Inadvertent repercussions of surpassing the EU fuel economy standard

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Research Questions

How does one or more member nations enacting a stricter fuel economy standard for heavy duty trucks impact the emissions reduction behavior for the rest of the EU?

To what extent is there carbon leakage and how does incongruous national and international policy affect the total cost of achieving the EU fuel economy standard?

Background

EC heavy freight trucks fuel economy standard: reduction in fleet-wide average emissions compared to 2019 (15% by 2025 and 30% by 2030)

Several existing technologies, but insufficient adoption and progress in fuel economy improvement

Policy is required to achieve these targets

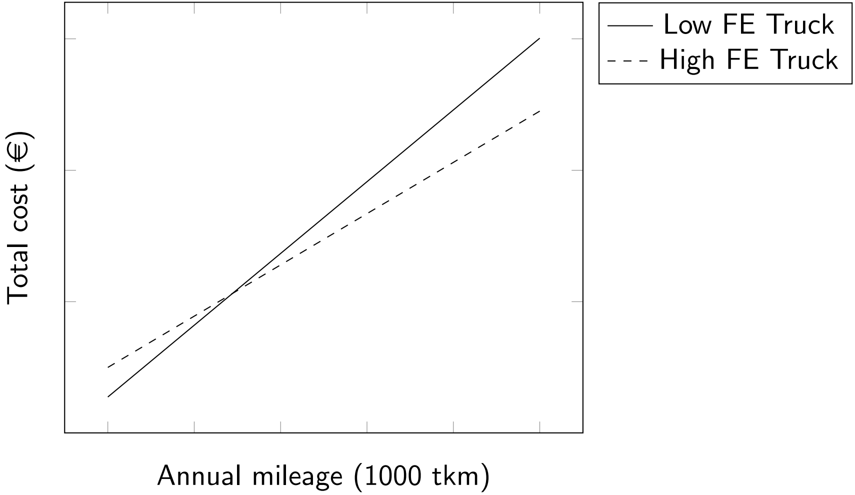
Modelling Demand

$$C(j) = \sum_{t,f=1,2} q_{t,r,f}(j) \left[p_{t,1} + \tau_{t,r,1} + (x_n \cdot l_n + (300 - x_n) l_i) \left(e_{t,1} v_{t,1} + \phi_{t,1} \right) \right]$$

$$\frac{\partial C(j)}{\partial q_{t,r,f}} = p_{t,1} + \tau_{t,r,1} + (x_n \cdot l_n + (300 - x_n) l_i)(e_{t,1} v_{t,1} + \phi_{t,1}) = 0$$

where $q_{t,r,f}$ is number of trucks with fuel efficiency $e_{t,f}$ in region r in period t, purchase price $p_{t,f}$, purchase tax $\tau_{t,r,f}$, variable fuel cost $v_{t,r}$, distance tax $\phi_{t,r}$ and $(x_n \cdot l_n + (300 - x_n) l_i)$ is annual mileage.

A graphic representation of demand



Modelling Supply

$$c_{t,f}(e_{t,f}) = A_{t,f} + \frac{1}{z_{t,f}}\left(b_{t,f} + \frac{1}{2}g_{t,f}e_{t,f}^{-1}\right)e_{t,f}^{-1}$$

$$\Pi = \max_{p_{t,f},e_{t,f},z_{t,f}} \sum_{r=1,2,f=1,2} \left[\begin{array}{c} n_1(p_{1,f} - c_{1,f}(e_{1,f}))q_{1,r,f} \\ +\ \delta n_2(p_{2,f} - c_{2,f}(e_{2,f}))q_{2,r,f} - (1-\sigma)h(z_{t,f}) \end{array} \right]$$

where A is fixed cost, $z_{t,f}$ is knowledge generation from R&D, $b_{t,f}$ and $g_{t,f}$ are calibration parameters, and $h(z_{t,f})$ is R&D investment.

Investment in R&D

$$\frac{\partial \Pi}{\partial z_{t,f}} = -n_1(1-\sigma)h_z(z_{t,f}) - \delta \rho n_2 n_1 \frac{\partial c_{t,f}(e_{t,f})}{\partial z_{t,f}} = 0$$

Truck producers invest in R&D until the discounted returns from R&D are equal to the marginal cost of fuel efficiency improvement.

Data

Parameter	Value	Units
Total EU road freight	13.417	billion tkm
Fixed cost low FE truck	55	€/1000 tkm
Fixed cost high FE truck	55	€/1000 tkm
Low fuel efficiency	24	L/1000 tkm
Diesel cost	0,78	€/L
Diesel tax	0,5	€/L
External cost	25	€/1000 tkm
Carbon damage cost	25	€/tonne CO_2
Baseline R&D expenditure	545	million €

Baseline scenario results

	Period 1	Period 2
Share high FE trucks	98%	99%
Price of high FE truck (€/1000 tkm)	62,3	65,5
High FE (L/1000 tkm)	20,3	16,7
Average fleet FE (L/1000 tkm)	20,4	16,8
R&D expenditure (million €	1.463	
Cost of policy (billion €)	418	
Cost of CO_2 saved (€/tonne CO_2)	36	

FE = fuel efficiency

Central scenario results

	Period 1	Period 2
Share high FE trucks in region 1	99%	99%
Share high FE trucks in region 2	57%	73%
Price of high FE truck (€/1000 tkm)	67,2	68,7
High FE (L/1000 tkm)	17,9	14,3
Δ CO_2 emissions region 1	- 12%	- 14%
Δ CO_2 emissions region 2	+ 0,6%	+ 0,8%
R&D expenditure (million €)	1.928	
Cost of policy (billion €)	669	
Cost of CO_2 saved (€/tonne CO_2)	49,3	

FE = fuel efficiency

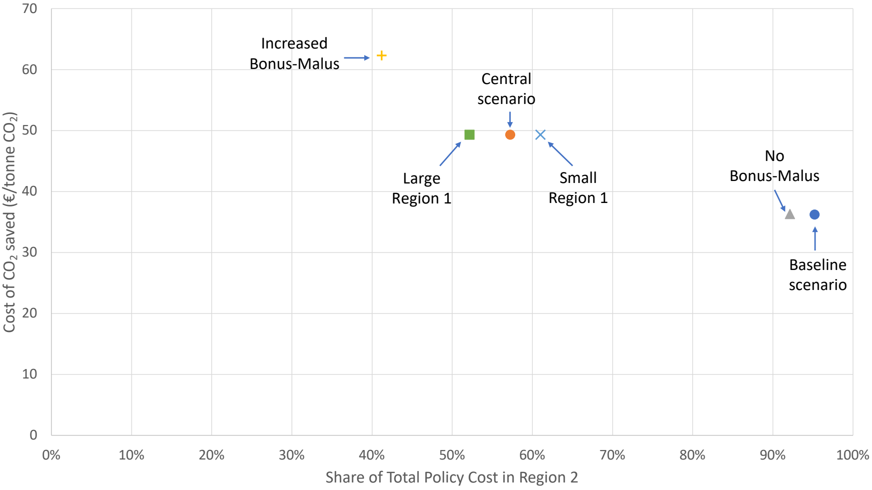
Policy simulation results relative to baseline (P1 | P2)

	High FE (L/1000 tkm)	High FE price (€/1000 tkm)	Share high FE region 2	Carbon leakage to region 2 (tonne CO_2)	R&D expenditure (mill €)
Baseline scenario values	20,3 | 16,7	62,3 | 65,5	98% | 99%	– | –	1.463
Central scenario	-11,8% | -14,3%	+7,7% | +5,0%	-41,7% | -26,0%	+0,6% | +0,8%	+31,8%
No Bonus-Malus region 1	-12,0% | -14,5%	+8,0% | +5,2%	-42,1% | -26,3%	+0,6% | +0,8%	+32,4%
Increased Bonus-Malus region 1	-11,6% | -14,0%	+7,5% | +4,8%	-41,3% | -25,6%	+0,6% | +0,8%	+31,1%
Region 1 1% of total EU	-11,8% | -14,3%	+7,7% | +5,0%	-40,0% | -24,9%	+0,12%|+0,14%	+31,8%
Region 1 10% of total EU	-11,8% | -14,3%	+7,7% | +5,0%	-44,0% | -27,4%	+1,3% | +1,6%	+31,8%

Cost of policy relating to cost of saved CO_2 (P1 | P2)

	Cost of Policy (bill €)			Average Fleet FE (L/1000 tkm)		Cost CO_2 saved €/tonne CO_2
	Region 1	Region 2	Total	Region 2	Total	
Baseline scenario values	20,9	396,8	417,7	20,4|16,4	20,4|16,4	36,2
Central scenario	287,0	382,1	669,0	20,5|16,9	20,4|16,4	49,3
No Bonus-Malus region 1	32,9	385,4	418,3	20,5|16,9	20,4|16,4	36,3
Increased Bonus-Malus region 1	541,4	378,7	920,1	20,5|16,9	20,4|16,4	62,3
Region 1 1% of total EU	261,1	408,1	669,2	20,4|16,8	20,4|16,4	49,3
Region 1 10% of total EU	319,4	349,5	668,8	20,7|17,1	20,4|16,4	49,3

Distribution of policy costs and cost of carbon saved



Conclusions

A single standard begets the lowest policy cost

Trade-off between Bonus-Malus feebate and R&D investment

Number of over-achievers has minimal effect on policy cost

Thank you!

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