



Measures of Price Sensitivity and the ULSD Assessment

Prepared for
Air Quality Stakeholders Mobile Sources Work Group
8/16/18

Introduction

- Basic review of measures used to describe price sensitivity.
- How the ULSD was put together?
- How to assess potential impacts of ULSD price differential on wood burning?

Own-price elasticity of demand

- Price Elasticity of Demand measures how sensitive quantity demanded is to a change in price

- Own- Price Elasticity of Demand Formula:

$$|E_d| = \frac{\% \Delta Q_d}{\% \Delta P}$$

- When $E_d > 0$ demand is said to be “elastic”
- When $E_d < 0$ demand is said to be “inelastic”

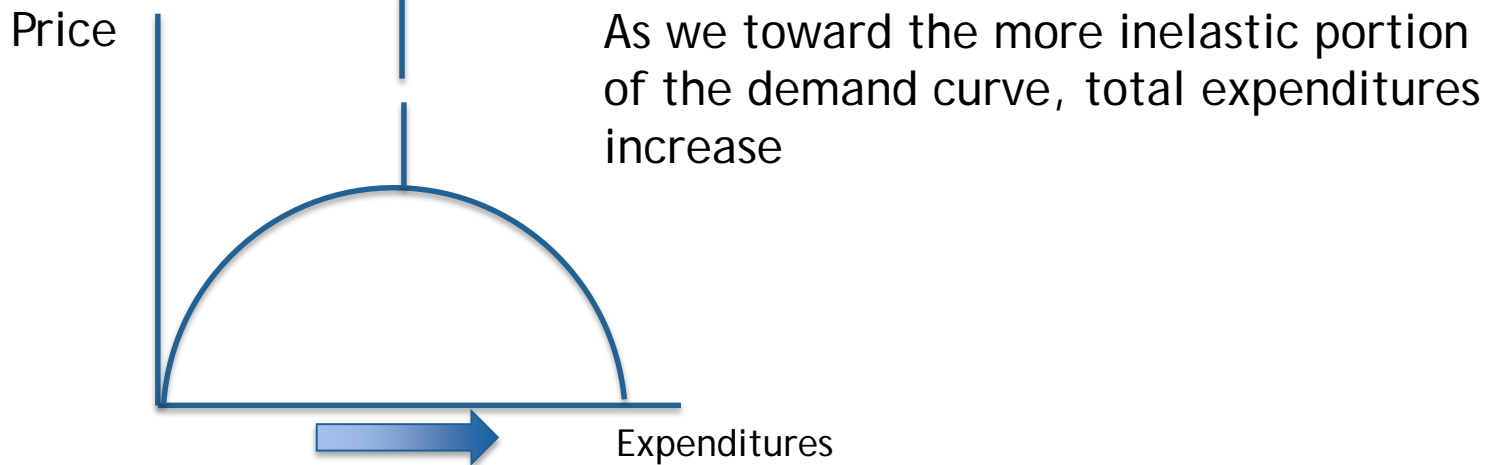
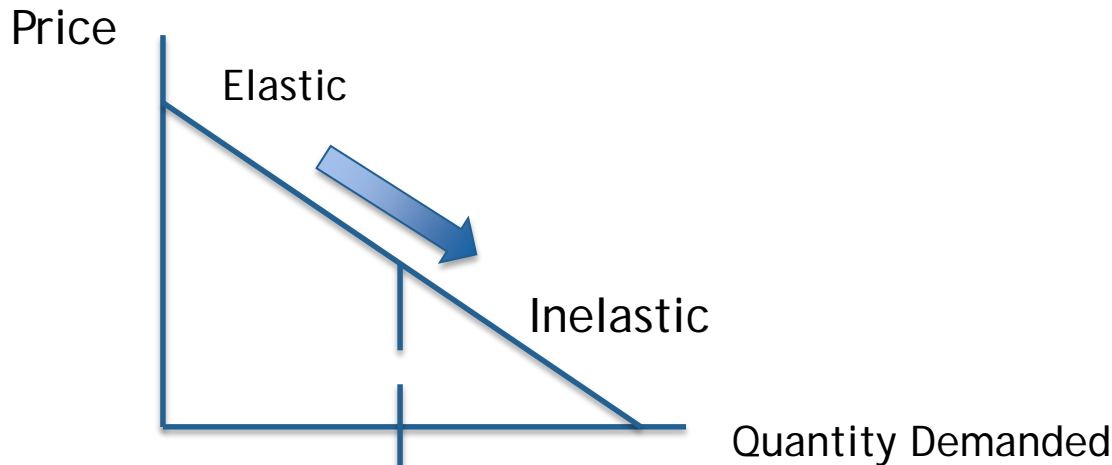
Price elasticity sensitivity factors in household heating

- How sensitive the quantity of heating oil consumed by a household is to changes in price depends on:
 - Availability of substitutes
 - i.e. Homes with central-oil only will be less sensitive to changes in oil price than a home with central-oil and a wood stove.

Price Elasticity of Demand and Relationship to total Expenditures

- When demand is “elastic” the price of a good and total expenditure move in opposite directions
 - As price increases, total expenditure decreases and vice versa
- When demand is “inelastic”, price of a good and total expenditure move in the same direction
 - As price increases, total expenditures increase and vice versa

Relationship between own-price elasticity of demand and total expenditure



Steps to Produce ULS Estimates

- Review literature to find range of price elasticity estimates for heating fuel oil and cross-price elasticity for firewood use.
- Collected data from Alaska Energy Data Gateway, American Community Survey (ACS), Energy Information Administration.
- Built Monte Carlo simulation with info collected.

More Steps

- How we calculated change in consumption and expenditures
 - First, calculate total household heating expenditures
 - Then calculate the change in consumption based on the ULSD Differential (higher price of fuel) and own-price elasticity of demand
 - Calculate new household heating expenditure by (Oil Price + Differential) multiplied by new oil consumption

Hypothetical Oil-Only Household

Oil (Gallons)	ULSD differential	Ed	Current heating expenditure
1200	0.34	0.2; 0.7	\$2,520

Current oil price per gallon	Current price per cord
\$2.10	\$232.16

Own –Price Elasticity of Oil

Remember the key question

- How does the ULS price change relate total household heating expenditure(s)?

- Formula

$$\Delta Q_o = -E_d \cdot \left(\frac{((\text{Oil Price} + \text{ULSD Differential}) - \text{Oil Price})}{\text{Oil Price}} \right) \cdot \text{Gallons of fuel}$$

Total Expenditure Calculation

- First, we calculate the change in consumption based on the ULSD Differential (higher price of fuel) and own-price elasticity of demand

$$\Delta Q = -0.7 \cdot \left(\frac{(\$2.10 + \$0.34) - \$2.10}{\$2.10} \cdot 1200 \right) = -136$$

- Next, calculate the change in total oil consumption

$$\Delta Q_t = 1200 - 136 = 1,064 \text{ Gallons}$$


- Finally, Multiply new oil consumption by (Oil Price + Differential)

$$\text{New Expenditure} = 1,064 \cdot (\$2.10 + \$0.34) = \$2,596.16$$


- Based on the own-price elasticity of demand being relatively inelastic we should an increase in expenditures

Results

Ed	Change in oil consumption	New oil consumption	Change in heating expenditures	New heating expenditures
-0.7	-136	1,064 Gallons	\$76.16 (increase)	\$2,596.16



Ed	Change in oil consumption	New oil consumption	Change in heating Expenditures	New heating Expenditures
-0.2	-39	1,161 Gallons	\$312 (increase)	\$2,832.84



What about other heating appliances?

- How much will wood consumption change when a change in oil-price occurs?
- Why is this an important question?
 - Important because an increase in wood-burning could diminish the effectiveness of a hypothetical switch to ULSD.

Cross Price Elasticity of Demand

- Measures the responsiveness of changes in quantity demanded for one good when the price for another good changes
- Primary question: How does demand for wood change with an increase in the price of oil?
 - When $E_c > 0$ substitute goods (Wood use up)
 - When $E_c < 0$ complementary goods (Wood use down)
- $$E_c = \frac{\% \Delta Q \text{ fire wood}}{\% \Delta \text{ Price of heating oil}}$$

Cross Price Elasticity Wood and Oil

- How does cross-price elasticity relate to changes in total household heating expenditures?

Hypothetical Wood/Oil Household

Wood (Cords)	Oil (Gallons)	ULSD Differential	Own-Price Elasticity of Demand	Cross-Price Elasticity of Demand	Current oil expenditure	Current wood expenditure
3.0	1200	0.34	-0.2, -0.7	0.2, 0.5, 0.7	\$2,520	\$696.48

Current Wood Price	Current Oil Price	Total Household Heating Expenditure	Oil Expenditure Share	Wood Expenditure Share
\$232.16 (Cord)	\$2.10 (Gallons)	\$3,216.48	0.78	0.22

Cross Price Elasticity of Demand for Household Heating in Fairbanks

$$\Delta Q_w = 0.2 \cdot \left(\frac{(\$2.10 + \$0.34) - \$2.10}{2.10} \cdot 3.0 \right) = 0.09$$

$$\Delta Q_o = -0.7 \cdot \left(\frac{(\$2.10 + \$0.34) - \$2.10}{\$2.10} \cdot 1200 \right) = -136$$

- Based on a Cross Price Elasticity of 0.2, and an own-price elasticity of -0.7 - as the price of oil increases from \$2.10 to \$2.44, cord consumption increases by 0.09 cords, and oil consumption decreases by 136 gallons.

Cross Price Elasticity for Wood and Oil

- We can then calculate the change in total expenditure per household
$$\Delta TotalExp = (\$2,832.84 + \$717.37) - \$3,216.48 = \$97.05$$
- Based on this calculation, a wood/oil household would consume slightly more wood and less oil, and have an increase in household heating expenditures of \$97.05
- Big Caveat: Assumes a price for wood (also collected)
- Limitations on cross-price effect (need to look at other demand functions)

How Firewood Consumption Changes with Oil price

Price Difference	Cross Price Elasticity Wood	Change in # Cords
0.34	0.2	0.09
	0.5	0.24
	0.7	0.34
0.43	0.2	0.12
	0.5	0.31
	0.7	0.44

Discussion

- Based on a Cross Price Elasticity of 0.2, and an own-price elasticity of -0.7, as the price of oil increases from \$2.10 to \$2.44, cord consumption increases by 0.09 cords, and oil consumption decreases by 136 gallons

Limitations and Things to Work On

- Assume all individuals pay the same market price for wood and oil
 - Many individuals cut their own wood, how to value time and effort?
- Household appliance efficiency?
Characteristics?
- Evaluate impact of different price differentials



UNIVERSITY OF
ALASKA
FAIRBANKS

Questions?
Thank You