Oil Shocks and the Zero Bound on Nominal Interest Rates

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Introduction – Shock Properties at the ZLB

Academic work has emphasized how demand shocks are amplified in a liquidity trap:

▸ amplification applies to shocks that move output and inflation in the same direction,

▸ e.g., government spending usually implies an increase in resource utilization and a burst of inflation (Eggertsson (2006), Christiano, Eichenbaum, Rebelo (2010), Uhlig (2010), Erceg and Lindé (2010)),

▸ normally, monetary policy leans against inflation (crowding out of private investment),

▸ in a deep recession at ZLB, policy rates remain unvaried, leading to a decrease in real rates (crowding in of private investment).
Transmission of oil shocks is also quite different at the zero lower bound. However,

- oil shocks tend to move output and inflation in opposite directions,
- at ZLB, the burst of inflation lowers real rates and stimulates the interest-sensitive component of GDP, mitigating the usual contractionary effects of the oil shock,
- if oil prices rise gradually, persistent rise in inflation might causes GDP to expand temporarily.
Brief Model Description


- home and foreign goods produced under monopolistic competition,
- oil use in production and consumption as in Bodenstein et al (2010),
- real and nominal rigidities (investment adj. costs, consumption habits, sticky prices and wages) as in Christiano, Eichenbaum, and Evans (2005),
- incomplete international financial markets (one-bond-economy, net positions only),
- one country imports oil in steady state.
Monetary Policy

Monetary Policy follows a standard Taylor Rule, but needs to respect the zero bound constraint on the nominal interest rate:

\[ i_{t}^{not} = \bar{i} + \gamma_i(i_{t-1}^{not} - \bar{i}) + (1 - \gamma_i)(\pi_t + \gamma_\pi(\pi_t - \bar{\pi}) + \frac{\gamma y}{4} y_{t}^{gap}), \]

and

\[ i_t = \max(0, i_t^{not}). \]
Laséen and Svensson (2009) suggest a method for obtaining simulations with arbitrary restrictions on the path of the nominal interest rate in a linear model with perfect foresight through a sequence of anticipated monetary policy shocks in the interest rate reaction function of the policymaker.

We repurpose their method to implement the zero lower bound constraint and solve for the endogenous duration of the zero bound constraint.

Code can be easily applied to any linearized model of any size (number of equations, number of country blocs). The codes will be available online soon.
Calibration follows Erceg, Guerrieri, and Gust (2005) and Bodenstein, Erceg and Guerrieri (2010).

Oil substitution elasticity is set to 0.4.

Trade substitution elasticity is set to 1.1.

Home country is calibrated to be the U.S. and accounts for 1/3 of world GDP. In steady state the home country produces 30% of its oil use.

The parameters in the interest rate reaction function imply a total weight on inflation of 2, on the output gap of 1/4. The smoothing coefficient is set to 0.8. Rule assures that the outcome to an oil shock under sticky prices are reasonably close to the outcome under flexible price.
Persistent Oil Demand Shock at the ZLB

Our analysis focuses on the effects of oil shocks against the backdrop of an initial severe recession in the home country:

- monetary policy attempts to stimulate the economy by lowering rates to zero,
- at the point in which the additional oil shock strikes ZLB is expected to bind for 10 quarters,
- in the following, all the responses will be shown in deviation from this initial recession.
Persistent Oil Demand Shock at the ZLB

Consider an oil demand (intensity) shock with a persistent growth component and a level error correction component in three cases: flexible price economy, sticky price economy without ZLB, sticky price economy with ZLB:

- in all three cases, home oil demand falls,
- long-term responses resemble those of a negative home technology shock,
- external sector different from technology shock: real exchange rate has to depreciate for an improvement of nonoil balance.
Persistent Oil Demand Shock at the ZLB

Under ZLB, shock generates persistent qualitative differences in the response of real GDP:

- GDP temporarily rises, persistently cushioned beyond the liquidity trap,
- policy rates constrained and oil shocks being inflationary, the real interest rate falls more,
- cushioning fall in investment,
- props up capital stock, leads to persistent wedge between real (nonoil) gross output (across cases),
- gross output falls gradually due to real rigidities and phasing in of shock,
- difference between gross output and GDP is a wedge implied by the presence of imported oil inputs in production,
- initial fall is gross output small enough so that the contraction in oil imports due to oil price rise translates into a boost to GDP.
Figure 1: An Oil Demand Shock at the Zero Lower Bound
Figure 2: An Oil Demand Shock at the Zero Lower Bound: Trade Flows

- Real Exports
- Foreign GDP
- Real Nonoil Imports
- Oil Balance (GDP share)
- Real Exchange Rate (consumption based)
- Trade Balance (GDP share)

Legend:
- Black: Home, ZLB Binds
- Red dashed: Home, ZLB Does Not Bind
- Blue dotted: Home, Flexible Prices/Wages
Rule without smoothing:

- away from ZLB less persistent rise in real rates for same oil shock,
- at ZLB, enhances the inflation response and further cushions the effects,
- initial rise in GDP more than doubled and wedge between GDP and gross output larger.
Figure 3: An Oil Demand Shock at the Zero Lower Bound: Monetary Policy Rule with No Smoothing
Sensitivity to Monetary Policy Rules

Rule using forecast of headline inflation:

- Looks past the peak inflation response and lowers rates in anticipation of the expected decline in oil prices,
- Implies larger inflation response (Bodenstein et al (2007)),
- Bigger fall in the real interest rate,
- Investment and consumption still fall, but are propped up relative to other rules,
- Fall in net real rates enhances the exchange rate depreciation,
- Boost to net exports leads to a temporary expansion in gross output.
Figure 4: An Oil Demand Shock at the Zero Lower Bound: Monetary Policy Rule Responds to a Forecast of Headline Inflation
Sensitivity Policy Model

Add in two features that may diminish the expansionary effects of oil shock at ZLB:

Financial accelerator:

- real interest rate affecting investment demand is no longer the risk-free rate, but takes into account information asymmetry between borrowers and lenders,
- asymmetric problem worsens in response to higher oil prices, a more severe contraction in investment could induce deflationary pressure,
- real policy rates may not fall as much, reducing the stimulative effects of higher oil prices at ZLB.

Lower exchange rate pass-through:

- may reduce the inflationary effects when the home currency depreciates in response to the rise in oil prices.
Figure 6: An Oil Demand Shock at the Zero Lower Bound: Comparison with a Policy Model

- **Real GDP, Policy Model**
- **Real GDP, Benchmark**
- **Real Exports, Policy Model**
- **Real Exports, Benchmark**
- **Real Interest Rate (5 year, AR), Policy Model**
- **Real Interest Rate (5 year, AR), Benchmark**
- **Headline Inflation (AR), Policy Model**
- **Headline Inflation (AR), Benchmark**

Legend:
- **Home, ZLB Binds**
- **Home, ZLB Does Not Bind**
Oil Supply Shock

Near-unit root oil supply shock:

- Large real exchange rate depreciation required to generate necessary and highly persistent improvement in trade balance.
- Only short-lived rise in inflation. Thus, similar behavior at and away from ZLB.
- If the oil supply shock lead to a period of increasing oil prices similar to the oil demand shock and protracted inflation, the oil supply shock would be compressed in the same manner.
- However, as argued in Bodenstein (2010) oil supply and demand shocks differ along exactly this dimension: oil supply shocks are near unit-root processes, but oil demand shocks are best described as AR(2) processes.
Figure 7: An Oil Supply Shock at the Zero Lower Bound

- Oil Price
- Policy Interest Rate (AR)
- Real Gross Output
- Real Interest Rate (5 year, AR)
- Real GDP
- Headline Inflation (AR)
- Real Exchange Rate (consumption based)
- Trade Balance (GDP share)

Legend:
- Home, ZLB Binds
- Home, ZLB Does Not Bind
- Home, ZLB Binds, Oil Demand Shock
Technology Shock

1% temporary decline in the level of the home country’s productivity:

- oil price response not large enough to substantially affect the transmission of technology shocks,
- rise in inflation made persistent by the real rigidities,
- effects cushioned at ZLB relative to normal times,
- as technology shock primarily affects output rather than inflation, no sign reversal of GDP or gross output response.
Figure 8: A Technology Shock at the Zero Lower Bound

- Oil Price
- Policy Interest Rate (AR)
- Real Gross Output
- Real Interest Rate (5 year, AR)
- Real GDP
- Headline Inflation (AR)
- Real Exchange Rate (consumption based)
- Trade Balance (GDP share)

Legend:
- Black: Home, ZLB Binds
- Red: Home, ZLB Does Not Bind
- Blue: Home, ZLB Binds, Oil Demand Shock