

# Heterogeneity in the Response to Gasoline Prices: Evidence from Pennsylvania and Implications for the Rebound Effect

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# Motivation

Economists are always interested in the price elasticity of driving.

- There is a deep literature estimating it using aggregate time series data.
- More recently, there have been studies using micro-level data:
  - Travel diary survey data (Linn 2014; Frondel and Vance 2011)
  - Odometer readings from inspections (Gillingham 2014; Knittel & Sandler 2014)
- Moreover, there is a clear policy motivation: the direct rebound effect
  - If consumers respond to gasoline price changes the same way as efficiency increases, the price elasticity of VMT demand *is* the direct rebound effect.

# This Paper

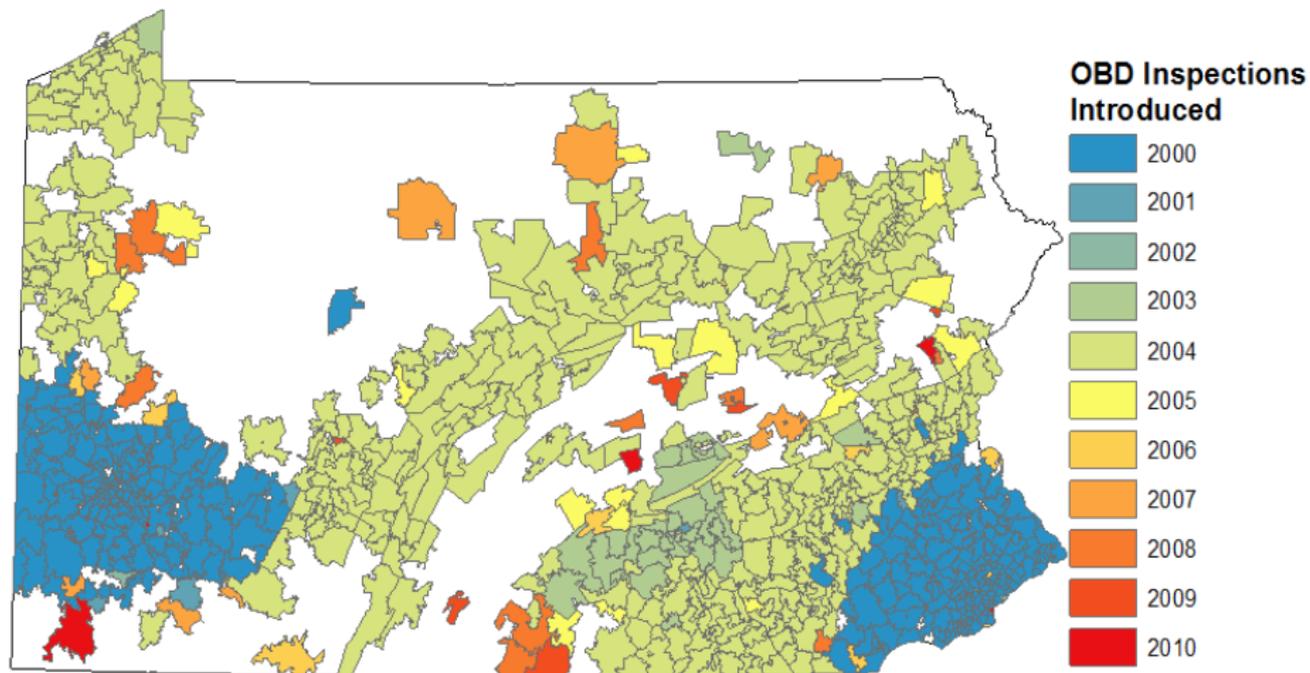
This paper brings new evidence to bear to improve our understanding of the consumer response to gasoline prices:

- We use annual odometer readings from most vehicles in Pennsylvania (PA).
- Our focus is on the *heterogeneity* in the gasoline price elasticity in several dimensions:
  - Changing response based on selection of the sample.
  - Changing response with changing gasoline prices.
  - Changing response by fuel economy of the vehicle.

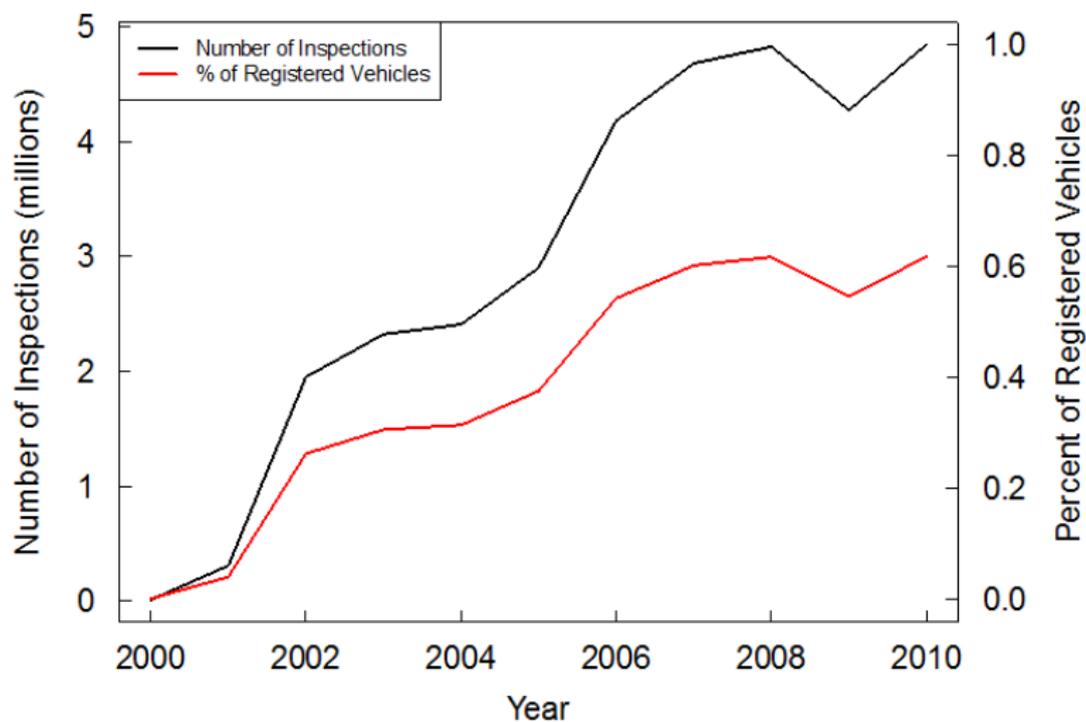
# Empirical Setting

- Starting in 2000, annual emissions vehicle inspections were rolled out across most of PA.
- The inspections involve of an check of whether the vehicle emissions equipment is working properly based on both the on-board computer diagnostic (OBD) and a visual check.
- The odometer reading and other vehicle information are electronically recorded at the time of inspection.

# Empirical Setting



# Empirical Setting



# Dataset

- Core Data: 2000-2010 annual inspection records for PA.
  - VIN, odometer reading, test date, registration zip code.
- VIN decoder.
  - Make, model, model year, body style, body type, engine displacement, engine size, fuel type, drive type, highway miles per gallon (MPG), city MPG, weight, fuel tank size, and manufacturers suggested retail price (MSRP).
- Gasoline prices (EIA).
- Unemployment/GDP (BEA).
- Census demographics.

# Key Summary Statistics

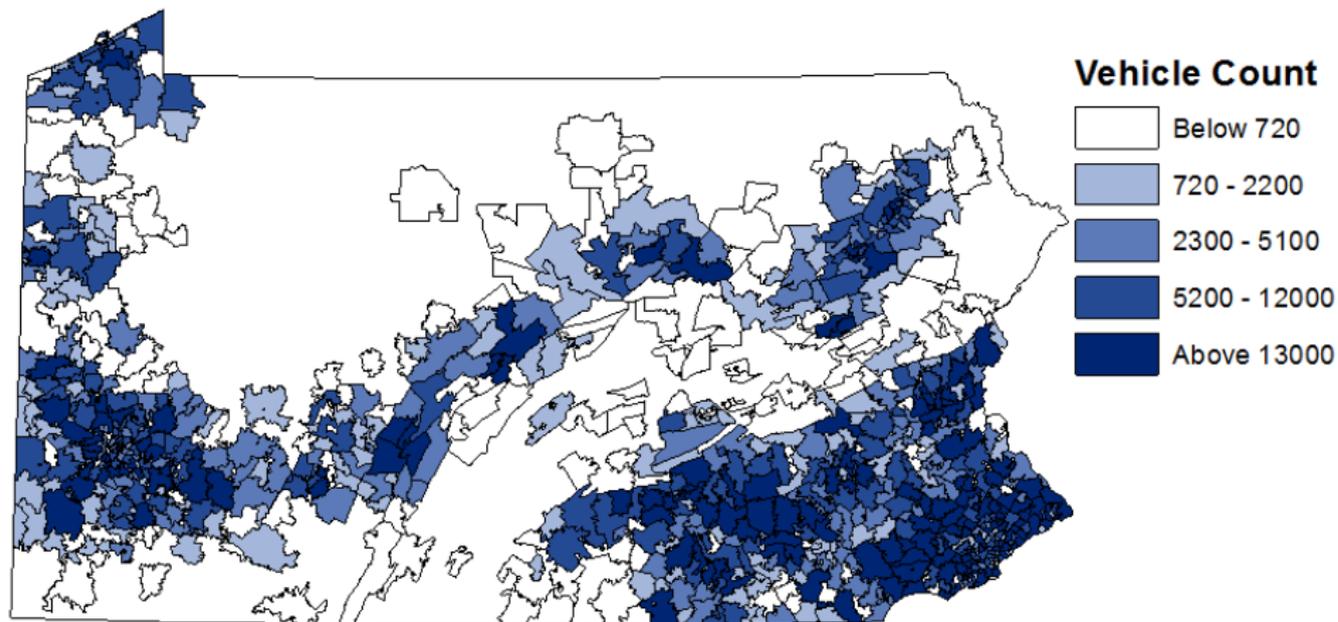
<b>Variable</b>	<b>Mean</b>	<b>Std. Dev.</b>	<b>Min.</b>	<b>Max.</b>	<b>N</b>
Annual VMT (miles)	10,640	9,180	0.01	200,000	33,154,057
Average gasoline price (2013\$/gal)	2.54	0.55	1.20	4.14	33,154,057
Fuel economy (mi/gal)	23.0	5.02	10.0	65.5	33,154,057
Unemployment rate (percent)	5.64	1.27	4.00	8.70	33,154,057
GDP (millions)	14,260	653	12,300	15,130	33,154,057

# Two Subsamples

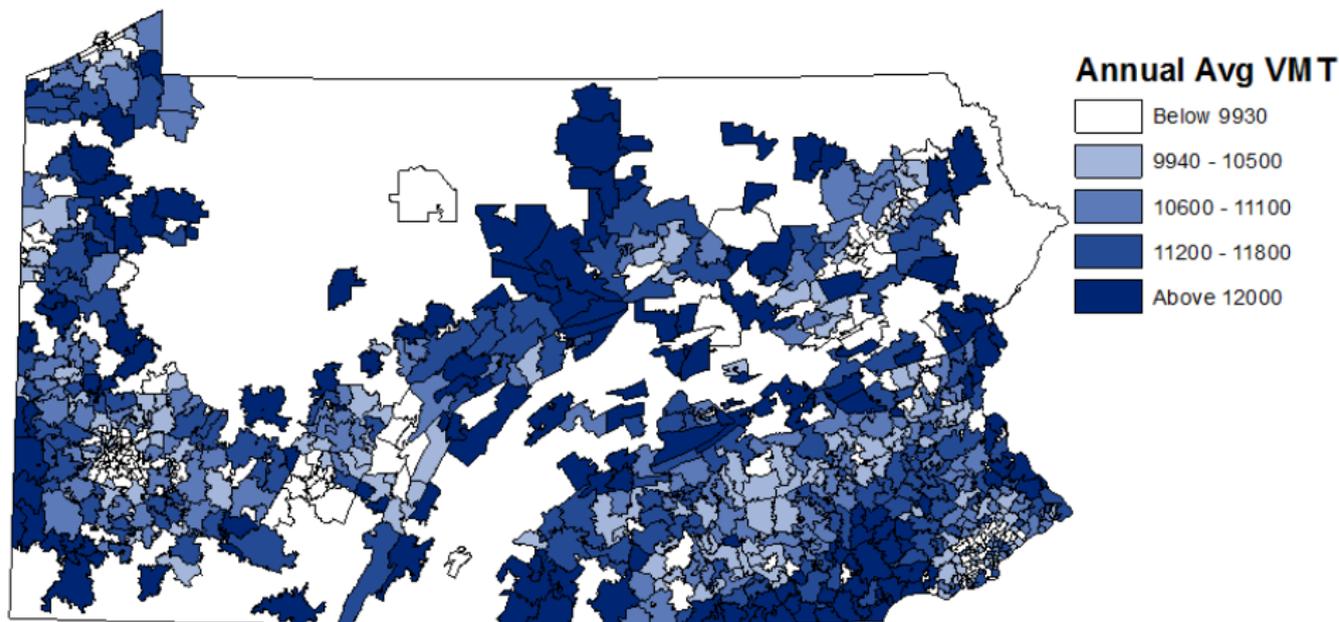
1. Vehicles present from 2002-2010
  - Primarily Philadelphia and Pittsburgh
2. Vehicles present from 2006-2010
  - Much more of the state

Variable	2002-2010		2006-2010	
	Mean	Std. Dev.	Mean	Std. Dev.
Annual VMT (miles)	8,690	6,150	9,330	6,730
Average gasoline price (2013\$/gal)	2.3	0.59	2.76	0.3
Fuel economy (mi/gal)	23.0	4.88	22.8	4.99
Unemployment rate (percent)	5.63	1.18	5.77	1.54
GDP (millions)	14,100	737	14,600	216
Vehicles	1,761,358		7,241,499	

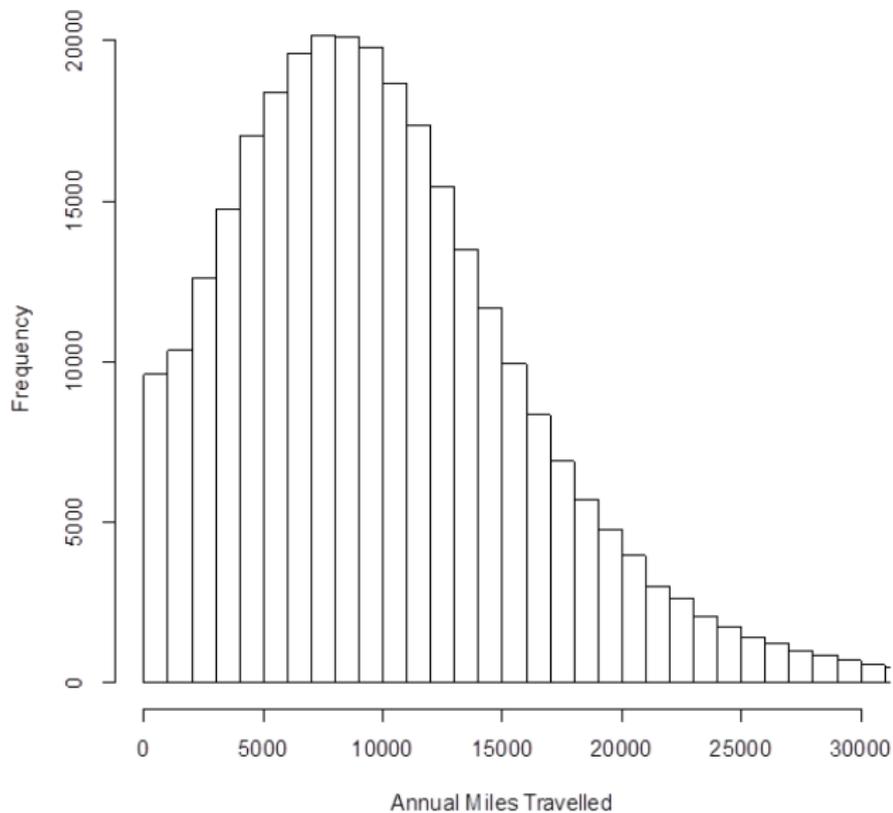
## Where Vehicles are Registered in 2010



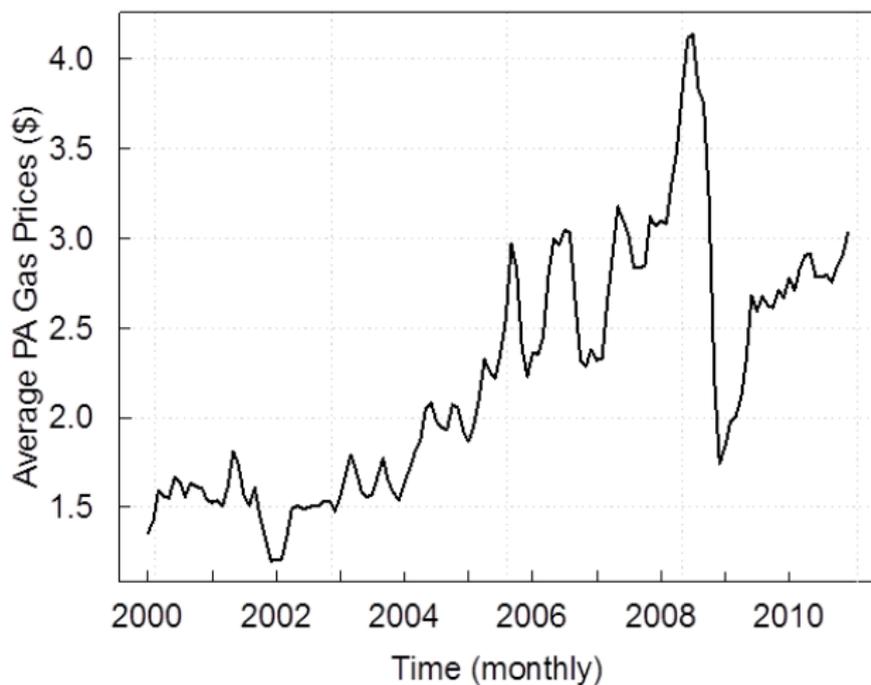
# Spatial Distribution of Driving 2000-2010



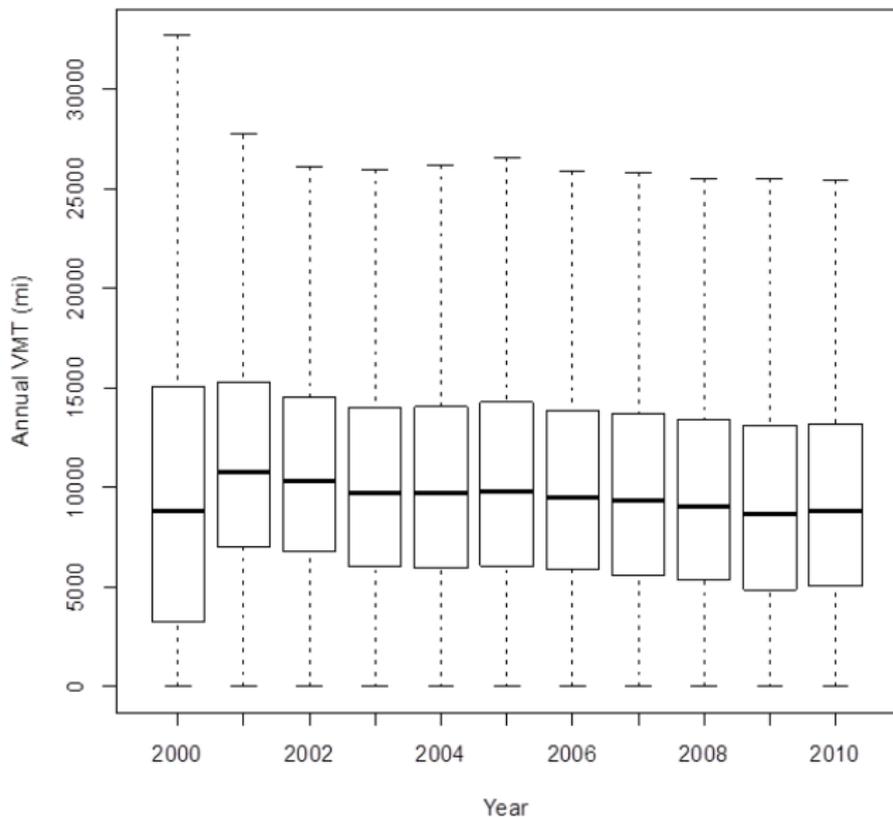
# VMT Histogram 2000-2010



## Gasoline Prices Showed Significant Variation



## Yet Driving Showed Little Change



# Modeling the Demand for Driving

Let the demand for VMT for vehicle  $i$  at time  $t$  be given by:

$$VMT_{it} = f(P_{it}, M_t, V_i, D_{it})$$

where

- $P_{it}$  is the price of driving (can explore different approaches)
- $M_t$  is a vector of macroeconomic conditions
- $V_i$  is a vector of vehicle characteristics
- $D_{it}$  is a vector of demographics

# Primary Specification

As a starting point, we specify the model in the following form:

$$\ln(VMT_{it}) = \alpha \ln(P_{it}) + \beta \ln(M_t) + \gamma V_i + \zeta D_{it} + \theta_i + \mu_t + \varepsilon_{it}$$

Here we specify  $P_{it}$  as the price of gasoline and  $\theta_i$  are vehicle fixed effects,  $\mu_t$  are year-month dummies.

# Results by Subsample

Dependent variable: ln VMT

	(1)	(2)
	2002-2010	2006-2010
ln gasoline price	-0.131*** (0.0182)	-0.117*** (0.00758)
ln unemployment	0.374*** (0.0136)	0.277*** (0.0045)
ln GDP	5.42*** (0.0039)	0.275*** (0.0023)
Vehicle FE	X	X
Year-month dummies	X	X
Adj $R^2$	0.665	0.706
Vehicles	1.57m	5.8m

\*\*\* denotes significant at 1% level

Included: vehicle characteristics, demographics

Clustered s.e. on vehicle in parentheses

# Varying Response with Gasoline Prices

Dependent variable:  $\ln$  VMT

	(1)	(2)
	2002-2010	2006-2010
$\ln$ gasoline price	-0.0387* (0.0356)	-0.0538** (0.0225)
$\ln$ gp*(gas \$2-\$3)	-0.0105 (0.0362)	0.051** (0.0210)
$\ln$ gp*(gas \$3-\$4)	-0.0448* (0.0345)	0.026* (0.0201)
$\ln$ gp*(gas >\$4)	-0.209*** (0.0389)	-0.128*** (0.0191)
$\ln$ unemployment	0.413*** (0.0237)	0.303*** (0.0118)
$\ln$ GDP	4.94*** (0.199)	4.24*** (0.104)
Vehicle FE	X	X
Year-month dummies	X	X
Adj $R^2$	0.54	0.706
Vehicles	1.57m	5.8m

\*\*\* denotes significant at 1% level

Included: vehicle characteristics, demographics

Clustered s.e. on vehicle in parentheses

# Varying Response by Vehicle Fuel Economy

Dependent variable: ln VMT

	(1)	(2)
	2002-2010	2006-2010
ln gasoline price	0.0689 (0.0983)	-0.046** (0.016)
ln gp*(FE <20mpg)	-0.284*** (0.0909)	0.127*** (0.00718)
ln gp*(FE 20-30mpg)	-0.169* (0.0908)	-0.0495*** (0.00622)
ln gp*(FE 30-40mpg)	-0.08 (0.0913)	0.0146 (0.0461)
ln unemployment	0.374*** (0.0237)	0.277*** (0.012)
ln GDP	5.38*** (0.182)	4.75*** (0.0971)
Vehicle FE	X	X
Year-month dummies	X	X
Adj $R^2$	0.65	0.71
Vehicles	1.57m	5.8m

\*\*\* denotes significant at 1% level

Included: vehicle characteristics, demographics

Clustered s.e. on vehicle in parentheses

# Robustness Checks

- Instrument for the gasoline price.
- Include/not include fuel economy.
- Examine different functional forms for VMT demand.
- Examine the relationship using quantile regression.
- Explore selection on different years.

# Conclusions and Policy Implications

- The response to gasoline prices is generally quite inelastic, with an elasticity on the order of  $-0.1$ .
- However, the elasticity is largely driven by times of high gasoline prices.
  - This helps to reconcile the earlier findings of low responsiveness in Small & van Dender (2007) and Hughes, Knittel, and Sperling (2008) with more recent findings of higher responsiveness.
- The elasticity is largely driven by lower fuel economy vehicles.

⇒ To the extent that the gasoline price is good proxy for the rebound effect, this suggests considerable heterogeneity in the direct rebound effect, which may lend itself to targeted policies.

# Many Thanks

Thank you all for your attention!

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