The Heterogeneous Incidence of Fuel Carbon Taxes: Evidence from Station-Level Data

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Motivation

- Emissions from road transport accounted for nearly 20 percent of global CO_2 emissions from fuel combustion in 2018.

- Carbon taxes on transport fuels are an increasingly popular policy instrument to mitigate emissions.

- Increases in fuel taxes have been opposed forcefully on the grounds that they disproportionately burden consumers in low income groups and rural areas.

- Given the increasing reliance on carbon taxes as a climate policy tool, the question of who bears the economic burden of transport sector carbon taxes is of central political importance.

- Tax incidence is critical for both its environmental and distributional implications.

This paper

- We study fuel carbon tax incidence, using a large tax reform and daily station-level data. We analyze

    - the pass-through of a substantial diesel carbon tax increase on to consumer prices
    - the heterogeneous geographic and socioeconomic incidence of fuel carbon taxes

- We find

    - less than full pass-through, at 80 percent on average
    - heterogeneity across the income distribution and the rural-urban continuum, with 76 percent pass-through in the highest income areas against 90 percent in the lowest income areas
    - no evidence that local competition would be significant factor explaining the heterogeneity
    - significant supply-side anticipation of the reform

Previous empirical literature

- The pass-through of fuel taxes in general on to consumer prices:

  - estimates range from 80 to 100 percent (Silvia and Taylor 2016, Doyle and Samphantharak 2008, Yilmazkuday 2017)

- Estimates for European countries diverge:
  - almost full pass-through in Spain on average (Stolper 2016, Bello and Contín-Pilart 2012)
  - under-shifting in Greece (Genakos and Pagliero 2019)

- Little or no pass-through of renewable fuel standard costs to average retail prices in the US

- Most previous studies of distributional effects compare expenditure shares across groups and assume uniformly full pass-through of taxes to prices (see Sterner 2012 for a review)

Our contribution

- We examine the effects of a large fuel carbon tax change (nearly 11 cents per liter) using microdata on prices

  - The size of the tax change could potentially affect pass-through
  - The large tax increase and information on the characteristics of each gas station location provide an opportunity to discern even small differences in price responses across the income distribution and the rural-urban continuum
  - The results add to the limited literature on the heterogeneous geographic and socioeconomic incidence of carbon taxes

Finland's 2012 carbon tax reform

- Fuels have both excice and value added taxes. The excise tax has a carbon tax component.

- In 2012, the carbon tax on diesel was increased from 20 €/tCO2 to 60 € /tCO2 (a nearly 11 cents per liter increase).

- Before the reform, the proportion of taxes in the retail price of diesel averaged 45%, and after the reform, 48%.

- The carbon tax increase was part of a larger environmental tax reform and received substantial media coverage

- The final tax bill was brought to the parliament in October 2011, about two months before the tax change went into effect.

Data

- Diesel and gasoline prices collected by two websites where volunteer spotters report fuel prices

  - by station and exact time when price was recorded
  - location and brand for the gas station
  - station-location pairs were complemented with station-specific information on services and location relative to highways

- Gas stations where matched with

  - postal code-level income data
  - rural-urban class (7 classes ranging from "sparsely populated" to "inner city".
  - measures of local competition

Estimation strategy

- We compare station-and-day-level diesel (treated) and gasoline (control) prices around the 2012 reform using a difference-in-differences (DID) approach:

$$P_{sft} = \gamma_1 + \gamma_2 D_f + \gamma_3 A_t + \gamma_4 D_f A_t + \boldsymbol{X}'_{sft}\gamma_5 + \varepsilon_{sft}$$

- Main identifying assumption: parallel trends of diesel and gasoline prices in the absence of the tax change.

- Provided that the assumption holds, γ_4 identifies the average causal effect of the carbon tax change on diesel prices.

Diesel and gasoline price trends around the tax reform

Diesel and gasoline prices around the 2012 tax reform
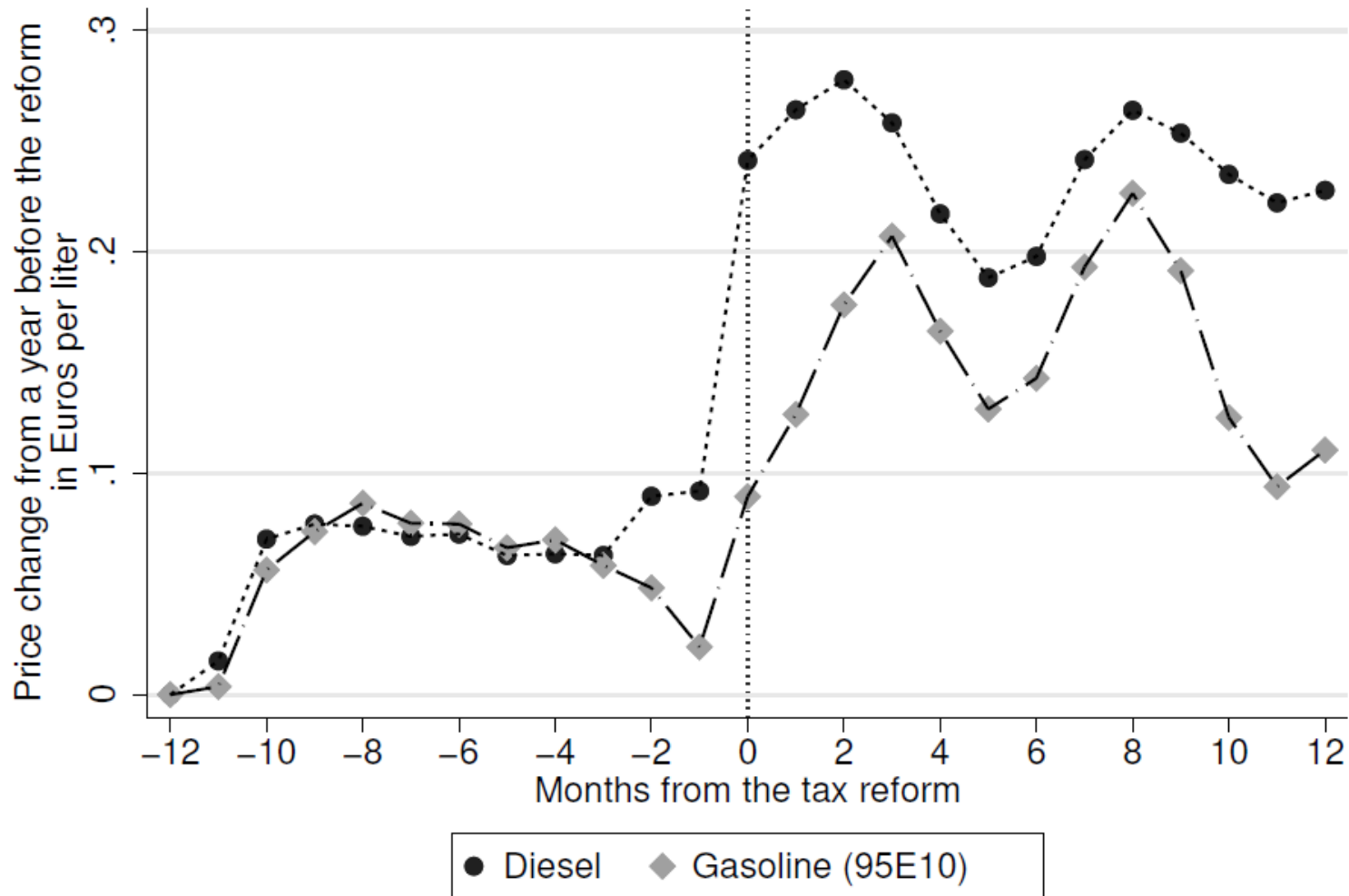
Average tax incidence

|	Whole period		Six months excluded	
	Fuel price	Fuel price	Fuel price	Fuel price
D×A	**0.073*** **	**0.073*** **	**0.066*** **	**0.067*** **
	(0.001)	**(0.002)**	**(0.002)**	**(0.002)**
D	-0.192***	-0.216***	-0.202***	-0.213***
	(0.001)	(0.001)	(0.001)	(0.001)
A	0.103***	0.079***	0.108***	0.111***
	(0.001)	(0.003)	(0.002)	(0.003)
Controls	No	Yes	No	Yes
Pass-through	**79.5%**	**79.9%**	**72.6%**	**73.3%**
N	219,034	219,034	163,693	163,693
R²	0.81	0.87	0.82	0.89

Heterogeneous effects across areal income levels and degree of urbanity

- We examine heterogeneous effects using the modified difference-in-differences regression

$$P_{sft} = \beta_1 + \beta_2 D_f + \beta_3 A_t + \boldsymbol{G'}_s\beta_4 + \beta_5 D_f A_t + D_f \boldsymbol{G'}_s\beta_6$$

$$+ A_t \boldsymbol{G'}_s\beta_7 + D_f A_t \boldsymbol{G'}_s\beta_8 + \boldsymbol{X'}_{sft}\beta_9 + \eta_{sft}$$

- Parameter β_5 identifies the causal effect of the carbon tax increase on diesel taxes in the baseline

- Coefficients in β_8 show how the causal effect in each group differs from that in the baseline group

- Standard errors: clustered at the municipality level

Differences in pass-through across the income distribution

Differences in pass–through between income groups
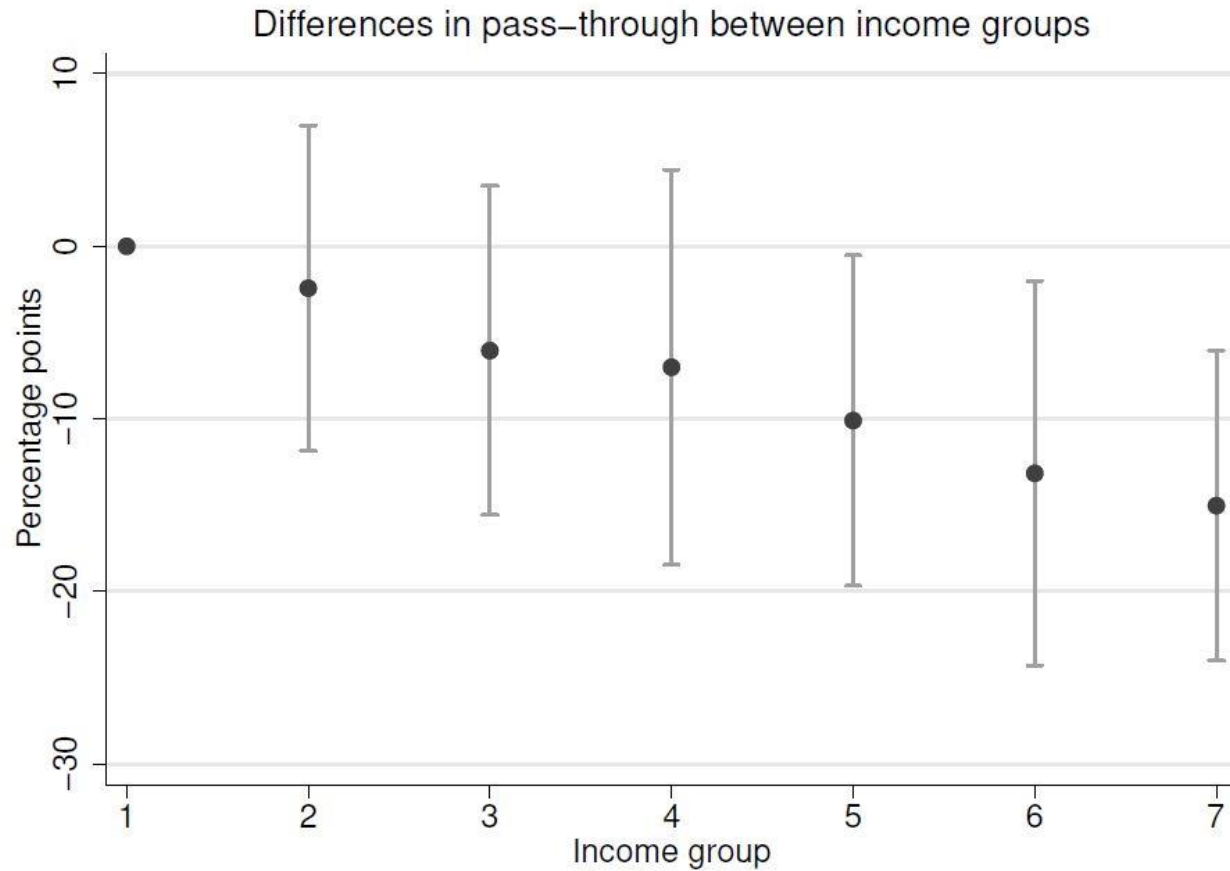
Differences in pass-through across the rural-urban continuum

Differences in pass–through between rural and urban areas
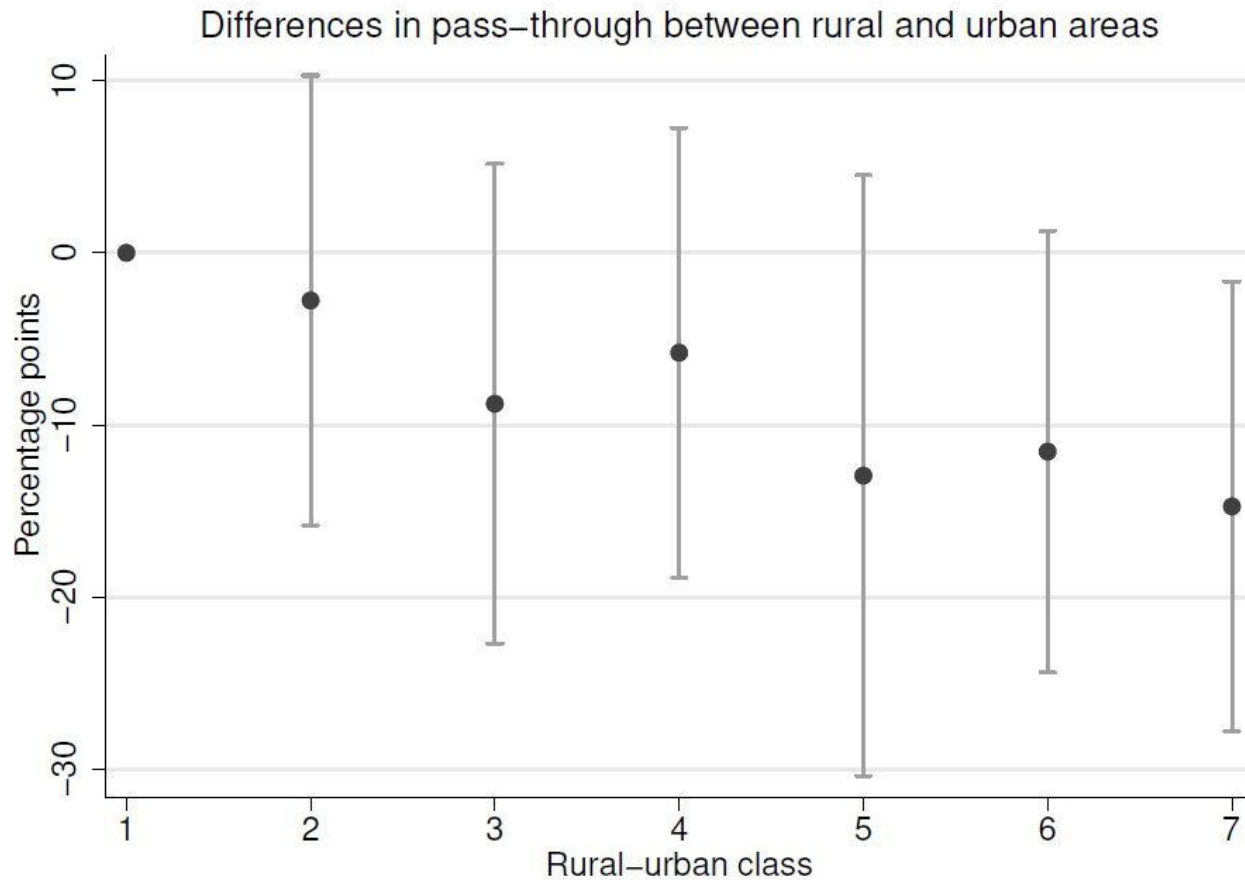
Carbon tax pass-through by areal income and rural-urban class: parameter estimates

	Areal income level (Panel A)/Rural-urban class (Panel B)						
	1st	2nd	3rd	4th	5th	6th	7th
Panel A. Effect by areal income level							
Pass-through	90.7%	88.3%	84.6%	83.7%	80.6%	77.5%	75.7%
D×A×G		-0.002	-0.006	-0.006	-0.009*	-0.012*	-0.014**
		(0.004)	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)
F-test D×A×G all: 4.16***							
Panel B. Effect by rural-urban class (from most rural to most urban)							
Pass-through	91.3%	88.5%	82.5%	85.5%	78.4%	79.8%	76.6%
D×A×G		-0.003	-0.008	-0.005	-0.012	-0.011	-0.013*
		(0.006)	(0.006)	(0.006)	(0.008)	(0.006)	(0.006)
F-test D×A×G all: 2.63*							

Distributional implications

- The carbon tax increase is passed through more to prices in low-income areas relative to high-income areas, and in rural areas relative to urban areas

- The Statistics Finland Household Budget Survey suggests that the share of fuel in total consumption is higher in middle- to high-income groups than in low-income groups

- This would attenuate somewhat the regressive nature of fuel taxes

- The opposite holds for the rural-urban continuum: the share of fuel in total consumption is the highest in rural and peri-urban areas

Competition

- Differences in the degree of competition across local markets is one potential explanation for the heterogeneity in pass-through

- We addressed the association of competition with pass-through differences using the number of nearby gas stations as a measure of competition

- The estimations also include several station characteristics potentially correlated with competition:

  - gas station brand, rural-urban class, population density

  - indicators for automated stations and stations along highways

- Pass-through is lower in the group of stations in municipalities with the most competition

- Overall conclusion: pass-through heterogeneity across areal income levels and rural versus urban areas at least in part due to factors other than competition

Conclusion

- We examine the effect of a large diesel carbon tax increase, nearly 11 cents per liter, which received substantial media coverage

- We find that carbon taxes are less than fully passed through to retail prices

- We also estimate how the pass through of fuel carbon taxes to consumer prices differs across income levels and between rural and urban areas

- We find evidence of notable geographic heterogeneity in the incidence of fuel carbon taxes

  - A 1-cent increase in the tax leads to a 0.77 cent price increase in the most urban areas, but to a 1-cent price increase in the most rural areas

- Many voters object to fuel carbon taxes on the basis of these taxes burdening in particular lower income groups and people living in small towns and rural areas. Our results lend support to these concerns.