The macroeconomic effects of oil supply news: Evidence from OPEC announcements

EIA Virtual financial workshop

Diego R. Känzig
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Introduction
Motivation

• Key question in macro: how oil prices affect the economy
• Answering this question is challenging because
  • Oil prices are endogenous
  • Not all oil price shocks are alike
• The literature has focused on oil supply and demand
• Less attention has been devoted to oil market expectations
  • Mainly because identifying shocks to expectations is difficult
This paper

- Propose a novel approach to identify a shock to oil supply expectations, exploiting institutional features of OPEC and high-frequency data
  - Isolate exogenous variation in oil price by looking at how oil futures prices change around OPEC announcements
  - Use as an instrument in an oil market VAR to identify oil market shock
- Shock is best thought of as a news shock about future oil supply
• **Oil supply news** leads to an immediate increase in **oil prices**, a gradual fall in **oil production**, a significant increase in **oil inventories** and a fall in **global activity**

• This has consequences for the **US economy**: **industrial production** falls and **consumer prices** rise significantly

• Also leads to higher **inflation expectations** and a depreciation of the **dollar** but has no effect on **uncertainty**
Identification
Identification

• Oil market has a *peculiar* structure
  • Market dominated by big player, OPEC, that reveals *information* about *future supply* in *lumpy* way
  • Very *liquid* futures markets for oil

This motivates the use of *high-frequency identification* techniques

**Idea:** Identify *oil supply surprises* from changes in oil futures prices in tight window around OPEC announcements

• Similar to high-frequency identification of *monetary policy shocks*
OPEC announcement

Having reviewed the oil market outlook, including the overall demand/supply expectations for the year 2007, in particular the first and second quarters, as well as the outlook for the oil market in the medium term, the Conference observed that market fundamentals clearly indicate that there is more than ample crude supply, high stock levels and increasing spare capacity. [...] 

In view of the above, the Conference decided to reduce OPEC production by a further 500,000 b/d, with effect from 1 February 2007, in order to balance supply and demand.

Source: Announcement from the 143rd meeting of the OPEC conference (14 Dec 2006)
Market reaction

Figure 1: Oil futures prices (1-month WTI crude) around announcement on 14 December 2006
Construction of oil supply surprises

- Collected **OPEC press releases** for the period 1983-2017
  - Total of **119 announcements**
- Compute **oil supply surprises**:

  \[ \text{Surprise}_{t,d}^h = F_{t+h,d} - F_{t+h,d-1}, \]

  where \( F_{t+h,d} \) is log settlement price of \( h \)-month ahead WTI crude contract on announcement day \( d \) in month \( t \)
- Aggregate surprises to **monthly** series

  \[ \text{Surprise}_t^h = \begin{cases} 
  \text{Surprise}_{t,d}^h & \text{if one announcement} \\
  \sum_i \text{Surprise}_{t,d_i}^h & \text{if multiple announcements} \\
  0 & \text{if no announcements} 
  \end{cases} \]
Construction of oil supply surprises

- **Key assumptions:**
  - Announcements *only* contain information about future supply
  - Risk premia are *constant* over window

  ⇒ Surprise series captures *changes in expectations* driven by *news* about future supply

- **Important choice:** *maturity* of the contract, $h$
  - To sharpen interpretation of news shock about future supply, use composite measure spanning first year of oil futures term structure
  - Results are *robust* to other choices
Figure 2: Oil supply surprise series constructed from changes in oil futures prices (principal component spanning first year of WTI crude term structure) around OPEC announcements
Oil supply surprise series

- Accords well with narrative accounts on historical episodes
- No evidence for autocorrelation
- Not forecastable by macroeconomic or financial variables
- Uncorrelated with measures of other structural shocks (e.g. global demand or uncertainty shocks)
Background noise

- **Trade-off** between capturing entire response to announcement and other confounding news
- Daily surprises could be subject to background noise

**Figure 3:** Announcement versus control days

- Variance on OPEC days significantly **larger**
Econometric framework
Econometric framework

- **Oil supply surprise series** has **good properties** but is likely only imperfect shock measure
- **Solution:** use the series as an **instrument** in proxy VAR to identify **oil supply news shock**
  - Allows for **measurement error** in the instrument
  - Can trace out responses of financial and macro variables jointly
Proxy VAR

- Structural VAR

\[ y_t = b + B_1 y_{t-1} + \cdots + B_p y_{t-p} + S \varepsilon_t, \quad \varepsilon_t \sim N(0, \Omega) \]

- Identification based on external instruments (Stock and Watson, 2012; Mertens and Ravn, 2013)
  - External instrument: variable correlated with the shock of interest but not with the other shocks
    \[
    \mathbb{E}[z_t \varepsilon_{1,t}] = \alpha \neq 0 \quad \text{(Relevance)}
    \]
    \[
    \mathbb{E}[z_t \varepsilon_{2:n,t}] = 0, \quad \text{(Exogeneity)}
    \]

- Use oil supply surprise series, Surprise\(_t^h\), as external instrument, \( z_t \), for oil price
Model specification

- $y_t$ includes real oil price, world oil production, world oil inventories, world industrial production, US IP, US CPI
- Identification sample: 1983M2-2017M12
- VAR is estimated in (log) levels
- Lag order: $p = 12$
Results
Baseline results

Figure 4: IRFs to oil supply news shock.

First stage regression: F: 22.67, robust F: 10.55, $R^2$: 4.22%, Adjusted $R^2$: 4.04%
Baseline results

- Shock leads to a large, **immediate increase** in oil prices, **sluggish fall** in oil production and significant **increase** in oil inventories
  ⇒ **consistent** with interpretation of a **news shock** about oil supply
- Global activity falls persistently
- This has consequences for the **U.S. economy**:
  - Industrial production **falls** and consumer prices **rise** significantly
- Changes in **oil supply expectations** have **powerful effects** even if current oil production does not move
**Figure 5:** Historical decomposition. Dashed lines are 90% CIs.

- **Oil supply news** have contributed meaningfully to historical variations in oil price.
- Events in the Middle East affect the oil price not only through *current* supply but also changes in *supply expectations*. 
To get a better understanding on how the shock propagates, study the effects on a wide range of financial and macroeconomic variables.

Implemented by augmenting baseline VAR by one variable at a time and computing impulse response.
Oil supply news lead to

- higher oil price and inflation expectations, but do not affect uncertainty
- higher consumer prices, even after excluding energy
- lower economic activity, broadly defined
- depreciation of dollar and deterioration of terms of trade and trade balance
**Figure 6:** Expectations and uncertainty measures
Oil supply news lead to

- higher oil price and inflation expectations, but do not affect uncertainty
- higher consumer prices, even after excluding energy
- lower economic activity, broadly defined
- depreciation of dollar and deterioration of terms of trade and trade balance
Figure 7: Core CPI and CPI components
**Oil supply news** lead to

- higher oil price and inflation expectations, but do not affect uncertainty
- higher consumer prices, even after excluding energy
- lower economic activity, broadly defined
- depreciation of dollar and deterioration of terms of trade and trade balance
Economic activity

Panel A: Monthly indicators

Panel B: Quarterly indicators
**Oil supply news** lead to

- higher oil price and inflation expectations, but do not affect uncertainty
- higher consumer prices, even after excluding energy
- lower economic activity, broadly defined
- depreciation of dollar and deterioration of terms of trade and trade balance
Figure 10: Exchange rates and trade
Robustness

Perform a battery of robustness tests

- **Identification**: Background noise, informationally robust instrument, futures contract, announcement type, two-shock proxy VAR, placebo
  
  ➤ Details on identification

- **Model specification**: local projections, variable selection, controls
  
  ➤ Details on specification

- **Sample period**: excluding 70s, pre-Great Recession, pre-Shale oil revolution
  
  ➤ Sub-sample analysis

⇒ Results turn out to be robust
Conclusion
Conclusion

- Propose a novel approach to identify oil supply news shocks, combining HFI literature with traditional oil market VARs
- Evidence for a strong channel operating through supply expectations
- Provides new insights to the debate on the drivers of oil price fluctuations and their effects on the macroeconomy
- Underlines the potential of the high-frequency identification approach
Thank you!
Institutional background

- **OPEC** is an intergovernmental organization of *oil producing nations*
  - Accounts for about **44%** of *world oil production*
  - Founded in 1960 by Iran, Iraq, Saudi Arabia and Venezuela
- Supreme authority is the **OPEC conference**, consisting of delegations headed by oil ministers of member countries
  - Meets *several times a year* to agree on *oil production plans*, including *production quotas* for the organization and its members
  - Decisions of the conference take the form of an *announcement*, issued shortly after the meeting
Institutional background

- **Crude oil** is an *internationally* traded commodity ⇒ **liquid futures markets**
- Most widely traded contracts: WTI crude and Brent crude futures
- **Focus on WTI crude**
  - First traded futures on crude oil, **longest history** (started trading in 1983)
  - Most *liquid* and largest volume market for crude oil (currently trading nearly 1.2 million contracts a day)
  - Relevant benchmark for the US
Figure 11: The autocorrelation function of the oil supply surprise series
## Surprise series: forecastability

**Table 1:** Granger causality tests

<table>
<thead>
<tr>
<th>Variable</th>
<th>p-value</th>
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<tbody>
<tr>
<td>Instrument</td>
<td>0.3749</td>
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<td>Oil price</td>
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<td>World oil production</td>
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<tr>
<td>World oil inventories</td>
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<td>World industrial production</td>
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<td>US industrial production</td>
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<td>US CPI</td>
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<td>Fed funds rate</td>
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<td>S&amp;P 500</td>
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<td>NEER</td>
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<td>Geopolitical risk</td>
<td>0.1526</td>
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<td>Joint</td>
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### Surprise series: correlation with other shocks

<table>
<thead>
<tr>
<th>Shock</th>
<th>Source</th>
<th>$\rho$</th>
<th>p-value</th>
<th>$n$</th>
<th>Sample</th>
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<tbody>
<tr>
<td><strong>Panel A: Oil shocks</strong></td>
<td></td>
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<tr>
<td>Oil price</td>
<td>Hamilton (2003)</td>
<td>0.06</td>
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<td>Oil supply</td>
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<td>369</td>
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<td></td>
<td>Caldara et al. (2019)</td>
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<td>Baumeister and Hamilton (2019)</td>
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<tr>
<td></td>
<td>Kilian (2009)</td>
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<td>0.09</td>
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<td>1975M02-2007M12</td>
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<td>Global demand</td>
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<td>0.51</td>
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<td>Oil-specific demand</td>
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<td>1975M02-2007M12</td>
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<td><strong>Panel B: Other shocks</strong></td>
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<td>Productivity</td>
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<td>Smets and Wouters (2007)</td>
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<td>1974Q1-2004Q4</td>
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<td>News</td>
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<td>135</td>
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<td>Kurmann and Otrok (2013)</td>
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<td>0.76</td>
<td>126</td>
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<td>Beaudry and Portier (2014)</td>
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<tr>
<td>Monetary policy</td>
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<td>Romer and Romer (2004)</td>
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<td></td>
<td>Smets and Wouters (2007)</td>
<td>0.04</td>
<td>0.64</td>
<td>124</td>
<td>1974Q1-2004Q4</td>
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<td>Uncertainty</td>
<td>Bloom (2009)</td>
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<td>Baker et al. (2016)</td>
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<td>0.15</td>
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<td>Financial</td>
<td>Gilchrist and Zakrajšek (2012)</td>
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<td></td>
<td>Bassett et al. (2014)</td>
<td>0.12</td>
<td>0.30</td>
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<td>1992Q1-2010Q4</td>
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<td>Fiscal policy</td>
<td>Romer and Romer (2010)</td>
<td>0.03</td>
<td>0.77</td>
<td>136</td>
<td>1974Q1-2007Q4</td>
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<td></td>
<td>Ramey (2011)</td>
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<td>Fisher and Peters (2010)</td>
<td>0.05</td>
<td>0.55</td>
<td>140</td>
<td>1974Q1-2008Q4</td>
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**Table 2: Data description and sources**

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Variable name</th>
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<tr>
<td><strong>Instrument</strong></td>
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<tr>
<td>NCLC.0h (PS)</td>
<td>WTI crude $h$th contract (settlement price)</td>
<td>Datastream</td>
</tr>
<tr>
<td>NCLC.0h (VM)</td>
<td>WTI crude $h$th contract (traded volume)</td>
<td>Datastream</td>
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<tr>
<td><strong>Baseline variables</strong></td>
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</tr>
<tr>
<td>WTISPLC</td>
<td>WTI spot crude oil price, deflated by US CPI</td>
<td>FRED</td>
</tr>
<tr>
<td>EIA1955</td>
<td>World oil production</td>
<td>Datastream</td>
</tr>
<tr>
<td>OILINV</td>
<td>OECD oil inventories (proxy)</td>
<td>Kilian &amp; Murphy</td>
</tr>
<tr>
<td>OECD+6IP</td>
<td>IP of OECD and 6 major countries</td>
<td>Baumeister &amp; Hamilton</td>
</tr>
<tr>
<td>INDPRO</td>
<td>US industrial production index</td>
<td>FRED</td>
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<tr>
<td>CPIAUCSL</td>
<td>US CPI for all urban consumers: all items</td>
<td>FRED</td>
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Figure 12: Series included in the VAR over the sample period 1974-2015
### Table 3: Strength of the instrument

<table>
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<tr>
<th></th>
<th>1M</th>
<th>2M</th>
<th>3M</th>
<th>6M</th>
<th>9M</th>
<th>12M</th>
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<tr>
<td>Coefficient</td>
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<td>0.981</td>
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<td>1.123</td>
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<tr>
<td>F-stat</td>
<td>24.37</td>
<td>24.25</td>
<td>24.33</td>
<td>22.90</td>
<td>22.35</td>
<td>13.58</td>
<td>22.67</td>
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<td>F-stat (robust)</td>
<td>12.01</td>
<td>11.86</td>
<td>11.92</td>
<td>11.32</td>
<td>11.11</td>
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<td>$R^2$</td>
<td>4.53</td>
<td>4.51</td>
<td>4.52</td>
<td>4.27</td>
<td>4.17</td>
<td>2.57</td>
<td>4.22</td>
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<tr>
<td>$R^2$ (adjusted)</td>
<td>4.34</td>
<td>4.32</td>
<td>4.33</td>
<td>4.08</td>
<td>3.98</td>
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<td>516</td>
<td>516</td>
<td>516</td>
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<td>516</td>
</tr>
</tbody>
</table>

**Notes:** First-stage regressions of oil price residual on proxies. F-stats above 10 indicate strong instruments.

- High-frequency surprises are **strong instruments** for oil price
Inflation expectations

**Figure 13:** Inflation expectations

- **Differential** effects between *households* and *professional forecasters*
- Response of SPF expectations **much weaker**, in line with recent literature on role of oil prices and expectations in inflation dynamics (Coibion, Gorodnichenko, and Kamdar, 2018; Hasenzagl et al., 2018)
Economic activity

Figure 14: Monetary policy and financial variables

- No significant effects on monetary policy and financial conditions
- Significant fall of stock market index
Economic activity

Figure 15: Consumption expenditures
Background noise

- Could other shocks during the event window confound the surprise series?
  - Potentially relevant as we are using daily event window
- Formally account for background noise using heteroskedasticity-based identification strategy à la Rigobon (2003)
Figure 16: Heteroskedasticity-based identification
• Do announcements only contain news about future supply?
  • For interpretation, it is crucial that they do not contain new information about other factors, e.g. global oil demand
• To mitigate this concern, construct informationally robust instrument, akin to Romer and Romer (2004) refinement of monetary policy shocks
Two steps

- Collect OPEC’s global demand forecasts published in OPEC oil market reports
- Construct refined instrument as residual of the following regression

\[
Surprise_m = \alpha_0 + \sum_{j=-1}^{2} \theta_j F_m^{OPEC} y_{q+j} + \sum_{j=-1}^{2} \varphi_j [F_m^{OPEC} y_{q+j} - F_{m-1}^{OPEC} y_{q+j}] + IRS_m
\]
Figure 17: Refined, informationally robust surprise series
Ordinary announcements

- Large part of the OPEC meetings were **extraordinary** meetings, scheduled *in response* to macroeconomic or geopolitical developments
  ⇒ Potential **endogeneity** problem
- As robustness, only use **ordinary** meetings
Ordinary announcements

First stage regression: $F: 9.75$, robust $F: 4.46$, $R^2$: 1.86%, Adjusted $R^2$: 1.67%

Figure 18: Ordinary announcements only
News and surprise shocks

• Is the instrument **only correlated** with oil supply **news shock**? Or does it also capture conventional, **unanticipated supply shocks**?
  ⇒ **Exogeneity assumption** might be violated
• To mitigate this concern, **identify an oil supply surprise and news shock jointly**, using Kilian’s (2008) exogenous supply shock measure and my oil supply surprise series
  • **Additional identifying assumption**: oil supply news shock does **not** affect oil production **on impact**
News and surprise shocks

First stage regression: $F: 3.76$, robust $F: 1.71$, $R^2: 1.44\%$, Adjusted $R^2$: 1.06\%

First stage regression: $F: 12.05$, robust $F: 5.66$, $R^2: 4.49\%$, Adjusted $R^2$: 4.11\%

Figure 19: Oil supply surprise and news shocks
Futures contracts

- A crucial choice was the maturity of the futures contract
  - As a benchmark, used 6-month contract
- Are results robust to using other maturities?
Figure 20: Different maturities of futures contracts
• Since the shale oil revolution, WTI has become less representative for the global price of oil
• Are the results robust to using Brent instead?
Futures contracts

First stage regression: $F: 10.27$, robust $F: 5.56$, $R^2: 1.96\%$, Adjusted $R^2: 1.77\%$

**Figure 21:** Brent spot and futures prices
Local projections

Figure 22: Local projections on shock series
Figure 23: LP-IV using surprise series
Figure 24: Kilian’s (2009) global activity indicator
Variable selection

Figure 25: Refiner acquisition costs as oil price indicator

First stage regression: F: 15.19, robust F: 9.55, $R^2$: 2.87%, Adjusted $R^2$: 2.68%
First stage regression: F: 20.98, robust F: 11.17, $R^2$: 4.01%, Adjusted $R^2$: 3.82%

**Figure 26:** Lag order: 24 lags
Figure 27: Stationary VAR
Quarterly model

Figure 28: Quarterly data

First stage regression: $F: 10.92$, robust $F: 6.96$, $R^2$: 6.03%, Adjusted $R^2$: 5.48%
Sub-sample analysis: pre Great Recession

First stage regression: F: 15.79, robust F: 8.66, $R^2$: 3.85%, Adjusted $R^2$: 3.61%

**Figure 29:** Exclude Great Recession period
Sub-sample analysis: pre shale oil


Figure 30: Exclude shale oil revolution
Sub-sample analysis: post 70s

Figure 31: Exclude the 1970s

First stage regression: $F: 19.78$, robust $F: 11.51$, $R^2: 4.55\%$, Adjusted $R^2: 4.32\%$