Estimation of the Rebound Effect for Travel Distance Using Micro-level Data for France

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How to cut driving emissions?

- The share of global energy-related GHG emissions due to transportation is 23% (EEA, 2017).
- In France, it is 28,5% of which 53,7% are due to private vehicles (Pourquier and Vicard, 2017).

How to cut driving emissions?

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- In France, it is 28,5% of which 53,7% are due to private vehicles (Pourquier and Vicard, 2017).
- Efficiency policies are widely used as a way to reduce greenhouse gas emissions.
- More efficiency usually means a *fall in the real cost* of unit energy service, e.g. driving.
- A lower real cost of driving creates incentives to drive more.

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- The direct rebound effect is defined as:
 - The efficiency elasticity of demand for driving (VKT)

Overview Literature review Motivation Methods Main Results Conclusions Key findings

 Most studies focus on the U.S., using panel data at a state level. Only few use micro-level data.

 Estimates range from 5% (Greene, 1992) to 40% (Linn, 2016) for the US. At the European level, they go from 9% (Stapleton et al., 2016) to 70% (Frondel and Vance, 2013).

 Some assumptions widely used in the literature can be potential sources of bias in estimations (Gillingham et al., 2016; Sorrell and Dimitropoulos, 2008).

Estimating the direct rebound effect in France

We use the primary definition of the direct rebound effect: The efficiency elasticity of demand for driving (VKT) and account for three main sources of bias.

We use micro-level data in France for 2008 and improve the methodology in Linn (2016) by controlling for selection bias.

 Our rich database allows us to account for household heterogeneity and vehicle characteristics, thus enhancing the rebound effect estimates.

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- The dependent variable, VKT, measures the travel distance during a reference week for one vehicle
- Fuel economy, *E*, is the inverse on-road fuel intensity per 100 km
- Fuel economy is available for *one* or *two* households vehicles

		Methods	
Model	structure		

$$ln(VKT_{hi}) = \beta_0^{vkt} + \beta_1^{vkt} ln(P_f) + \beta_2^{vkt} ln(E_{hi}) + \beta_3^{vkt} ln(E_{hj}) + X_h + \epsilon_{hi}$$

Overview		Methods	
Model	structure		

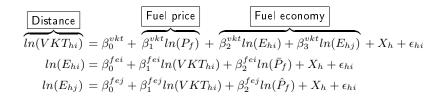
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$$\underbrace{\boxed{\text{Distance}}}_{ln(VKT_{hi})} = \beta_0^{vkt} + \overbrace{\beta_1^{vkt}ln(P_f)}^{\text{Fuel price}} + \overbrace{\beta_2^{vkt}ln(E_{hi}) + \beta_3^{vkt}ln(E_{hj})}^{\text{Fuel economy}} + X_h + \epsilon_{hi}$$

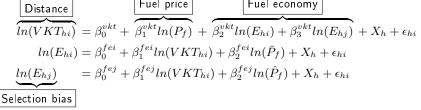
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- A system in which VKT and fuel efficiency are simultaneously determined to address endogeneity. The estimation technique is 3SLS.
- Correction of selection bias in presence of endogenous explanatory variables(Wooldridge, 2010).

		Methods	
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$$\begin{aligned}
& Fuel economy\\
ln(VKT_{hi}) &= \beta_0^{vkt} + \beta_1^{vkt} ln(P_f) + \overbrace{\beta_2^{vkt} ln(E_{hi}) + \beta_3^{vkt} ln(E_{hj})}^{\mathsf{Fuel}} + X_h + \epsilon_{hi}\\
& ln(E_{hi}) &= \beta_0^{fei} + \beta_1^{fei} ln(VKT_{hi}) + \beta_2^{fei} ln(\bar{P}_f) + X_h + \epsilon_{hi}\\
& ln(E_{hj}) &= \beta_0^{fej} + \beta_1^{fej} ln(VKT_{hi}) + \beta_2^{fej} ln(\hat{P}_f) + X_h + \epsilon_{hi}
\end{aligned}$$

The rebound effect takes into account variation in fuel economy of all vehicles in the household :

$$\eta_E(VKT) = \beta_2^{vkt} + \beta_3^{vkt} \times 40\%$$

	VTK_i		E_i		E_j	
VTK_i			0.00403	(0.003)	0.00958	(0.006)
E_i	0.321***	(0.045)		. ,		, ,
E_j	-0.0445**	(0.014)				
Rebound Effect	0.305***	(5.74)				
P_{f}	-0.464***	(0.085)				
Monthly Income	0.110***	(0.022)	0.00568	(0.004)		
Interaction prices and income:	P_f		\bar{P}_f		\hat{P}_{f}	
Q2	0.0560	(0.053)				
Q3	0.136*	(0.063)				
Q4	0.296***	(0.070)				
Interaction No of vehicles:			Veh_i		Veh_j	
Log vehicle age - 0			-0.0336***	(0.002)		
Log vehicle age - 1			-0.00457	(0.007)	0.0312*	(0.015)
Log vehicle weight - 0			-0.100***	(0.022)		
Log vehicle weight - 1			0.0270***	(0.004)	0.174***	0.009)
Loghorsepower - 0			-0.375***	(0.018)		
Log horsepower - 1			-0.0272	(0.019)	0.429***	(0.023)
Inverse Mill's Ratio	0.136***	(0.012)			-0.0311**	(0.012)
Observations	4698					
R^2	0.616		0.439		0.805	
A. Giraldo	Rebound	Effect for T	ravel Distance		AFSE 20	18 8/

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Conclusions

- We find that almost one third of fuel savings following an efficiency improvement are lost due to the direct rebound effect.
- We provide further evidence on endogeneity of fuel economy and interdependence of travel distance among vehicles in multivehicle households. Moreover, our model does not support the symmetry assumption.
- Reducing carbon emissions require the combination of energy efficiency improvements with other policies (e.g. taxes, behavioral).
- We will use this model in order to simulate three different policies shocks: prices, fuel economy and income.





Thank you

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