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Income and Price Elasticity of Hawaii Energy Demand

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Income elasticity of demand measures the sensitivity or responsiveness of consumers to the change in their income. Similarly, price elasticity of demand measures the sensitivity or responsiveness of consumers to the change in price of the good consumed. The sensitivity is reflected in the quantities consumed. In mathematical forms, price elasticity of demand is calculated as the ratio between the percentage change in quantity(Q) demanded and the percentage change in price(P) (%ΔQ/%ΔP); income elasticity of demand is the ratio between percentage change in quantity demanded and percentage change in income(Y) (%ΔQ/%ΔY). The value of the elasticity represents the percentage change in demand with respect to one percentage change in income or price. For example, if income elasticity of electricity demand is 1.5, it implies that the demand for electricity increases by 1.5 percent for each one percent increase in income. Elasticity of larger than 1.0 means the demand is sensitive to the change in income or price and is called elastic demand. Elasticity of less than 1.0 means the demand is not sensitive to the change in income or price and is called inelastic.

Using data from 1970 to 2008, we found that Hawaii consumers were not very sensitive to changes in electricity prices and the price of gasoline. Energy consumption in Hawaii has not been very sensitive to the change in income either.

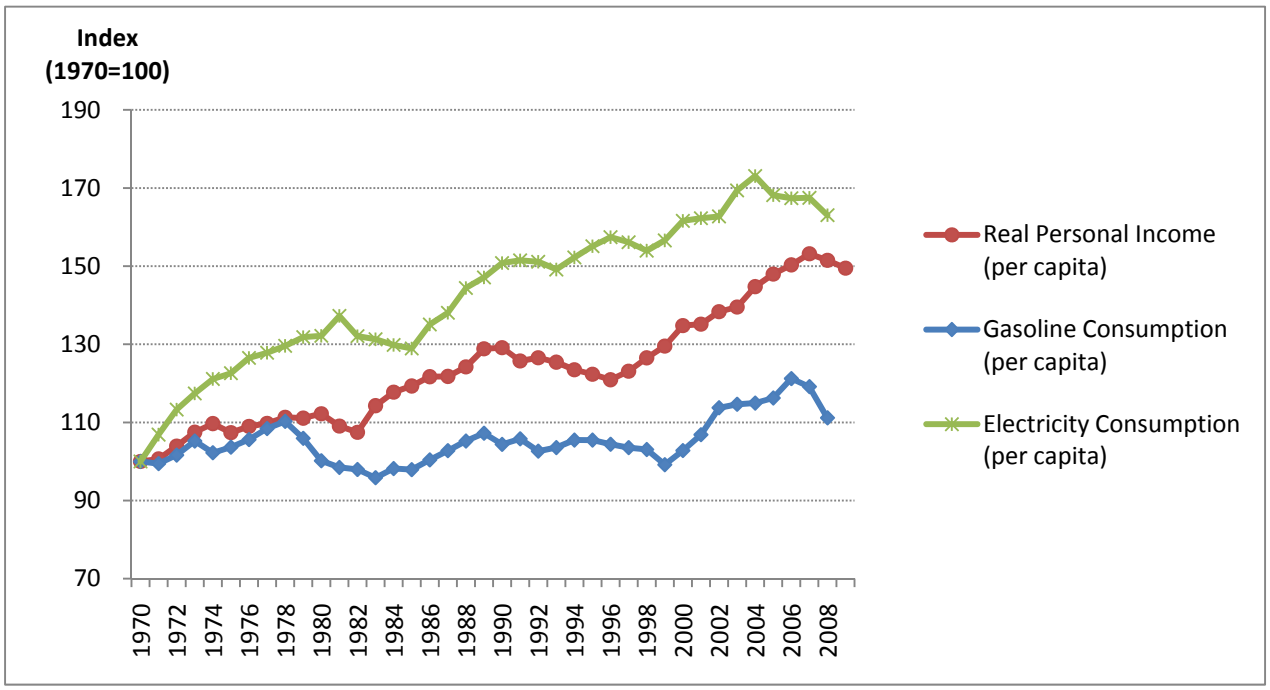
Energy consumption has been affected by a variety of factors such as income, energy prices, energy efficiency and various policy measures to conserve energy. In this short analysis, we examine how Hawaii's energy consumption has responded to the changes in income and energy prices.

Income and Energy Consumption

In general, energy consumption increases with income and production growth; although it would not grow as fast as income or production due to the development of new technologies for higher energy efficiency and the transformation of the modern economy to a less energy-intensive structure.

While it would be true for most energy sectors, the growth pattern of energy demand could vary significantly by energy sector. The graph below shows the growth of Hawaii's per capita energy consumption in two major energy sectors, electricity and motor gasoline, compared to the growth of per capita income from 1970 to 2008. Measured per capita, the consumption of electricity grew rapidly for the period from 1970 to 2008 (faster than income growth mostly owing to its fast growth in 1970s), while gasoline consumption reflects great volatility without a clear growth trend (except the prolonged growth in 2000s until 2008 when the economy was hit by skyrocketing oil prices and a deep recession).

Figure1. Growth Paths of Per Capita Income and Per Capita Energy Consumption (1970-2008)

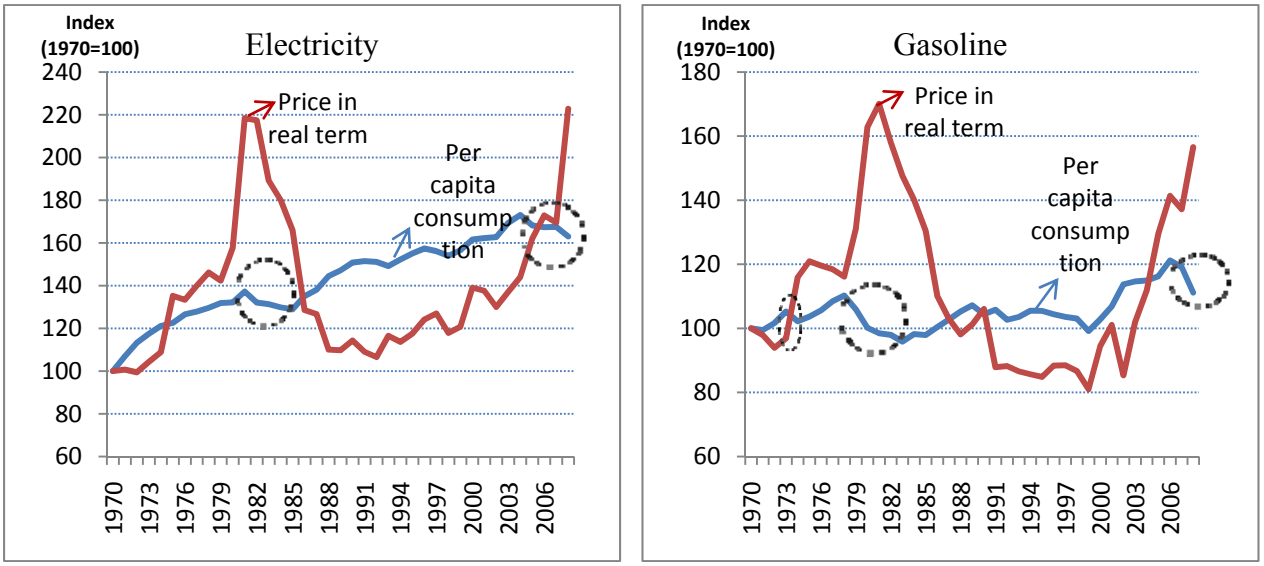


Source: Energy Consumption Data—U.S. Energy Information Administration (EIA)
Personal income data – U.S. Bureau of Economic Analysis(BEA)
Price Index –U.S. Bureau of Labor Statistics (BLS)

Price and Energy Consumption

Price is another key variable that affects the level of energy consumption. Figure 2 shows the historical trend of price and per capita consumption of electricity and gasoline. The negative impacts of price on energy consumption were clearly observed during three extreme periods: the two oil crises in the 1970s and one in 2008. For the rest of the period, however, energy consumption did not respond tightly to price changes.

Figure2. Price and Consumption Trend of Electricity and Gasoline in Hawaii (1970-2008)



Source: U.S. Energy Information Administration (EIA)

Price elasticity of energy consumption tends to be low because there is little room for substitution. Indeed, in many empirical studies that covered different regions and different time periods, the price elasticity of energy demand were estimated to be very low both in the short and long run.

The short-run elasticity of energy demand to price would be fairly low because it would take a period of adjustment while consumers actually change their demand for energy use after they observe changes in energy prices. Most consumers have only a limited ability to reduce their energy consumption immediately because it would require a major change in lifestyle. For instance, consumers would respond to energy price increases by switching to more energy efficient appliances and cars, or to move closer to their workplaces. All of these adjustments could take a year or longer to take place if at all.

The price effect can be very low even in the long run if the negative price effect is surpassed by other factors. Consumers may choose to adjust their budgets to higher gasoline costs because they prefer or need a bigger car or must live in an outlying suburb. In this case, the effect of higher gasoline price would be felt as reduced spending in other sectors instead of reduced gasoline consumption.

Estimation of Income and Price Elasticity of Energy Consumption

Putting trends of two related variables together provides a quick guide to how the two variables have interacted over time. However, since the realized energy consumption is the result of mixed effects, identifying the effect of one variable on another based on graphs has only limited validity. For example, the decrease in energy consumption during the oil crises cannot be fully attributed to price effects. Although economic growth has not been closely affected by the energy price change during normal economic periods, an extreme instability and rise in oil price as in oil crises have led to a world-wide recession. Therefore, some of the decrease in energy consumption during the oil crises must have had been caused by income decrease that was triggered by the oil crises.

In order to measure the income and price effect separate from each other, we estimated them using a multi-variable regression method. The regression was conducted for each energy sector and end-user using the annual energy consumption data by EIA for the year from 1970 to 2008. The equation used in the estimation is as follows.

$$Ln(E_t) = \alpha + \beta_1 Ln(E_{t-1}) + \beta_2 Ln(P_t) + \beta_3 Ln(Y_t) + \varepsilon_t$$

Ln: natural logarithm
E_t : per capita energy consumption
Y_t : per capita personal income in real term
P_t : energy price (adjusted for inflation)
t : index for time (year)

Then, β_2 estimates the short-run price elasticity and β_3 estimates the short-run income elasticity of energy demand. The long-run price and income elasticity of energy demand can be estimated as $\frac{\beta_2}{1-\beta_1}$ and $\frac{\beta_3}{1-\beta_1}$ respectively.

The estimated elasticities of Hawaii energy demand for electricity and motor gasoline are reported in Table 1. As expected, the long-run elasticities are estimated bigger than the short-run elasticities. Although all short-run elasticities presented in the table show right signs, they are barely different from zero suggesting highly price and income inelastic energy demand in the short-run.

Table1. Short-run and Long-run Elasticities of Hawaii Energy Demand

	Electricity Consumption		Motor Gasoline Consumption
	Residential	Commercial & Industrial	
Price Elasticity			
Short-run	-0.07	-0.04	-0.03
Long-run	-0.54	-0.27	-0.15
Income Elasticity			
Short-run	0.13	0.08	0.07
Long-run	0.99	0.57	0.35

Elasticity of energy consumption to income and price varies by energy sector and by end-user. In general, people have been more responsive to the changes in income and price in the consumption of electricity than in the consumption of gasoline.

Within the electricity consumption, residential consumption has been more responsive to the change in income and price change than commercial and industrial consumption.

The estimated results imply that, with some time lags, the electricity consumption for residential use would decrease by 0.54 percent while the electricity consumption for commercial and industrial use would decrease by 0.27 percent as a result of a price increase of 1 percent.

On the other hand, motor gasoline consumption is estimated to decrease by 0.15 percent with some time lag with 1 percent price increase.

Historically, Hawaii's energy consumption has been more responsive to income change than price change. It was estimated that 1 percent increase in income would result in almost same percentage increase in the residential electricity consumption, and 0.57 and 0.35 percent increase in the electricity consumption for commercial & industrial use and gasoline consumption.

These results are based on the energy consumption behaviors in Hawaii during the past 40 years. With enhanced technologies, new policy measures to improve energy efficiency and the State's commitment to renewable energy, however, Hawaii's energy consumption pattern for coming years could be very different.

This publication is produced by the Research and Economic Analysis Division (READ) of the Department of Business, Economic Development & Tourism (DBEDT), State of Hawaii which is responsible for its content and presentation.

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