A dynamic carbon tax on gasoline

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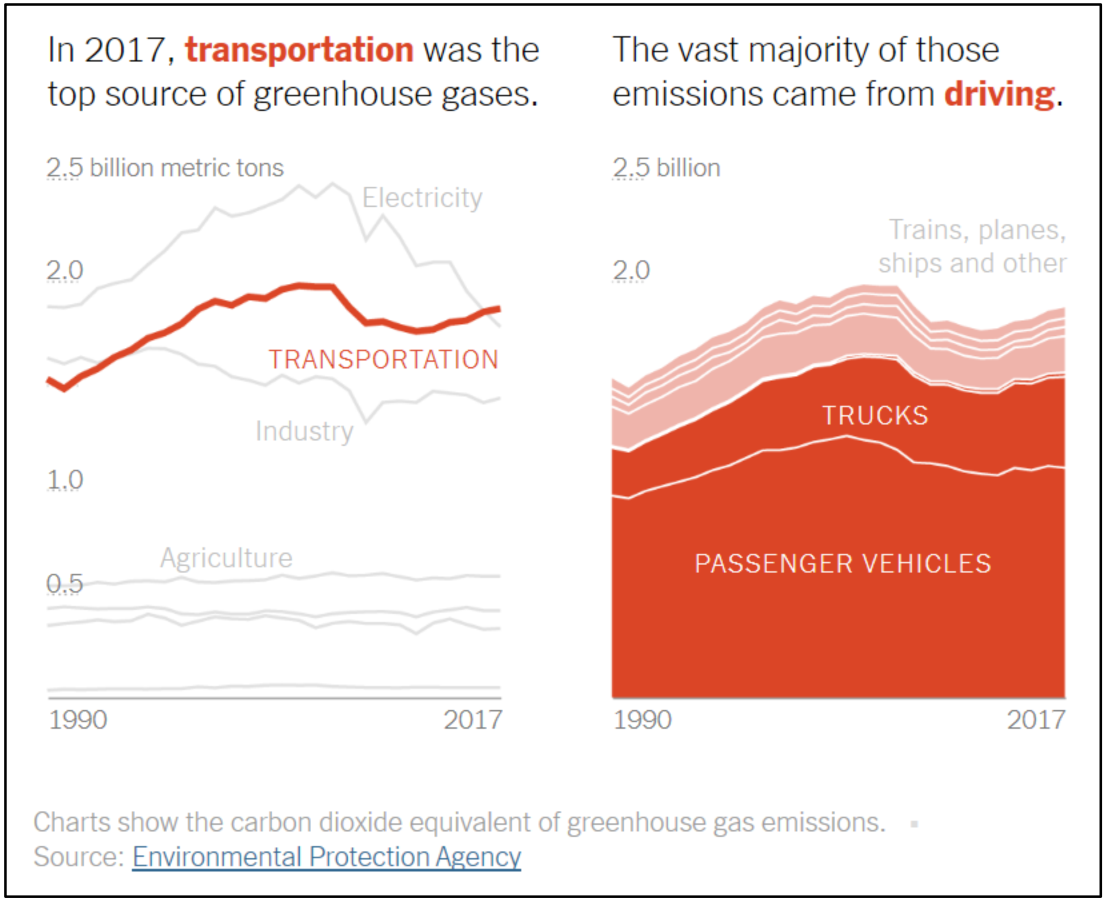
Introduction

- We need to decarbonise road transport and to do it cost-effectively.

US trends



https://www.nytimes.com/interactive/2019/10/10/climate/driving-emissions-map.html

"Even as vehicles have become more efficient, Americans, buoyed by a strong economy and low gas prices, have been driving more miles and buying more SUVs and pickup trucks."
(C. Gately, researcher)

Vehicle choice matters

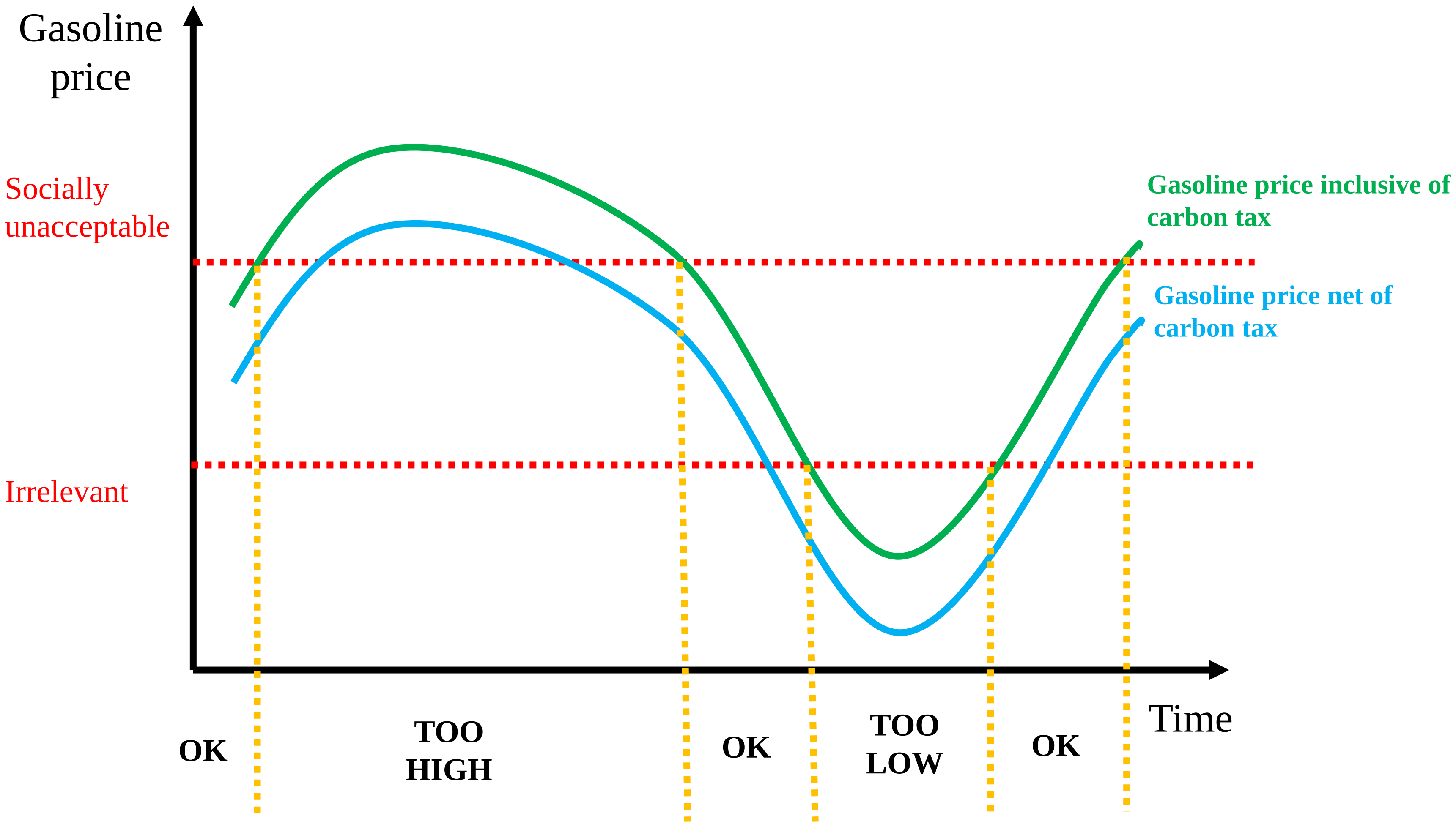
The problem

- In theory, carbon pricing is the most cost-effective policy approach for greening the vehicle fleet (Anderson and Sallee, 2016). But..
- Let us consider a carbon tax on gasoline. We have two issues related to the dependency of the domestic gasoline market on the volatile international crude oil market:

1) Oil price reductions: the price signal of the carbon tax is offset, potentially making the tax irrelevant (i.e., the gasoline price gets so low that the carbon tax hardly makes a difference in terms of the cost of driving a car); Oil price increases: the price signal of the carbon tax is magnified, potentially making the tax socially unacceptable (i.e., the gasoline price gets so high that the carbon tax makes driving overly expensive).

2) When choosing which car to buy, gasoline price uncertainty reduces the present value of future fuel costs. Increased uncertainty about future gasoline prices plays in favour of less fuel efficient cars.

Between socially unacceptable and irrelevant



Gasoline price uncertainty favours brown cars

- When choosing which car to buy, a consumer will choose the one that scores highest in terms of her utility.
- The utility that consumer *i* derives from purchasing car *j* at time *t*, u_{ijt}, depends on *i*'s appreciation of car characteristics and on her expectation about fuel costs over the car's lifetime.
- Assuming *i*'s discount rate depends (also) on uncertainty about future gasoline prices (easy assumption), the positive effect of increased uncertainty on utility, u_{ijt}, is smaller for more fuel efficient cars.
- Why? Because you further discount future fuel costs, which for a more fuel efficient car are smaller in the first place.
- The same consumer could choose a more fuel efficient car or a less fuel efficient one depending on her degree of uncertainty about future gasoline prices.

What we do

- We consider a dynamic carbon tax which adjusts inversely to the oil price. Such a tax results in a more stable gasoline price (partly controlled by the policymaker), more predictable by consumers. Reduced uncertainty about future gasoline prices strengthens the carbon tax incentive for investment in green cars.

  → Compared to a standard static carbon tax, a dynamic carbon tax can be expected to be more effective in promoting green cars.

- This study A) proposes a mechanism for such dynamic carbon tax, and B) using US data, it tests whether gasoline price uncertainty negatively correlates with new vehicle fuel efficiency.

Our dynamic carbon tax (DCT) (1)

- Our DCT has two components: the tax rate ($/gallon) and its positive or negative adjustment, which depends on the difference between the reference oil price and the actual oil price the previous month.
- For the DCT to be revenue-neutral, the adjustment is bound by the current reserve accumulated in previous periods. Net of the current adjustment, if the oil price is lower (higher) than the reference level, the reserve increases (decreases).
- Notation:

  $\bar{C}$: Carbon tax ($/gallon); C_t: Adjusted carbon tax; A_t: Tax adjustment
  $\bar{B}$: Reference Brent price; B_t: Brent price
  β: Estimated change in wholesale gasoline price for $1 change in Brent oil price (= $0,024 according to Borenstein, 2008)
  R_t: Reserve

Our dynamic carbon tax (DCT) (2)

- Determining the level of the DCT:

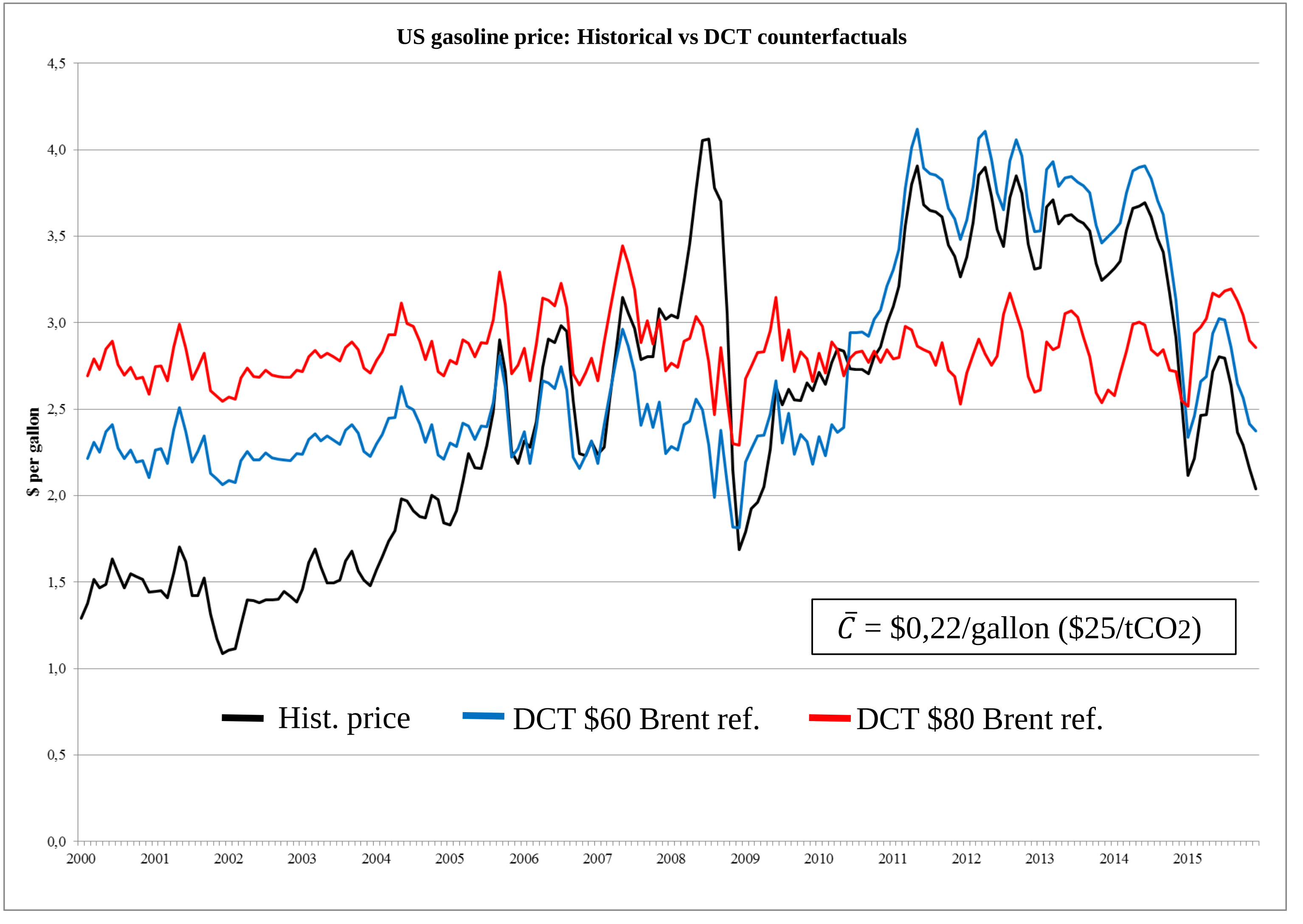
1) $C_t = \bar{C} + A_t$

2) $A_t =$
$$\begin{cases} \beta(\bar{B} - B_{t-1}) - \bar{C} & if\ \ \beta(\bar{B} - B_{t-1}) \geq \bar{C} \\ -MIN\{-1[\beta(\bar{B} - B_{t-1}) - \bar{C}]; R_{t-1}\} & if\ \ \beta(\bar{B} - B_{t-1}) < \bar{C} \end{cases}$$

where: $R_{t-1} = R_{t-2} + A_{t-1}$

Note: $A_1 \geq 0$

Our dynamic carbon tax (DCT) (3)



Our dynamic carbon tax (DCT) (4)

Mean and St. dev. of gasoline carbon tax and gasoline prices (tax-inclusive).

	Historical	CT	DCT $60 Brent	DCT $80 Brent
Tax: Mean		$0,22	$0,22	$0,32
Tax: St. dev.		$0,00	$0,51	$0,79
Price: Mean	$2,51	$2,73	$2,73	$2,83
Price: St. dev.	$0,83	$0,83	$0,63	$0,18

Over the period considered, the DCT with $60 as reference Brent price is equivalent to the static carbon tax in terms of the mean “mark-up” on the gasoline price. However, gasoline price volatility is reduced by 24%.

Gasoline price volatility and MPG

- Data

Household and vehicle characteristics (including purchase month): Microdata from the US 2009 National Household Travel Survey.

Gasoline prices: State-level monthly average prices (tax-inclusive) from Energy Information Administration and Dept. of Transportation.

41,985 vehicles (N) purchased within 24 months before the interview.

- Model

Following Li *et al*. (2014), reduced-form demand model (OLS) for MPG of newly purchased vehicle *i*, in state *s*, at time (month) *t*, augmented with the standard deviation of gasoline prices, *P*:

$$ln(MPG_{i,s,t}) = f\left(ln(\Pi_{s,t}), ln\left(1 + \frac{\tau_{s,t}}{\Pi_{s,t}}\right), ln\left(StDev(P_{s,t-K})\right), \boldsymbol{H}_i, \boldsymbol{D}_s, \boldsymbol{D}_t\right)$$

where: $P = \Pi + \tau$; H_i are household demographics; D_s and D_t are state and time dummies; and K = 6, 12, 18.

Econometric results

	(1) ln(MPG) b/se	(2) ln(MPG) b/se	(3) ln(MPG) b/se
$\ln(\Pi)$	0.088***	0.072***	0.051***
	(0.02)	(0.02)	(0.02)
$\ln(1+\tau/\Pi)$	0.499***	0.482***	0.381***
	(0.12)	(0.11)	(0.10)
$\ln(St.Dev.(P)_6)$	-0.002		
	(0.01)		
$\ln(St.Dev.(P)_{12})$		-0.018**	
		(0.01)	
$\ln(St.Dev.(P)_{18})$			-0.082**
			(0.03)
Observations	42984	42950	41500

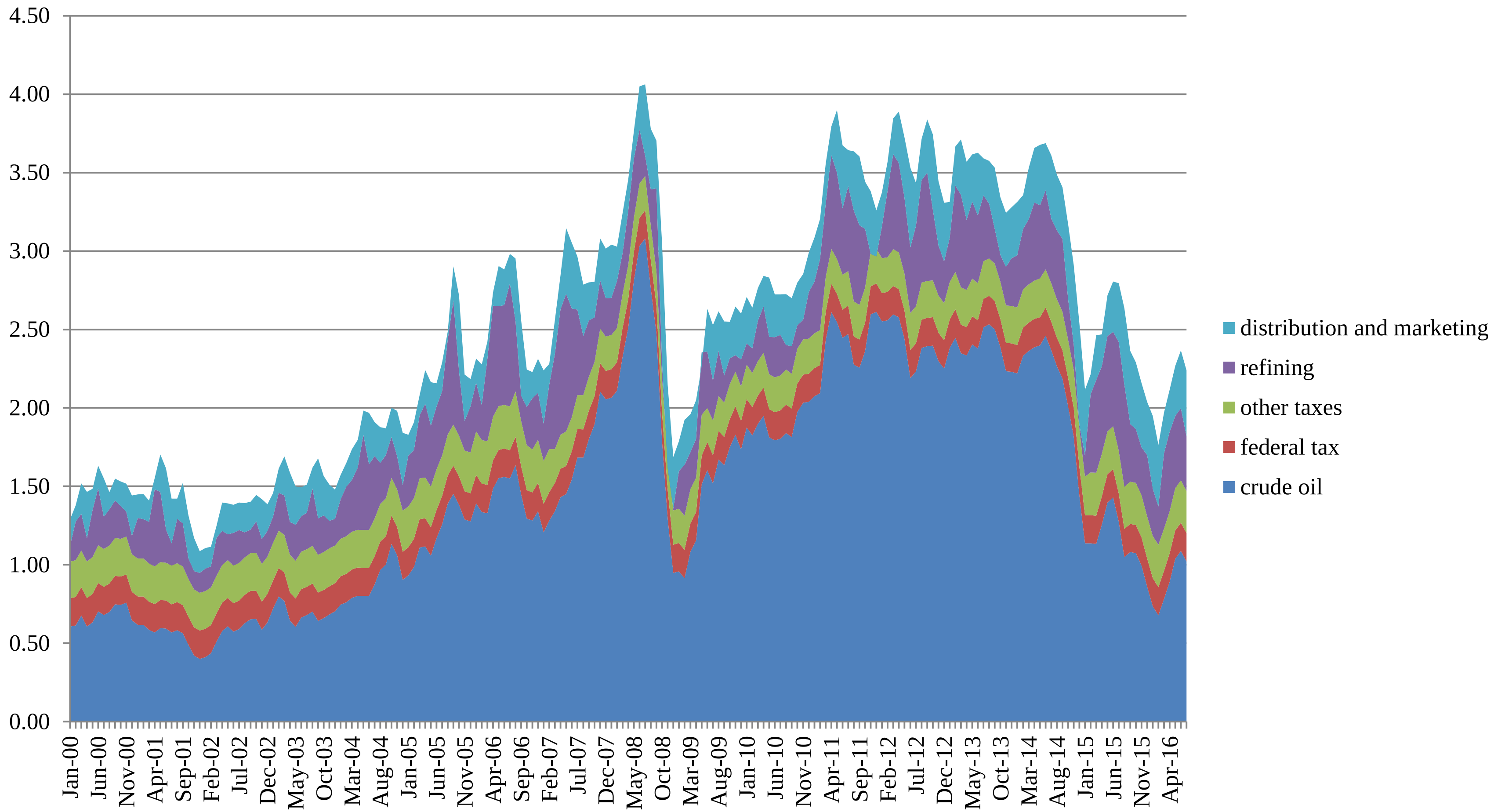
* p<0.10, ** p<0.05, *** p<0.010

Depending on how much price volatility the DCT is able to eliminate, the mean positive effect of reduced volatility (uncertainty) on MPG could be even bigger than that of the carbon tax per se.

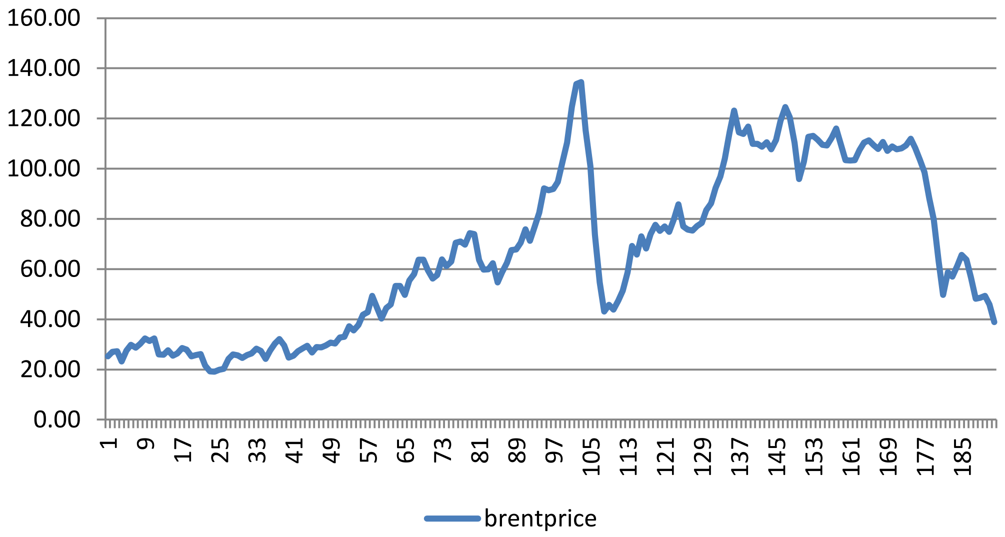
Conclusions

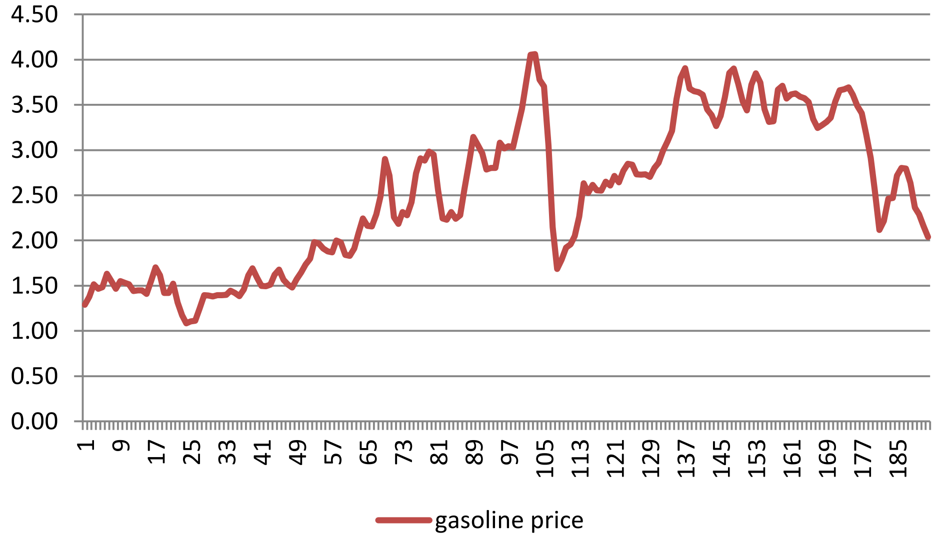
- Compared to a standard static carbon tax on gasoline, a DCT as the one we propose could be more effective in greening the car fleet and probably more socially acceptable too.
- A DCT could be one useful additional policy instrument for decarbonising road transport.
- We have empirically investigated the correlation between gasoline price volatility and new car fuel efficiency. To our knowledge, we are the first to do it. The correlation found is negative, as expected.
- More empirical work is needed. First, replicate the econometric exercise, using larger (over the time dimension) datasets and/or data from other countries. Second, test for causal effect of gasoline price volatility on MPG.

Extra material (1)



Extra material (2)





Extra material (3)

	(1)				
	count	mean	sd	max	min
mpg	262371	26.32076	8.909668	141.1	6.4
Price, $	116831	3.044517	.5384689	4.83	1.709
Rolling volat. 12 months	104708	.378507	.1782778	1.058729	.1442518
Family income, $	250792	12.09716	5.340417	18	1
Education level	268181	3.216883	1.151648	5	1
Number of people in the~e	268836	2.498903	1.232701	13	1
Number of adults	268836	2.019075	.6962677	8	1
MSA population size	268834	4.070858	1.628195	6	1
Household race	266794	2.114583	9.092983	97	1
Number of drivers	268836	1.988766	.7823971	8	0
Number of workers	268836	1.173861	.9735348	6	0
Age of the respondent	268811	57.04415	14.60121	92	18
Sex of the respondent	268836	1.578959	.493727	2	1
Population per sq mile	268834	2736.832	4119.053	30000	50
Med.Condition	268394	.1044397	.3058307	1	0
Rail dummy	268836	.1608267	.3673717	1	0
Self-employed dummy	141280	.2019536	.4014592	1	0
Second city dummy	268822	.1639561	.3702364	1	0
Urban dummy	268822	.0900894	.2863103	1	0
Suburban dummy	268822	.2281882	.4196653	1	0
Town and country dummy	268822	.5177664	.4996852	1	0
Observations	268836				

Extra material (4)

$$\mu_{it,k} \equiv E\{g_{it,k}|I_{it}\}; \;\; \sigma_{it,k} \equiv E\{(|g_{it,k} - \mu_{it,k}|)|I_{it}\}$$

$$u_{ijt} = -\alpha p_{jt} - \gamma \left[\sum_{k=0}^{T} \left(1 + r^*_{it,k}\right)^{-k} \mu_{it,k}\, m_{ij,t+k}\, MPG_j^{-1}\right] + \beta X_j$$

where

$r^*_{it,k} = r_i + f\left(\sigma_{it,k}\right)$, and $f'_\sigma > 0$

We then consider partial differentiation of u_{ijt} with respect to $\sigma_{it,k}$. We have:

$$\frac{du_{ijt}}{d\sigma_{it,k}} = \gamma k \frac{\mu_{it,k}\, m_{ij,t+k}}{\left(1 + r_i + f\left(\sigma_{it,k}\right)\right)^{k+1}} \frac{1}{MPG_j} f'_\sigma$$