Chapter 2

THE ECONOMIC COSTS OF OIL PRICE VOLATILITY

1. Summary

Oil price volatility has changed over time and can be separated into price shocks or spikes and ongoing fluctuation. Shocks are caused by adjustments or threats to international supply while fluctuation is driven by changes in demand due to business cycles and the hedging and speculation of markets. The economic cost of historic price shocks is well studied and has been estimated by Hamilton as 0.5% GDP per year over the last 50 years. The cost associated with the strategic oil reserve should be added to this and has been estimated by Koplow at between $1.6b and $5.4b. The economic cost of ongoing price fluctuation is less clear. Eleven qualitative cost headings have been described in this paper but care must be taken as these are not mutually exclusive and some may be included in the estimates of price shock made by Hamilton. Further, it is important to note that for the purposes of RMI's *Winning the Oil Endgame* the externality cost required is the difference between current oil price volatility and the fuel price volatility in a potential off-oil scenario. It is impossible to calculate this future volatility level but it is unlikely to be zero. A reasonable approximation might be that such a future scenario would include ongoing price fluctuation but not price spikes. The historic externality cost of oil price volatility versus an off-oil alternative scenario can therefore be estimated as c. $5458b per year (0.5% x $10,446b + $1.6b5.4b).

2. Introduction

Economists traditionally assume that oil prices will forever remain volatile, because that is how all market commodities behave, even without political interference. When starting this analysis of potential alternatives to oil, some of which could have different price behavior, we asked what seemed to the leading energy economists we consulted to be a novel question: What would be the economic value of making the price of oil, or its functional equivalent, nonvolatile (riskless)? As might be expected, we got as many different answers as we asked economists, but all seemed to agree that the cost of oil prices' being volatile had not previously been evaluated, although there is a large literature on the economic cost of oil-price spikes.

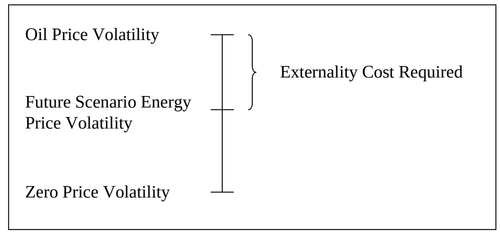
In principle, it seemed to us that there were eight economic costs of oil-price volatility: the cost of commodity hedging; the capital cost of excess capacity built to meet peak demand (often associated with low price) but unamortizable at low price; the increased cost of capital to energy firms to reflect their increased investment risk; the opportunity cost of worrying about oil price instead of paying attention to other issues; the suboptimization of investment strategy reflecting aversion to oil-price and consequent risks; the carrying cost of the Strategic Petroleum Reserve; asymmetrical economic effects (Hamilton hysteresis—more economic cost from high prices than benefit from low prices); and the cost of imperfect Federal Reserve foresight in combating inflation when oil prices spike up.

There is increasing evidence that oil-price volatility is inherent, for such structural reasons as the mismatch between OPEC's target price range (~$22–28/bbl) and the industry's own threshold pricepoint (~$18/bbl); capital-loop instability (low prices suppress industry investment for a few years, soon causing spot shortages that make price temporarily overshoot); and complex mismatches of social and marketing preferences on the demand side. Other instabilities emerge from conflicting timescales in the oil enterprise: immediate policy concerns such as Iraq, the 10–20-year timescale of infrastructure planning, and the half-century timescale of strategic R&D and social investments and of major shifts in energy carrier.

3. Factors of Oil Price Volatility

Somewhat simplistically, the objective can be stated as 'qualify and quantify the social cost to the U.S. of oil price volatility, as an externality of dependence on oil.' We break this objective into four major factors that will require assessment:

1. Define oil price volatility
2. Identify the causes of price volatility, both for the current oil market and for the proposed off-oil solution (can this be totally non-volatile?)
3. Qualify the costs associated with oil price volatility
4. Quantify the differential cost of the price volatility between the current oil-dependent solution and the potential off-oil solution.



Define Oil Price Volatility

Historically, oil price movements have experienced two separate regimes. Prior to 1987, constant nominal prices were punctuated by shocks. Post-1987, continuous volatility has been introduced by the interrelated set of spot, futures, and other derivatives markets. Volatility is a characterization of price changes over time and can be defined as the standard deviation in a given period. The cost of oil price volatility is not simply the economic cost of price increases but the cost of the fluctuation itself. The period over which volatility is studied will thus affect the costs, and care must be taken in differentiating between price shocks and ongoing volatility or noise.

a. Pindyck, R. *Long Run Evolution of Energy Prices*: *Volatility is stable (although signs of increase since 1960), and can be explained by non-mean reverting models (geometric Brownian motion) as well as mean-reverting models.*
b. Plourde, A., and Watkins G.C. [1994] Crude oil prices between 1985 and 1994: how volatile in relation to other commodities?, *Resource and Energy Economics*20:245262: *Oil price volatility shown to be greater than all other commodities.*

Identify the causes of price volatility, both for the current oil market and for the proposed off-oil solution

Volatility in energy commodities is caused by changes in supply and fluctuations in international business cycles that destabilize demand and so prices. Excessive speculation in futures exchanges can then amplify these price swings. It is unclear what level of volatility would be experienced in an 'off-oil scenario'.

Arguments for zero volatility:

- Diverse portfolio of granular, short-lead-time oil substitutes is more responsive to demand volatility and less prone to supply shocks (end-use efficiency, fungible natural gas, biofuels, and hydrogen).
- Renewables are characterized by high capital expenditure and low/zero operating expense—i.e., constant financing cost.
- Potential for 100% domestic energy production, avoiding geopolitical risk.
- Easy storage of hydrogen can smooth volatility.

Arguments against zero volatility:

- Easy storage of oil has not reduced price volatility so hydrogen storage will not make a difference either.
- Continued demand-side volatility due to weather changes and international business cycles.
- New sources of supply-side volatility: biofuel prices driven by highly volatile agricultural commodity pricing, windpower unreliable.
- Similar short-term capacity constraints will occur in supply, even if the lead-time is shorter.
- Continued speculative trading

[Comment: It is highly unlikely that a future scenario will have zero volatility but it is also impossible to forecast what the real volatility might be. It is suggested that the cost of oil price volatility not be compared with zero volatility, but instead be limited to the costs associated with unstable international supply.]

Qualify the Costs Associated with oil Price Volatility

Analysis of economic costs must focus on dead weight loss associated with price volatility and avoid transfer of wealth within the economy (e.g., from consumers to producers). Internal discussions have generated a hypothesis of ten cost elements, although these are not mutually exclusive:

1. The cost of commodity hedging—in principle, ascertainable from derivatives markets or by applying CAPM or a similar model to historic oil betas (though this may not capture consequent price volatility in other energy markets, and the causality is tangled and interactive).
2. The capital cost of excess capacity built to meet peak demand (often associated with low price) but un-amortizable during periods of low price.
3. The increased cost of capital to energy firms to reflect their increased investment risk.
4. The opportunity cost of worrying about oil price instead of making worthier decisions.
5. The societal cost of suboptimal investment strategy, economywide, resulting from aversion to oil-price and consequent risks.
6. The carrying cost of the Strategic Petroleum Reserve and perhaps also of private inventories.
7. Oil shocks and the asymmetrical (Hamilton hysteresis) economic cost associated with disruptive effects of short-term instabilities (e.g., capital-loop instability: low prices suppress industry investment for a few years, soon causing spot shortages that make prices temporarily overshoot).
8. The economic cost of excess inflation induced by the Fed's imperfect foresight when responding to fluctuating oil prices and their macroeconomic effects.
9. Knock-on effect of creating volatility in other energy markets (gas, coal, electricity) due to substitutability.
10. An offsetting benefit might be that volatile oil prices may stimulate more or faster development and deployment of new technology—though perhaps not at lower cost and risk than would otherwise occur—and once made, such technological advances and investments to deploy them are typically irreversible.

Quantifying the Cost of Oil Price Volatility versus a Counterfactual Hypothetical Non-Volatile World

Total Cost Estimates:

a. Earley, R. (rearley@eia.doe.gov) *Energy Price Impacts on the US Economy*, EIA April 2001 (www.eia.doe.gov/oiaf/economy/energy_price.pdf) : *Macroeconomic model keeping quarterly oil price static 199-2000 estimates 0.2% increased GDP growth (~$20b/y)* [Comment: short period, not including price shocks, and uses DRI macro-model with fixed coefficients

b. Hamilton, J.D,. email (see chapter appendix) based on [2003] What is Oil Shock?, *Journal of Econometrics*: "*in my opinion the sort of answer to your question that could be defended is, eliminating energy supply volatility would be worth about 1/2 of one percent of GDP each year.*" [Comment: Hamilton is only measuring the cost of major historic price shocks and not ongoing volatility/noise.]

c. Pindyk, R. "*There is no evidence that there is ANY economic cost to the U.S. of oil (or natural gas) price volatility. (The same is true of volatility in other commodity markets.)*"

d. Federer, J.P. [1996], Oil Price Volatility and the Macroeconomy, *Journal of Macroeconomics* 18 (1): 126 (Winter): "*both oil price and volatility have a negative impact on output growth but in different ways: volatility has a negative and significant impact immediately and again eleven months later, whereas price changes have an impact after about one year. Further, volatility correlates with price increase, and volatility is more important than price.*"

e. Hooker, M.A.[1996] What happened to the oil price-macroeconomy relationship? *Journal of Monetary Economics* 38: 195213: *showed that between 197394 oil price changes no longer explained GDP or unemployment but volatility did.*

f. Awerbach, S. and Sauter, R. [2003] *Oil Price Volatility and Economic Activity: A Survey and Literature Review*: *Since the 1980s, oil price volatility is more significant in its effect on economic activity than the oil price level. Volatile environment weakens the effect of oil price level changes since it reduces the 'surprise'.*

Discussion of the Individual Elements of Cost (with additional headings from Awerbuch survey)

1. The cost of commodity hedging.
   a. Bolinger, M. et al. [2002], *Quantifying the Value That Wind Power Provides as a Hedge Against Volatile Natural Gas Prices*, Lawrence Berkeley National Laboratory: '*at the time a hedge is established, the cost of hedging can be thought of as being equal to any premium paid to lock in prices going forward, plus any transaction costs incurred.' Cost of hedging away natural-gas price risk over a 10-year period using financial swaps is estimated at $0.005/kWh*
2. The capital cost of excess capacity built to meet peak demand but un-amortizable during periods of low price.
   a. Mabro, R. [2001], *Does Oil Price Volatility Matter?* Oxford Institute for Energy Studies: "*The alleged economic rationale is that we are considering a market which sends signals about the allocation of resources. That would be perfectly correct if these price changes caused rapid adjustments in supply and demand. But they do not because the commodity traded is not physical oil but either a claim on future oil or a price differential which is not a commodity at all.*"
3. The increased cost of capital to energy firms to reflect their increased investment risk.
   a. Labys, W.C. [2000], *Globalization, Oil Price Volatility, and the U.S. Economy*, p. 16: *Higher oil price volatility can lead to a reduction in investment, leading in turn to a long term reduction in supply, higher prices, and potentially to reduced macroeconomic activity.*
4. The opportunity cost of worrying about oil price instead of making worthier decisions.
   a. Labys, W.C. [2000], *Globalization, Oil Price Volatility, and the US Economy*, p. 16: *Increasing volatility can impose economic disruption costs and higher transactions costs on consumers and producers, adding to inflation, or cutting rates of growth, or both.*
5. The societal cost of suboptimal investment strategy.
   a. Pindyk, R "*Because investment in oil-related capital (e.g., offshore production wells and pipelines) is largely irreversible, greater oil price volatility will raise the threshold that triggers investment—i.e., increases the expected rate of return, or hurdle rate, needed to justify an investment. But some people mistakenly think that this means that greater volatility implies less investment, and that need not be the case. Greater volatility also means that the price, which fluctuates more widely, is more likely to hit a given threshold over any finite time interval. Thus over any given period of time, the expected value of the flow of investment spending (or the capital stock) could be somewhat higher, somewhat lower, or unchanged as a result of increased price volatility. This means that there is no investment-based argument for government intervention to somehow reduce price volatility.*"
   b. Federer, J.P. [1996], Oil Price Volatility and the Macroeconomy, *Journal of Macroeconomics* 18(1): 126 (Winter): *Refers to Bernanke who shows that it is ideal for companies to postpone irreversible investment expenditures when they experience uncertainty concerning future prices.* [Comment: i.e., option value.]
   c. Ciner, C. [2001] Energy shocks and Financial Markets: Nonlinear Linkages, *Studies in Nonlinear Dynamics and Econometrics* 5(3): 203212 (October): *shows causal relation between crude oil prices and stock market returns has become stronger since volatility increases of 1986 onwards.*

6. The carrying cost of the Strategic Petroleum Reserve and perhaps also of private inventories.
    a. Leiby, P.N.(leibypn@ornl.gov) *Energy Security, Oil Shocks and the Strategic Petroleum Reserve*, ORNL, 2003: *capacity 752M barrels, current size 600M barrels, investment in facilities & crude oil > $20b*
    b. Koplow, D & Martin, A [1998], "Fueling Global Warming: Federal Subsidies to Oil in the United States", A Report for Greenpeace, Economics Incorporated: *estimates the annual cost of maintaining the SPR in 1995 as being between $1.6b and $5.4b depending on whether you include the financing cost of the debt.*
7. Oil shocks and the asymmetrical economic cost associated with disruptive effects caused by short-term instabilities.
    a. Mork, K. [1989], Oil and the Macroeconomy, When Prices Go Up and Down: An Extension of Hamilton's Results, *Journal of Political Economy*, vol. 97, No. 51: *oil price increases have a clear negative impact on economic growth while oil price declines don't affect economic activity significantly.*
    b. Federer, J.P. [1996], Oil Price Volatility and the Macroeconomy, *Journal of Macroeconomics* 18(1):126 (Winter):: *shows some relationship between asymmetry and counter inflationary policy response* [Comment: overlap with item 9 below], *uncertainty* [Comment: overlap with item 6 above], *and sectoral shifts* [Comment: cost not initially identified, see item 11 below].
    c. Labys, W.C. [2000], *Globalization, Oil Price Volatility, and the U.S. Economy*, p. 21: *OECD has estimated that the last $10 per barrel increase in oil prices, if sustained would increase inflation in the principle economies by adding 0.5%, and would lower their GDP growth rate by 0.25%.*
    d. Greene, D.L. [2000] Costs of Oil Dependence: A 2000 Update p. 7: *oil consuming economies incur two costs from OPEC power 1) the economy's ability to produce is reduced because a key factor of production is more expensive (loss of potential GDP), estimated at $1.8 trillion in undiscounted 1998 dollars between 1970 and 1999; 2) sudden changes in oil prices increase unemployment, further reducing economic output (macroeconomic adjustments), estimated at $1.1 trillion in undiscounted 1998 dollars between 1970 and 1999.*
    e. Greenspan, A. [April 17, 2003] Testimony to the Joint Economic Committee *"all economic downturns in the United States since 1973, when oil became a prominent cost factor in business, have been preceded by sharp increases in the price of oil."*
    f. Hamilton, J. [2003] What is an oil shock?, *Journal of Econometrics & Historical Effects of Oil Shocks*: *nonlinear relation between oil price changes and GDP growth: oil price increases are much more important than oil price decreases, and increases have significantly less predictive content if they simply correct earlier decreases.*
    g. Jones, D.W. & Leiby, P.N. [1996], *The Macroeconomic Impacts of Oil Price Shocks: A Review of Literature and Issues*: *estimates using the business cycle methods for the U.S. are in the range of –5% to –7% GNP for cumulative effects.*
8. The economic cost of excess inflation induced by the Fed's imperfect foresight when responding to fluctuating oil prices.
    a. Juncal, Cunado et al. [2000] "Do oil price shocks matter? Evidence from some European countries," University of Navarra: *oil prices have permanent effects on inflation and short run but asymmetric effects on production growth rates.*
    b. Jones, D.W. et al. [2001] *Oil Price Shocks and the Macroeconomy: What has been learned since 1996*, Oak Ridge National Laboratory: *the most thorough research to date has found that post-shock recessionary movements of GDP are largely attributable to the oil price shocks, not to monetary policy although a recent study concluded that monetary policy was responsible for nearly all of the GDP loss.* [Comment: overlap with oil shocks]

9. Knock-on effect of creating volatility in other energy markets (gas, coal, electricity) due to substitutability.
10. Offsetting benefit of volatile oil prices stimulating more or faster development and deployment of new technology.
11. Sectoral shifts: shift of specialized labor and capital from one sector to another is slowed when prices change as workers wait for conditions to improve.
    a. Federer, J.P. [1996], Oil Price Volatility and the Macroeconomy, *Journal of Macroeconomics* 18(1):126 (Winter):: *volatility reinforces the disturbance of sectoral adjustment on the labor market and therefore leads to greater unemployment.*
    b. Jones, D.W. et al. [2001] *Oil Price Shocks and the Macroeconomy: What has been learned since 1996*, Oak Ridge National Laboratory: *considerable reallocation of labor occurs after oil price shocks, amounting to as much as 11% of the labor force in manufacturing.*