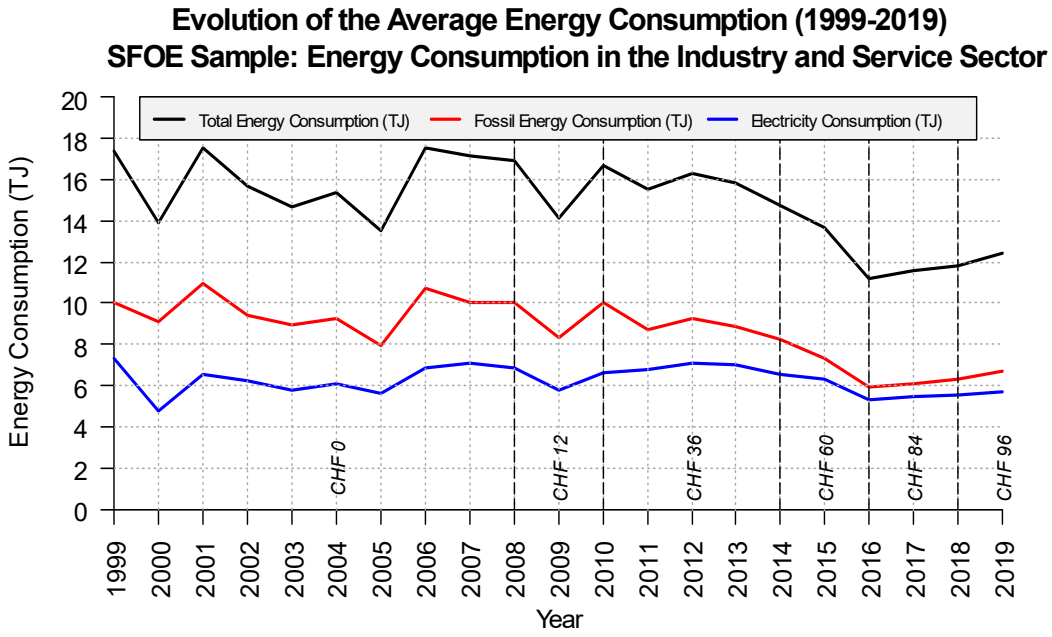
Description of the two Datasets II: Average Energy Consumption (TJ)

SFOE: Representative sample of installations:

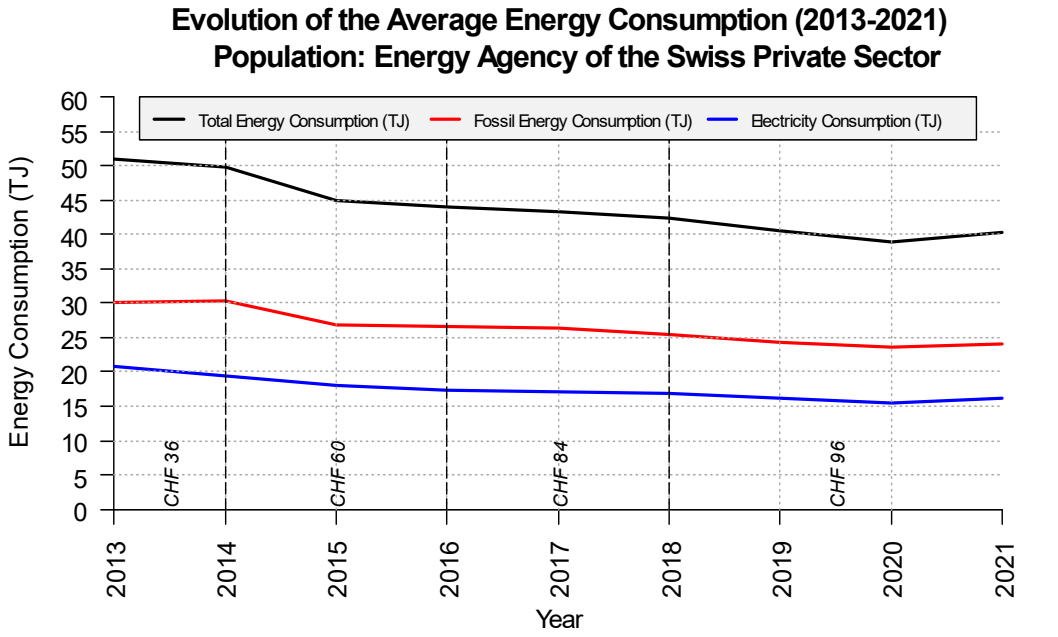
- Average energy consumption has been decreasing since 2008.

EnAW: Firms exempted from the CO_2 tax → target agreement:

- The higher average energy consumption of EnAW-firms is due to data on company instead of installation level.



Data Source: Swiss Federal Office of Energy SFOE (N = 113'271)



Data Source: Energy Agency of the Swiss Private Sector EnAW (N = 41'079)

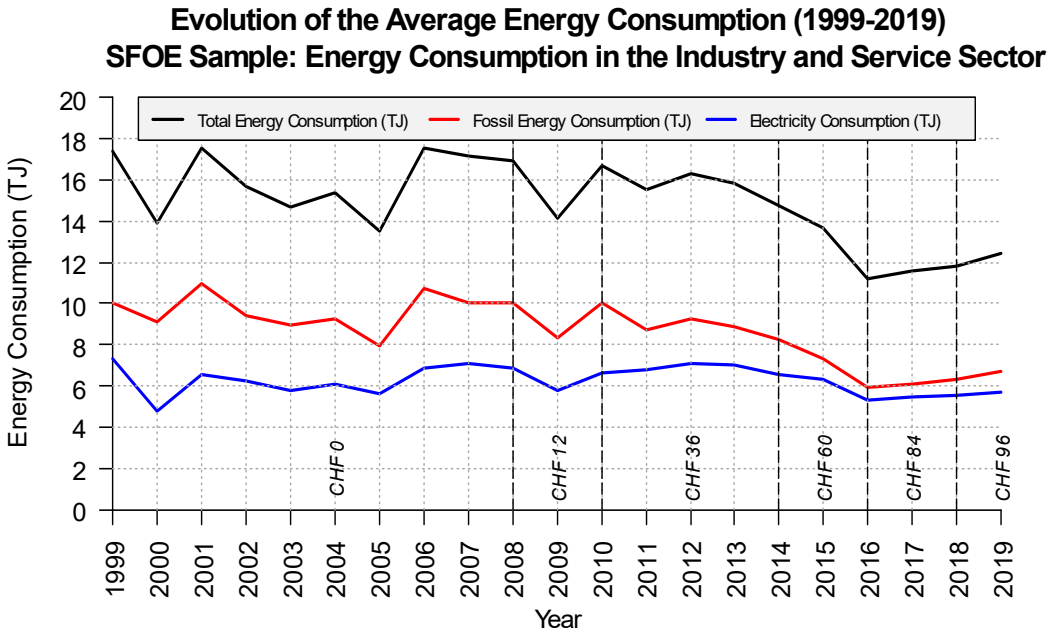
Description of the two Datasets III: Average Energy Consumption (TJ)

SFOE: Representative sample of installations (absolute Values):

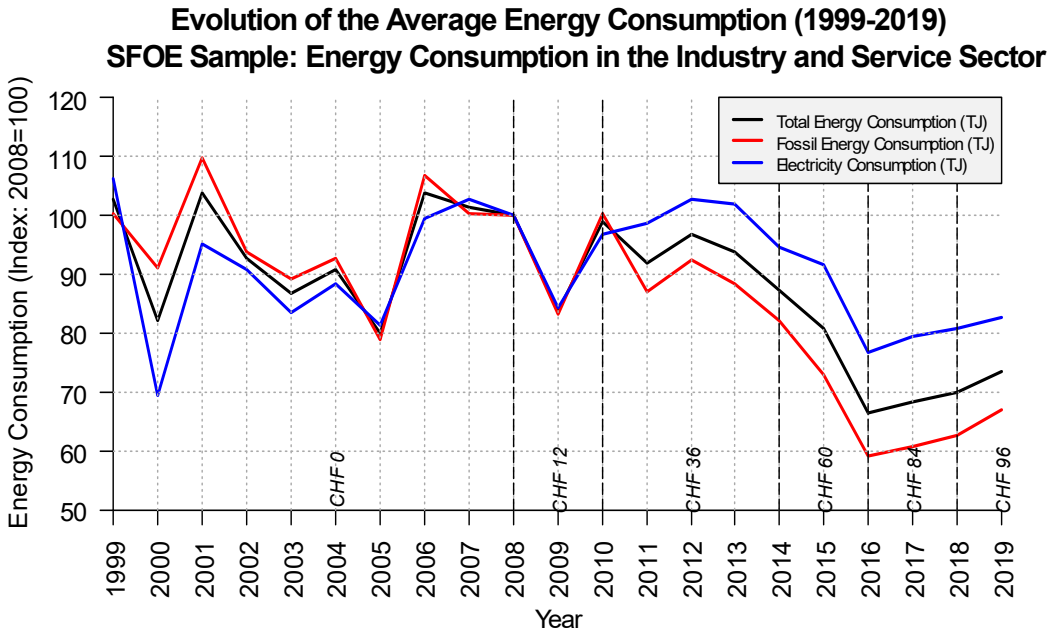
- Average energy consumption has been decreasing since 2008.

SFOE: Representative sample of installations (Index: 2008 = 100):

- Fossil energy consumption (-33%) is decreasing more than electricity consumption (-17%). This might be a hint for substitution processes.



Data Source: Swiss Federal Office of Energy SFOE (N = 113'271)



Data Source: Swiss Federal Office of Energy SFOE (N = 113'271)

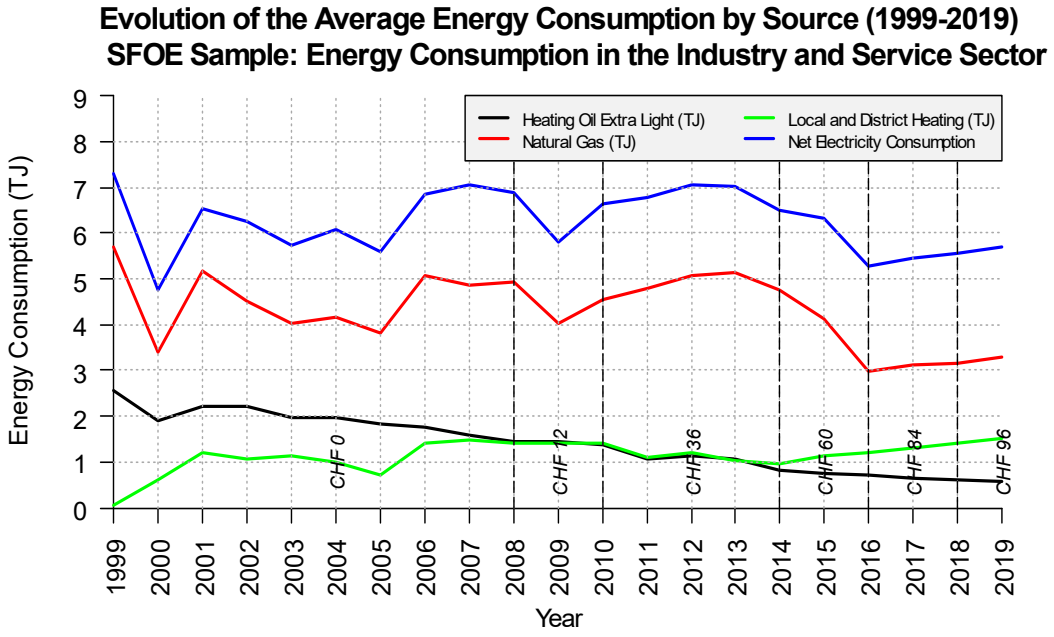
Description of the two Datasets IV: Average Energy Consumption (TJ)

SFOE: Representative sample of installations (absolute Values):

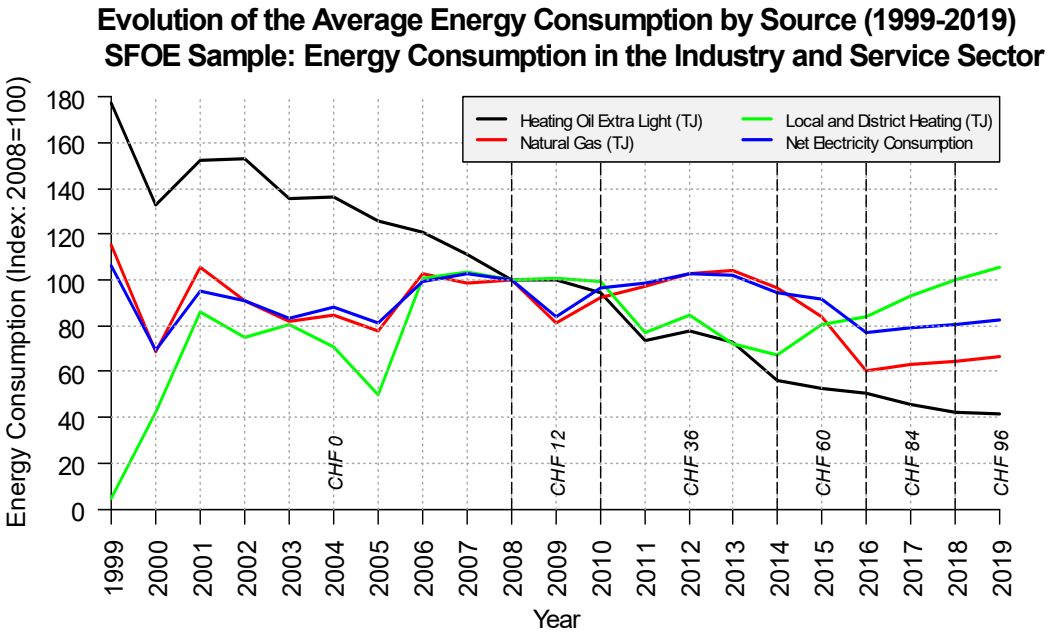
- Average energy consumption of heating oil has been decreasing most since 2008. It is partly substituted by district heating.

SFOE: Representative sample of installations (Index: 2008 = 100):

- The consumption of heating oil has been decreasing the most (-59%).
- The consumption of district heating is increasing (+6%). →Buildings program, Heating degree-days are decreasing.



Data Source: Swiss Federal Office of Energy SFOE (N = 113'271)



Data Source: Swiss Federal Office of Energy SFOE (N = 113'271)

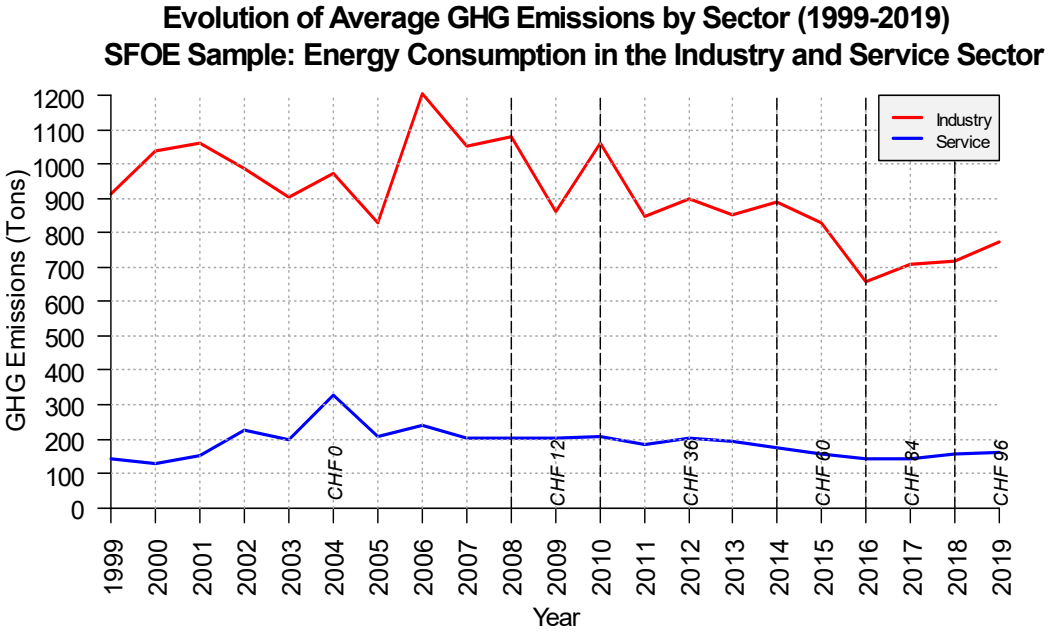
Description of the two Datasets V: Average Green House Gas Emissions by Sector (Tons)

SFOE: Representative sample of installations:

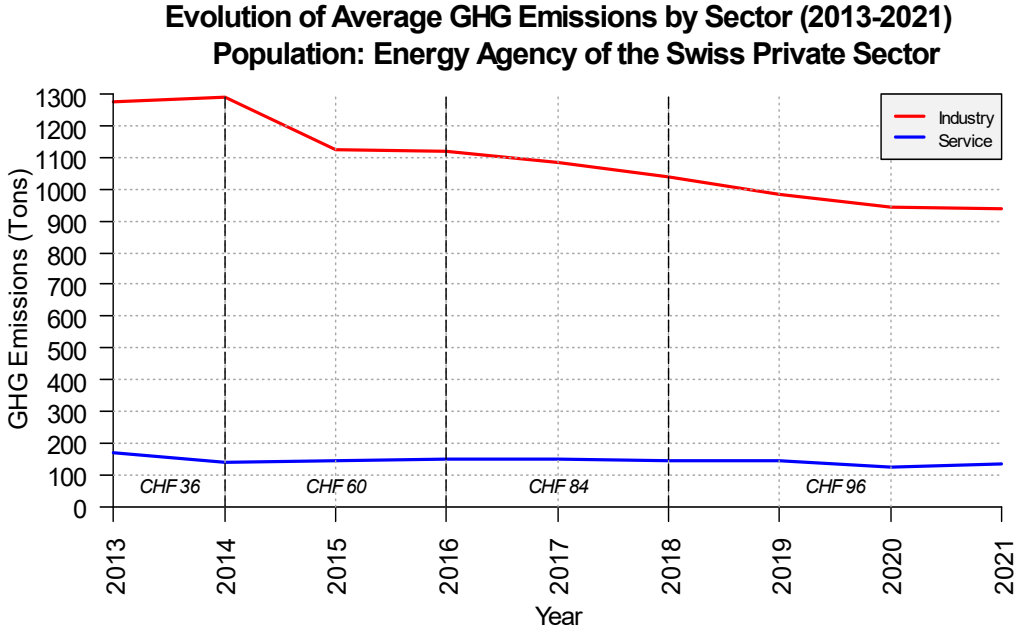
- Average greenhouse gas emissions have been decreasing since 2008.

EnAW: Firms exempted from the CO_2 tax → target agreement:

- The reduction path of the participants with binding target agreements is more stable.



Data Source: Swiss Federal Office of Energy SFOE (N = 113'271)



Data Source: Energy Agency of the Swiss Private Sector EnAW (N = 41'079)

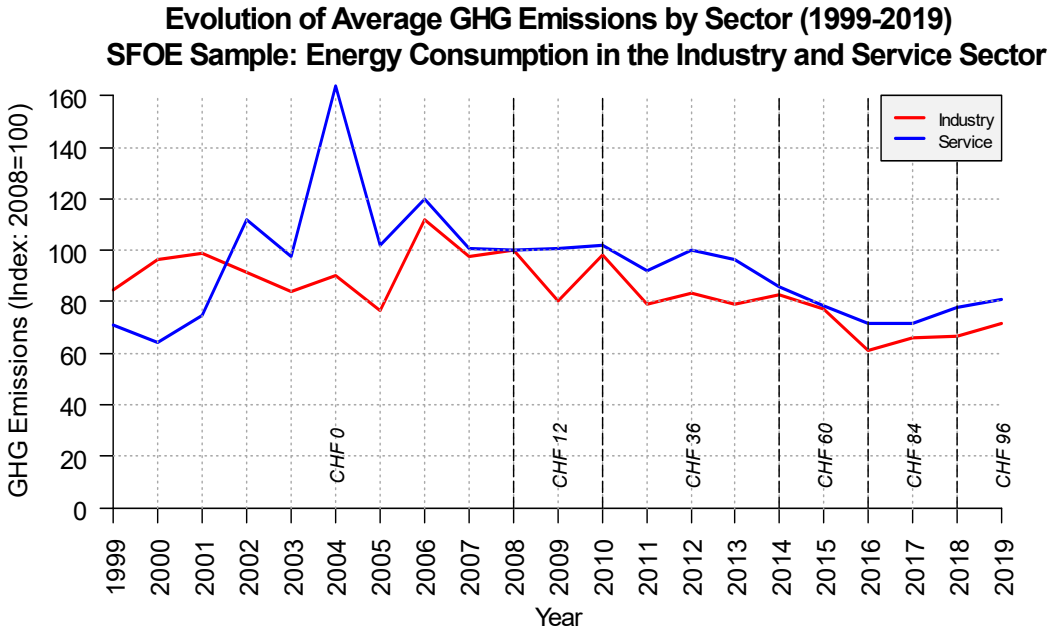
Description of the two Datasets VI: Average GHG Emissions by Sector (Index: 2008/2013 =100)

SFOE: Representative sample of installations:

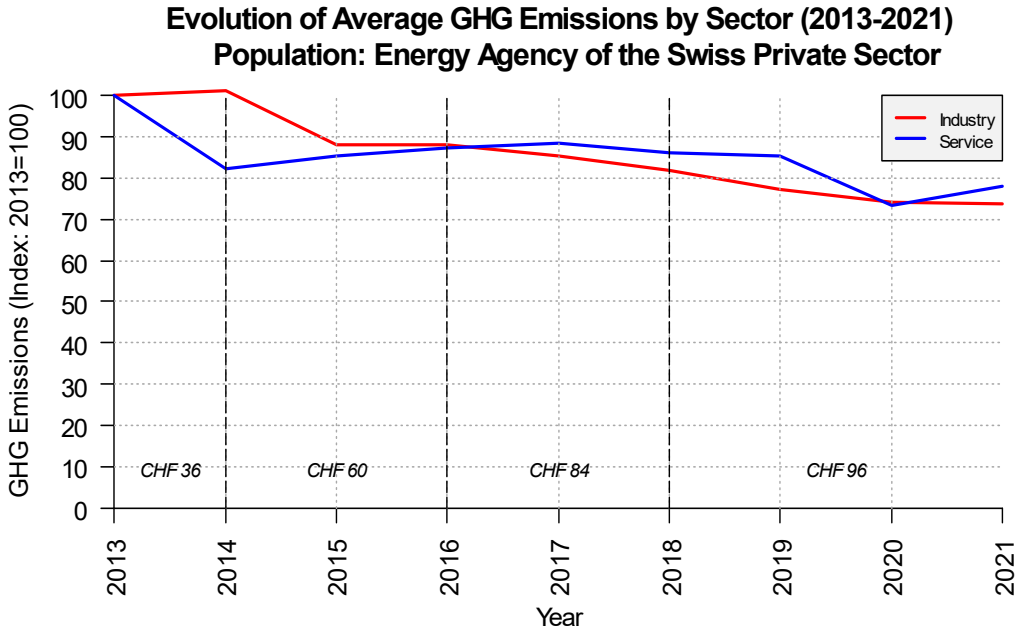
- The industry sector reduces average GHG Emissions by 38% and the service sector by 29% compared to 2008.

EnAW: Firms exempted from the CO_2 tax → target agreement:

- The industry sector reduces average GHG Emissions by 26% and the service sector by 22% compared to 2013.



Data Source: Swiss Federal Office of Energy SFOE (N = 113'271)



Data Source: Energy Agency of the Swiss Private Sector EnAW (N = 41'079)

Summary Statistics of Fixed Effects Regression Estimates of a previous Study presented at IEPPEC 2018 (t = 1999, …, 2016)

Dependent variable: log(CO_2) Regressor	Model 1	Model 2	Model 3	**Model 4**
Dummy CO_2 Tax CHF 12 (2008, 2009)	-0.0490**	-0.0560**	0.00894	**0.00860**
	(0.00871)	(0.0100)	(0.0121)	(0.0121)
Dummy CO_2 Tax CHF 36 (2010, 2011, 2012, 2013)	-0.103**	-0.112**	-0.0544**	**-0.0532****
	(0.0110)	(0.0151)	(0.0188)	(0.0187)
Dummy CO_2 Tax CHF 60 (2014, 2015)	-0.248**	-0.261**	-0.127**	**-0.125****
	(0.0150)	(0.0218)	(0.0295)	(0.0295)
Dummy CO_2 Tax CHF 84 (2016)	-0.246**	-0.241**	-0.164**	**-0.161****
	(0.0181)	(0.0267)	(0.0446)	(0.0443)
R-squared (within)	0.017	0.046	0.058	**0.055**
Firm Specific Controls	NO	YES	YES	**YES**
Economy Wide Controls	NO	NO	YES	**YES**
Trimmed upper 1%	NO	NO	NO	**YES**

Note: Asterisks indicate the significance level at 5% (*) and 1% (**). The standard errors in parentheses are corrected for heteroscedasticity and serial correlation across clusters. Data Source: Swiss Federal Office of Energy.

- The baseline period are the years 1999-2007 (Pre-policy period: No CO_2 tax was levied until 2008).
- By controlling for other effects, the CO_2 levy has a significant negative impact on the greenhouse gas emissions.
- The effect is stronger, the higher the CO_2 tax. In 2016 the impact is -16% compared to the baseline.
- ☝ Installations operating under a target agreement are not identified. Other policies might have an impact as well, e.g. the buildings program.

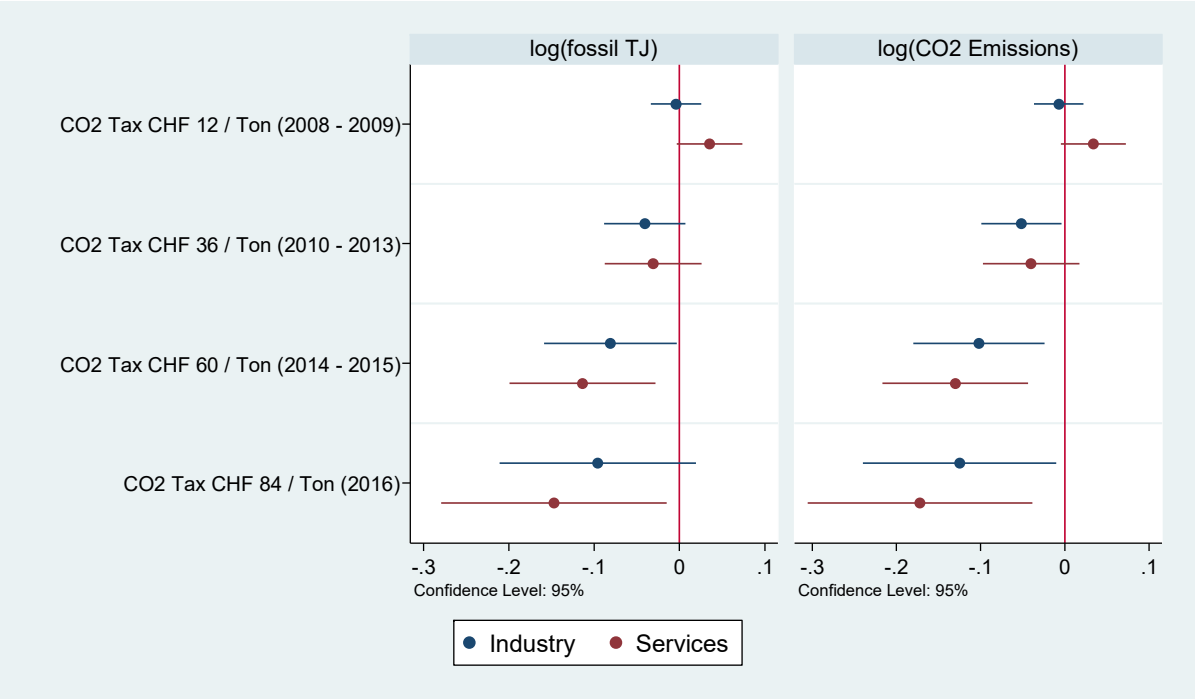
Summary Statistics of Fixed Effects Regression Estimates for the Comparison of the Industry & the Service Sector

Dependent variable: Regressor	**log(CO_2)** Model 2A	**log(CO_2)** Model 2B
Dummy CO_2 Tax CHF 12 (2008, 2009)	**-0.00720**	**0.0339**
	(0.0150)	(0.0197)
Dummy CO_2 Tax CHF 36 (2010, 2011, 2012, 2013)	**-0.0517***	**-0.0401**
	(0.0243)	(0.0292)
Dummy CO_2 Tax CHF 60 (2014, 2015)	**-0.102***	**-0.130****
	(0.0398)	(0.0441)
Dummy CO_2 Tax CHF 84 (2016)	**-0.125***	**-0.172***
	(0.0586)	(0.0680)
R-squared (within)	0.052	0.063
Sector	Industry	Services
Trimmed upper 1%	YES	YES

Note: Asterisks indicate the significance level at 5% (*) and 1% (**). The standard errors in parentheses are corrected for heteroscedasticity and serial correlation across clusters. Data Source: Swiss Federal Office of Energy.

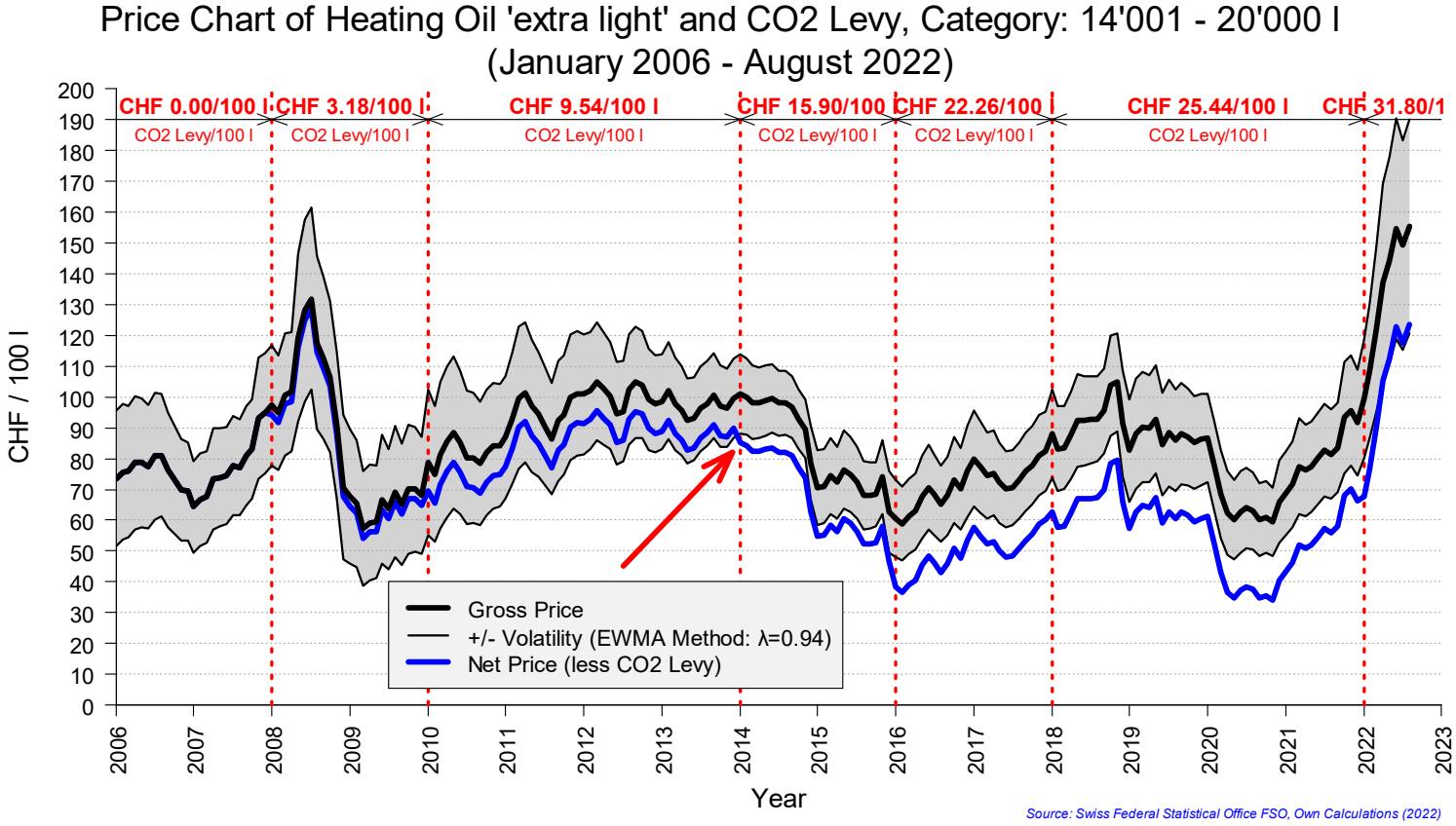
- The effect of the CO_2 tax in 2016 (CHF 84 per ton of CO_2eq) is in the industry sector a reduction of 12.5% (= 100 × (-0.125)) compared to the pre-policy period (before 2008).
- The effect of the CO_2 tax in 2016 (CHF 84 per ton of CO_2eq) is in the service sector a reduction of 17.2% (= 100 × (-0.172)) compared to the pre-policy period.

Coefficient Plot for the Comparison of the Industry & the Service Sector based on the previous Regression



- Between 2008 – 2013 (tax rate ≤ CHF 36/ton), the impact of the tax was slightly higher in the industry sector than in the service sector.
  → This might be due to more reduction potential in the industry sector.
- Between 2014 – 2016 (tax rate ≥ CHF 60/ton), the impact of the tax was slightly higher in the service sector than in the industry sector.
  → The impact of the CO_2 levy in the service sector could also be confounded through the contributions of the buildings program.
- However, the differences between the two sectors are not significant (CIs' not overlapping).

Price Chart of Heating Oil extra light (Data source: Federal Statistical Office)



- Gross price of heating oil extra light: **black line.**
- Net price (= gross price − CO_2 tax) of heating oil extra light: **blue line.**
- From 2016 onwards, the net price dropped out of the natural price fluctuations of heating oil.
- Consistent with the results of the econometric analysis: The impact of the low CO_2 taxes, in the first years after its introduction, was quite limited.

Conclusion and Outlook I

What is the effect of the Swiss climate policy mix on firms energy consumption and CO_2 emissions in the industry and service sector?

- Substantial reductions in the CO_2 emissions for the average firm in the industry and service are possible, especially so when the CO_2 emissions are heavily taxed (levy ≥ CHF 60 / ton CO_2eq).
- The estimation results must be primarily driven by the CO_2 tax. In order to avoid paying the CO_2 tax (the stick) companies must agree to an emissions target in exchange (the carrot).
- However, to test the null-hypothesis, which states that the impact on greenhouse gas emissions mitigations does not differ between the two groups, firms operating under a target agreement must be identified. This is ongoing work as this presentation has shown.

Conclusion and Outlook II

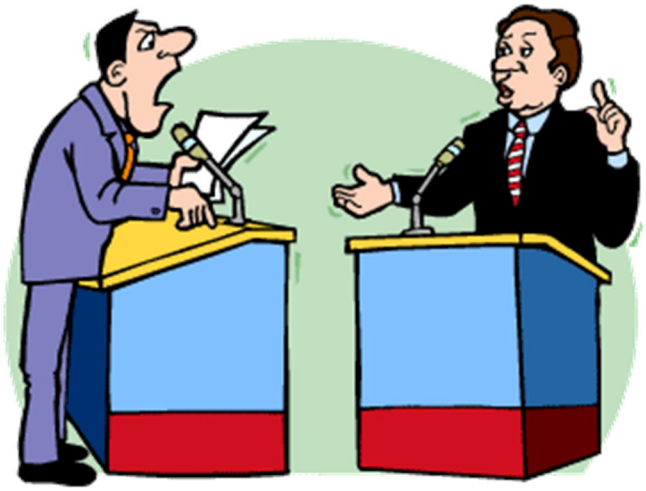
What are the challenges facing such a research question?

- Data collecting from a federal as well as from private institution is extensively time consuming.
- SFOE data is collected by survey on installation level, whereas data from the Energy Agency is on company level:
  → Target agreements versus CO_2 taxes can be disaggregated down to the company level.
  → The distribution of the reductions among the individual installations belonging to the same company cannot be identified.
  → However, without linking these two datasets, such information is missing (see previous study).
- Another confounder is the national buildings program.
- Self selection into the target agreement must be must be considered.

Conclusion and Outlook III

There is an ongoing political discussion of eliminating entry restrictions for the participation in the target agreements program and being exempted from the CO_2 tax instead.

Research to quantify these two instruments is necessary!



End of the Presentation

Thank you very much for your attention.

Thomas Leu