Evaluating the Economic Impact of Decarbonisation Policies in Road Transport

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Background

- Transport is globally the largest final energy consuming sector
- Share in energy use and GHG emissions projected to increase in the future (mainly in non-OECD)
- Deep transport CO_2 reductions required in order to meet the global 2-degrees stabilization target
- It may take time for biofuels and new technologies (hybrids, fuel cells etc.) to be effective fleet-wide
- Basic policies discussed:
  - Fuel economy / CO_2 emission standards
  - Fuel taxes

Vehicle Taxes

- Very different across European countries; taxation is considered a matter of national sovereignty; in most countries vehicle taxes are not fuel-neutral
- But currently most countries base vehicle taxes – at least partly – on CO_2 emissions
- Current taxation schemes in many European countries imply high costs per ton of carbon
- Company car taxation is different; may compromise the effectiveness of such policy instruments

Feebates – A promising type of vehicle tax?

- Cars emitting CO_2 above a threshold (e.g. 120 g/km) pay a fee; those emitting less than the threshold receive a rebate
- If tax rate is constant (for each g/km) then marginal compliance costs are equalized across all car models
  - But most current systems do not apply constant tax rates
- If threshold decreases over the years, feebates provide a credible long-term price signal that can stimulate innovation – technology-neutrally
  - Makes sense because cost of carbon emissions increases over the years

Features of Feebates

- Market-based instrument
- Equivalent to a flexible fuel economy / CO_2 standard
- Oriented to consumers because they directly affect car prices, in contrast to standards that impose an obligation on the supply side
- Can be designed to be revenue-neutral
  - But current real-world applications (e.g. Netherlands, France, Ireland) turned out to be costly for governments
- Not detrimental to consumer welfare: consumers can shift to low-carbon cars in the same segment
- Impressive results from implementation in some countries: significant drop in new-car CO_2 emissions

Our Modelling Approach – 1

- Discrete-choice consumer demand model for differentiated products (automobiles)
- Structural estimation of demand by heterogeneous consumers with Nested Multinomial Logit model (Berry S., *Rand Journal of Economics* 25, 242–262)
- NML model relatively simple, allows for linear estimation techniques for multiple policy simulations without large computational burden (compared to random coefficients model of Berry, Levinsohn & Pakes, *Econometrica* 63, 841–889)
- We use two levels of nests to allow for more consumer heterogeneity – and estimate several variants of the NML model to be more confident that policy conclusions are not specification-dependent

Data

- Automotive data obtained from ‘JATO Dynamics’
- Coverage: 9 EU countries (AT, BE, DE, DK, GR, IT, NL, PT, ES), period: 1998–2008
- Dataset includes following variables:

Make
Model
Vehicle length
Vehicle width
Engine size
Max. engine power
Max. torque
Fuel type
Transmission type
Body type
Max. speed
Acceleration 0-100 km/h
Fuel consumption

CO_2 emissions
Airbag for driver seat offered as standard
Airbag for passenger seat offered as standard
Air conditioning system offered as standard
Climate control offered as standard
Segment type
Retail price
Sales volume

Different model specifications

- Two alternative ways to aggregate observations of the dataset:
  - Cars grouped according to model, engine type (gasoline/diesel) and engine size (e.g. 1151-1250 cc, 1251-1350 cc etc.) (6061 observations)
  - Cars grouped according to model and engine type only (3139 observations)
- Two ways that price enters the demand equation:
  - Linearly (leads to more dispersed elasticities, which are a linear function of price)
  - Logarithmically (produces more dispersed markups; implies constant expenditure)
- IV estimation using standard + alternative approach to select instruments

Econometric estimation results

Variables	Aggregate		Disaggregate linear		Disaggregate logarithmic	
	OLS	IV	OLS	IV	OLS	IV
α (price)	-0.0094**	-0.054**	-0.0048**	-0.038**	-0.36**	-2.02**
	(0.00041)	(0.0058)	(0.00029)	(0.0022)	(0.011)	(0.091)
σ_1 (group)	0.999**	0.530**	0.99**	0.95**	0.99**	0.84**
	(0.0015)	(0.170)	(0.012)	(0.016)	(0.0011)	(0.020)
σ_2 (subgroup)			0.99**	0.91**	0.98**	0.71**
			(0.0025)	(0.014)	(0.0024)	(0.020)
Engine capacity	0.045**	0.316**	-0.17**	0.062**	-0.17**	0.046*
	(0.0052)	(0.089)	(0.0061)	(0.017)	(0.0056)	(0.019)
CO_2 emissions	1.86**	-3.52	2.53**	1.57**	2.62**	0.37
	(0.082)	(2.26)	(0.066)	(0.24)	(0.062)	(0.33)
Horsepower	1.25**	4.62**	1.88**	4.69**	2.35**	5.79**
	(0.091)	(1.32)	(0.068)	(0.27)	(0.065)	(0.30)
Frame	-0.062**	0.058†	-0.047**	0.025**	-0.0025	0.28**
	(0.0033)	(0.032)	(0.0024)	(0.0057)	(0.0028)	(0.015)
Manual gearbox	0.011	-0.15*	-0.015**	-0.16**	-0.020**	-0.14**
	(0.0076)	(0.062)	(0.0053)	(0.013)	(0.0049)	(0.016)
Climate control	0.0043	0.020	0.0028	0.051**	0.027**	0.15**
	(0.0056)	(0.039)	(0.0041)	(0.0098)	(0.0040)	(0.015)
Constant	-3.04**	-5.82**	-3.00**	-3.59**	-0.0027	12.90**
	(0.025)	(0.98)	(0.019)	(0.083)	(0.091)	(0.77)
F-test	24,727.15**	262.35**	36,826.02**	3,134.33**	41,526.77**	1,428.98**
Wald test, null: $\sigma_1 = \sigma_2$				29.71**		137.86**
Underidentification test		8.70*		102.07**		164.11**
Overidentification test		7.84*		821.47**		6.16*

Significance levels: † : 10%, * : 5%, ** : 1%. $N = 3,139$ for the aggregate model and $N = 6,061$ for the disaggregate. Standard errors are reported in parentheses. Time and country dummies are included but not reported for brevity.

‘Feebate’ Policy Simulations for Germany

- Fee/rebate per vehicle sold according to formula:

$$A = t \times (CO2 - PP)$$

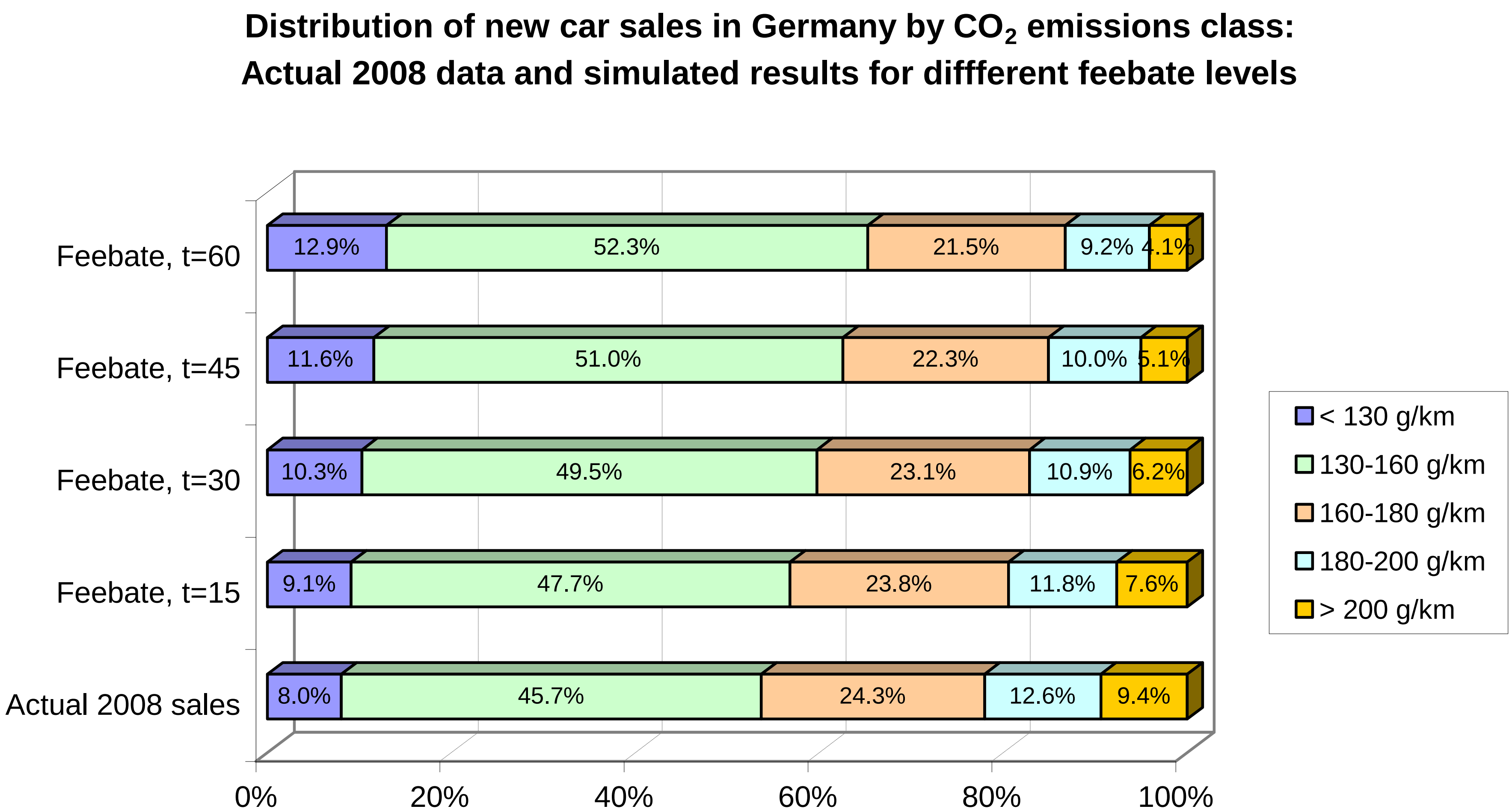
- *A in € , t* in € per g/km
- Cars emitting above *PP* pay a fee; those emitting less than *PP* receive a rebate
- Scenarios for *t* = 15, 30, 45, 60 (corresponding to carbon taxes of 75–300 € / t CO_2), and for pivot points *PP* = 120, 140, 160 g CO_2 / km
- Additional scenarios for revenue-neutral policies, asymmetric feebates and welfare-improving feebates
- Feebate levied at consumer/producer level, passes through (not by 100%) to car price

Change in new car prices, sales & revenues by car size & emissions class

	Prices				Sales				Revenues per car			
	S	M	L	All	S	M	L	All	S	M	L	All
Lenient scheme ($t = 10$, $PP = 135.2$)												
<130	-1.2	-0.4	-0.3	-1.0	25.1	19.1	24.1	22.9	-11.5	-4.2	-1.9	-8.4
130-160	0.7	0.7	0.7	0.7	3.5	4.6	8.1	5.8	3.7	4.7	3.0	4.5
160-180	2.1	1.8	1.3	1.6	-14.3	-6.9	-10.1	-6.7	14.4	12.4	8.3	9.7
180-200	2.7	2.5	2.0	2.2	-28.9	-21.0	-17.0	-16.2	19.0	16.3	13.1	14.3
>200		3.0	2.8	2.6		-37.1	-39.3	-36.4		20.3	12.4	12.3
All	0.2	1.3	1.8	1.6	10.6	2.9	-3.0	-0.8	-2.3	4.8	4.9	0.8
Stringent scheme ($t = 40$, $PP = 127.7$)												
<130	-2.7	0.04	0.2	-2.0	118.8	72.6	98.0	101.9	-35.1	-7.1	1.6	-24.3
130-160	5.3	4.3	4.0	4.3	1.0	6.1	18.6	9.4	28.8	27.5	17.2	26.6
160-180	10.2	8.6	6.5	7.8	-53.0	-33.4	-44.4	-34.8	70.5	60.1	39.3	45.7
180-200	12.2	11.2	9.3	10.0	-77.7	-65.7	-60.3	-59.1	85.8	73.8	59.3	63.4
>200		13.0	11.8	11.3		-85.6	-87.0	-84.2		85.9	56.0	50.5
All	3.0	6.6	8.6	7.7	41.0	5.4	-15.9	-3.3	-6.3	21.6	21.1	3.4

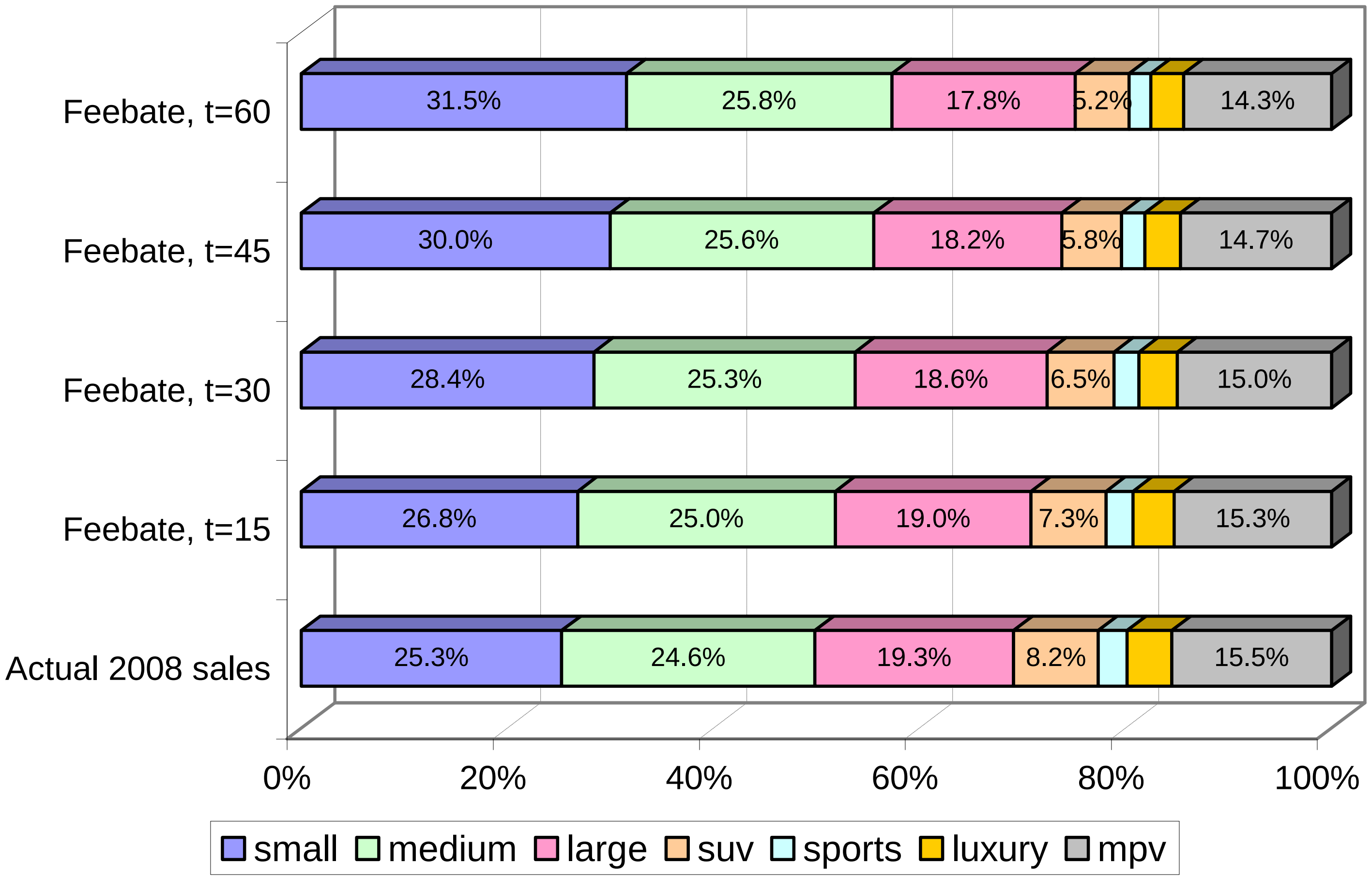
Both schemes are revenue-neutral. Reported numbers are percentage changes. S=Small, M=Medium, L=Large.

Comparison of policies according to feebate stringency for a given pivot point – 1



Comparison of policies according to feebate stringency for a given pivot point – 2

Distribution of new car sales in Germany by vehicle segment:
Actual 2008 data and simulated results for different feebate levels



Results: Impacts on emissions, public revenues & consumer welfare

Scheme		Change in:				
t	PP	Total sales	Consumer surplus	Producer surplus	Emissions cost	Total welfare
Revenue-neutral symmetric schemes						
10	135.2	-23.8 (-0.8)	-96 (-1.7)	-30 (-0.8)	-60 (-4.2)	-66 (-0.3)
20	132.7	-47.6 (-1.6)	-191 (-3.3)	-58 (-1.5)	-110 (-7.7)	-139 (-0.7)
30	130.2	-71.9 (-2.5)	-288 (-4.9)	-84 (-2.1)	-155 (-10.7)	-217 (-1.0)
40	127.7	-97.3 (-3.3)	-388 (-6.7)	-109 (-2.8)	-196 (-13.4)	-300 (-1.4)
30.7	130	-73.7 (-2.5)	-295 (-5.1)	-86 (-2.2)	-158 (-10.9)	-223 (-1.1)
71.6	120	-186.7 (-6.4)	-732 (-12.6)	-175 (-4.4)	-315 (-20.8)	-593 (-2.8)
Revenue-neutral asymmetric schemes						
-10/+20	130.6	-26.3 (-0.9)	-106 (-1.8)	-34 (-0.8)	-66 (-4.6)	-74 (-0.3)
-20/+10	136.7	-43.5 (-1.5)	-175 (-3.0)	-52 (-1.3)	-101 (-7.0)	-127 (-0.6)
-5/+20	127.2	-14.4 (-0.5)	-58 (-1.0)	-19 (-0.5)	-38 (-2.7)	-39 (-0.2)
-20/+5	139.4	-41.0 (-1.4)	-165 (-2.8)	-49 (-1.2)	-95 (-6.6)	-119 (-0.6)
-10/+30	127.3	-28.2 (-1.0)	-114 (-2.0)	-36 (-0.9)	-70 (-4.9)	-80 (-0.4)
-30/+10	136.6	-61.8 (-2.1)	-248 (-4.3)	-72 (-1.8)	-134 (-9.3)	-185 (-0.9)
-5/+30	123.8	-15.4 (-0.5)	-62 (-1.1)	-21 (-0.5)	-41 (-2.9)	-43 (-0.2)
-30/+5	138.8	-58.8 (-2.0)	-236 (-4.1)	-67 (-1.7)	-127 (-8.8)	-176 (-0.8)
Welfare-improving schemes						
10	130	-29.1 (-1.0)	-118 (-2.0)	-37 (-0.9)	-62 (-4.4)	61 (0.3)
20	120	-73.2 (-2.5)	-293 (-5.0)	-92 (-2.3)	-122 (-8.4)	473 (2.2)
-2/+3	130.6	-6.0 (-0.2)	-24 (-0.4)	-8 (-0.2)	-14 (-1.0)	13 (0.06)
-10/+20	123.8	-34.2 (-1.2)	-138 (-2.4)	-44 (-1.1)	-68 (-4.7)	141 (0.7)
Sales-increasing schemes						
0/+10	120	0.6 (0.02)	3 (0.04)	0.3 (0.01)	-1.5 (-0.1)	-31 (-0.15)
0/+10	140	3.8 (0.1)	15 (0.3)	4 (0.1)	-6 (-0.4)	-167 (-0.8)
0/+10	160	12.7 (0.4)	52 (0.9)	15 (0.4)	-13 (-0.9)	-508 (-2.4)

Conclusions

- It is possible to design a feebate program for new automobiles that curbs carbon emissions without reducing total welfare
- But needs careful design in order to account for trade-offs between environmental effectiveness, public finances and consumer/producer surplus
- Revenue-neutral tax schemes (politically most attractive) may not be welfare-improving *in the short run*; more stringent policies increasing public revenues can improve welfare

➢ But purpose of feebates is to provide long-term price signal, not work miracles in 1-2 years

Limitations & Research outlook

- Non-dynamic model simulates small changes from an equilibrium to another ⇨ may underestimate short-term consumer response
- Dynamic policy simulations necessary to make the analysis more realistic (e.g. more stringent taxation over the years), but needs assumptions about supply side (i.e. technical progress in cars)
- What is the role of changing consumer preferences / shifting demand function?
- What is the effect on i) used cars, ii) mileage?
- Distributional aspects (need to include household data on car ownership & use)

Recent advances in literature on greening road transport

- Combination of econometric with engineering approaches to simulate auto manufacturers' response (adoption of fuel-saving technologies or trading off fuel economy with other attributes)
  (Klier & Linn *Journal of Public Economics* 133 (2016) 41–63, Whitefoot, Fowlie & Skerlos 2012)
- Assessment of the welfare impacts from producers 'gaming' emission standards
  (Reynaert & Sallee, NBER Working Paper 22911, 2016)
- Distributional effects of fuel economy standards in the US – new vs. new & used vehicles
  (Davis & Knittel, NBER Working Paper 22925, 2016)
- Review of the recent literature
  (Anderson & Sallee, Annual Reviews of Resource Economics, 2016)

What role for feebates after the ‘dieselgate’?

- Discrepancy between test and on-road fuel economy & emissions has been well known and increasing in recent years
- Any regulatory or economic instrument based on reported emission levels is problematic
- To decarbonize transport, a carbon/fuel tax is preferable. Political acceptance can be improved through an environmental tax reform (increase fuel taxes, decrease labour/income taxes, provide targeted compensation to low-income households)