Conversion of Shipping Fleets from Diesel to Compressed Natural Gas: A Real Options Analysis

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Methodology

1) Incorporating Real Options Analysis (ROA): What market conditions are required for profitable shifts from diesel to compressed natural gas (CNG) for private regional trucking?
2) How do these market conditions compare under net present value (NPV) vs. ROA decision making?

Introduction

Natural Gas in the U.S. Transportation Sector:
- Natural Gas Supply and Prices: U.S. production has rapidly increased due to advances in hydraulic fracturing technologies, resulting in marked price declines.
- Environmental Issues: CNG cleaner-burning than gasoline or diesel.
- Energy Portfolio: Natural gas in 2009 provided 25% of the total energy used in the U.S., but only 3% in the transportation sector.
- Barriers to CNG for Transportation: High sunk costs (vehicle modification and station construction) and lack of adequate refueling stations.

Heavy-Duty Vehicles and CNG:
- Heavy-Duty Vehicles: High annual mileages and low fuel efficiency, representing 4% of registered vehicles, but accounting for approximately 20% of U.S. 2010 fuel use and GHG emissions from the transportation sector.
- In February, 2014, President Obama announced the timeline for issuing post-2018 greenhouse gas and fuel efficiency standards for heavy-duty vehicles.

Real Options Approach:
- Treats investment opportunity as a financial call option.
- Accounts for Managerial flexibility, investment cost irreversibility, and uncertainty suitable for assessing investment opportunity in volatile markets.
- Model energy prices as stochastic geometric Brownian motion (GBM) process.

Solve optimal threshold prices
- Two boundaries:
    - Cross boundary 1: Switch to CNG,
    - Cross boundary 2: Switch to diesel,
    - Waiting Region: Stay with incumbent fuel.

Results-- Switching Boundaries

Results:
- High CNG truck costs and station construction costs are a significant barrier to the adoption of CNG.
- Under current low CNG prices there is potential gain for large-high mileage fleets to switch from diesel to CNG.
- The waiting region suggested by ROA is larger than NPV, given ROA captures uncertain fuel prices.

Conclusions

Data

Monthly Spot Prices ($/DGE): October 1983 to January 2014 (EIA)
- U.S. No. 2 diesel retail sales by refiners.
- U.S. price of natural gas sold to commercial consumers.
- Normalized by PPI (BLS) at dollar value in January 2013.

Table 1 M&O Costs, Fuel Taxes for Diesel and CNG Fleets ($/DGE)

Switching Cost is varied by Fleet Size (FS) and Vehicles Miles Traveled (VMT)
- Fleet Size: 20/40/60 units per fleet
- VMT: 50,000,000/70,000,000/100,000,000 miles per year

Table 2 Statistical Summaries and Stochastic Parameters (Oct. 1983 -- Jan. 2014)

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