Box 1 The nature and causes of oil price volatility

The nominal price of Brent (the international marker of oil) averaged 111/bbl during 2011-13. This was the highest of any 3-year period since 1860 in real terms. During 2011-13 oil price volatility dropped to historical lows, shortly after experiencing a record high during the great recession of 2008/09. This box (which draws heavily from Baffes and Kshirsagar 2014) examines the nature and causes of oil price volatility. It concludes that the recent spike in volatility—the second highest of the past 25 years—reflected uncertainty regarding the health of the global economy induced by the 2008 financial crisis while a similar spike in 1990 was related to supply disruption concerns associated with the first Gulf war. The analysis also shows that high prices are neither a necessary nor a sufficient condition for elevated price volatility since both high and low volatility can take place under high and low prices. Last, concerns that oil prices have become more volatile after 2008 are inconsistent with the empirical evidence.

During 2008, the price of oil changed by more than 5 percent in a single day in 27 out of 260 trading sessions. It exceeded the 5 percent threshold only once in 2011 and once in 2012, while in no day oil prices changed more than 5 percent during 2013 (Figure box 1.1). Thus, on the basis of this simple metric, 2008 has been the most volatile year in the recent history of the oil market while 2013 was one of the least volatile years.

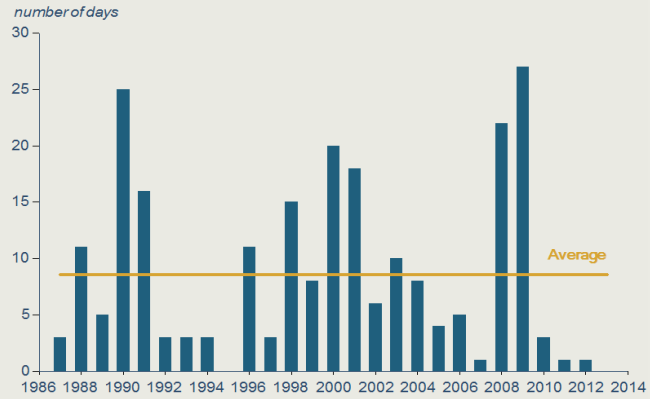
Next, the volatility of returns was calculated based on daily Brent prices from January 20, 1987 to December 31, 2013 (6,643 observations.) Volatility of returns, a measure used frequently by the financial literature, is defined as vol(r_t) = 100*Std[log(p_t) – log(p_{t-1})], where Std[.] denotes the standard deviation while p_t and p_{t-1} represents the current and lagged price of oil. Figure box 1.2 depicts vol(r_t) and p_t since 1988. In order to smooth out outliers and also take into account seasonality, both indices are presented as 250-day moving averages, roughly corresponding to a full year. Indeed, it becomes apparent that the last three years have been characterized by the highest oil price level and the lowest oil price volatility.

Last, the kurtosis of r_t for the five years 2008 to 2012 was calculated as well—kurtosis "measures" the proportion of extreme observations of a distribution; a normal distribution has a kurtosis of 3. As shown in Figure box 1.3, every successive year after 2009 has experienced a reduction in the dispersion of the empirical oil price change distribution—the kurtosis of r_t declined from 7.1 in 2008 and 2009 to just 3.7 in 2013. Therefore, returns have become much less dispersed after the 2008/09 financial crisis.

Three messages emerge from this analysis. First, during the past 25 years the global oil market has been subjected to two distinct spikes in volatility: 1990 (first Gulf war) and 2008/09 (great recession); this finding has been confirmed econometrically by numerous authors, including Salisu and Fasanya (2013) and Charles and Darné (2013). Second, while the 1990 spike was associated with a modest increase in oil prices, the 2008/09 spike emerged alongside the largest post-second World War commodity price boom. Third, despite oil prices remaining at historically high levels during 2011-13, price volatility dropped to record lows.

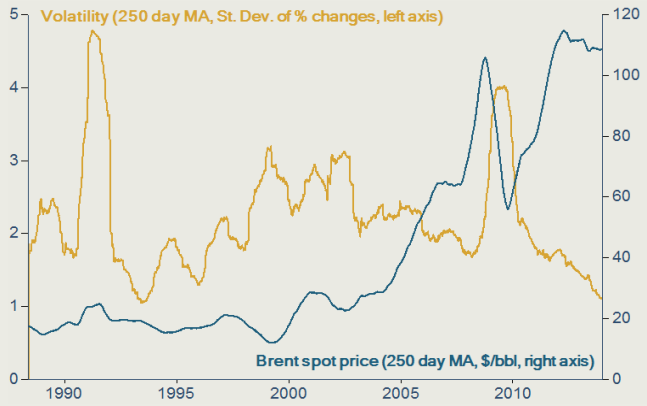
What causes spikes in oil price volatility? In addition to supply disruptions, concerns about the health of the global economy, and hence demand, is the most frequently mentioned factor. The relationship between macroeconomic

Figure B1.1 Price change greater than 5 percent



Source: World Bank.

Figure B1.2 Volatility of oil prices and price levels



Source: World Bank.

conditions and oil shocks has been studied extensively. Hamilton (2013) identified four major oil price shocks during the past 25 years and noted that two of them—1990 and 2002/03—were related to supply disruption concerns associated with the Gulf wars while two—1999/2000 and 2007/08—were caused by demand changes. Bloom (2013) noted that macroeconomic shocks associated with recessions—a case in point being the 2008 financial crisis—are more uncertain than positive shocks. Moreover, because recessions are rare events with no clear consensus on their likely depth and duration, which are often amplified by policy uncertainty, they tend to cause greater market volatility than positive shocks. This is consistent with the fact that one of the two largest volatility spikes of the past 25 years coincided with the great recession.

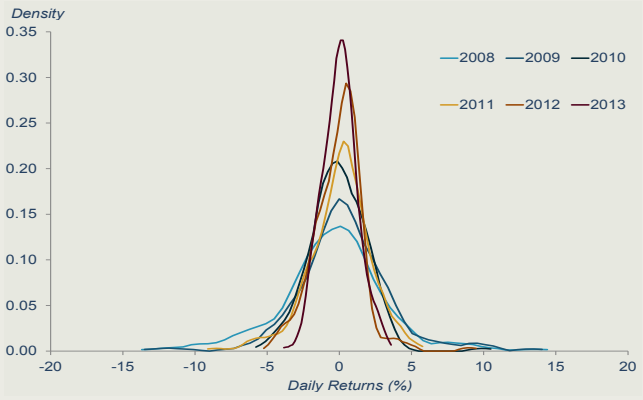
The next step is to examine the relationship between vol(r_t) and the volatility of the S&P 500 index, vol(SP_t). The S&P 500 index, which consists of the largest 500 companies traded in U.S. equity markets, is often viewed as an indicator of expectations about overall macroeconomic conditions. Figure box 1.4 confirms a strong correlation between vol(r_t) and vol(SP_t) during the 2008/09 financial crisis but no correlation in 1990. Thus, visual inspection alone strongly suggests that the 2008/09 volatility episode was associated with the 2008 financial crisis (and therefore demand-driven) while the 1990 episode reflected supply concerns induced by the first Gulf war (and, by induction, supply-driven).

To validate this conjecture, a Granger causality test was applied to vol(r_t) and vol(SP_t). Specifically, vol(r_t) was regressed on vol(r_{t-1}) and vol(SP_{t-1}) for each 250-day moving window during 1988-2013. Subsequently, White's robust standard errors were calculated. A *p*-value of less than 0.01 associated with the parameter estimate of vol(SP_{t-1}) would be consistent with a Granger-causal relation from vol(SP_t) to vol(r_t).

Causality analysis results (not reported in this box) confirm that vol(SP_t) began "Granger-causing" vol(r_t) in 2007, albeit in a limited way. The strongest causation was detected in 2009 (i.e., as the regressions included more observations from 2009, the parameter estimate of vol(SP_{t-1}) was becoming progressively more significant). The causation began dissipating in 2010 and more so in 2011, effectively disappearing by 2012. These Granger-causality results suggest that the 2008/09 spike in oil price volatility emanated from macroeconomic concerns and thus should be viewed as demand-driven. On the other hand, the absence of Granger-causality in 1990 leaves supply disruptions due to the Gulf war the likely explanation of the spike in volatility. The results are consistent with Hamilton's (2013) finding that the 1990 and 2007/08 volatility episodes are supply- and demand-driven, respectively.

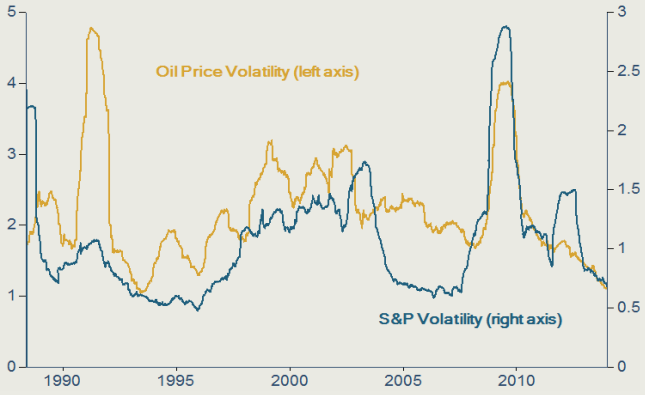
The three measures of volatility presented here (price changes in excess of 5 percent, standard deviation of returns, and within-year dispersion of returns) suggest that the view that oil price volatility will be permanently higher after 2008 is not supported by the empirical evidence. Furthermore, the evidence suggests that high oil prices are neither a necessary nor a sufficient condition for elevated price volatility since both high and low price volatility can take place under high and low prices. Indeed, the 1990 spike in volatility was associated with only a moderate increase in oil prices. while elevated volatility during the late 1990s, coincided with the lowest price level in recent history (when oil prices dropped temporarily below $10/bbl). Last, volatility during 2008/09 spiked well after the collapse of oil prices in late 2008.

Figure B1.3 **Dispersion of oil price changes**



Source: World Bank.

Figure B1.4 **Volatility of oil price and S&P 500**



Source: World Bank.