The Macroeconomic Benefits of the EV Transition

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Global oil market volatility drives volatile gas prices
U.S. gasoline prices are closely tied to international oil prices

Monthly Crude Oil ($/Barrel, left axis) vs. U.S. Regular Gasoline ($/Gallon, right axis)

Sources: EIA, Haver Analytics
Large run ups in oil price preceded several U.S. recessions

Inflation-Adjusted WTI Prices ($/Barrel) vs. Real GDP Growth (y/y % Chg.), with Recession Shading

U.S. EV owners are insulated from oil price volatility
Based on historical data, BEV fueling costs are lower and less volatile

Hypothetical Monthly U.S. Average Fueling Costs ($)

Fueling costs calculated assuming:
• 1,035 miles/month based on annual miles per vehicle of 12,416 according to Highway Statistics 2000; fhwa.dot.gov
• U.S. monthly average residential price of electricity per kWh. Residential electricity prices vary by state. Source: EIA, Haver Analytics
• U.S. monthly average regular gasoline price. Source: EIA, Haver Analytics
• Median efficiency of 2021 MY electric models is 104 mpge (or 3.1 mi/kWh). Source: fueleconomy.gov.
• Median fuel economy for 2021 MY is 23.6 miles per gallon. Source: epa.gov.
U.S. electricity grid is ~60% powered by coal and natural gas whose prices are less volatile than oil and in which the U.S. is self-sufficient.

Brent Prices vs. U.S. Cost of Fossil Fuels for Electricity Generation ($/M Btu)

- Coal
- Natural Gas
- Brent

Annual U.S. Natural Gas and Coal Net Imports (Quadrillion Btu)

Since 2017, U.S. has been a net exporter of natural gas and coal.

Sources: EIA, Haver Analytics. Assume 1 barrel of crude oil = 5,691,000 Btu; EIA.
U.S. vulnerability to oil price shocks has fallen greatly due to increased U.S. production and greater energy efficiency.

**U.S. Net Imports of:**
- Crude Oil and Petroleum Products (M Brls/Day)
- Natural Gas (B Cubic Ft)

**U.S. Energy Intensity**
1970 = 100, Ratio of total primary energy consumption to real GDP

Sources: EIA, Haver Analytics

Sources: Bureau of Economic Analysis, Haver Analytics
Gasoline and diesel are 22-23% of current U.S. energy consumption and two-thirds of petroleum use

U.S. Share of Energy Consumption by Source

<table>
<thead>
<tr>
<th>Source</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
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<tr>
<td>Renewables</td>
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<td>12</td>
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1Motor gasoline and diesel consumption for the transportation sector.
2Other petroleum products include liquefied petroleum gases and other; jet fuel; kerosene; distillate fuel oil use outside the transportation sector; residual fuel oil; petrochemical feedstocks; and other petroleum (e.g., aviation gasoline, road oil, misc. petroleum products).

Sources: EIA, Haver Analytics
But sentiment remains closely tied to gas prices. Lower, stable EV fueling costs could positively impact sentiment.

“Consumer sentiment becomes more pessimistic with rising gas prices. This effect is strongest for consumers who lived through the recessionary oil crises in the 1970s...”

- Binder and Makridis (2022)

“[W]e also find that aggregate demand and other oil demand shocks have significant influence on household satisfaction with economic policy measures ‘to fight inflation and unemployment.’”

- Güntner and Linsbauer (2018)

“[H]istorically energy price shocks have been an important factor in explaining U.S. real consumption growth, but by no means the dominant factor.”

- Edelstein and Kilian (2009)

Sources: EIA, University of Michigan, Haver Analytics
Increasingly renewable U.S. electricity generation will further increase climate benefits as the U.S. vehicle fleet transitions to EVs.

~60% electricity generation from fossil fuels in 2020 down to ~45% in 2040.

Sources: EIA, Annual Energy Outlook 2022, Reference case; Haver Analytics
“Electrifying 100% of car miles traveled (thereby eliminating gasoline vehicle carbon emissions) increases electricity-sector carbon emissions by 23-27% if vehicles are charged at night but could decrease electricity-sector carbon emissions if vehicles are charged during the day.”

If you further net out avoided gas/diesel emissions from ICE vehicles, annual welfare gains of 100% EV adoption relative to zero EV adoption can increase by as much as 9%-28% with optimized charging (i.e., charging primarily in the afternoon).

Conclusion

The EV transition reduces U.S. vulnerability to macroeconomic shocks from oil price volatility and geopolitical risk. In doing so, it should reduce economic volatility.

The EV transition shifts U.S. energy consumption away from crude oil to self-sufficient sources that power the U.S. electricity grid.

EV owners can expect lower and more stable fueling costs on average recognizing that there may be local variation in electricity pricing. Avoiding gas price shocks should reduce downside to consumer sentiment.

The climate benefits of the EV transition will increase over time as the electricity grid becomes cleaner.