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What if the Biggest EU Member States had emulated Sweden's outstanding Carbon Tax?

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2021 INTERNATIONAL ASSOCIATION ENERGY ECONOMISTS ONLINE CONFERENCE

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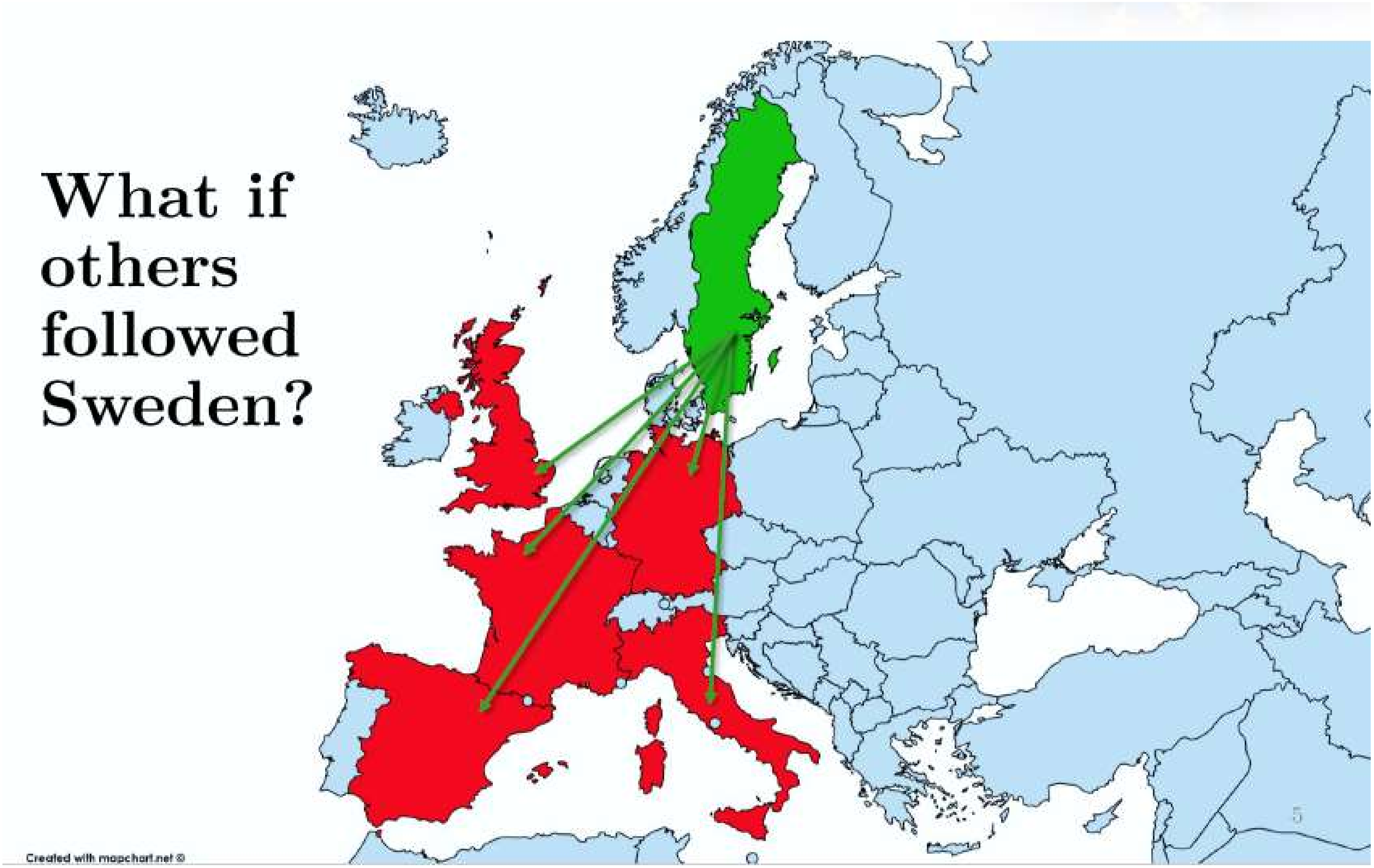
Background

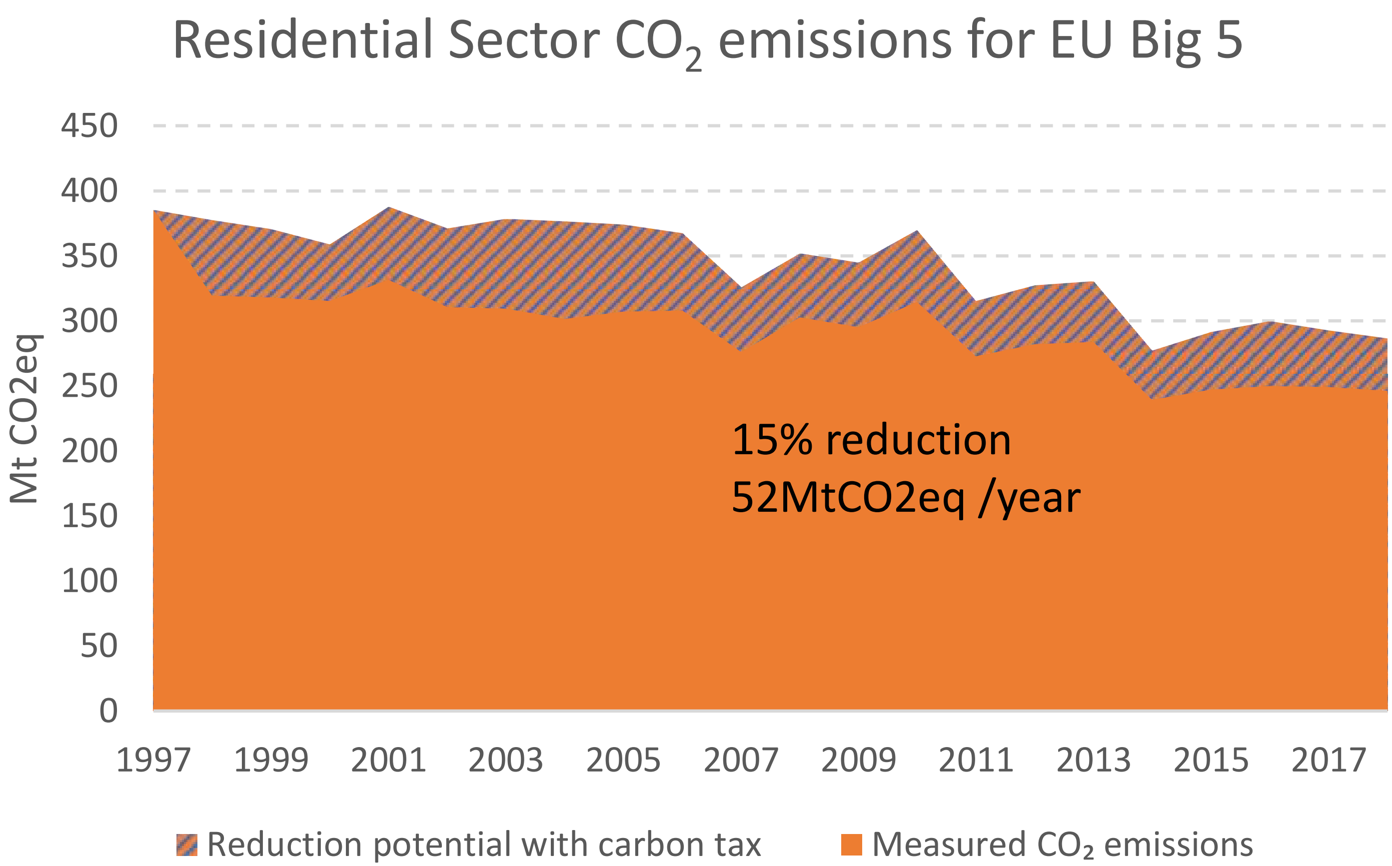
- **FORMAS funded project**
  - **Climate policies for urban households – Attitudes and effects**
- **Empirical analysis of determining factors of buildings' energy use**
- **6 EU countries: France, Germany, Italy, Sweden, and the UK**
- **Econometrics & Simulation**

(Andersson, 2019)



(Map created by Jens Ewald)

Results



Residential Sector CO_2 emissions for EU Big 5
Mt CO2eq
450
400
350
300
250
200
150
100
50
0
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
15% reduction
52MtCO2eq /year
Reduction potential with carbon tax
Measured CO_2 emissions

Swedish carbon tax rates

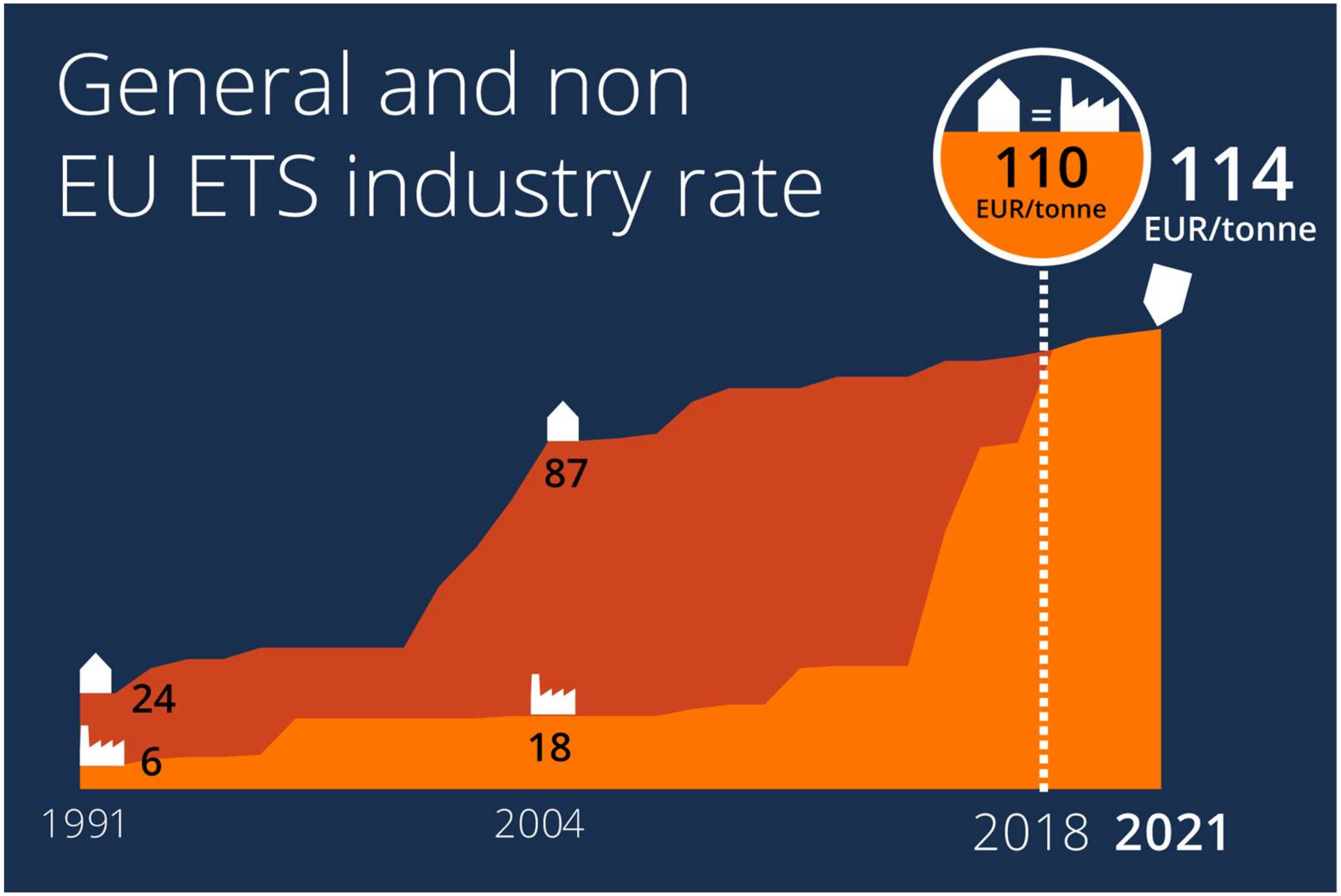


Image from :
https://www.government.se/government-policy/taxes-and-tariffs/swedens-carbon-tax/

Global comparison

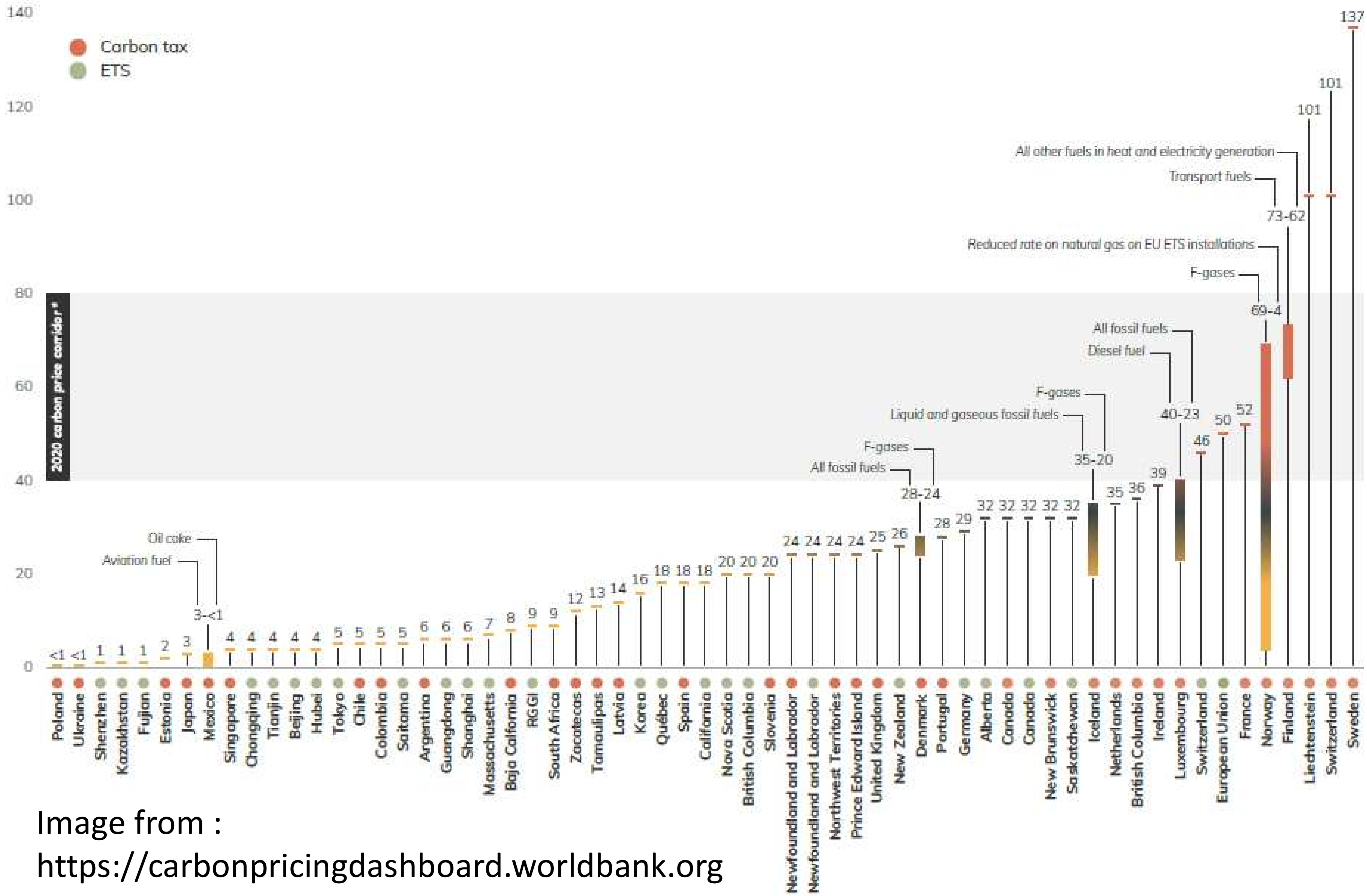
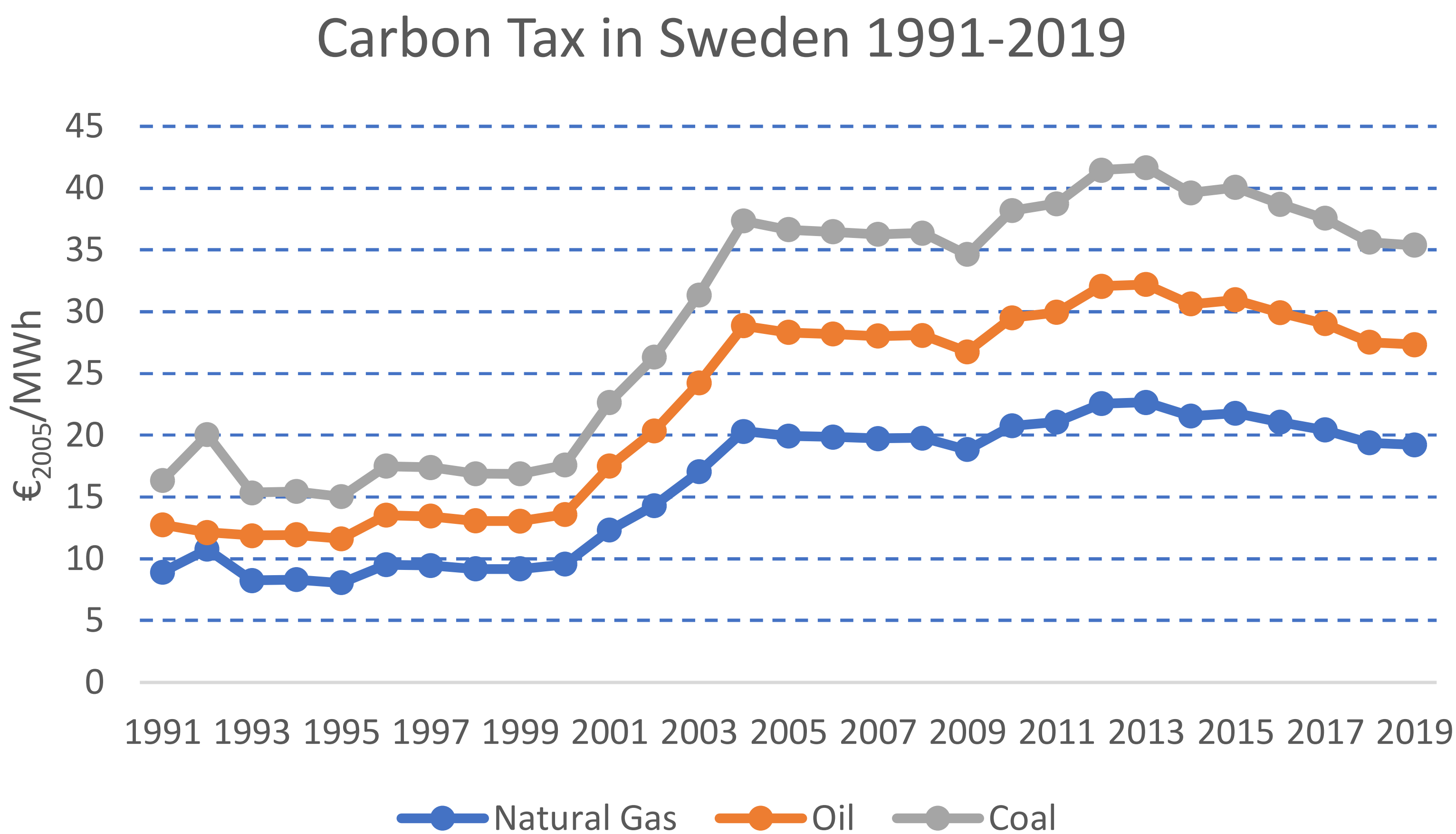


Image from :
https://carbonpricingdashboard.worldbank.org

Application to Gas, Oil & Coal



MWh/1000m3 Gas	10.55
MWh/m3 Oil	9.91
MWh/ton Coal	6.67

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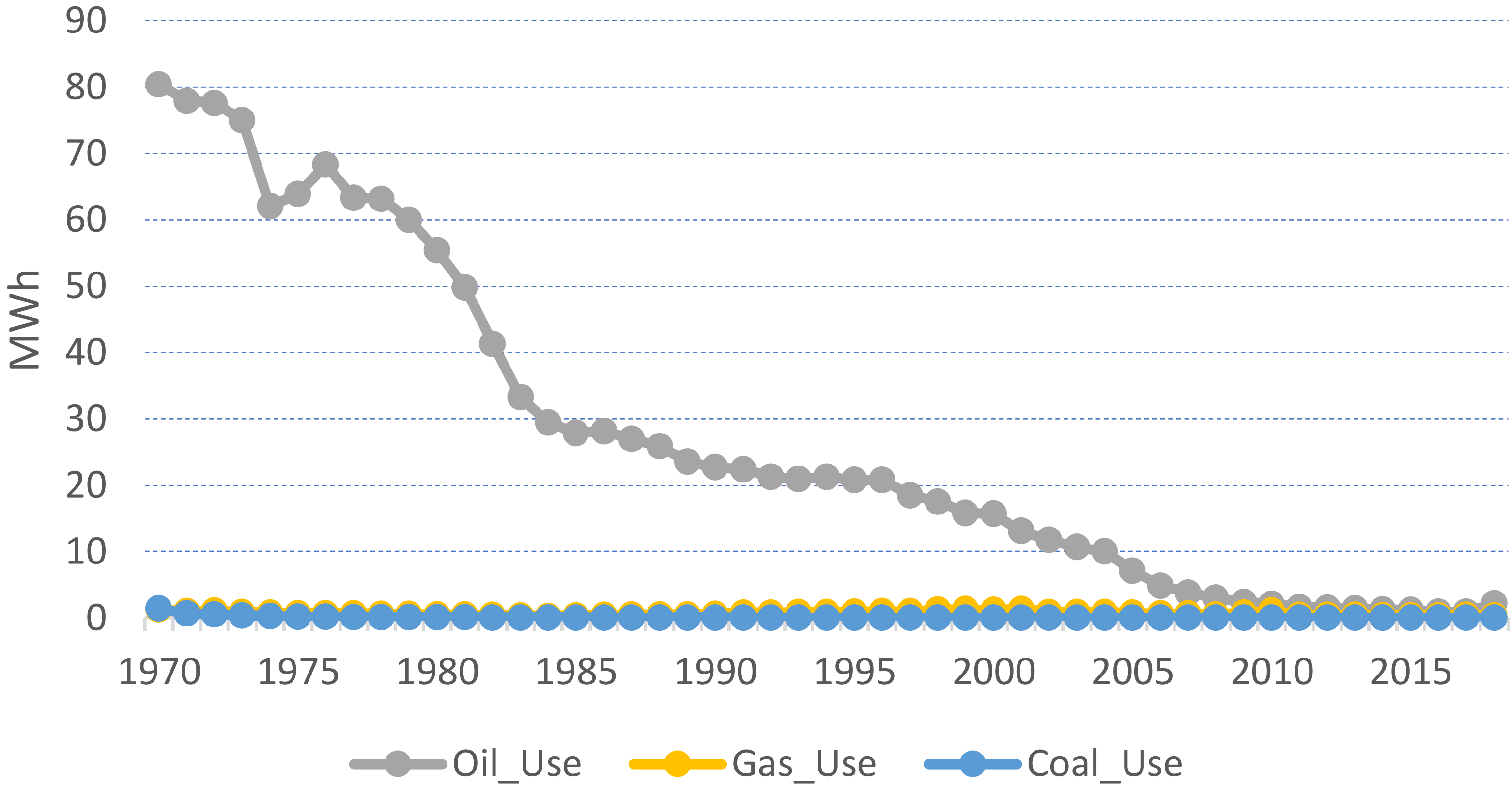
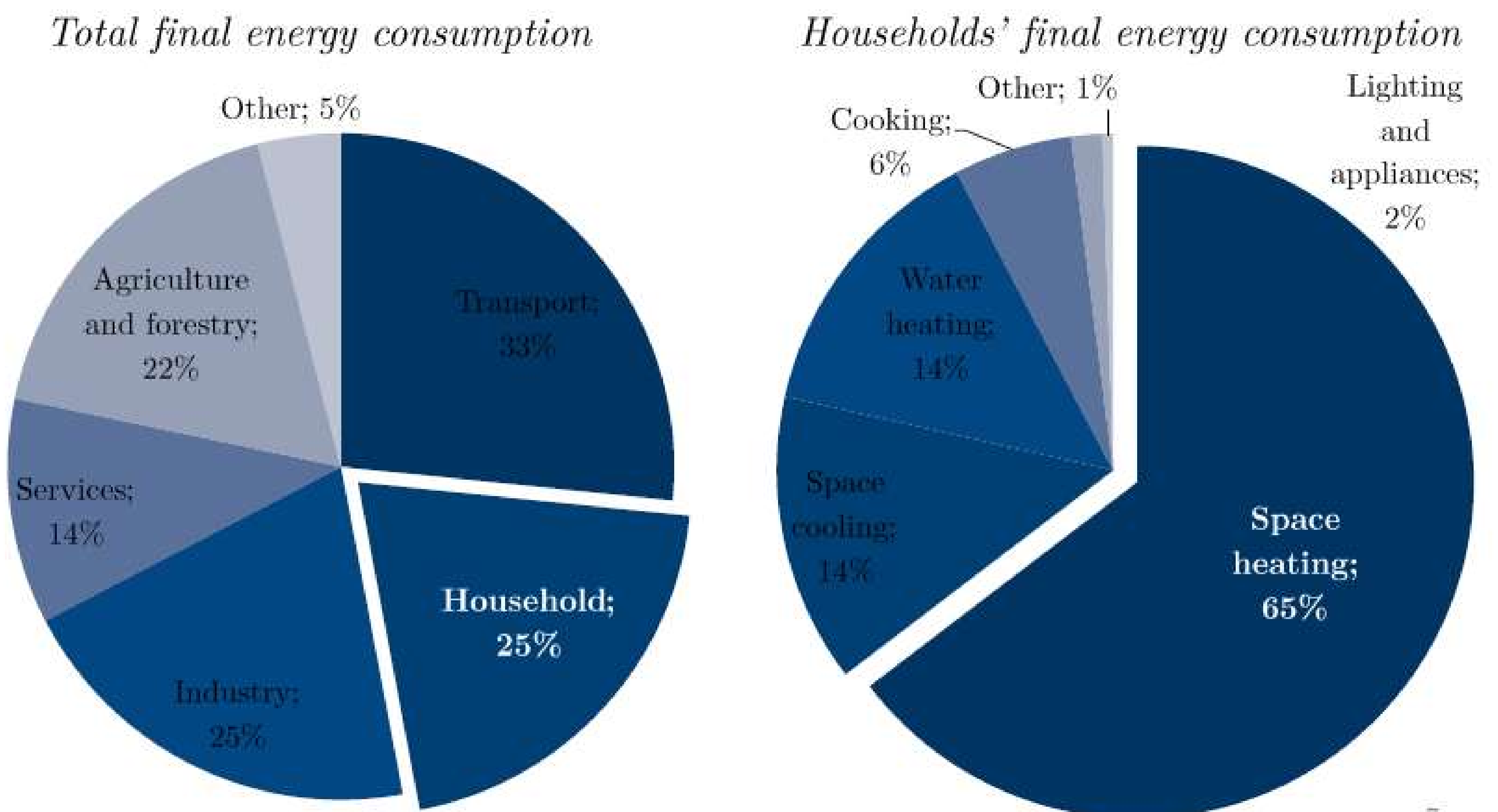
Fossil fuel use in Swedish Residential Sector



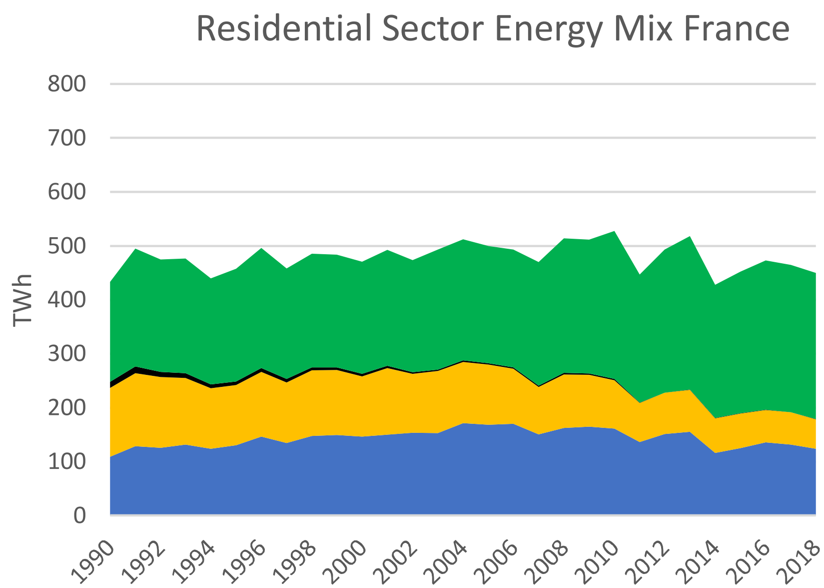
75% in 1970

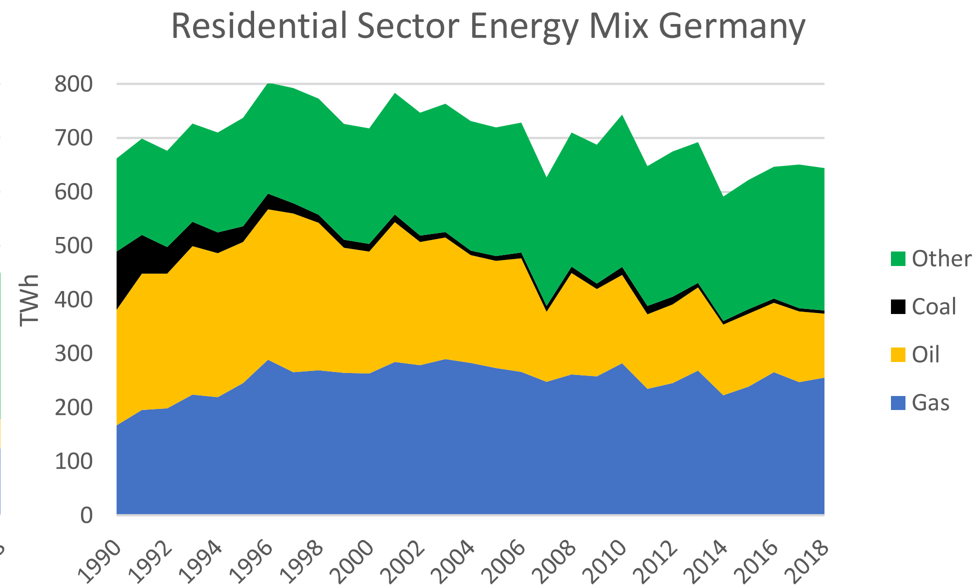
The Residential Sector

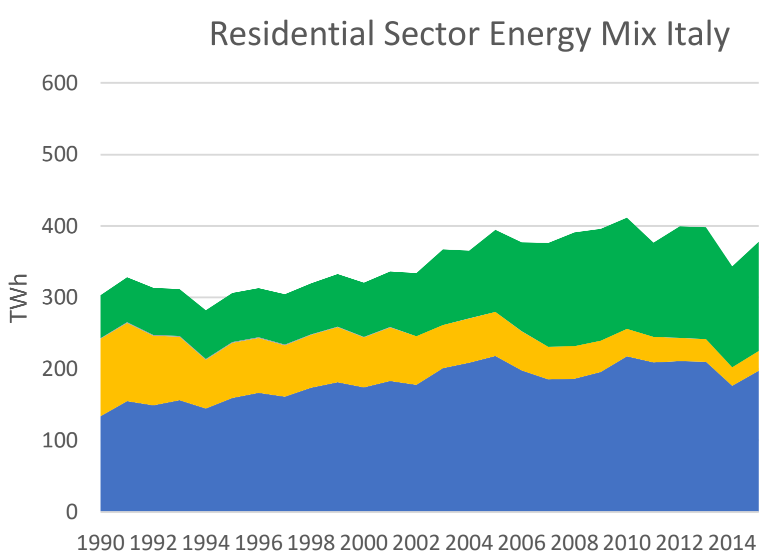


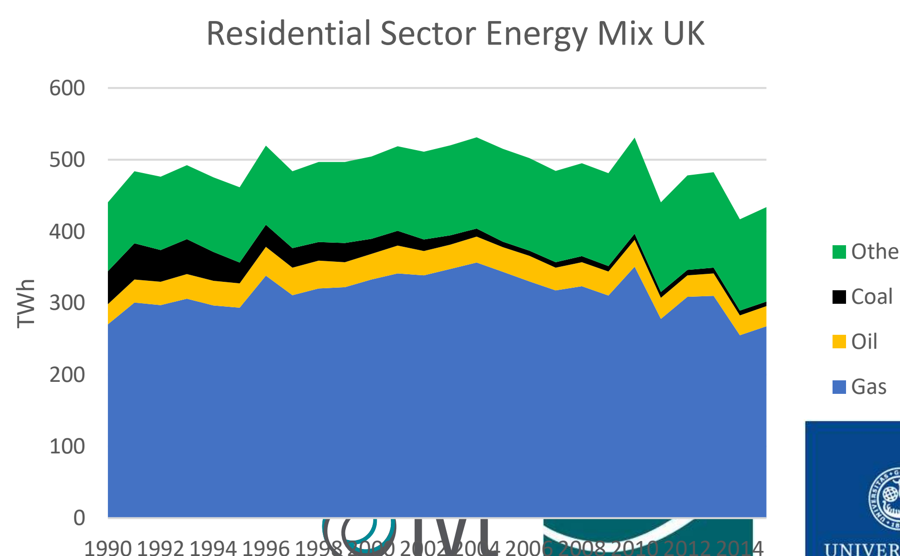
Source: Eurostat

Energy Balances









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This Study – Part A

1. Calculate Price Elasticity of demand for EU Residential Sector.
2. Simulate how a Swedish level of CO_2 price would have affected emissions

Data for EU Price Elasticity

- Annual panel data 1990-2015
- **France, Germany, Italy, Spain, Sweden, UK**

	Variable	Mean	Std. Dev.	Min	Max
Consumption	E_{TOT} (TWh)	342	205	71	776
	E_{SH} (TWh)	226	159	27	602
Price	wap_{TOT} (€$_{05}$/MWh)	84	20	47	134
	wap_{SH} (€$_{05}$/MWh)	67	171	34	109
Income	inc (€$_{05}$/capita)	15755	2794	9343	21366
Weather	hdd (°C)	2890	1176	1485	5874
Dwellings	dwe (#)	21140	9919	3962	38131

Estimation Method

- Autoregressive Distributed Lag Model (AR1)

$$E_{it} = f(E_{i,t-1}, wap_{i,t}, inc_{i,t}, Year, hdd_{i,t}, dwe_{i,t})$$

- Fixed Effects (FE) estimator
- Arellano & Bond (1991) one-step GMM estimator
  - $\Delta E_{it} = \gamma \Delta E_{it-1} + \beta_1 \Delta P_{it} + \beta_2 \Delta I_{it} + \Delta x'_{it} \beta + \Delta \nu_{it}$
- Kiviet (1995) bias corrected LSDVC estimator

Results EU Price Elasticity

Long-run price elasticity: -0.22/(1-0.44)=0.39

		(1) FE	(2) GMM	(3) LSDVC
$E_{i,t-1}$	L.l_tot	0.41***	0.36***	0.44***
		(0.061)	(0.055)	(0.087)
$wap_{i,t}$	l_wap_tot	-0.23***	-0.23***	-0.22***
		(0.030)	(0.027)	(0.041)
$inc_{i,t}$	l_inc	0.098***	0.13***	0.096***
		(0.033)	(0.031)	(0.025)
$hdd_{i,t}$	l_hdd	0.46***	0.47***	0.46***
		(0.048)	(0.042)	(0.056)
$dwe_{i,t}$	l_dwe	0.80***	0.83***	0.76***
		(0.12)	(0.12)	(0.16)
$Year$	year	-0.0041***	-0.0046***	-0.0038**
		(0.0015)	(0.0013)	(0.0016)

Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

(Modelling carried out by Jens Ewald)

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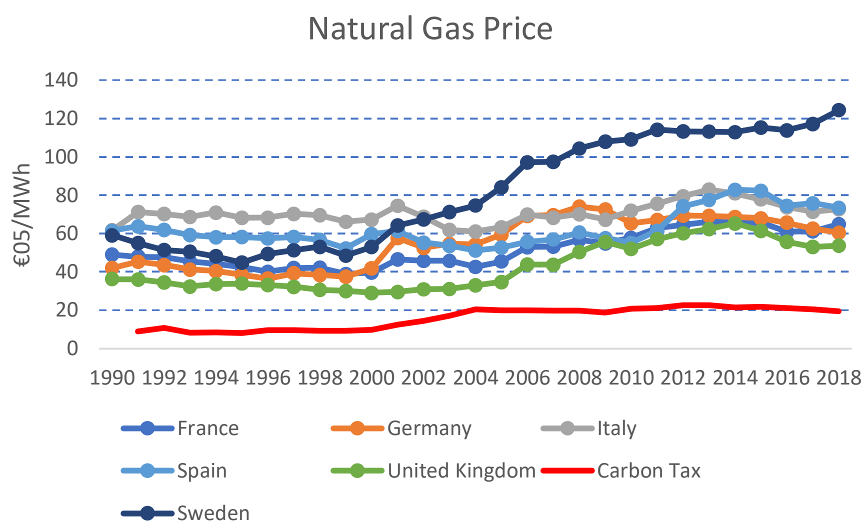
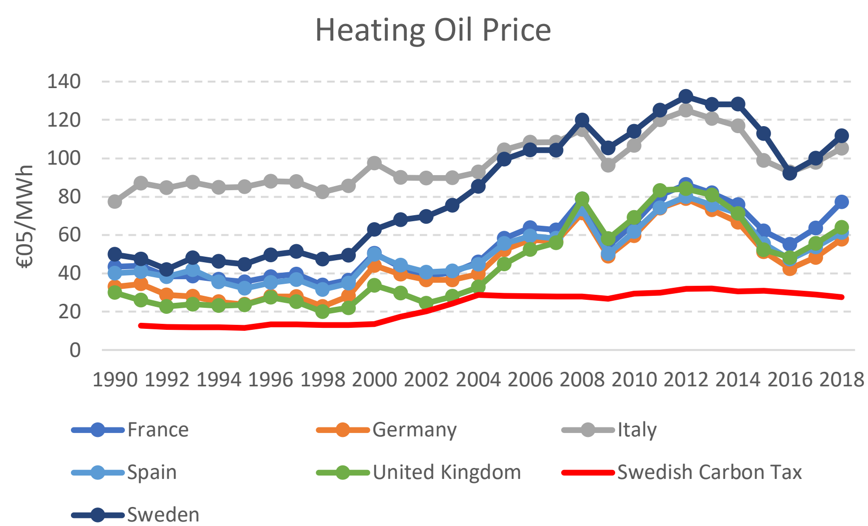
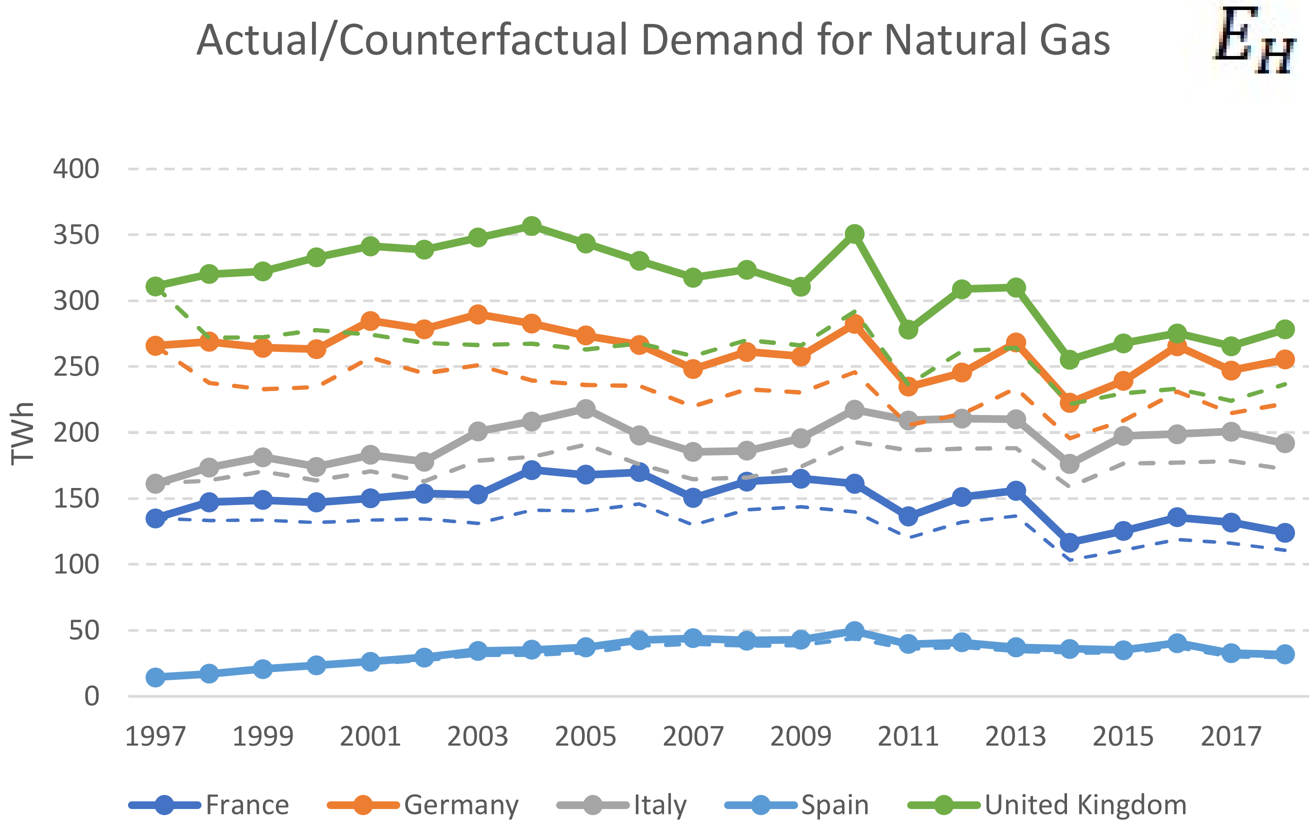
Energy Prices



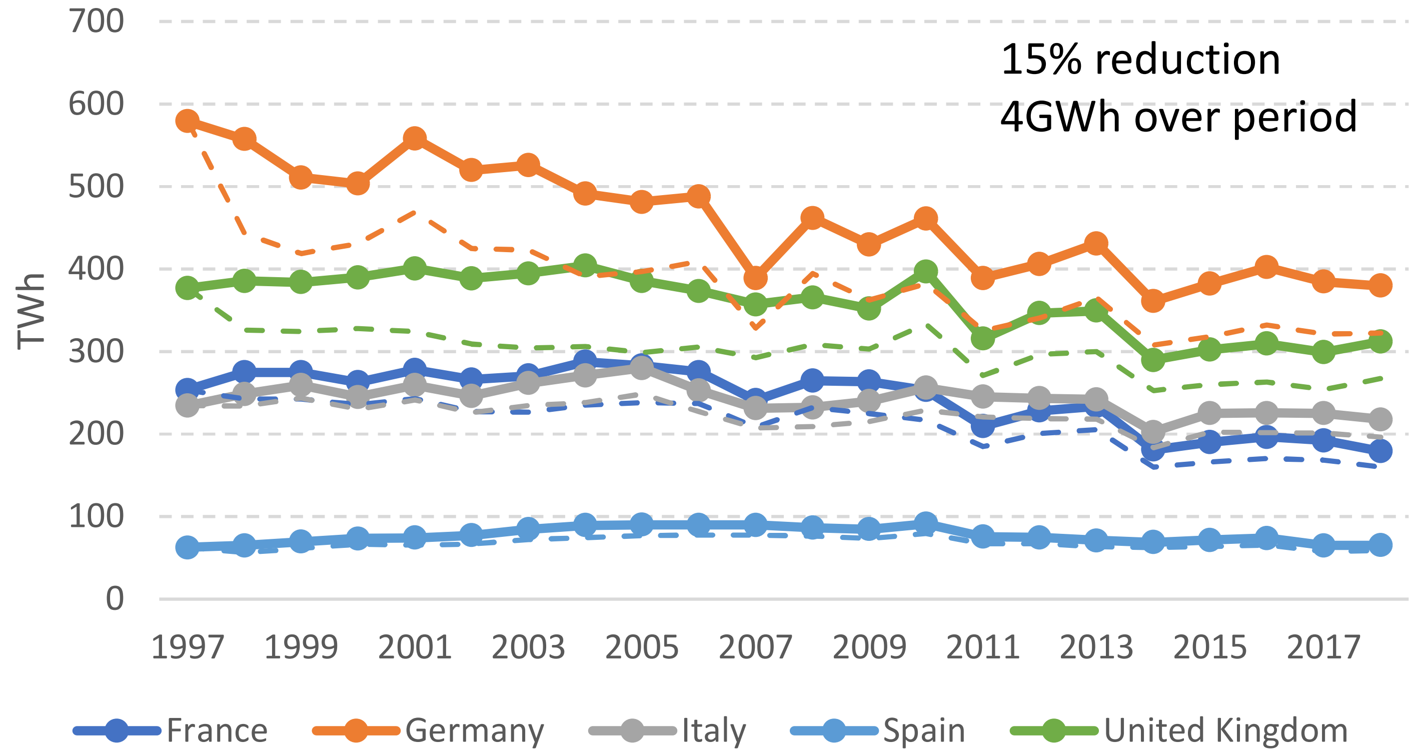


Actual/Counterfactual demand for Natural Gas

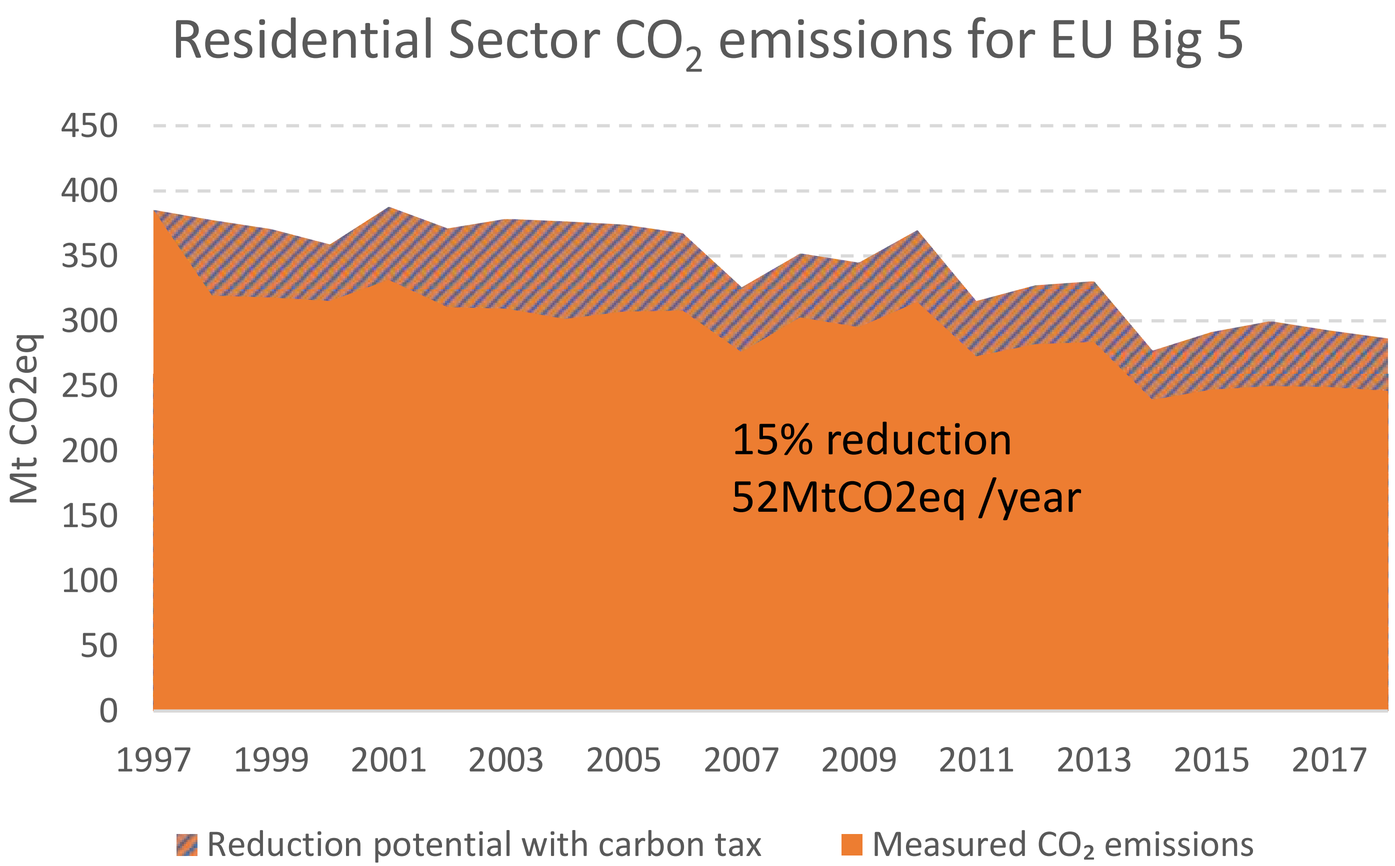
$$E_H = E_{i,t}\left(\frac{P}{P_{j,i,t}}\right)^{\beta}$$



Actual/Counterfactual demand for Oil+Coal+Natural Gas



Simulation Emissions



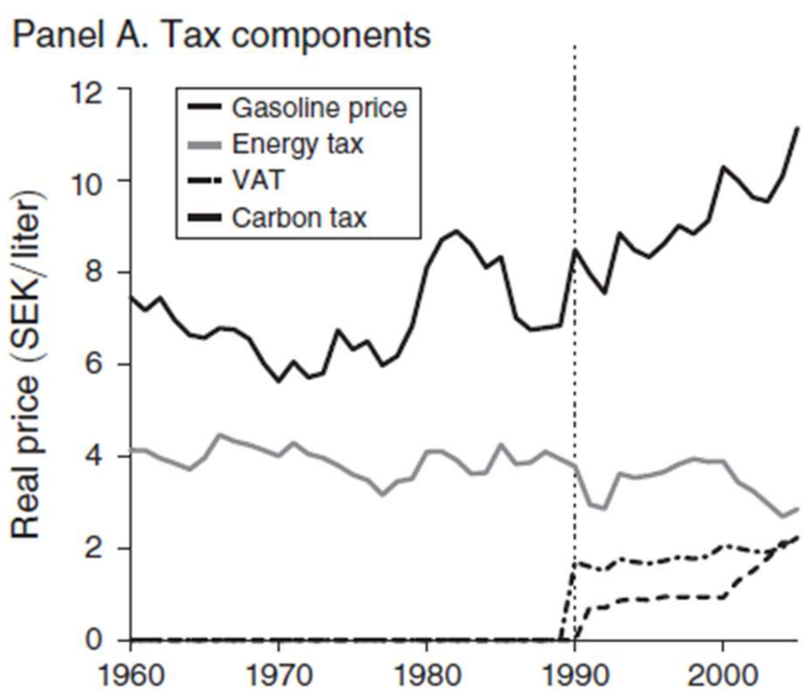
Carbon Intensity Gas	kg/MWh	202
Carbon Intensity Oil	kg/MWh	274
Carbon Intensity Coal	kg/MWh	342

American Economic Journal: Economic Policy 2019, 11(4): 1–30
https://doi.org/10.1257/pol.20170144

Part B

Carbon Taxes and CO_2 Emissions: Sweden as a Case Study†

By Julius J. Andersson*



Andersson, 2019

TABLE 3—ESTIMATION RESULTS FROM GASOLINE CONSUMPTION REGRESSIONS (Andersson, 2019)

	OLS (1)	OLS (2)	OLS (3)	OLS (4)	IV(EnTax) (5)	IV(OilPrice) (6)
Gas price with VAT	–0.0575	–0.0598	–0.0612	–0.0603	–0.0620	–0.0641
	(0.024)	(0.021)	(0.016)	(0.012)	(0.020)	(0.014)
Carbon tax with VAT	–0.260	–0.232	–0.234	–0.186	–0.186	–0.186
	(0.042)	(0.049)	(0.053)	(0.043)	(0.038)	(0.038)
Dummy carbon tax	0.109	0.0604	0.0633	0.0999	0.0977	0.0949
	(0.040)	(0.061)	(0.061)	(0.066)	(0.070)	(0.059)
Trend	0.0207	0.0253	0.0244	0.0341	0.0342	0.0344
	(0.003)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)
GDP per capita		–0.00108	–0.00105	–0.00366	–0.00367	–0.00368
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Urban population			0.0127	0.0301	0.0313	0.0329
			(0.075)	(0.067)	(0.064)	(0.058)
Unemployment rate				–0.0242	–0.0242	–0.0242
				(0.006)	(0.005)	(0.005)
Constant	6.228	6.407	5.372	4.407	4.313	4.198
	(0.167)	(0.142)	(6.202)	(5.446)	(5.152)	(4.693)
p-value: $\beta_1 = \beta_2$	0.001	0.004	0.003	0.004	0.004	0.001
Instrument F-statistic					3.57	310.93
p-value					0.067	<0.001
Observations	42	42	42	42	42	42
R^2	0.72	0.73	0.73	0.76	0.76	0.76

Fuel Switching?

- Proposal 1 : Multiply price elasticity we calculate by a factor to simulate the effects of fuel switching.
  - How to calculate factor? See Andrersson, 2019

- Proposal 2 : Calculate Elasticity of demand for heating to carbon tax for Sweden using Andersson (2019) equation :

$$\ln(x_t) = \alpha + \beta_1 p_t^v + \beta_2 \tau_{t,CO_2}^v + \beta_3 D_{t,CO_2} + X_t \gamma + \epsilon_t,$$

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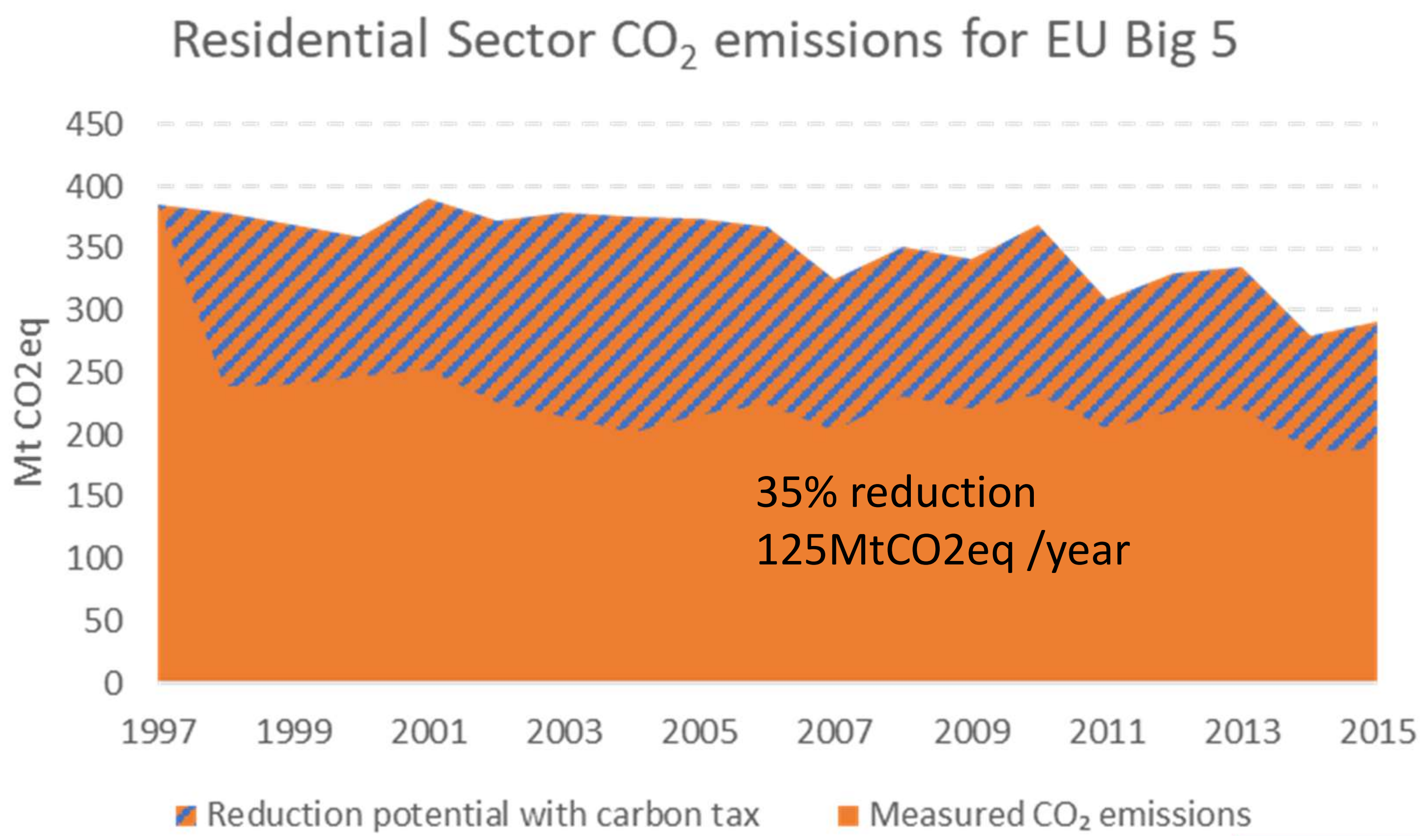
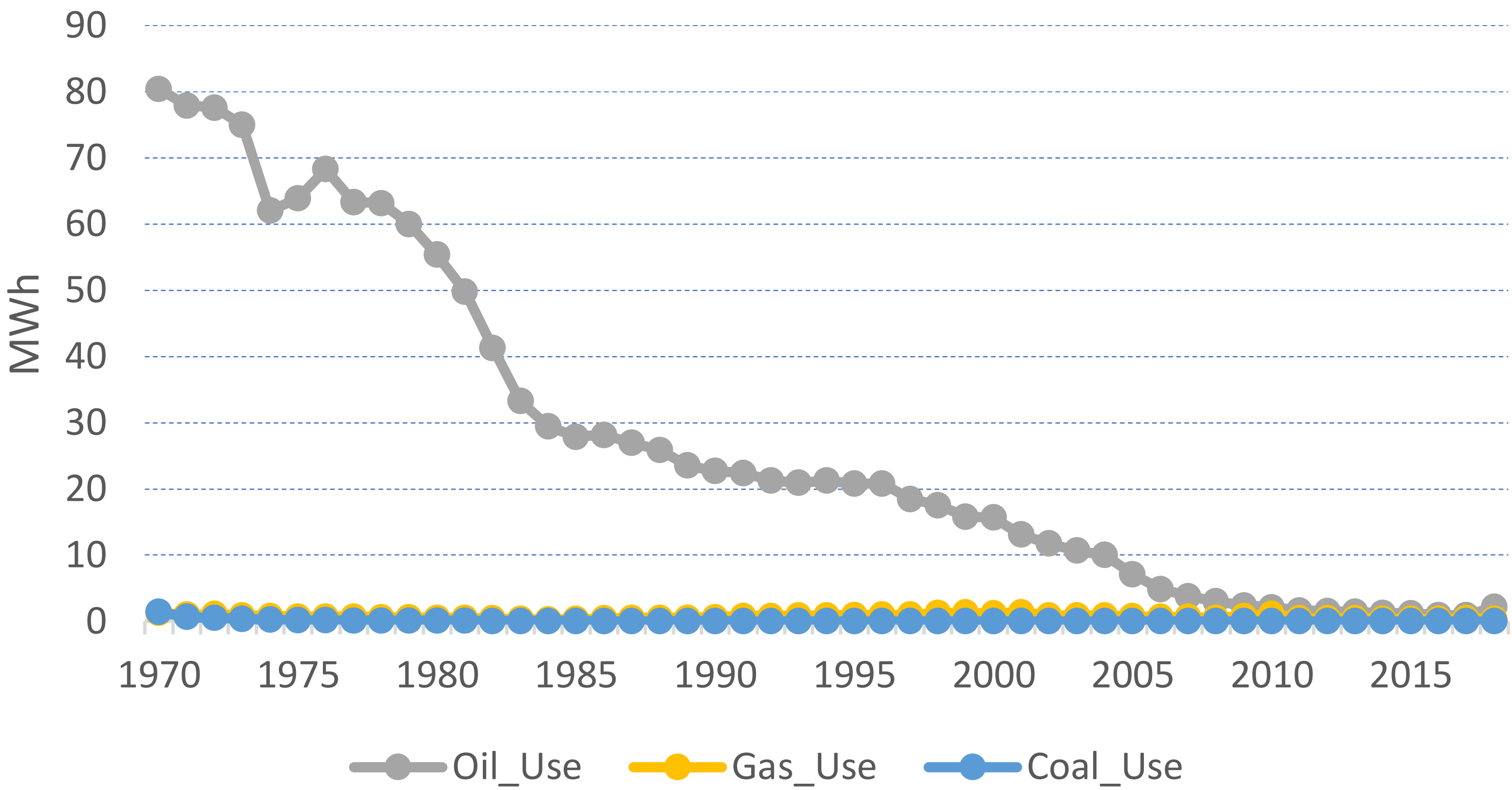
Approach 1 : Savings by applying Swedish CO_2 Tax with 3*(-0.39) elasticity



Fossil fuel use in Swedish Residential Sector



Carbon Price elasticity for Residential Sector

Regression results for oil

	Dependent variable:			
	log(tot.oil/pop.sw)			
	(1)	(2)	(3)	(4)
P.oil.exCO2	-0.003	-0.01^{**}	-0.01^{**}	-0.01^{***}
	(0.004)	(0.004)	(0.004)	(0.004)
CO2Tax..VAT	-0.03^{***}	-0.03^{***}	-0.05^{***}	-0.03^{***}
	(0.01)	(0.01)	(0.02)	(0.01)
d.CO2.91	0.86^{***}	0.29	0.53	-0.08
	(0.30)	(0.28)	(0.37)	(0.22)
Year	-0.04^{***}			
	(0.01)			
inc.pc	-0.0001^{***}	-0.0002^{***}	-0.0001^{***}	-0.0001^{***}
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Urban.	-0.15^{*}	-0.28^{***}	-0.28^{***}	-0.33^{***}
	(0.07)	(0.07)	(0.07)	(0.07)
Unemploy	-0.07^{**}	-0.07^{*}	-0.06^{*}	
	(0.03)	(0.03)	(0.03)	
hdd			0.0001	
			(0.0001)	
f.ave			-0.01	
			(0.01)	
Constant	101.74^{***}	27.35^{***}	27.75^{***}	31.07^{***}
	(21.87)	(5.51)	(5.76)	(5.37)
Observations	49	49	49	49
R^2	0.98	0.97	0.97	0.97
Adjusted R^2	0.97	0.97	0.97	0.96
Residual Std. Error	0.24 (df = 41)	0.27 (df = 42)	0.27 (df = 40)	0.28 (df = 43)
F Statistic	255.99^{***} (df = 7; 41)	234.28^{***} (df = 6; 42)	171.66^{***} (df = 8; 40)	262.02^{***} (df = 5; 43)

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

(Modelling carried out by Franck Nadaud and Eoin Ó Broin)

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Bounds F-test (Wald) for no cointegration

- 1-1-1-0 is best model under AIC
- Bounds (k=4) are I(0) 3.178 I(1) 4.450
- F = 9.3131, p-value = 1e-06

	term	estimate	std.error	t.statistic	p.value
1	(Intercept)	3.599	0.7541	4.77***	2.442e-05
2	**P.oil.exCO2**	-0.026	0.0063	-4.16***	1.619e-04
3	**CO2Tax..VAT**	-0.045	0.0152	-3.00***	4.529e-03
4	**inc.pc**	-0.001	0.0000	-1.50*	1.397e-01

Regression results for oil	
	Dependent variable:
	log(tot.oil/pop.sw)
P.oil.exCO2	-0.01***
	(0.004)
CO2Tax..VAT	-0.03***
	(0.01)
d.CO2.91	-0.34
	(0.26)
inc.pc	-0.0002***
	(0.0000)
Constant	5.22***
	(0.50)
Observations	49
R^2	0.95
Adjusted R^2	0.95
Residual Std. Error	0.34 (df = 44)
F Statistic	213.47*** (df = 4; 44)
Note:	*p<0.1; **p<0.05; ***p<0.01

Ratio CO_2 Tax elasticity / Price Elasticity

OLS :

-0.03/-0.01

= <u>2.3</u>

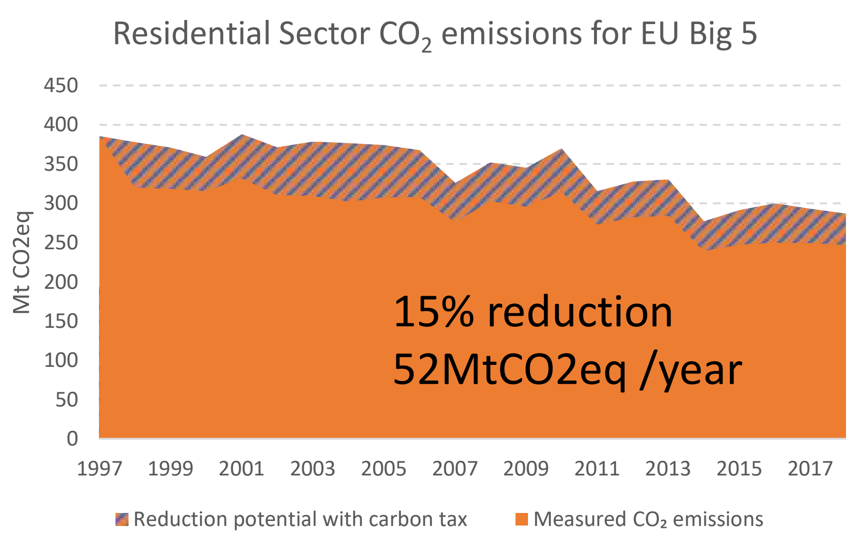
ARDL :

-0.045/-0.026

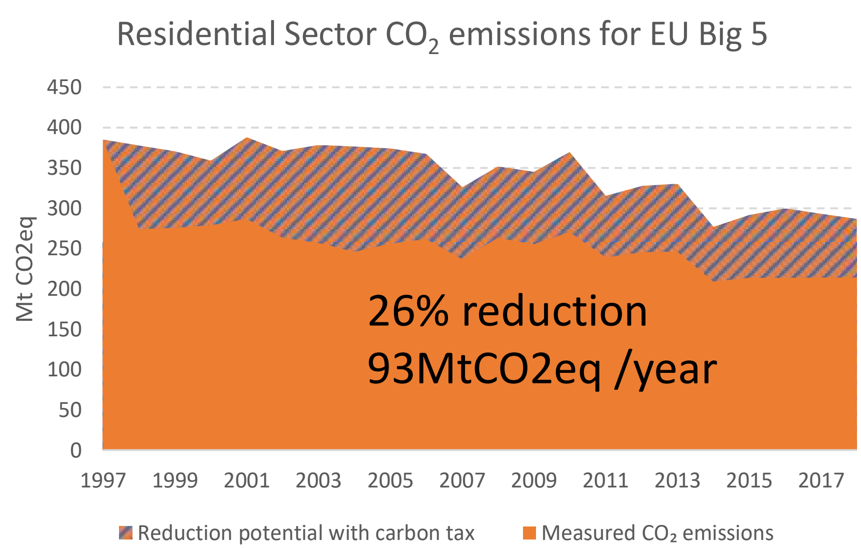
= <u>1.7</u>

Fuel Switching?

Price elasticity = -0.39



Carbon Tax elasticity = -0.39 * 2



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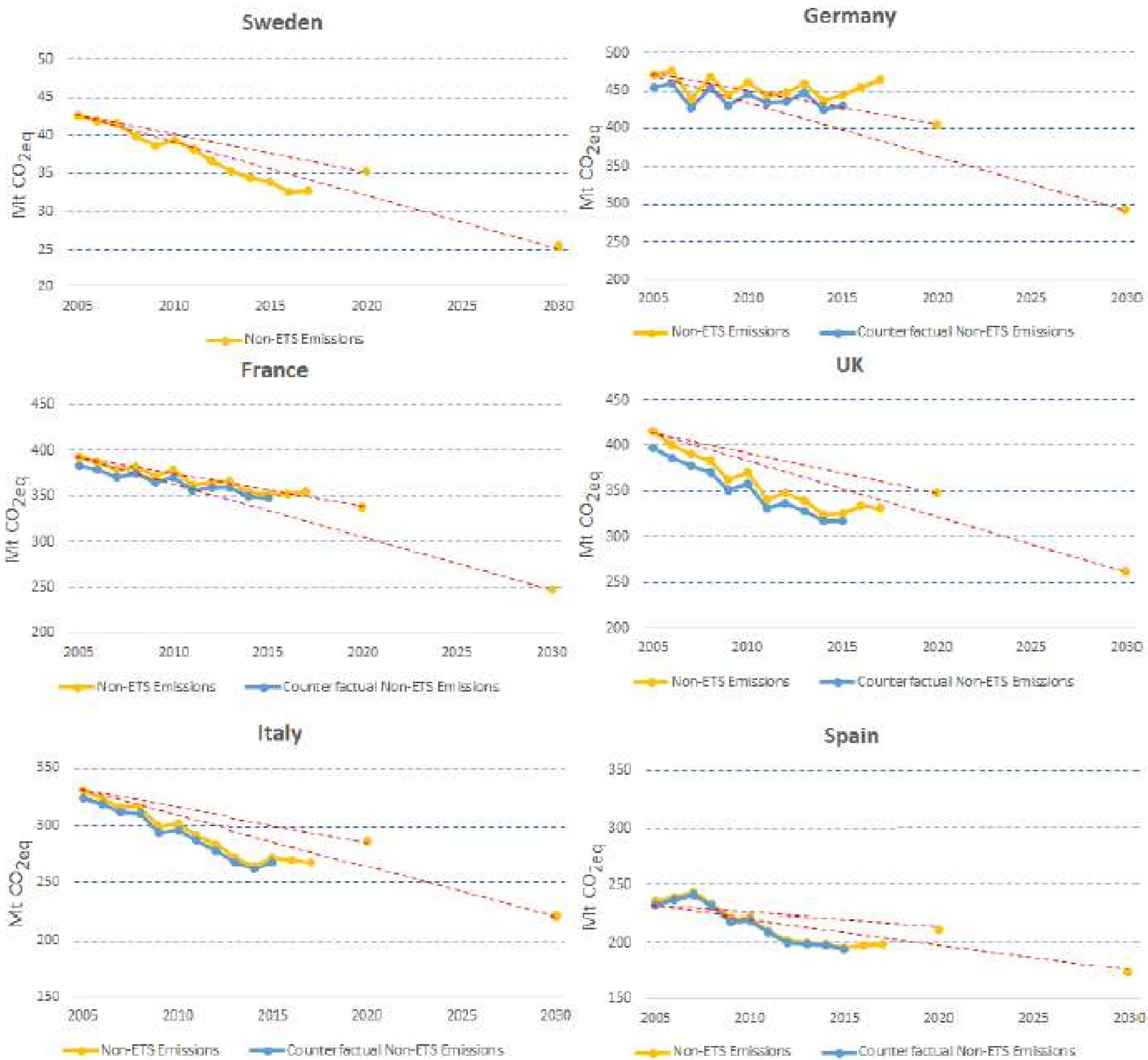

APPLICATIOn

Conclusions

- At a long run price elasticity of -0.39 15% reduction in CO_2 emissions from residential sector of five large EU countries if Swedish level of Carbon Taxes had been adopted.
- At a long run carbon tax elasticity of 2*(-0.39), which incorporates fuel switching, reduction increases to 26%.

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